PHASE I
WATERSHED ASSESSMENT
AND TMDL
FINAL REPORT

DANTE LAKE
CHARLES MIX COUNTY, SOUTH DAKOTA

South Dakota Watershed Protection Program
Division of Financial and Technical Assistance
South Dakota Department of Environment and Natural Resources

Steven M. Pirner, Secretary

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SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM
ASSESSMENT/PLANNING PROJECT FINAL REPORT

DANTE LAKE WATERSHED ASSESSMENT AND TMDL
FINAL REPORT

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Sponsor

South Central Water Development District

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Executive Summary

Project Title: South Central Lakes Watershed Assessment Project

Project Sponsor: South Central Water Development District

Project Start Date: April 1, 2000	Project Completion Date: December 31, 2001
Original Funding:	**Total Budget:** $ 189,438.00
Total EPA Budget:	$ 113,663.00
Total Expenditures of EPA Funds:	$ 126,857.14
Total Section 319 Match Accrued:	$ 77,510.11
Budget Revisions:	319 - $ 22,000.00 Reverted 319 - $ 8,805.86
Total Project Expenditures:	$ 204,367.25

Summary of Accomplishments

Dante Lake is a small 18.7 acre (7.6 ha) impoundment on Dante Creek, a tributary of Choteau Creek, approximately 2 miles north of the town of Dante near the south eastern boundary of Charles Mix County, South Dakota. The reservoir has an average depth of 11 feet (3.4 meters) and a maximum depth of 23 feet (7 meters). Dante Lake has 0.7 mi (1.1 km) of shoreline and holds 194 acre-feet of water. An unnamed creek (henceforth, Dante Creek) is the primary tributary to Dante Lake which drains a small 2,844-acre watershed of mostly cropland with about a fifth of the acreage used for grazing.

Small waterbodies such as Dante Lake can be expected to be particularly sensitive to changes in local weather patterns such as yearly variability in rainfall and seasonal temperatures. In-lake nitrogen and phosphorus levels are affected by the amount of tributary inflow. Total dissolved solids concentrations appear to be inversely related to the amount of annual rainfall. Yearly average in-lake TDS concentrations may vary by more than twofold (i.e. 1,800 – 3,900) increasing during dry years and decreasing during wet years, presumably due to the increased influence of evaporation during drier periods. Dante Lake is listed as a degraded waterbody impaired by TSI and targeted for TMDL development by the 2004 Integrated Report (SD DENR, 2004).

During the assessment, Dante Lake is meeting ecoregional-based beneficial use evaluation criteria (fully supporting, mean TSI $\leq$ 65.00) based on AnnAGNPS modeling, BMPs and watershed phosphorus reduction attainability. Long-term data suggest in-lake TSI values vary depending upon rainfall patterns. Data also indicate lower dissolved oxygen concentrations in the summer months ($\leq$ 5.0 mg/L), especially in drier years. Implementing recommended tributary and in-lake BMPs for phosphorus to reduce in-lake TSI values should improve dissolved oxygen concentrations in Dante Lake. The addition of a mechanical aeration for operation during periods of low algal densities and surface dissolved oxygen concentrations will provide oxygen (air) to the hypolimnion breaking up stratification and increasing, conversion of organic matter improving dissolved oxygen concentrations throughout the lake and improve overall water clarity. Oxygenation of the hypolimnion during the summer will also increase the available habitat for fish. Any realized reductions in tributary loading will improve Dante Lake TSI values and dissolved oxygen concentrations.

Current data indicate that a 6.4 percent reduction in total phosphorus can be achieved in this watershed to meet the TMDL goal of 1,474 kg/yr total phosphorus for a mean in-lake TSI of 63.86. The recommended reductions will improve compliance with South Dakota's narrative criteria and the designated beneficial uses of the watershed, specifically, warmwater permanent fish life propagation water, immersion recreation water, limited contact recreation water, fish and wildlife propagation, recreation, and stock watering water. The installation of a mechanical aeration device in concert with implementation of tributary and in-lake BMPs will meet warmwater permanent fish life propagation and immersion recreation numeric standards for dissolved oxygen ($\geq$ 5.0 mg/L) throughout the year. Based on data from this assessment, a phase II implementation project should be designed and initiated in this watershed to achieve this goal.

ACKNOWLEDGEMENTS

South Central Water Development District
Charles Mix County Conservation District
Douglas County Conservation District
Charles Mix County Commission
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South Dakota Conservation Commission
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US Environmental Protection Agency
South Dakota Department of Environment and Natural Resources
South Dakota Department of Game, Fish and Parks

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INTRODUCTION

PURPOSE

The purpose of this water quality assessment was to determine the sources of impairment to Dante Lake and the tributaries in its watershed for the determination of Total Maximum Daily Load (TMDL). Dante Lake is listed as a degraded waterbody targeted for TMDL development based on the 2004 Integrated Report (The 2004 South Dakota Integrated Report for Surface Water Quality Assessment, (SD DENR 2004)). The local creeks and small tributaries contribute loadings of sediment and nutrients related to snowmelt and spring rain events. The discharge from this watershed reaches Choteau Creek which flows into the Missouri River.

An unnamed creek (henceforth Dante Creek) is the primary tributary to Dante Lake. The creek drains a small 2,844-acre watershed of mostly cropland with about a fifth of the acreage used for grazing (Figure 1). Confined feeding areas for livestock have not been documented for the watershed but several may be present as they are a common local feature, and cattle have ready access to the tributary and associated riparian areas. The stream carries sediment and nutrient loads that degrade water quality in the lake and cause increased eutrophication.

GENERAL LAKE DESCRIPTION

Dante Lake is a 18.7 acre (7.6 ha) impoundment on Dante Creek, a tributary of Choteau Creek. The lake is located approximately 2 miles north of the town of Dante near the south eastern boundary of Charles Mix County, South Dakota (Figure 1). The reservoir has an average depth of 11 feet (3.4 meters) and a maximum depth of 23 feet (7 meters). Dante Lake has 0.7 mi (1.1 km) of shoreline and holds 194 acre-feet of water. The lake has appreciable average depth (>10 ft) for a small waterbody and is therefore more subject to varying periods of temporary stratification during the summer. The Dante Lake drainage comprises a small portion of the Lewis and Clark Lake hydrologic unit. The hydrologic unit has a priority rank of 13 out of 39 watersheds assessed in the South Dakota Unified Watershed Assessment.

LAKE IDENDIFICATION AND LOCATION

Lake Name : Dante Lake	State : South Dakota
County : Charles Mix	Township: 95N
Range : 62W	Sections : 4 and 9
Nearest Municipality: Dante	Latitude: 43.0667
Longitude: 98.1767	EPA Region: 8
Primary Tributary: Dante Creek	Receiving Waters: Dante Creek to Choteau Creek
HUC Code: 10170101	HUC Name: Lewis and Clark Lake

BENEFICIAL USES AND WATER QUALITY STANDARDS

The State of South Dakota has assigned all of the water bodies that lie within its borders a set of beneficial uses. Along with these assigned uses are sets of standards for the chemical properties of the lake. These standards must be maintained for the lake to satisfy its assigned beneficial uses. All bodies of water in the state are assigned the beneficial uses of fish and wildlife propagation, recreation, and stock watering (9). The following beneficial uses are assigned to Dante Lake:

(4) Warmwater permanent fish life propagation
(7) Immersion recreation
(8) Limited contact recreation
(9) Fish and wildlife propagation, recreation, and stock watering

Table 9 (page 21) lists the parameters that must be considered when maintaining beneficial uses as well as the concentrations of each applicable parameter. When multiple standards for a beneficial use exist, the most restrictive standard is used.

TROPHIC STATE COMPARISON

The trophic state index of a lake is a numerical value that ranks the lake's relative productivity. Developed by Carlson (1977), the trophic state index (TSI) allows a lake's productivity to be easily quantified and compared to other lakes. Higher TSI values correlate with higher levels of primary productivity. A comparison of Dante Lake to other lakes in the Northwestern Glaciated Plains ecoregion (Table 1) shows that a high level of productivity is common for the ecoregion. Dante Lake is moderately lower than average for productivity in this group of lakes (avg TSI: 76). The values provided in Table 1 were generated from the most recent statewide lake assessment final report (Stueven and Stewart, 1996).

Table 1. TSI comparison for selected area lakes.

Lake	County	TSI	Mean Trophic State
Academy	Charles Mix	81.69	Hyper-eutrophic
Corsica	Douglas	79.93	Hyper-eutrophic
Cottonwood	Sully	78.55	Hyper-eutrophic
Rosette	Edmunds	78.45	Hyper-eutrophic
Geddes	Charles Mix	77.60	Hyper-eutrophic
Hiddenwood	Walworth	77.46	Hyper-eutrophic
Dante	**Charles Mix**	**72.13**	**Hyper-eutrophic**
Wilmarth	Aurora	72.09	Hyper-eutrophic
Loyalton	Edmunds	66.65	Hyper-eutrophic

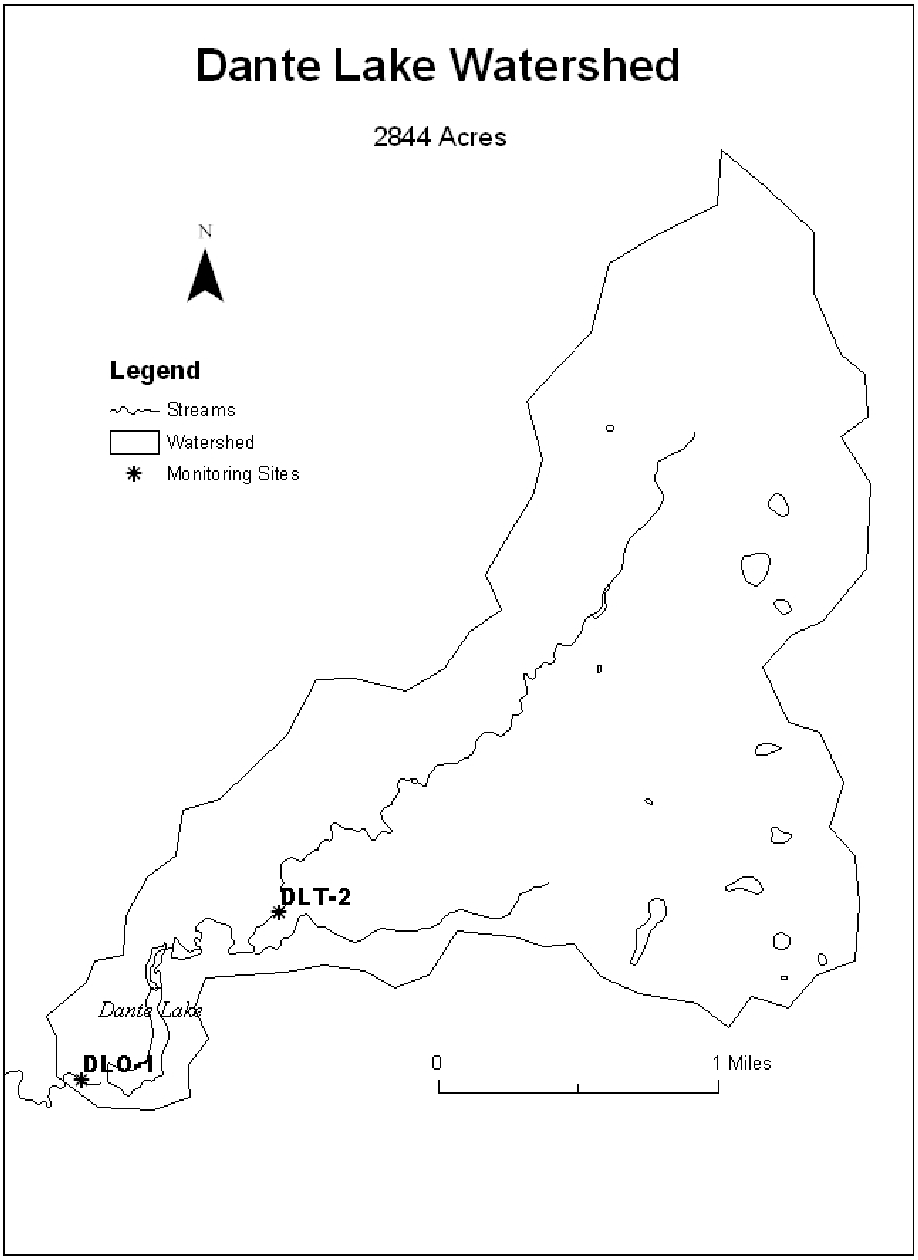

Figure 1. Dante Creek tributary monitoring sites.

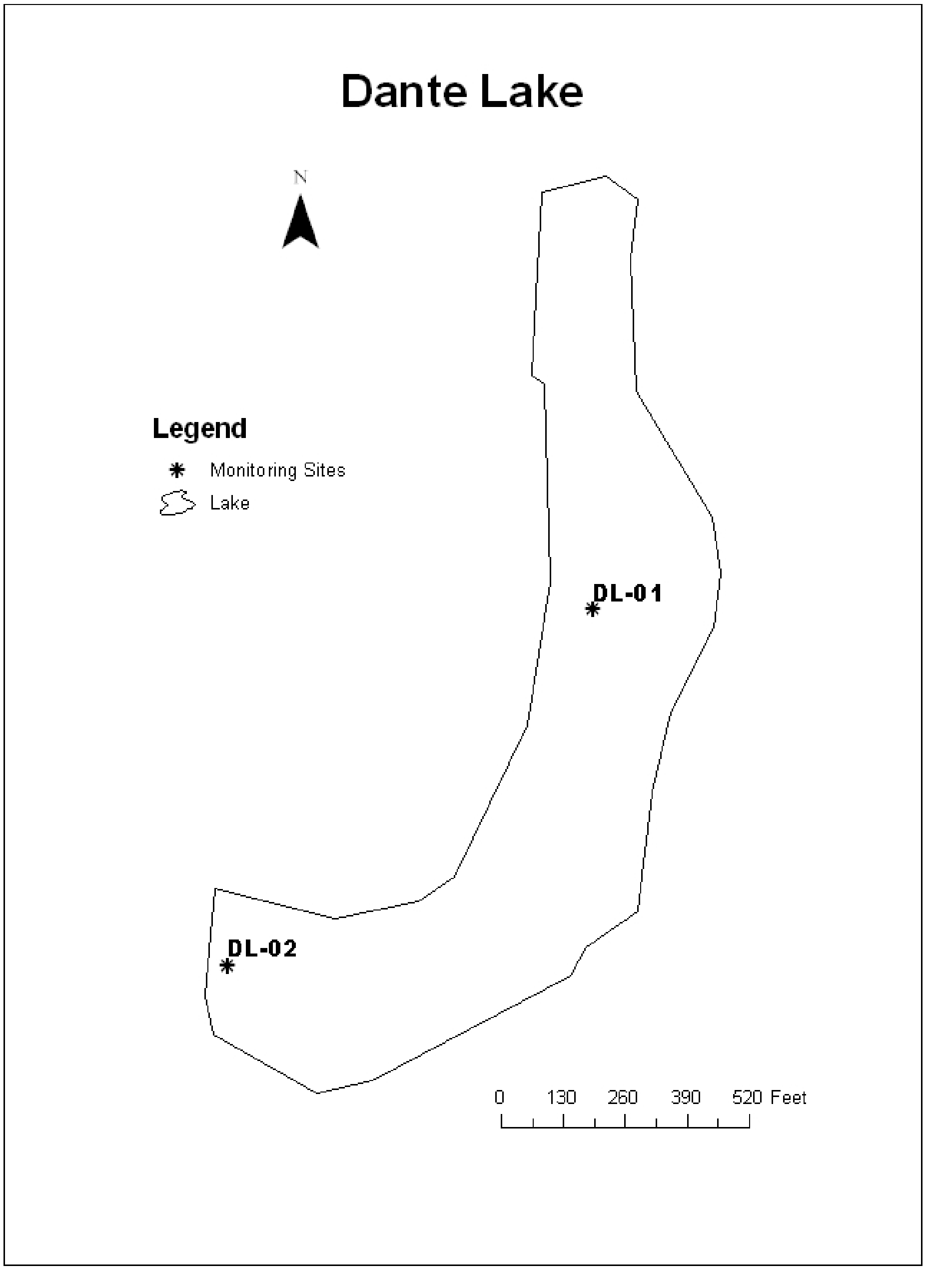

Figure 2. Dante Lake in-lake monitoring sites.

RECREATIONAL USES

The South Dakota Department of Game, Fish, and Parks provided a list of existing public facilities that are maintained at area lakes (Table 2). Dante Lake provides limited boating, fishing and swimming opportunities. There appears to be little public access (1) along the lake for shore fishing and swimming and less than 5 public acres near the shoreline. There is a single public boat ramp located about 500 feet from the north end of the dam. There are no other facilities such as toilets, picnic tables, and designated camping grounds (Table 2).

Table 2. Recreational Facilities at area lakes.

	State Park	Ramps	Boating	Camping	Fishing	Public Toilets	Picnic Tables	Swimming
Academy			X		X			X
Andes			X		X			X
Dante		**1**	**X**		**X**			**X**
Francis Case	1	9	X	X	X	X	X	X
Geddes		1	X		X			X
Platte		1	X		X			X
Wagner					X	X	X	X

GEOLOGY, SOILS AND CLIMATE

Dante Lake and its primary tributary are located near the mid-point of the south east border of Charles Mix County which is formed by the course of Choteau Creek. Dante Lake was created by a dam on Dante Creek. The flows into Choteau Creek, a tributary of the Missouri River. The Dante Lake drainage lies near the south-eastern border of the Northwestern Glaciated Plains ecoregion (ecoregion 42). This portion of the ecoregion, called the Southern Missouri Coteau Slope, is characterized by mesic soils rather than frigid soils with a substantial cap of rock-free loess. The predominant (virtually 100%) soil association in the watershed is the Hemme-Ethan-Onita. Those soils are described as well to moderately well drained, nearly level to gently rolling silty and loamy soils on uplands and in upland swales.

Located east of the Missouri River, the Dante Lake watershed was subject to several periods of glaciation which formed the topography and parent material of present day soils. The Late Wisconsin period of glaciation, some 10 to15 thousand years ago, was the last to affect the area.

The level to rolling uplands of the watershed and surrounding area are cropped to sunflowers, wheat, millet, and barley. Corn is a marginal crop locally that does well during wet years. It is estimated that 78% of the land in the watershed is cropland, 20% rangeland and pasture, and 2% roads and residences. The riparian areas are usually grazed. Willows, green ash, and elm tend to grow in local streamside habitats.

The climate of Charles Mix County is sub-humid continental with dry winters and wet springs.

Annual precipitation can be expected to yield nearly 22 inches, most of which falls from April through September. Rainfall in the immediate watershed area has been somewhat better in recent years, reading approximately 24 to 25 inches annually. The average seasonal snowfall in Charles Mix County is 25 inches per year.

PROJECT DESCRIPTION

GOALS

The goal of this assessment project was to determine and document sources of impairments to the watershed of Dante Lake and to develop feasible alternatives for restoration.

OBJECTIVES

Objective 1. Lake Sampling

The objective was to determine current conditions in the lake and calculate the trophic state. This information were used to determine the total amount of nutrient trapping that is occurring in the lake and the amount of nutrient reduction required to improve the trophic condition of Dante Lake.

Nutrient and solids parameters were sampled monthly in the water column of one mid-lake site for one year. Surface, mid-depth and bottom samples are collected to obtain seasonal dissolved oxygen-temperature profiles. For one sampling date of this project in April 2001 a deeper site near the dam was added to the sampling schedule for the purpose of obtaining a better spring oxygen/ temperature profile.

Water samples were collected with a Van Dorn sampler and the sample bottles iced and shipped to the lab. Samples including those for fecal coliform bacteria were analyzed by the SD State Health Lab in Pierre. Other biological samples, such as algae, were analyzed by Aquatic Analysts, White Salmon, Washington, and by staff from Water Resources Assistance Program in the Matthew Training Center Laboratory, Pierre, SD.

All samples were collected using the methods described in the Standard Operating Procedures for Field Samplers by the Watershed Assessment Team, DENR. Figure 1 shows the locations of the in-lake sampling sites.

Objective 2. Tributary Sampling

Water quality samples were collected at two tributary sampling sites, one approximately one-half mile upstream of the lake inlet (DLT-2) and one below the lake spillway (DLO-1). Samples were collected during spring runoff, storm events, and monthly base flows for a period of one year. No samples were taken during stagnant (no flow) conditions. Tributary water quality monitoring sites are shown in Figure 1.

Samples were collected twice weekly during the first week of spring snowmelt runoff and once a week thereafter until runoff ceases. Storm events and base flows were sampled throughout the project period of one year. During this project, flows generally stopped after the first of June. There was only one summer storm flow date recorded.

Sediment and nutrient loading to Dante Lake from the major tributary will be estimated through hydrologic and chemical monitoring. The information was used to locate critical areas in the watershed to be targeted for implementation.

Stevens Type F Stage Recorders (water level recorders) and ISCO flow meters were installed at the pre-selected tributary monitoring sites. This equipment generates data on the daily discharge of nutrients and sediment from the watershed into Dante Lake. Because of dry conditions during 2000, the data obtained was limited primarily to the months of April and May. There was little runoff in the watershed until the spring of 2001.

Objective 3. Quality Assurance / Quality Control (QA/QC).

Duplicate and blank samples were collected during the course of the project to provide defendable proof that sample data were collected in a scientific and reproducible manner. A minimum of 10 percent of all water quality samples collected were QA/QC samples that will be reported separately. QA/QC data collection was completed on schedule with the proposed timeline.

Objective 4. Watershed Modeling

Evaluation of agricultural impacts to the water quality of the Dante Lake watershed were determined using the Annualized Agricultural Nonpoint Source model (AnnAGNPS). The local coordinator utilized public records and personal contact with landowners and operators in the watershed to gather the required data which consists of 21 individual land parameters with additional information collected for animal feeding operations.

AnnAGNAPS is a data intensive watershed model that routes sediment and nutrients through a watershed by utilizing land uses and topography. The watershed was divided into cells of varying size and shape depending on topography. Each cell was assigned a primary land use and soil type. Best Management Practices (BMPs) are then simulated by altering the land use in the individual cells and the resulting reductions in sediment and nutrients are calculated at the outlet to the watershed.

The input data set for AnnAGNAPS Pollutant Loading model consists of 33 sections of data, which can be supplied by the user in a number of ways. This model utilized digital elevation maps (DEMs) to determine cell and reach geometry, Soil Survey Geographic Database (SSURGO) soil layers to determine primary soil types and the associated National Soil Information System (NASIS) for each soil's properties, and primary land use based on a 40 acre grid pattern, collected initially to execute the AGNAPS version 3.65 model. Impoundment data was obtained using Digital OrthoQuads (DOQs) layers using ArcView Global Information System (GIS) software. Weather data was generated using a synthetic weather generator based on climate information from the Wagner weather station. Model results are based on 25 simulated years of data for precipitation ranging from 13.4 to 29.6 inches per year. Mean annual precipitation for the Dante Lake watershed is about 24 inches.

Watershed modeling also includes the assessment of Animal Feeding Operations (AFOs) located within the drainage under investigation. However, data provided by the local conservation district indicated no AFOs were present in the Dante Lake watershed.

Findings from the AnnAGNAPS report together with water quality data were used to form conclusions and develop recommendations for watershed and lake rehabilitation.

Objective 5. Lake Modeling

The reduction response model used to predict lake response to reductions in tributary loading was BATHTUB (Walker, 1999). BATHTUB is predictive in that it will assesses impacts of changes in water and/or nutrient loadings, and estimate nutrient loadings consistent with given water quality management objectives. In-lake and tributary data collected from the assessment project was used to calculate existing conditions and to predict parameter-specific and mean TSI values based on general reductions in loadings from Dante Creek during 2000 and 2001.

Objective 6. Sediment Survey

The sediment survey of Dante Lake was completed during January of 2001. Safe ice conditions permitted the timely completion of the survey.

Objective 7. Public Participation

Public participation and involvement were provided for and encouraged. Informational meetings were held for the general public and to inform the involved parties of progress on the study. These meeting provided an avenue for input from the residents in the area. Landowners were asked to provide information applicable to assessing the condition of animal feeding operations and land management practices within the watershed.

Objective 8. Restoration Alternatives and Final Report

Field data were analyzed and used to generate loading calculations that in turn were used to develop hydrologic, sediment, and nutrient budgets for the watershed. The results of

AnnAGNPS modeling will be used in conjunction with the water quality and hydrologic budgets to determine critical areas in the watershed.

The feasible management practices were compiled into a list of alternatives for the development of an implementation project and included in the final project report.

Evaluation of Goal Achievements

The goal of the watershed assessment completed on Dante Lake was to determine and document sources of impairment to the lake and to develop feasible alternatives for restoration. This was accomplished through the collection of tributary and lake data and aided by the completion of the AnnAGNPS watershed modeling tool. Data analysis and modeling permitted the identification of impairment sources. This will aid the state's nonpoint source program (NPS) by allowing strategic targeting of resources to portions of the watershed that will provide the greatest benefit per expenditure.

MONITORING RESULTS

TRIBUTARY MONITORING

Flow Calculations

One tributary site (DLT-2) and outlet monitoring site (DLO-1) were selected on Dante Creek which is the primary tributary to Dante Lake (Figure 2). The tributary site was equipped with a Stevens Type F stage recorder and an Intermountain R2 unit was used at the outlet site. A Marsh- McBirney Model 210D flow meter was utilized to determine flows at various stages. The stages (water levels) and flows were then used to create a stage/discharge table for each site. Stage-to-discharge tables are presented in Appendix B.

Load Calculations

Total nutrient and sediment loads were calculated using FLUX, of the Army Corps of Engineers eutrophication model. FLUX uses individual sample data and daily discharges to develop six loading calculations (methods) for each parameter. As recommended in the application sequence, a stratification scheme and method of calculation was determined using total phosphorus load. This stratification scheme is then used for each of the additional parameters.

The FLUX program uses six different calculation techniques for calculating nutrient and sediment loading. The sample and flow data for this program can be stratified (adjusted) until the coefficients of variation (CV) for all six methods converge or are similar. The lower the CV value the greater the accuracy of the loading estimates. This methodology may be applied to each relevant parameter to determine the appropriate method (model) for specific parameters. Models and CV values for each parameter and sampling site are listed in Table 3. These methods were used on the tributary site (inlet site) and the outlet site of Dante Lake to calculate nutrient and sediment loadings for this project.

Export coefficients can then be determined for each parameter by dividing the area of the watershed or sub-watershed into the previously calculated load for that parameter. This calculation gives the kilograms of sediment or nutrients per acre delivered from the watershed or any sub-drainage thereof (kg/acre). These values are used to target areas with excessive nutrient and sediment loads within larger watersheds for BMP implementation.

Table 3. Model and coefficient of variation by parameter for FLUX analysis in Dante Creek, Charles Mix County, South Dakota from 2000 through 2001.

	DLO-1 (Dante Lake Outlet)		DLT-2 (Dante Lake Inlet)	
Parameters	**Model (Method)**	**Coefficient of Variation (CV)**	**Model (Method)**	**Coefficient of Variation (CV)**
Alkalinity	Q wt C	0.115	IJC	0.064
Total Solids	Q wt C	0.204	Q wt C	0.414
Total Dissolved Solids	Q wt C	0.213	Q wt C	0.419
Total Suspended Solids	Q wt C	0.463	Q wt C	0.233
Volatile Total Suspended Solids	Q wt C	0.356	Q wt C	0.188
Ammonia	IJC	0.191	Q wt C	0.809
Nitrate-Nitrite	Q wt C	0.242	Q wt C	0.170
Total Kjeldahl Nitrogen	Q wt C	0.180	Q wt C	0.294
Inorganic Nitrogen	Q wt C	0.232	Q wt C	0.421
Organic Nitrogen	Q wt C	0.177	Q wt C	0.086
Total Nitrogen	Q wt C	0.202	Q wt C	0.242
Total Phosphorus	Q wt C	0.210	Q wt C	0.296
Total Dissolved Phosphorus	Q wt C	0.371	Q wt C	0.374

Q wt C = Flow weighted concentration model
IJC = International Joint Committee model (modifies Q wt C by a factor to adjust for bias where concentrations varies with flow)

Tributary Sampling Schedule

Samples were collected at tributary and outlet sites, from May 2000 through April 2001 when flows were present. Flows were observed only during spring of both years (March – June) with one exception, August 8, 2000. Samples were collected with a suspended sediment sampler. Water samples were then filtered, preserved, and packed in ice for shipment to the State Health Lab in Pierre, SD. The laboratory analyzed the following parameters:

Fecal Coliform Bacteria
Total Solids
Total Suspended Solids
Nitrate
Total Phosphorus
Total Dissolved Phosphorus
E. coli Bacteria
Alkalinity
Total Dissolved Solids
Ammonia
Total Kjeldahl Nitrogen (TKN)
Volatile Total Suspended Solids
Un-ionized Ammonia

Personnel conducting sampling at tributary sites recorded the following visual observations of weather and stream characteristics:

Precipitation	Wind
Odor	Septic Conditions
Dead Fish	Film
Turbidity	Channel Width
Water Color	Ice Cover

Parameters measured in the field by sampling personnel were:

Water Temperature	Water Depth
Air Temperature	Dissolved Oxygen
Field pH	Conductivity

Sample data collected at the Dante Lake tributary and outlet site is presented in Appendix C.

South Dakota Water Quality Standards

The State of South Dakota assigns at least two (9, 10) of the eleven beneficial uses to all streams and rivers in the state, those being fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10) (SD DENR, 2004). The tributary to Dante Lake, a short intermittent stream of less than 4 miles in length is classified only for (9, 10).

Table 4. State Beneficial Use Standards for the Dante Lake tributary

Parameter	mg/L(except where noted)	Applicable Beneficial Use
Nitrate	50 (mean) 88 (single sample max.)	Fish & wildlife propagation, stock watering and recreation
Alkalinity	750 (mean) 1,313 (single sample)	Fish & wildlife propagation, stock watering and recreation
pH (standard units)	6.0 – 9.5	Fish & wildlife propagation, stock watering and recreation
Total dissolved solids	2,500 (30-day mean) 4,375 (single sample)	Fish & wildlife propagation, stock watering and recreation
Conductivity (µS/cm @ 25C)	2,500 (30-day mean) 4,375 (single sample)	Irrigation

Watershed Overview

Tributary inflow and surface runoff are the primary sources of water for Dante Lake. There are no ground water connections documented at the present time. Small water bodies such as Dante Lake can be expected to be particularly sensitive to changes in local weather patterns such as yearly variability in rainfall and seasonal temperature. In-lake nitrogen and phosphorus levels are affected by the amount of tributary inflow. Total dissolved solids concentrations appear to be inversely related to the amount of annual rainfall. Yearly average in-lake TDS concentrations may vary by more than twofold (i.e. 1,800 – 3,900) increasing during dry years and decreasing during wet years, presumably due to the increased influence of evaporation during drier periods. For example, the project year 2000 was a dry year in the watershed and most in-lake TDS concentrations for that year exceeded 3,000 mg/mL (Appendix C).

Water and Nutrient Budgets

As creeks pass through impoundments they often lose nutrient and sediment loads carried by the flowing water. This was evident in Dante Lake where considerable phosphorus and nitrogen was retained in the small reservoir (Table 5). Those nutrients were utilized by dense aquatic weed beds and large algae populations often present in Dante Lake. Sediments (total suspended solids) are deposited on the bottom of a reservoir basin by settling under reduced flow conditions as well as captured by the beds of vegetation.

The hydrologic (water) inputs to Dante Lake included rainfall, surface runoff and tributary inflow. Hydrologic output is primarily through the reservoir outlet. Secondary water losses to the reservoir result from seepage into the ground and evaporation. Approximately, five percent of the total incoming water was lost to evaporation. Little change in total alkalinity load was evident between the inlet and outlet sites (Table 5).

Table 5. Dante Lake Nutrient, Sediment, and Water Budgets

Parameter	Units	Inlet	Outlet	Retained in Dante Lake	Percent Retained
Total Phosphorus	(kg)	1,575	701	874	55.5%
Total Dissolved Phosphorus	(kg)	1,297	416	881	67.9%
Total Alkalinity	(kg)	297,526	301,862	-4,335	-1.5%
Total Suspended Solids	(kg)	69,071	55,325	13,747	19.9%
Total Nitrogen	(kg)	7,591	4,007	3,584	47.2%
Water	hm3/yr	2.622	2.490	0.132	5.0%

Seasonal Loadings

Seasonal loading of Dante Lake occurs primarily during snowmelt and spring rain events. Tables 6 and 7 depict loadings and concentrations of nitrogen and phosphorus as well as water discharge volumes that occurred during each month of this study. The spring months of March, April, and

May accounted for 97% of the total discharge that occurred during the project. A single large rainstorm in August 2000 contributed the remaining 3%.

Table 6. Seasonal Loading of Nitrogen to Dante Lake

Total Nitrogen Date Month/Year	**Days**	**Sample Count**	**Volume (hm3)**	**Mass (kg)**	**Conc (ppb)**	**Percent Discharge**
May-00	17	1	0.037	101	2,769	1.41%
Jun-00	30	1	0	0	860	0.00%
Jul-00	31	0	0	0	0	0.00%
Aug-00	31	1	0.072	210	2,927	2.74%
Sep-00	30	0	0	0	0	0.00%
Oct-00	31	0	0	0	0	0.00%
Nov-00	30	0	0	0	0	0.00%
Dec-00	31	0	0	0	0	0.00%
Jan-01	31	0	0	0	0	0.00%
Feb-01	28	0	0	0	0	0.00%
Mar-01	31	1	1.704	4,987	2,927	64.96%
Apr-01	30	4	0.772	2,196	2,843	29.43%
May-01	15	1	0.038	97	2,543	1.45%

Table 7. Seasonal Loading of Phosphorus to Dante Lake.

Total Phosphorus Date Month/Year	**Days**	**Sample Count**	**Volume (hm3)**	**Mass (kg)**	**Conc (ppb)**	**Percent Discharge**
May-00	17	1	0.037	21	568	1.41%
Jun-00	30	1	0	0	67	0.00%
Jul-00	31	0	0	0	0	0.00%
Aug-00	31	1	0.072	44	609	2.74%
Sep-00	30	0	0	0	0	0.00%
Oct-00	31	0	0	0	0	0.00%
Nov-00	30	0	0	0	0	0.00%
Dec-00	31	0	0	0	0	0.00%
Jan-01	31	0	0	0	0	0.00%
Feb-01	28	0	0	0	0	0.00%
Mar-01	31	1	1.704	1,038	609	64.96%
Apr-01	30	4	0.772	453	587	29.43%
May-01	15	1	0.038	19	508	1.45%

Annual Loading

To calculate the current and future water quality in an impoundment, BATHTUB (Army Corps of Engineers Eutrophication Model) utilizes phosphorus and nitrogen loads entering the reservoir.

Table 8 shows these loads and their standard errors (CV) calculated using FLUX (Army Corps of Engineers Loading Model) for inlet site DLT-2 to Dante Lake.

Table 8. Annual Lake Loadings for Dante Lake

Parameter	Concentration (mg/L)	FLUX Load (kg/yr)	Coefficient of Variation (CV)
Total Phosphorus	0.600	1,575	0.210
Total Dissolved Phosphorus	0.495	1,297	0.371
Total Alkalinity	113.5	297,526	0.115
Total Suspended Solids	26.3	69,071	0.463
Total Nitrogen	2.89	7,591	0.202

TRIBUTARY WATER QUALITY PARAMETERS

Temperature

As many organisms and biological processes are temperature sensitive. Water temperature is of importance to any aquatic ecosystem. Blue-green algae tend to be more abundant in warmer waters while many green algae and diatom species generally do better under cooler conditions. Water temperature also plays an important role in the physical / chemical cycles of the aquatic environment. Oxygen is more water-soluble in cooler water. Higher toxicity of un-ionized ammonia is directly related to warmer water temperatures.

Dante Creek water temperatures varied from 2.76^o C to 15.12^o C at outlet site DLO-1 and from 0.43^o C to 13.99^o C at tributary site DLT-2. The reason for low values is that temperature measurements were taken only during the spring when stream flows were present. These temperatures fall within the water quality standard for the beneficial uses of the tributary which states that surface temperatures should not exceed 32.2^o C (90F).

It must be noted that samples at outlet site DLO-1 were collected only during April 2001 due to lack of spillway flows at other times, whereas samples at tributary site DLT-2 were able to be collected in spring of 2000 as well as April 2001(Appendix C).

Dissolved Oxygen

Dissolved oxygen (DO) concentrations in most unpolluted streams and rivers remain above 80% saturation, the maximum amount of oxygen that remains in solution at a given water temperature. Conditions of super-saturation can occur due to vigorous mixing of water and air at the bottom of high waterfalls and water discharges from large reservoirs as well as from photosynthetic activity (oxygen production) by dense algae populations. Solubility of oxygen generally increases as water temperature decreases and decreases with increasing altitude (Hauer and Hill, 1996). Stream morphology, turbulence, turbidity, flow, and water salinity all can have an effect on oxygen concentrations.

DO in Dante Creek ranged from 7.85 mg/L to 13.05 mg/L at site DLO-1 (reservoir tailwaters) and from 7.76 mg/L to 16.50 mg/L at tributary site DLT-2. While there were no notable differences between the two sites, it is worth mentioning that all DO readings (along with all other parameters) were taken mostly in spring during cool water conditions when oxygen levels are higher than during the warmer months. All DO readings conformed to the assigned water quality standard (for site DLO-1 only) which requires dissolved oxygen levels to be maintained at concentrations higher than 5.0 mg/L.

pH

pH is the measure of hydrogen ion concentration. The more free hydrogen ions present in water, the more acidic it is. The pH concentrations in Dante Creek were not extreme in any samples collected during this project. pH values ranged from 8.10 to 8.63 su at site DLO-1 and from 7.13 to 8.11 su at tributary site DLT-2. The high alkalinity of Dante Creek waters prevents extreme changes in stream pH. All readings were within the acceptable range (6.0 – 9.0) of pH specified for this creek by the most recent water quality standards.

Total Alkalinity

Alkalinity refers to the quantity of different compounds that shift the pH of waters to the alkaline side of neutral (> 7.0). Various carbonate and bicarbonate compounds, usually compounds of calcium and magnesium, generally originate from dissolution of sedimentary rock (Allan, 1995). Alkalinity in aquatic environments usually ranges between 20 and 200 mg/L (Lind, 1985). However, waters within the state have a wider range of alkalinities. In many state waters, a range (at the high end) of 200-300 mg/L is not uncommon.

Alkalinity during the spring months varied from 111 to 163 mg/L at site DLO-1(which reflected the range recorded at in-lake sites) and from 109 to 333 mg/L at site DLT-2. The state standard for Dante Creek is < 750 mg/L as a 30-day mean or <1313 mg/L for a single sample. The maximum alkalinity value of 333 mg/L recorded during the sampling period was well within those limits.

Total Solids

Total solids are suspended and dissolved materials that occur in natural water. Dissolved solids are defined as materials that pass through a fine filter. Suspended solids are materials that are retained by the filter such as sediment and algae. Dissolved solids concentrations are derived by subtracting suspended solids from total solids, the latter being obtained directly from the water sample by weight. Volatile total suspended solids (VTSS in Appendix Table C) are that portion of suspended solids that are organic and are determined by burning the sample in a muffle furnace at 500C. Dissolved organic matter or organic carbon was not measured during this project.

Total Suspended Solids (TSS)

Under the normal range of stream flows, suspended solids amount to only one to several percentage points of total solids, most of which is nearly always present in the dissolved form. Suspended solids ranged from 8 to 30 mg/L at site DLO-1 (reservoir tailwaters) and from 2 to

102 mg/L at site DLT-2. The volatile portion comprised 48% of TSS at site DLO-1 and 22% at site DLT-2. All TSS values obtained were within the state standards, 150 and 263 mg/L, for Dante Creek.

Total Dissolved Solids (TDS)

TDS varied from 1405 to 2696 mg/L (mean 2027 mg/L) at site DLO-1 and from 788 to 4662 mg/L at site DLT-2 (mean 2406 mg/L). There were two exceedances of the state standard for TDS (4375 mg/L for a single sample) recorded during this project in late May and early June 2000 at site DLT-2. The concentrations measured were similar in both cases, 4,659 and 4,662 mg/L, respectively. Evaporation and low flows during 2000 may have produced those high TDS levels.

Total Ammonia

Ammonia is a nitrogen end-product of bacterial decomposition of organic matter and is the form of nitrogen most readily available for uptake by plants and algae. Sources of ammonia in the watershed may come from cattle grazing streamside, confined animal feeding areas, cropland runoff, decaying vegetation, or bacterial conversion of other nitrogen compounds.

Of six samples collected at outlet site DLO-1, only two contained measurable ammonia concentrations, 0.25 mg/L on April 4 and 0.15 mg/L on April 24, 2001 (Appendix Table C). No water samples were taken at this site during 2000 due to absence of spillway discharges. Similarly, at tributary site DLT-2 during 2000, only two of six samples contained measurable but small concentrations of ammonia, 0.03 mg/L on May 18, and 0.14 on Aug 8, 2000. Of six samples collected at this site during spring 2001, three contained measurable ammonia, including one large spike of 1.17 mg/L for the initial sample of the year on March 22. This may have been part of snowmelt runoff with a large accumulation of livestock waste and organic matter over the winter months. The subsequent two samples contained relatively little ammonia (< 0.15 mg/L).

Un-ionized Ammonia

Un-ionized ammonia (NH4-OH) is the fraction of ammonia that is toxic to aquatic life. The concentration of un-ionized ammonia is determined by calculation using water pH and water temperature measured at the time the water sample is collected. As temperature and pH increase so does the percent of ammonia that is toxic to aquatic organisms. Since pH, temperature, and ammonia concentrations constantly change in the environment, un-ionized ammonia is calculated by individual sample, rather than from a loading basis, to determine compliance with water quality standards.

The water quality standard for Dante Creek is 0.05 mg/L times 1.75 for a single sample or 0.0875 mg/L. It can seen that, based on the previous discussion of local ammonia levels, excessive un-ionized ammonia does not seem to be a serious problem in the Dante Lake watershed, at least not during the spring months. The un-ionized fractions calculated for the two largest ammonia samples, 1.17 and 0.25 mg/L, were approximately .001 and .01 mg/L, respectively, well below the limit of 0.0875 mg/L.

Nitrate-Nitrite

Nitrate and nitrite (NO_3 and NO_2) are inorganic forms of nitrogen easily assimilated by algae and aquatic macrophytes. Sources of nitrate and nitrite can be from fertilizer, septic tank drainfields, ground water and decaying organic matter. Nitrate-nitrite can also be derived from ammonia through denitrification by bacteria. The rate of denitrification increases with increasing temperature and decreasing pH.

Nitrate/nitrite ranged from 0.1 to 0.9 mg/L (mean: 0.5 mg/L) at site DLO-1 and from 0.05 to 2.1 mg/L at tributary site DLT-2 (mean: 0.8 mg/L). Six of ten samples collected at the tributary site contained low to moderate levels (0.05 to 0.7 mg/L) but samples from late March and most of April 2001 had relatively high concentrations of nitrate/nitrite (1.0 to 2.1 mg/L). This may have been the result of ground accumulation of nitrogen over the previous fall and winter from fertilizer, animal waste, etc., and greater spring runoff in 2001 compared to 2000.

Total Kjeldahl Nitrogen / Organic Nitrogen

Total Kjeldahl Nitrogen (TKN) is used to calculate the concentration of organic nitrogen in a water sample. TKN minus ammonia derives organic nitrogen. Sources of organic nitrogen include decaying organic matter, septic systems or agricultural waste. Organic nitrogen is further broken down to more usable ammonia and nitrates by bacteria.

With the exception of one or two samples, virtually all TKN at both sites was organic nitrogen (94% and 96%). Organic nitrogen ranged from 0.72 mg/L to 1.30 mg/L at site DLO-1 (mean: 1.09 mg/L) and from 0.60 mg/L to 1.74 mg/L at site DLT-2 (mean: 0.90 mg/L). A single sample collected at the latter site on March 22, 2001, possibly originating in snowmelt runoff, contained similar amounts of ammonia and organic nitrogen, 1.17 mg/L and 1.08 mg/L, respectively (Appendix Table C). Organic nitrogen levels were not noticeably higher than those of other nutrient-enriched streams in the state.

Total Nitrogen

Total nitrogen is the sum of TKN and nitrate-nitrite. Total nitrogen will be used later in this report to determine nutrient limitation for Dante Lake. Total nitrogen concentrations varied from 1.26 mg/L to 2.12 mg/L at site DLO-1 (mean: 1.68 mg/L) and from 0.66 mg/L to 3.45 mg/L at site DLT-2 (mean: 1.82 mg/L). Total nitrogen levels did not appear to be particularly high for a nutrient-enriched waterbody.

Total Phosphorus

Phosphorus is one of the macronutrients required for primary production. In comparison to carbon, nitrogen, and oxygen, it is often the least abundant in the environment (Wetzel, 2000). Past EPA surveys found that, everything else being equal, natural background phosphorus levels relative to nitrogen tended to increase as one traveled west from the eastern US, from a relatively wet to a drier climate, whereas nitrogen levels decreased over the same distance (Omernik, 1977). In many of our state lakes and streams, phosphorus is disproportionately abundant relative to nitrogen. This may be due both to the drier climate mentioned above with higher background levels of phosphorus in local soils, and man-induced enrichment.

Total phosphorus is the sum of all attached and dissolved phosphorus in a water body. Once phosphorus sorbs to any substrate it is not readily available for uptake and utilization by macrophytes and algae until it is released from the substrate under anoxic conditions, for example, at the bottom of a deep lake. Sources of phosphorus can be natural from geology and soil, from decaying organic matter, waste from septic tanks, or agricultural runoff.

Phosphorus levels tended to be high at both monitored sites. They ranged from 0.150 mg/L to 0.326 mg/L at site DLO-1 (mean: 0.218 mg/L) and from 0.050 mg/L to 0.743 mg/L at site DLT-2 (mean: 0.314 mg/L). The highest value was obtained from a sample collected at DLT-2 on March 22, 2001 which also contained high ammonia and nitrate concentrations (Appendix Table C).

Total Dissolved Phosphorus

Total dissolved phosphorus is the fraction of total phosphorus that is readily available for use by algae and aquatic macrophytes. Dissolved phosphorus will sorb on suspended materials if they are present in the water column and if they are not already saturated with phosphorus.

Dissolved phosphorus varied widely from 0.039 mg/L to 0.214 mg/L at site DLO-1 (mean: 0.107 mg/L) and from 0.020 mg/L to 0.640 mg/L at site DLT-2 (mean: 0.239 mg/L). It comprised 49% of total phosphorus at site DLO-1 but made up 76% at site DLT-2.

Fecal Coliform Bacteria

Fecal coliform bacteria live in the intestinal tract of warm-blooded animals and are used as indicators of organic waste and the presence of pathogenic bacteria in a waterbody. Some common types of fecal coliform are Escherichia coli (E. coli), Salmonella, and Streptococcus, which are associated with livestock, wildlife, and human waste (Novotny, 1994). Since there are no municipalities in the watershed, cattle are the most probable source of fecal coliform in the tributary, based on previous assessments in other similar watersheds.

Fecal bacteria concentrations are often highly variable in space and time. Environmental factors such as sunlight exposure, and water temperature and chemistry can affect fecal coliform numbers in a waterbody. The lifespan of fecal bacteria in a lake or creek environment is relatively short compared to the persistence of associated animal waste, so the absence of fecal coliform does not necessarily indicate the absence of animal waste.

Fecal coliform concentrations at the outlet site DLO-1 for nearly all sampling dates (April 4-30, 2001) were at or below the detection limit for this parameter (10 colonies/100mL). The exception occurred on April 24, 2001, when the outlet sample contained 2,800 colonies/100mL, which exceeded the single sample criterion (2000 colonies/100mL) for limited contact recreation. The sample was collected during the largest runoff event recorded during this project.

Fecal coliform concentrations at tributary site DLT-2 varied widely from 10 colonies/100mL to 20000 colonies/100mL with an average of 3,284 colonies /100mL (Appendix C). The tributary has no fecal coliform standard assigned for its listed beneficial uses. Although the high tributary bacteria densities were not reflected in lake samples, the sources of these high bacterial levels must be identified to protect immersion recreation in Dante Lake. It is likely that the tributary riparian area and nearby pastures are receiving heavy use from cattle and other livestock. Since high nutrient concentrations usually accompany elevated fecal coliform counts, controlling animal waste would decrease both fecal bacteria and nutrient concentrations alike.

Some of the tributary bacteria data collected during this project indicated the presence of E. coli at levels higher than those of total fecal coliform (Appendix Table C). This is the result of standard laboratory testing procedures. Fecal coliform tests are conducted with an incubation temperature of 45°C whereas E. coli are incubated at only 35°C. The higher incubation temperatures for the fecal coliform test inhibit the growth of some E. coli, resulting in lower counts for total fecal coliform.

INLAKE MONITORING

In-lake Sampling Schedule

Sampling began on May 16, 2000 at one mid-lake site (DL-01) and was continued on a monthly or twice-monthly basis until the completion of the project during May 2001. During July 2000, a deeper site near the dam (DL-02) was added for the purpose of obtaining more reliable oxygen/temperature profiles in the shallower lake observed in 2000, a year of below average rainfall in the watershed.

Water samples were filtered, preserved, and packed in ice for shipping to the State Health Lab in Pierre, SD. Sample data collected at Dante Lake is presented in Appendix C. The laboratory assessed the following parameters:

Fecal Coliform Bacteria	Alkalinity
Total Solids	Total Dissolved Solids
Total Suspended Solids	Ammonia
Nitrate/Nitrite	Total Kjeldahl Nitrogen (TKN)
Total Phosphorus	Volatile Total Suspended Solids (VTSS)
Total Dissolved Phosphorus	Un-ionized Ammonia
Chlorophyll a	

Personnel conducting sampling at the mid-lake site recorded visual observations of weather and lake characteristics:

Precipitation	Wind
Odor	Septic
Dead Fish	Film
Water Depth	Ice Cover
Water Color	

Parameters measured in the field by sampling personnel were:

Water Temperature	Air Temperature
Conductivity	Dissolved Oxygen
Field pH	Turbidity
Secchi Depth	

South Dakota Water Quality Standards

All public waters within the State of South Dakota have been assigned beneficial uses. All state lakes are classified for the use of (9)-fish and wildlife propagation, recreation, and stock watering. Each beneficial use has assigned to it specific water quality standards that must not be exceeded in order to support that use. Dante Lake has been designated for the beneficial uses of:

Warmwater permanent fish life propagation
Immersion recreation
Limited contact recreation
Fish and wildlife propagation, recreation, and stockwatering

Table 9 lists the parameters that must be considered when maintaining beneficial uses as well as the concentration of each applicable parameter. When multiple standards for a beneficial use exist, the most restrictive standard is used.

Table 9. State beneficial use standards for Dante Lake

Parameter	mg/L(except where noted)	Applicable Beneficial Use
Alkalinity (CaCO3)	750 (mean) 1,313 (single sample)	Fish & wildlife propagation, recreation & stock watering
Coliform, fecal (colonies/100 ml)	200 (mean) 400 (single sample)	Immersion recreation
Conductivity (µS / cm @ 25C)	4,000 (mean) 7,000 (single sample)	Fish & wildlife propagation, recreation & stock watering
Unionized Ammonia (as N)	0.04 (mean) 1.75 x 0.04 (single sample)	Warmwater permanent fish life propagation
Nitrates as N	50 (mean) 88 (single sample)	Fish & wildlife propagation, recreation & stock watering
Oxygen, dissolved	> 5.0	Immersion & limited contact Recreation Warmwater permanent fish life propagation
pH (standard units)	6.5- 9.0	Warmwater permanent fish life propagation
Total suspended solids	90 (mean) 158 (single sample)	Warmwater permanent fish life propagation
Total dissolved solids	2,500 (mean) 4,375 (single sample)	Fish & wildlife propagation, recreation & stock watering
Temperature	26.7C (80F)	Warmwater permanent fish life propagation

Lake Water Quality Parameters

Water Temperature

Water temperature plays an important role in any aquatic ecosystem. Many aquatic organisms and biological processes are temperature sensitive. Blue-green algae tend to be more abundant in warmer waters while many green algae and diatom species generally do better in cooler conditions. Water temperature also exerts considerable control over the physical/chemical cycles in the aquatic environment. Oxygen is more soluble in cooler water. Higher toxicity of un-ionized ammonia is directly related to warmer temperatures.

Water temperatures in Dante Lake ranged from 7.71^{o} C to 26.92^{o} C near the surface and from 3.67^{o} C to 26.61^{o} C near the bottom. The maximum temperature was reached in mid-August and exceeded the designated standard. State standards require water temperatures in Dante Lake to be maintained below 26.7^{o} C (80F) to support the beneficial use of warmwater permanent fish life propagation.

Dissolved Oxygen

A number of factors influence the concentration of dissolved oxygen (DO) in a lake or reservoir. Temperature is one of the most important of these factors as noted above. As water temperature increases, its ability to hold oxygen in solution declines. Daily and seasonal fluctuations in DO may occur in response to algal and bacterial action (Bowler, 1998). As algae photosynthesize during the day, they produce oxygen, which raises the concentration in the sunlit surface layers of the water column (epilimnion). When photosynthesis ceases at night, respiration utilizes the available oxygen causing a decrease in concentration. In highly eutrophic lakes such as Dante, a high rate of production (algae and aquatic weeds) and subsequent decomposition of this organic material can result in low oxygen concentrations, particularly in the deeper strata of the lake (hypolimnion). These severe conditions prevailed over the entire summer in Dante Lake during the present assessment.

During this project, Dante Lake had already become depleted in DO in the lower half of the water column by early April (sites DL-1 and DL-2). By the beginning of summer 2000, the entire water column, from the surface to the bottom substrate, was similarly affected by low oxygen levels of less than 5.0 mg/L (Appendix Table C). DO did not recover to acceptable levels until autumn of that year with a single exception recorded on July 31 which unaccountably showed adequate DO (>5.0 mg/L) in deeper water and high concentrations in the surface layer (11-12 mg/L). A short-lived summer bloom of a single species of green algae observed on that date may have been responsible for those high DO readings (Table 14). A severely depleted oxygen profile was recorded in late August 1994 for Dante Lake with surface DO at 5.0 mg/L and oxygen concentrations in the lower half of the water column falling to near zero (Steuven and Stewart, 1996). This was accompanied by a low chlorophyll a concentration and reduced algae population.

The poor oxygen environment monitored in Dante Lake during this project may be attributable to large amounts of accumulated oxidizable organic matter that may be present in this small reservoir. Sources may be from dense beds of aquatic plants and summer blue-green algae blooms from previous years as well as periodic inputs of organic material in the form of livestock waste from watershed pastures and/or cattle grazing near Dante Creek.

Dissolved oxygen values ranged from 4.0 to 13.32 mg/L at the surface and from 0.28 to 9.76 mg/L near the bottom. A dissolved oxygen criterion of 5.0 mg/L is required to support both warmwater permanent fish life propagation and immersion recreation in Dante Lake. Four surface DO violations occurred during lake stratification with dissolved oxygen values, two in

July, one in August and one in September of 2000 during below average rainfall. All other months, surface DO values were above the 5.0 mg/L criterion. Lower algal biovolume and chlorophyll-a concentrations were also recorded during these times (Figure 3). Long-term surface DO concentrations were below criterion only once (July 1989) with relatively low algal densities.

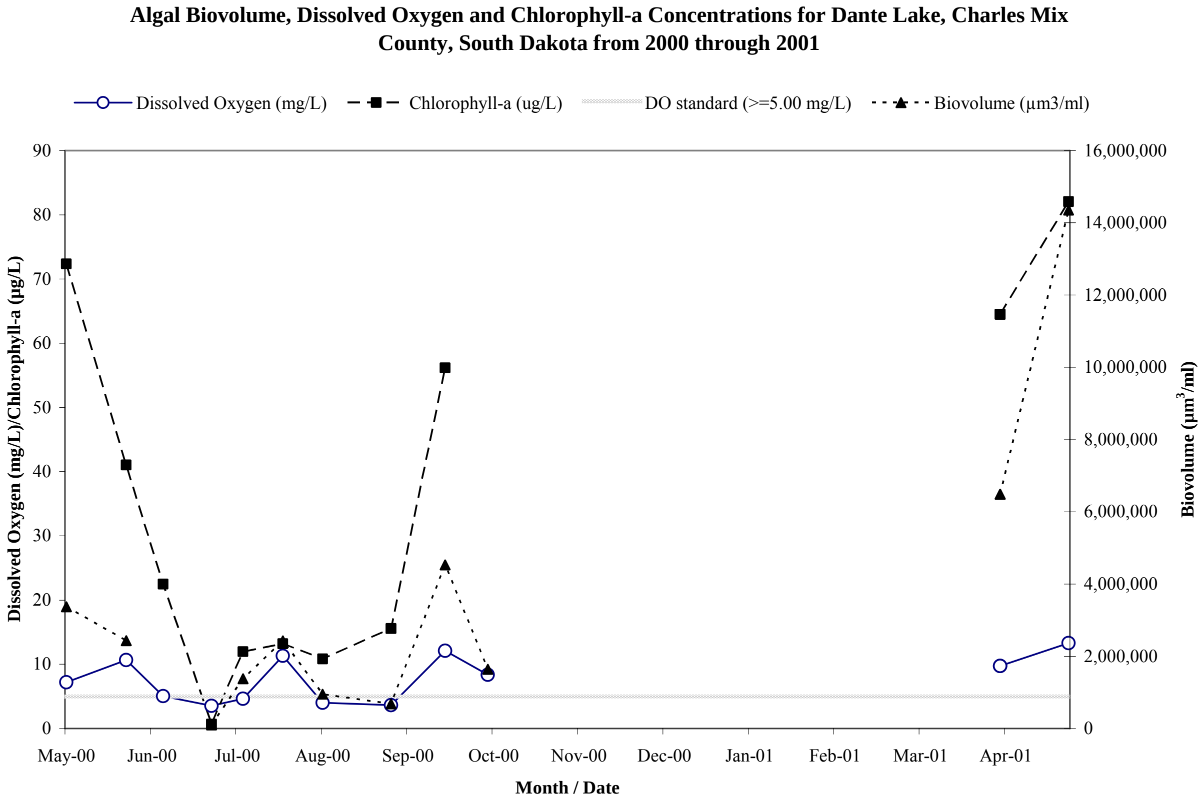

Figure 3. Algal biovolume, dissolved oxygen and chlorophyll-a concentrations for Dante Lake, Charles Mix County, South Dakota from 2000 through 2001.

Algal production during the summer was limited due to total phosphorus availability. Dante Lake is considered to be a macrophyte dominated lake with large densities of submerged macrophytes (see page 44). The majority of macrophyte growth begins in the late spring to early summer and continues into the fall. High densities of submerged macrophytes in Dante Lake require a large quantity of phosphorus (total and dissolved) for growth; this limits the amount of phosphorus available to algae for growth and reproduction. Available total and especially dissolved phosphorus concentrations during this time were extremely low with total phosphorus ranging from 0.048 mg/L to 0.055 mg/L and total dissolved phosphorus ranging from 0.015 mg/L to 0.029 mg/L. Most of the summer of 2000, rainfall in the area was not enough to create discharge from Dante Creek to Dante Lake. Discharge at DLT-1 occurred only one day during the summer of 2000 (estimated 29.3 cubic feet, August 8, 2000); however, this one day nutrient influx did not elicit an algal response in Dante Lake as of August 14, 2000 (six days later). Theoretically, runoff from the watershed would have increased in-lake phosphorus concentrations increasing algal densities resulting in higher surface water dissolved oxygen concentrations during the summer months. Thus years with hot dry summers dissolved oxygen may be below surface water quality standards.

Nutrients, especially phosphorus, have been shown to increase eutrophication in lakes and reservoirs throughout the country increasing oxygen depletion caused by decomposition of algae and aquatic plants (Carpenter et al., 1998). Carpenter et al. (1998) and Bertram (1993) also indicate that reductions in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Nurnberg (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 AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg also developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes (UT DWQ, 2006). Dante Lake's morphological characteristics are well within those Nurnberg used to develop regression models (Nurnberg ranges: $\bar{z}$ mean depth (m), 1.8 – 200; A_o lake surface area (hectares), 1.0 – $8.2*10^6$ and $\bar{z} / A_o^{0.5}$ (m/km^2), 0.14 – 48.1; Dante values: $\bar{z}$ (m), 3.2; A_o (hectares), 7.6 and $\bar{z} / A_o^{0.5}$ (m/km^2), 11.6) which support SD DENR conclusions that nutrients affect dissolved oxygen concentrations and algal populations in Dante Lake. This view is also supported by Carpenter et al. (1998). Thus reduction in nutrient (phosphorus) loads to the lake will improve dissolved oxygen concentrations and overall water quality in Dante Lake. South Dakota's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waterbodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen).

However, if after treatment of sources and a sufficient period of time for recovery (10+ years) dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. Lower dissolved oxygen concentrations in the summer months, especially in dry years, may require the addition of a mechanical aeration for operation during periods of low surface dissolved oxygen concentrations. Adding oxygen (air) to the hypolimnion will break up stratification and increase conversion of organic matter improving dissolved oxygen concentrations throughout the lake profile. Two lakes in South Dakota, Stockade Lake in Custer County and Lake Waggoner in Haakon County, have or have had aeration systems installed to breakup stratification to improve water quality. Stockade Lake aeration system was put into service in 1999 and operates only during the summer months during thermal stratification. SD GF&P monitoring results indicate aeration during the summer did not allow the lake to stratify improving the dissolved oxygen profile increasing fish habitat during the summer. Improved water quality especially dissolved oxygen concentrations has been observed in Stockade Lake in resent years and based on SD GF&P monitoring data and current SD DENR statewide lake assessment data (SD GF&P, 2004, SD GF&P, 2005, SD GF&P, 2005a and SD DENR, 1996). In 2006, SD DENR proposed a change in listing criteria based on TSI (Trophic State Index) parameters based on Secchi and chlorophyll-a TSI values and grouped by fishery classifications. Using this criteria, the 2006 Integrated Report indicates that Stockade Lake be de-listed as fully meeting the modified lake listing criteria. Waggoner Lake installed a mechanical aeration system in the mid 1990's to breakup thermal stratification and improve drinking water taste. This system operated during the summer months through 2002 when the City of Philip switched its drinking water source from Waggoner Lake to West River/Lyman Jones rural water. A mechanical aerator is recommended and should be considered to improve the overall water quality in Dante Lake. Dante Lake is a small (18.7 acre) lake and a good candidate for an aeration system which should improve sporadic low dissolved oxygen concentrations observed in the summer months during this assessment.

Hypolimnetic aeration should improve organic matter reduction from anoxic (slow organic conversion) to conversion in the presence of oxygen (rapid organic conversion). Proposed nutrient load reduction BMPs (best management practices) to reduce nutrient loading from the watershed should also reduce organic loading to Dante Lake. Along with the addition of a mechanical aeration system, dissolved oxygen concentrations will improve and meet current beneficial use based surface water quality standards (≥ 5.00 mg/L) throughout the year.

Dissolved Oxygen and Temperature Profile

Temperature and DO profiles were measured to determine oxygen availability and temperature conditions throughout the water column and to detect occurrence of stratification. Many of the deeper lakes in temperate climates stratify, or form layers. This usually occurs in summer in eutrophic lakes where large differences in water density are produced by strong insulation and high temperatures (Monson, 2000).

No enduring oxygen/temperature stratification was identified at the mid-lake site DL-1. Probably, Dante Lake was too shallow, particularly in year 2000, to maintain prolonged summer stratification. The temperature profiles, in particular, showed a well-mixed water column from late spring to fall (Appendix D). This uniformity was also reflected by the DO profiles. Oxygen levels remained uniformly low (< 5 mg/L) throughout the summer from surface to bottom. The deeper site DL-2 near the dam spillway (> 6 m) showed temporary thermal / DO stratification in early July 2000 and April 2001 as did site DL-1 in April and May 2001. However, the occurrence of stratification in mid-spring is considered atypical in temperate lakes. Probably, the maintenance of stratification in Dante Lake depends on extended periods of calm weather conditions, as even moderate wind velocities appear to be capable of dissipating stratification in this small reservoir. Installation of the proposed mechanical aeration system should improve dissolved oxygen profiles during the summer months increasing available fish habitat.

Chlorophyll-*a*

Chlorophyll-*a* is the primary photosynthetic pigment found in oxygen-producing organisms (Wetzel, 1982). Chlorophyll a is a good indicator of a lake's productivity and state of eutrophication. The concentration of chlorophyll a may be recorded as mg/m3, µg/L, or ppb and is used in Carlson's (1977) Trophic State Index to rank a lake's state of eutrophication.

Dante Lake chlorophyll concentrations varied by more than 100-fold during this project from less than 0.70 mg/m3 on July 6, 2000 to 71.0 mg/m^3 (mean: 23.2 mg/m^3) on May 3, 2001 (Figure 4). Low chlorophyll levels and algae populations in summer from July to early September may have been related to reduced rainfall and runoff from the watershed during 2000, as discussed in the algae section (Biological Monitoring) of this report. Small summer algae populations may have been partially responsible for low summer DO levels in Dante Lake during 2000.

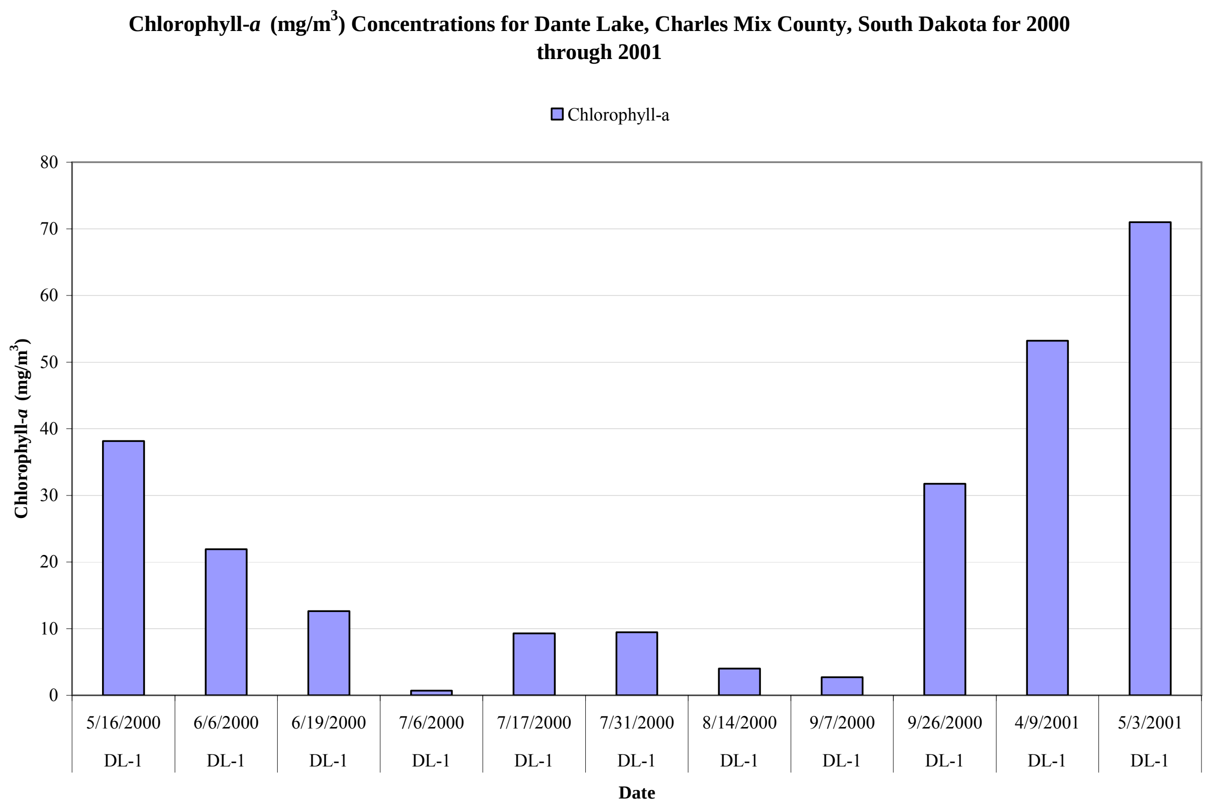

Figure 4. Chlorophyll-*a* (mg/m^3) Concentrations in Dante Lake

Alkalinity and pH

The primary measurements of acidification are alkalinity and pH. The pH scale ranges from 0 to 14, with 7 being neutral. Water with pH < 7 is considered acidic, whereas water with pH > 7 is considered basic. The pH of water is regulated mostly by the interaction of H+ ions. Natural waters exhibit wide variations in acidity and alkalinity. The pH of natural waters ranges between the extremes of 2 and 12 (Wetzel, 2001). Most forms of aquatic life require an environment where pH remains within a range of 6.5 to 9.0. pH in Dante Lake varied from 7.30 to 8.80 which falls within the acceptable range for aquatic life. The maximum value was recorded for a surface sample on May 3, 2001 during a spring algae bloom. Algae, when present in large numbers, have the capability of increasing water pH as a result of the photosynthesizing process.

Alkalinity refers to the buffering ability of the carbonate system in water. The term is used interchangeably with 'acid neutralizing capacity', which is the capacity to neutralize strong inorganic acids (Wetzel, 2001). Alkalinity is a product of geological setting. Soils rich in carbonate rock, such as limestone, provide a source of high alkalinity (Monson, 2000). In general, increased alkalinity inhibits (buffers) drastic pH changes. Alkalinity typically ranges from 20 to 200 mg/L in natural environments (Lind, 1985). In Dante Lake, alkalinity concentrations ranged from 110 to 177 mg/L. Concentrations above 100mg/L are considered to contain significant buffering capacity.

Fecal Coliform Bacteria

Fecal coliform concentrations at in-lake site DL-1 were at or below the detection limit for this parameter (10 colonies/ 100ml) for all sampling dates. These concentrations were far below the 400 colonies/ 100 ml limit for the immersion recreation beneficial use in Dante Lake (Appendix Table C).

Turbidity / Secchi Depth

Turbidity is a measure of water cloudiness and indicates the presence of fine suspended organic or inorganic particulate matter. Turbidity is measured in Nephelometric Turbidity Units or NTU, which measure scattering, shadowing, and absorption of light by suspended particles as it passes through a water sample. Due to the wide variety of sizes, shapes, and densities of suspended particles, there is often little or no apparent relationship between the turbidity of a sample and the concentration of the particulate matter present.

There are no state standards for turbidity in lakes and streams. It is important to note that high turbidity limits photosynthetic activity and reduces the abundance of food organisms (Bowler, 1998). Aquatic plants are negatively impacted at values > 30 NTU. Fish experience a reduction in feeding energy intake at values > 50 NTU, in addition, the structure and dynamics of fish and zooplankton populations can be affected (Claffey, 1955).

Turbidity in Dante Lake surface waters ranged from 1.7 to 22.0 NTU (mean 13.9 NTU). Turbidity values did not appear to be sufficiently high to significantly impact the lake macrophyte and fish communities. The presence of dissolved humic substances (colloids) in Dante Lake gives the water a tea color and affects both NTU and Secchi depth readings.

Secchi disk visibility is the more commonly used measurement to determine water clarity. No state standards for this parameter exist, however, Secchi readings are an important tool used for determining the trophic state of a lake. Two primary causes for low Secchi readings are high concentrations of suspended solids and algae. For Dante Lake, water color is an additional factor, as noted above.

Secchi values for Dante Lake at site DL-1 ranged from 1.7 ft (0.5 m) to 10.3 ft (3.1 m) with a 14-sample mean of 3.5 ft (1.1 m). This is about average for eutrophic eastern South Dakota lakes. The lowest Secchi readings were recorded during spring algal blooms and the maximum value occurred when algae populations were at a yearly minimum in early July. Interestingly, that was also the date for the lowest surface turbidity reading (1.7 NTU). Usually, there is not a strong correspondence between Secchi and NTU readings due to the different methodologies involved.

Total Suspended Solids

Under normal lake conditions, suspended solids (TSS) make up only one to several percentage points of total solids. Most solids are nearly always present as dissolved solids in typical lake waters.

TSS values for the project ranged from 8 to 16 mg/L (mean: 11mg/L). Those are relatively small values, well below the fish life propagation limit for Dante Lake of 158 mg/L for a single sample and 90 mg/L for a 30-day average. Some literature sources report that lake fisheries begin to be significantly affected when average TSS values exceed 80 mg/L (ibid).

Total Dissolved Solids

Total dissolved solids (TDS) is that portion of total solids that pass through a 0.45 um filter. TDS are composed mostly of earth compounds such as carbonates, bicarbonates, sulfates, and chlorides (Wetzel, 1983).

Total dissolved solids in Dante Lake averaged 3048 mg/L with a maximum of 3910 mg/L and a minimum of 1478 mg/L. TDS concentrations tended to be somewhat higher in summer and fall than in spring at site DL-1 (Appendix Table C). This may be the result of increased evaporation during the warm season of the year 2000 which was, moreover, a year of below average rainfall in the watershed (see Watershed Overview p. 20). There was one questionable high value (3910 mg/L above) recorded for site DL-2 on April 9, 2001.

Nitrogen

Several forms of nitrogen commonly occur in a waterbody, including organic nitrogen, ammonia, and nitrate-nitrite. Natural sources of nitrogen include precipitation, biological processes (i.e. nitrogen fixation) wildlife waste, and surface and groundwater drainage. Human nitrogen sources include sewage inputs of organic nitrogen, agricultural fertilizer applications, and livestock waste.

Total Kjeldahl Nitrogen (TKN) is a measure of organic nitrogen plus ammonia. Therefore, organic nitrogen can be calculated by subtracting ammonia from TKN. At mid-lake site DL-1, organic nitrogen exceeded ammonia concentrations by more than ten times in seven of ten samples. This proportion is more or less typical in lake samples obtained during the growing season. The remaining three samples contained elevated ammonia concentrations that made up from 19% to 27% of TKN and occurred in late September and October, and early May, in concentrations from 0.27 to 0.56 mg/L. Organic nitrogen in surface waters varied from 0.90 mg/L to 2.49 mg/L during the project (mean: 1.57 mg/L) and made up nearly 81% of total nitrogen.

Ammonia is the nitrogen end-product of bacterial decomposition of organic matter. This form of nitrogen is the most readily available (usable) to algae and aquatic plants for uptake and growth. Sources of ammonia may include animal wastes, decayed organic matter, or bacterial conversion of other nitrogen compounds. Ammonia is present in water primarily in two forms: $NH4+$ (ionized) and $NH4OH$ (un-ionized). The latter un-ionized or "un-dissociated" form is highly toxic to aquatic organisms, especially fish (Wetzel, 2001). For this reason, the state standard for ammonia is limited to un-ionized ammonia.

When samples are analyzed for total ammonia, 0.02 mg/L is designated as the detection limit. In other words, a concentration of ammonia below 0.02 mg/L is considered undetectable. Two samples collected in Dante Lake were in that category. These samples were assigned values of half the detection limit (0.01 mg/L), assuming that a trace amount of ammonia was present in the two samples. The same approach was used to estimate trace nitrate concentrations. Ammonia concentrations at site DL-1 ranged from 0.01 to 0.56 mg/L. A single sample collected at DL-2 in early April 2001 contained 1.12 mg/L ammonia. Un-ionized ammonia, correlated with pH and water temperature, ranged from 0.001 to 0.026 mg/L. None of the un-ionized ammonia values were in violation of the state standard which limits concentrations to 0.07 mg/L for single samples.

Nitrate-nitrite was usually found in low concentrations in other monitored South Dakota state lakes. Often nitrate was present below or slightly above the detection limit (0.1 mg/L). This was also the situation in Dante Lake where nitrate concentrations hovered around the detection limit (Appendix Table C). A single exception was recorded on April 9, 2001 when the nitrate level spiked to 0.9 mg/L at mid-lake site DL-1. This may have been due to spring runoff containing fertilizer residue, although the nitrate concentration at downstream site DL-2 on the same date was only 0.1 mg/L. No samples violated the nitrate standard for Dante Lake of < 88 mg/L.

Total nitrogen (TN) is obtained by adding TKN and nitrate-nitrite concentrations. Total nitrogen values were used to determine whether nitrogen or phosphorus is a limiting nutrient in Dante Lake. Total nitrogen at site DL-1(surface samples) ranged from 1.27 to 2.55 mg/L with a mean of 1.94 mg/L. A single nitrogen sample collected at site DL-2 contained 2.66 mg/L TN on April 9, 2001.

Phosphorus

Like nitrogen, phosphorus is a biologically active element. It cycles through different states in the aquatic environment. Its concentration in any one form depends on the degree of biological assimilation or decomposition occurring in the environment. The predominant inorganic form of phosphorus in lakes is orthophosphate. Concentrations of orthophosphate were measured as total dissolved phosphorus (TDP) in this assessment.

Total phosphorus (TP) concentrations of non-polluted waters are usually less than 0.1 mg/L (Lind, 1985). Total phosphorus values in Dante Lake (site DL-1) varied widely from 0.048 mg/L to 0.222 mg/L (mean: 0.113 mg/L). Highest in-lake phosphorus concentrations were observed in spring and the lowest in summer. Elevated phosphorus concentrations during early spring may be largely due to tributary input and surface runoff (nutrient loading) mostly in March and April. Summer low TP values may be the result of previous uptake by algae and large beds of aquatic weeds.

Phosphorus is often a limiting nutrient for algae and macrophyte production in many eutrophic lakes. Excessive loading of this nutrient presents an increased eutrophication risk. Agricultural practices are likely sources of external phosphorus loading in this watershed.

Dissolved phosphorus is the portion of total phosphorus that is readily available for plant utilization. TDP concentrations in unpolluted waters are usually less than 0.02 mg/L (Lind, 1985). TDP concentrations in Dante Lake ranged from 0.011 to 0.083 mg/L at site DL-1 (mean: 0.031 mg/L). Concentrations were above the minimum amount (0.02 mg/L) required for rapid algal growth (ibid.) on three of ten sampling dates, July 2000, and April and May 2001.

Trophic State

Trophic state relates to the degree of nutrient enrichment of a lake and its ability to produce aquatic macrophytes and algae. The most widely used and commonly accepted method for determining trophic state is the Trophic State Index (TSI) (Carlson 1977). It is based on the measurement of Secchi depth, total phosphorus, and chlorophyll a concentration in the surface waters of a lake. The calculated individual TSI values of the above parameters are averaged to give the lake's trophic state in index values from 1 to 100, with each 10-unit increase representing a doubling of the algal biomass produced in the lake. Four ranges of index values (Table 10) define Carlson's trophic levels, which include oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic, in order of increasing productivity.

Table 10. Carlson's trophic levels and index range for each level.

Trophic Level	Numeric Range
Oligotrophic	0 – 35
Mesotrophic	36 – 50
Eutrophic	51 – 65
Hyper-eutrophic	66 – 100

Lakes with TSI values less than 36 are considered to be oligotrophic and contain very small amounts of nutrients, little plant life, and are usually very clear. Lakes that score in the range of 36 to 50 are considered mesotrophic and have more nutrients and higher primary production than oligotrophic lakes. Eutrophic lakes fall in the range of 51 to 65 and are subject to algal blooms and have high primary production. Hyper-eutrophic lakes receive scores greater than 65 and are subject to frequent and massive blooms of algae that severely impair their beneficial uses and diminish aesthetic qualities.

Dante Lake is located near the southeastern boundary of the Northwestern Glaciated Plains Ecoregion. As determined in Ecoregion Targeting for Impaired Lakes in South Dakota (Stueven et al., 2000) lakes in this region should have a mean TSI value of 65 or less to fully support their assigned beneficial uses. Partial support is assigned to lakes with TSIs in the range between 65 and 75. Lakes that do not support designated uses have TSI values greater than 75. Dante Lake is presently rated as fully supporting based on the project average TSI (May 2000 – May 2001) of 63.8 and a summer average of 62.0 (Table 11).

Table 11. TSI. Summer TSI readings for Dante Lake.

Site	Date	Secchi TSI	Phosphorus TSI	Chlorophyll a TSI
DL-1	6/19/00	61.78	68.74	64.47
DL-1	7/17/00	52.55	61.96	61.47
DL-1	8/14/00	55.44	60.00	53.22
DL-1	9/26/00	62.29	68.74	73.51
Averages		**58.01**	**64.86**	**63.17**

Summer Average 62.02

Table 11 shows that only three readings of twelve exceeded the TSI 65 limit, two for phosphorus and one for chlorophyll. Over all, the values obtained place Dante Lake in the eutrophic category on Carlson's (1977) scale.

Limiting Nutrients

Great emphasis is placed on regulating nutrient loading to waterbodies to control aquatic productivity. In aquatic systems, the most significant nutrient factors causing a shift from a lesser to a more productive state are nitrogen and phosphorus. Nitrogen is difficult to control because of its highly soluble nature. Phosphorus is easier to control, making it the primary nutrient targeted for reduction when attempting to control eutrophication. The ideal ratio of nitrogen to phosphorus (N:P) for algae and aquatic plant growth is 10:1 (EPA, 1990). Ratios higher than 10 indicate a phosphorus-limited system and those less than 10:1 are an indication of a nitrogen-limited system.

N:P ratios for Dante Lake ranged from 6:1 to 50:1 with an average of 22. Figure 5 shows that the lake was phosphorus-limited for most of the year (2000); even though elutriate analysis showed the lake sediments contained high concentrations of phosphorus (Table 18). Due to in-lake stratification, sediment phosphorus was unavailable to the water column for algal growth during the summer. Two samples collected near the bottom during May and June 2000 indicated that N:P ratios were similar to surface waters for the same dates (bottom ratios: 22 and 20). Significantly lower ratios for surface waters, obtained in April and May 2001, of 11 and 6, respectively, suggested that heavier spring runoff in 2001 was supplying more phosphorus to Dante Lake which became temporarily nitrogen-limited in May 2001 producing relatively average algal growth and dissolved oxygen concentrations (Figure 5).

SD DENR recommends placing a mechanical aeration device in the lake to breakup stratification increasing total phosphorus concentrations and algal growth producing increased surface water dissolved oxygen concentrations during the summer when little or no runoff occurs.

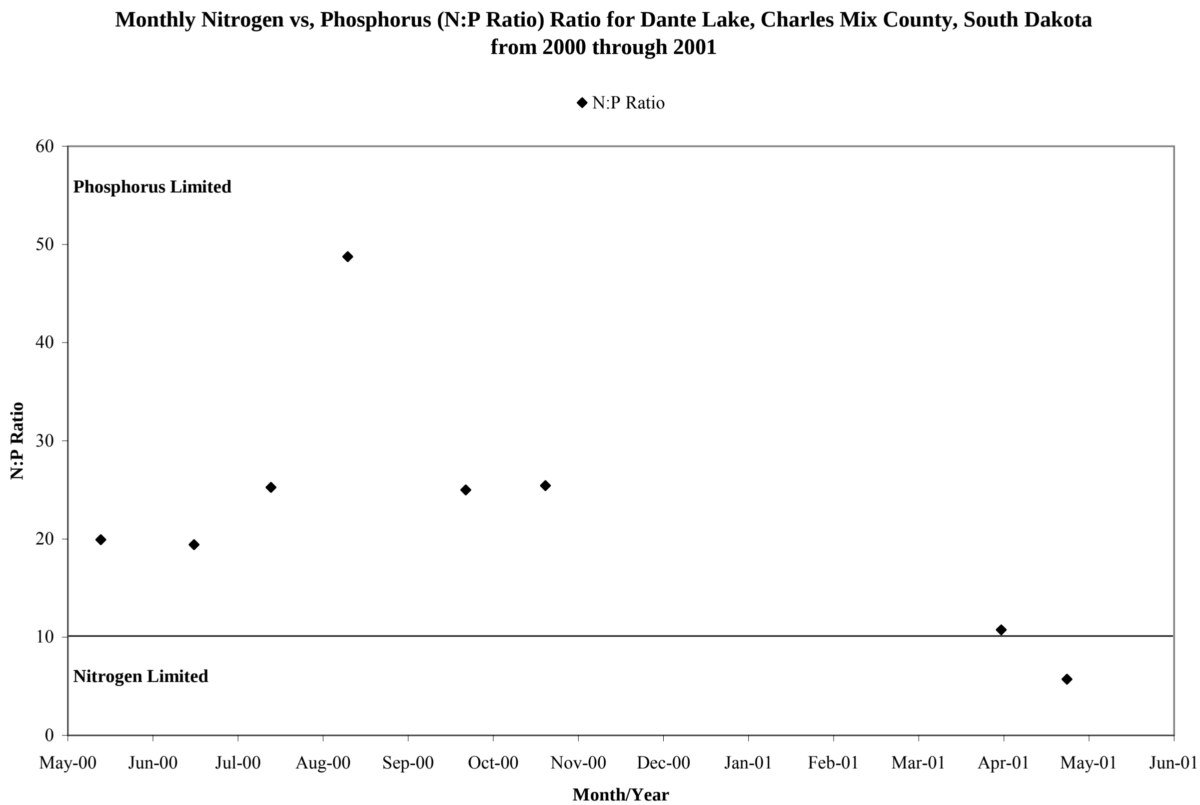

Figure 5. Nitrogen vs. Phosphorus (TN:TP) Ratio for Dante Lake

Long-term Trend

Dante Lake is listed on the state's 2004 Integrated Report as an impaired waterbody and is at present barely supporting beneficial uses with a project average TSI of nearly 64. However, past water quality data as well as data collected during the present assessment indicate that there is a long-term trend in declining water quality as a result of nutrients, sediment, and aquatic weed and algal growth. Some symptoms noted during the present investigation included low summer DO levels, low fish diversity, and excessive aquatic weed growth. Moreover, in recent years (e.g. 1998 and 2002) Dante Lake supported massive summer blue-green algae blooms.

Data from the 1996 South Dakota Lakes Assessment Final Report is included with TSI data collected during this study in Figure 6. The mean TSI value for the year 2000 is only slightly higher than for samples collected during the 1979 assessment. However, if no corrective action is taken, water quality conditions may degrade to those noted in 1991 and 1994, which, apparently, were years with high watershed runoff (Figure 6).

Moderate reductions in nutrient and sediment loading to Dante Lake should help to stabilize water quality conditions at the year 2000 level or improve them to what they were in 1979. To fully support beneficial uses, TSI should remain below 65. Achieving a stable TSI of less than 65 in highly eutrophic lakes is a practical goal for implementing a watershed restoration project in Dante Lake.

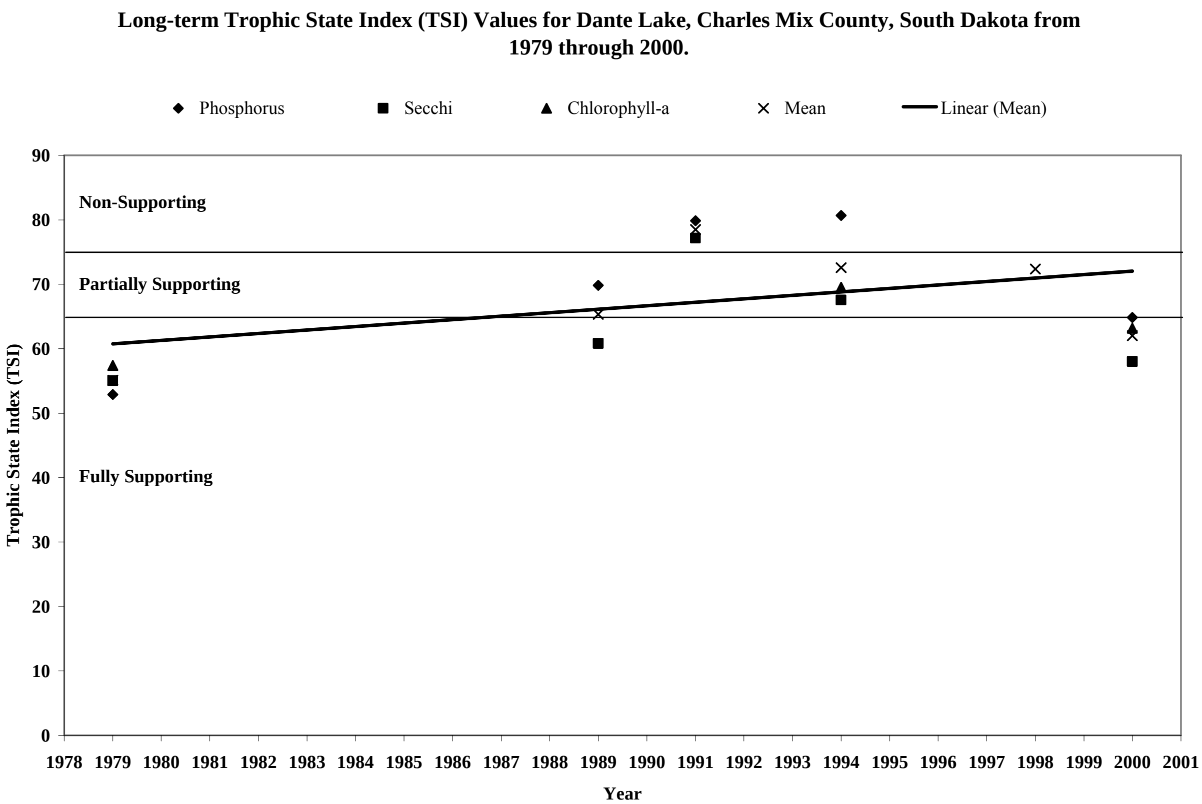

Figure 6. Long-term Trophic State Index (TSI) Values

Reduction Response Model

In-lake reduction response modeling was conducted using BATHTUB, a eutrophication response model designed by the United States Army Corps of Engineers (US ACOE, 1999). The model predicts changes in water quality parameters related to eutrophication (phosphorus, nitrogen, chlorophyll-*a*, and water transparency). Lake and tributary sample data were used to calculate existing conditions in Dante Lake. Tributary loading data was obtained from FLUX model output. Inlet phosphorus concentrations were reduced in increments of 10% and modeled to generate an in-lake reduction curve.

The predicted in-lake concentrations of phosphorus decreased as modeled tributary loads decreased (Table 12). Individual parameter (phosphorus, chlorophyll, and Secchi visibility) TSI values gradually decreased with the reduction of phosphorus load. Phosphorus TSI values were markedly higher than chlorophyll and Secchi TSI values. All predicted phosphorus TSI values, following < 40% reductions in the present nutrient load, placed the lake in a partially supporting category, whereas current chlorophyll and Secchi TSIs were in the full support range requiring no reduction of present nutrient load to maintain full support status for the lake (Figure 7).

The average TSI value for phosphorus, chlorophyll, and Secchi combined (about 64) may be said to be marginally fully supporting (close to the boundary between partial and full support (65)). The recommended target for an average TSI value in Dante Lake is approximately 64.32. This value can be attained with a moderate reduction of 4% in the present tributary phosphorus load (Figure 8). This goal can be reached if the following tributary BMPs are implemented in the watershed; minimal tillage on croplands near the stream channel, riparian restoration (a variety of techniques), stabilize eroded streambanks, buffer strip planting, waste management on animal feeding areas, and restricting cattle access to the stream and installing cattle watering areas away from stream riparian zones.

Table 12. Reduction Response modeling results for Dante Lake, Charles Mix County, South Dakota for 2000 through 2001.

Variable	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	99%
TOTAL P MG/M3	108.2	97.4	86.7	75.9	65.1	54.3	43.6	32.8	22.0	11.3	5.9	1.6
TOTAL N MG/M3	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0	1852.0
C.NUTRIENT MG/M3	86.0	80.3	73.9	66.9	59.2	50.7	41.7	32.0	21.8	11.2	5.9	1.6
CHL-A MG/M3	27.0	24.3	21.6	18.9	16.3	13.6	10.9	8.2	5.5	2.8	1.5	0.4
SECCHI M	1.1	1.1	1.2	1.3	1.5	1.6	1.8	2.1	2.5	2.9	3.3	3.6
ORGANIC N MG/M3	793.1	731.8	670.5	609.2	547.9	486.6	425.3	364.0	302.7	241.4	210.8	186.2
TP-ORTHO-P MG/M3	50.4	45.6	40.8	36.0	31.2	26.4	21.7	16.9	12.1	7.3	4.9	3.0
ANTILOG PC-1	891.7	758.3	632.0	513.7	404.3	305.0	216.8	141.0	78.7	31.2	13.5	2.8
ANTILOG PC-2	11.9	11.7	11.4	11.1	10.7	10.3	9.7	9.0	8.0	6.3	4.8	2.6
(N - 150) / P	15.7	17.5	19.6	22.4	26.1	31.3	39.1	51.9	77.3	151.2	289.8	1087.3
INORGANIC N / P	18.3	21.6	25.8	31.2	38.5	48.9	65.1	93.4	155.8	406.9	1641.2	1665.8
TURBIDITY 1/M	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
ZMIX * TURBIDITY	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
ZMIX / SECCHI	2.5	2.3	2.1	1.9	1.8	1.6	1.4	1.2	1.1	0.9	0.8	0.7
CHL-A * SECCHI	28.6	27.7	26.7	25.5	24.0	22.3	20.1	17.2	13.5	8.3	4.8	1.4
CHL-A / TOTAL P	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
FREQ(CHL-a>10) %	90.2	86.9	82.5	76.4	68.2	57.2	43.1	26.3	10.1	0.9	0.0	0.0
FREQ(CHL-a>20) %	56.9	50.2	42.7	34.5	26.0	17.5	9.8	4.0	0.8	0.0	0.0	0.0
FREQ(CHL-a>30) %	31.6	25.8	20.1	14.6	9.7	5.6	2.6	0.8	0.1	0.0	0.0	0.0
FREQ(CHL-a>40) %	17.3	13.3	9.7	6.5	3.9	2.0	0.8	0.2	0.0	0.0	0.0	0.0
FREQ(CHL-a>50) %	9.6	7.0	4.8	3.0	1.7	0.8	0.3	0.1	0.0	0.0	0.0	0.0
FREQ(CHL-a>60) %	5.5	3.9	2.5	1.5	0.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0
CARLSON TSI-P	71.7	70.2	68.5	66.6	64.4	61.8	58.6	54.5	48.7	39.1	29.7	10.6
CARLSON TSI-CHLA	62.9	61.9	60.8	59.5	58.0	56.2	54.0	51.2	47.3	40.7	34.4	21.4
CARLSON TSI-SEC	59.2	58.1	57.0	55.7	54.4	52.9	51.2	49.3	47.1	44.5	43.0	41.6
Mean	**64.6**	**63.4**	**62.1**	**60.6**	**58.9**	**56.9**	**54.6**	**51.7**	**47.7**	**41.4**	**35.7**	**24.5**

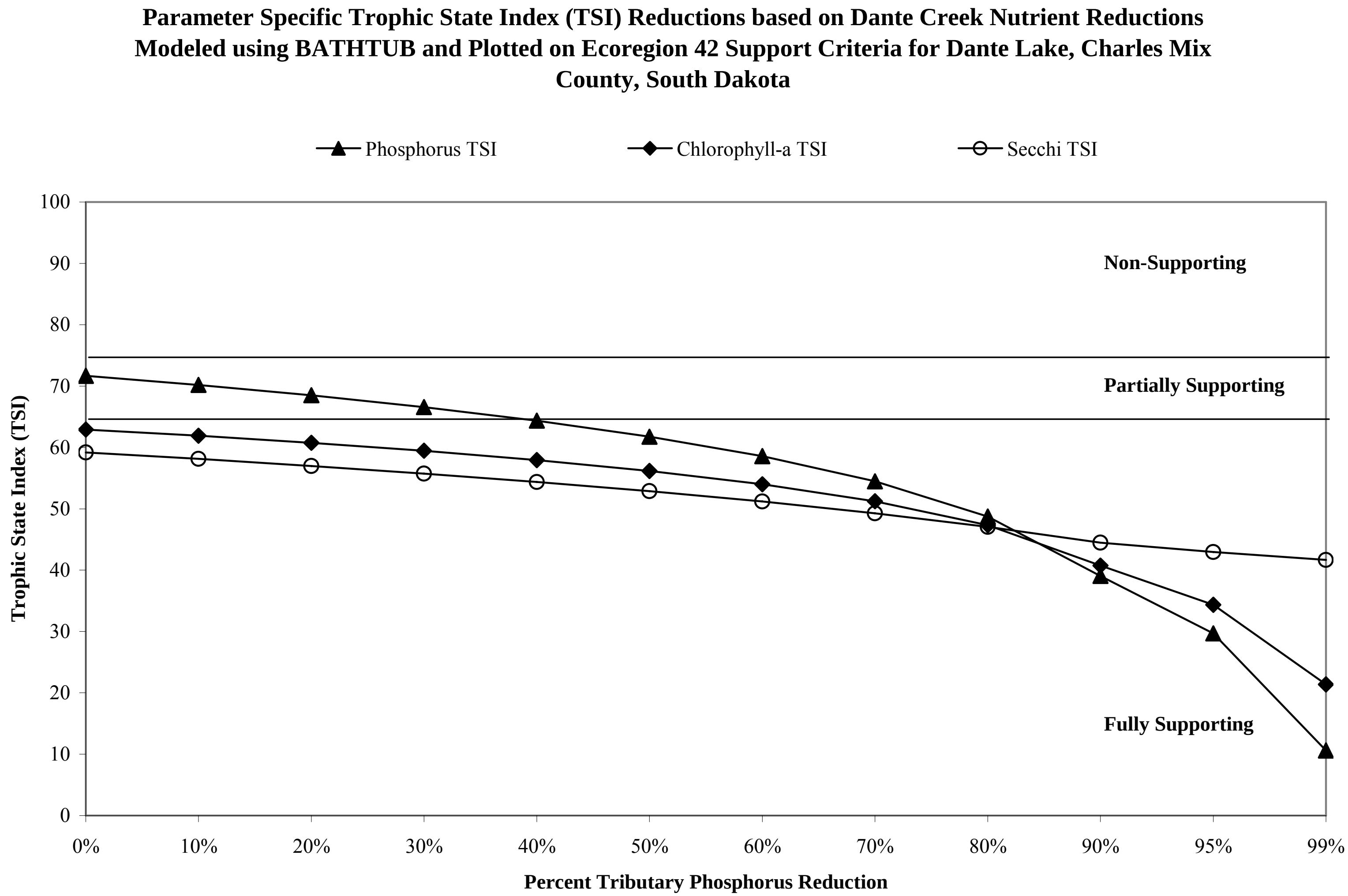

Figure 7. Parameter Specific TSI Reduction based on Tributary Total Phosphorus Reductions for Dante Lake, Charles Mix County, South Dakota from 2000 through 2001 Tributary Loadings.

Mean Trophic State Index (TSI) Reductions based on Dante Creek Nutrient Reductions Modeled using BATHTUB and Plotted on Ecoregion 42 Support Criteria for Dante Lake, Charles Mix County, South Dakota

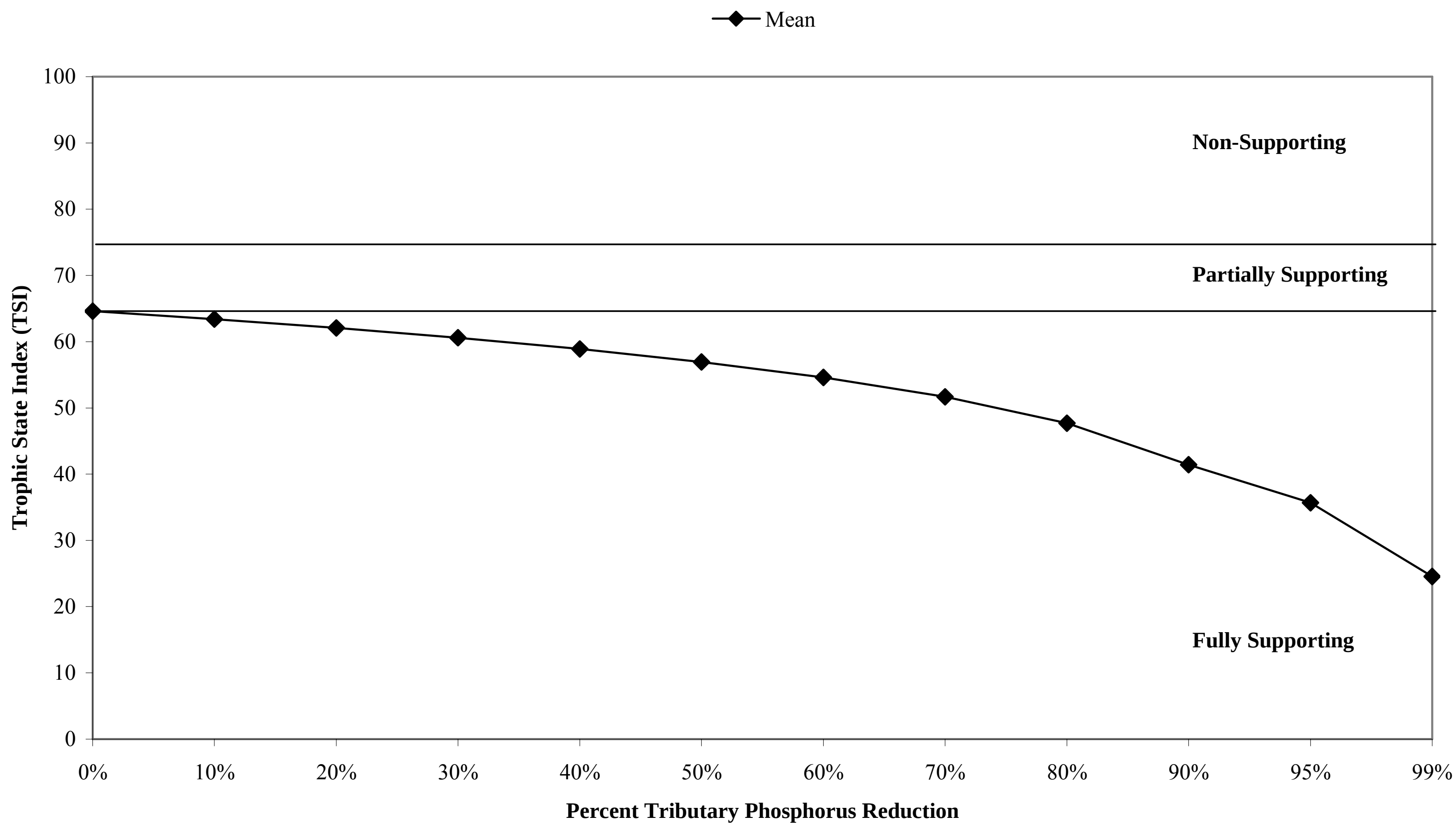

Figure 8. Mean TSI Reduction based on Tributary Total Phosphorus Reductions for Dante Lake, Charles Mix County, South Dakota from 2000 through 2001 Tributary Loadings.

BIOLOGICAL MONITORING

Phytoplankton

Surface samples of planktonic algae were collected on 11 sampling dates from May 16, 2000 to May 3, 2001 at a mid-lake site. A total of 54 algal taxa, including two “unidentified algae” categories, were collected from this small 19-acre impoundment (Table 13). Algae species richness (the number of algal taxa observed) during this survey was rated as “below average” when compared to 13 other recently monitored small state lakes (< 200 ac) which had a mean of 75 taxa.

Diatoms (Bacillariophyceae) represented the most diverse group of algae in Dante Lake with 20 species, followed by five phyla of flagellated (motile) algae with 18 taxa, including an “unidentified flagellates” category. The other algal groups in this lake were less varied. Non-motile green algae (Chlorophyta) contributed 9 taxa (all green algae including green flagellates contributed 16 taxa) and blue-green algae (Cyanophyta), 6 taxa.

Green flagellates (Chlorophyta) were the most diverse phylum of motile algae with 7 taxa, followed by yellow-brown (or, golden-brown) flagellates (Chrysophyta) with 4 taxa. The remaining 6 identified taxa were equally distributed among three phyla of motile algae, euglenoid flagellates (Euglenophyta), cryptomonads (Cryptophyta), and dinoflagellates (Pyrrhophyta).

Dante Lake algal biovolume (roughly algal biomass) showed a high seasonal variability during the study period, ranging over more than two magnitudes from 96,644 μm^3/ml in early July 2000 to 14,354,680 µm3/ml in early May 2001 (Table 15). Partly as a result of those large fluctuations in the size of seasonal algae communities, the mean biovolume for this study amounted to only 3,485,726 µm3/ml for an average algae density (abundance) of 48,285 cells/ml. In terms of the size of the annual algal biovolume calculated for the period of the present assessment, Dante Lake ranks in the lower 50% of recently monitored small state lakes, even though it is presently classified as hyper-eutrophic.

The phytoplankton population during this survey consisted primarily of flagellated algae which made up 40% of total algae numbers and 46% of the biovolume. Non-motile green algae comprised 34% of total algal abundance but only 10% of total biovolume, in contrast to diatoms which contributed only 7% of density but made up 32% of algal biovolume. Blue-green algae contributed 17% and nearly 10% to total algal abundance and biovolume, respectively. Dinoflagellates represented the least important algae grouping in Dante Lake during this investigation, accounting for only 0.1% of density and slightly more than 1% of annual biovolume.

The seasonal distribution of algae abundance in the reservoir for the study period consisted of essentially two peaks in algae numbers (where a ‘peak’ is defined as a value equal to or larger than 1.5 times the annual mean). Those peaks occurred July 31, 2000, and May 3, 2001 (Table 14).

Table 13. Algal Species and Densities for Dante Lake, Charles Mix County, South Dakota from 2000 through 2001.

#	Algae Species (54 taxa)	% Density	samples	Algae Type
1	Gloeocystis sp.	26.7	1	Green Algae (colonial)
2	Rhodomonas minuta	12.9	11	Flagellated Algae (Cryptophyte)
3	Chrysochromulina parva	11.1	4	Flagellated Algae (Yellow-Brown Algae)
4	Oscillatoria agardhii	10.5	6	Blue-Green Algae (filamentous)
5	unidentified flagellated algae	6.3	4	Flagellated Algae
6	Chlamydomonas sp.	4.5	8	Flagellated Algae (Green Algae)
7	Aphanizomenon sp.	4.5	3	Blue-Green Algae (filament)
8	Nitzschia paleacea	3.6	4	Diatom (pennate)
9	Oocystis pusilla	3.1	2	Green Algae (colonial)
10	Cryptomonas erosa	3.0	9	Flagellated Algae (Cryptophyte)
11	Sphaerocystis schroeteri	2.9	2	Green Algae (colonial)
12	Microcystis aeruginosa	1.8	1	Blue-Green Algae (colonial)
13	Scourfieldia sp.	1.7	2	Flagellated Algae (Green Algae)
14	Cyclotella meneghiniana	1.6	7	Diatom (centric)
15	Selenastrum minutum	1.3	4	Green Algae
16	Chaetoceros elmorei	0.9	3	Diatom (centric)
17	unidentified algae	0.9	2	Algae
18	Synedra acus	0.6	1	Diatom (pennate)
19	Spermatozoopsis sp.	0.4	2	Flagellated Algae (Green Algae)
20	Oscillatoria sp.	0.4	2	Blue-Green Algae (filament)
21	Anacystis marina	0.2	1	Blue-Green Algae (colonial)
22	Chromulina sp.	0.2	1	Flagellated Algae (Yellow-Brown Algae)
23	Oocystis lacustris	0.1	2	Green Algae (colonial)
24	Ankistrodesmus falcatus	0.1	4	Green Algae
25	Glenodinium sp.	0.1	3	Flagellated Algae (Dinoflagellate)
26	Elakatothrix gelatinosa	0.1	1	Green Algae (colonial)
27	Nitzschia acicularis	0.1	2	Diatom (pennate)
28	Ochromonas sp.	0.1	2	Flagellated Algae (Yellow-Brown Algae)
29	Pascheriella tetras	0.1	2	Flagellated Algae (Green Algae)
30	Carteria sp.	0.1	2	Flagellated Algae (Green Algae)
31	Cocconeis placentula	0.0	1	Diatom (pennate)
32	Gomphonema subclavatum	0.0	2	Diatom (pennate)
33	Gomphonema angustatum	0.0	2	Diatom (pennate)
34	Navicula cryptocephala	0.0	1	Diatom (pennate)
35	Euglena sp.	0.0	1	Flagellated Algae (Euglenoid)
36	Amphora perpusilla	0.0	1	Diatom (pennate)
37	Synedra ulna	0.0	1	Diatom (pennate)
38	Navicula capitata	0.0	1	Diatom (pennate)
39	Navicula sp.	0.0	2	Diatom (pennate)
40	Nitzschia palea	0.0	1	Diatom (pennate)
41	Nitzschia sp.	0.0	1	Diatom (pennate)
42	Stephanodiscus minutus	0.0	1	Diatom (centric)
43	Synedra sp.	0.0	1	Diatom (pennate)
44	Synedra delicatissima	0.0	1	Diatom (pennate)
45	Synedra rumpens	0.0	1	Diatom (pennate)
46	Amphiprora paludosa	0.0	1	Diatom (pennate)
47	Ankistrodesmus sp.	0.0	1	Green Algae
48	Kirchneriella sp.	0.0	1	Green Algae (colonial)

Table 13 (continued). Algal Species and Densities for Dante Lake, Charles Mix County, South Dakota from 2000 through 2001.

#	Algae Species (54 taxa)	% Density	samples	Algae Type
49	Trachelomonas sp.	0.0	2	Flagellated Algae (Euglenoid)
50	Chlorogonium sp.	0.0	1	Flagellated Algae (Green Algae)
51	Synura uvella	0.0	1	Flagellated Algae (Yellow-Brown Algae)
52	Pandorina morum	0.0	1	Flagellated Algae (Green Algae)
53	Gymnodinium palustre	0.0	1	Flagellated Algae (Dinoflagellate)
54	Dactylococcopsis sp.	0.0	1	Blue-Green Algae

A single green alga, *Gloeocystis* sp., was primarily responsible for the mid-summer algae maximum. In Dante Lake, other green algae (Chlorophyta) such as *Oocystis pusilla* and *Sphaerocystis schroeteri*, also appeared to be most abundant during the warmest part of the year in July and August. This is a somewhat unusual occurrence because green algae, along with diatoms, are known to prefer cooler water temperatures than are found in summer. However, as Reid (1961) points out, planktonic green algae (Chlorococcales) may frequently be dominant in ponds and small eutrophic lakes.

Elevated (above average) algae numbers were present in late September, due primarily to a moderate bloom of the blue-green alga *Aphanizomenon* (18,217 cells/ml) and high numbers of the small cryptophyte flagellate *Rhodomonas minuta* (15,033 cells/ml). However, most of the biomass of this assemblage was supplied by another cryptophyte *Cryptomonas erosa* and by a moderate bloom of the diatom *Cyclotella meneghiniana*.

Flagellated algae were mainly responsible for the second algal maximum on May 3, 2001 as well as the elevated algae densities observed a month earlier. While motile algae such as *Rhodomonas minuta* (31,000 cells/ml) and *Chrysochromulina parva* (48,240 cells/ml) and others accounted for 78% of algal abundance in early May, diatoms such as *Nitzschia paleacea, Synedra acus*, and *Cyclotella meneghiniana* provided 62% of the total algal biovolume on that date (Table 14). The densities of flagellated algae present in Dante Lake during April and May 2001 were some of the largest populations reported in recently monitored state lakes. Comparable numbers were found in Hayes Lake and Lake Waggoner, small eutrophic impoundments in central and western South Dakota, during spring 2001.

The importance of pigmented flagellates in the algae community of Dante Lake can be ascribed to lake-basin morphology and local water quality. Flagellates made up 97.5% of the algae population in early April 2001 and 78% in early May (Table 14). The pond-like character of this small lake with a narrow wind-sheltered basin, abundant macrophytes, abundant phosphorus, and probably an accumulation and decay of nitrogenous organic matter, derived from decayed local vegetation and imported from the drainage, may have created favorable conditions for those motile species. Ammonia, an end product of decay, is particularly important for growth of *Chrysochromulina* (Wetzel, 2001).

Table 14. Dante Lake Algae Abundance (cells/ml) and Biovolume (µm^3/ml)

Date	Algae Group	cells / ml	%	µm^3/ml	%
16-May-00	Flagellated Algae	7,543	16.4	1,415,207	42.0
	Dinoflagellates	0		0	
	Blue-Green Algae	38,102	82.2	1,828,896	54.3
	Diatoms	701	1.5	126,591	3.7
	Non-Motile Green Algae	0		0	
	Unidentified Algae	0		0	
Total		46,346		3,370,694	
6-Jun-00	Flagellated Algae	11,489	56.0	1,840,510	78.5
	Dinoflagellates	215	1.0	150,333	6.4
	Blue-Green Algae	8,590	41.9	412,320	13.9
	Diatoms	214	1.0	30,388	1.2
	Non-Motile Green Algae	0		0	
	Unidentified Algae	0		0	
Total		20,508		2,433,551	
6-Jul-00	Flagellated Algae	372	63.4	16,269	16.8
	Dinoflagellates	0		0	
	Blue-Green Algae	0		0	
	Diatoms	215	36.7	80,375	83.2
	Non-Motile Green Algae	0		0	
	Unidentified Algae	0		0	
Total		587		96,644	
17-Jul-00	Flagellated Algae	352	1.7	42,869	3.1
	Dinoflagellates	0		0	
	Blue-Green Algae	0		0	
	Diatoms	470	2.2	178,521	12.9
	Non-Motile Green Algae	20,436	96.2	1,158,270	84.0
	Unidentified Algae	0		0	
Total		21,258		1,379,660	
31-Jul-00	Flagellated Algae	1,836	1.2	207,621	8.5
	Dinoflagellates	0		0	
	Blue-Green Algae	9,342	6.1	74,737	3.1
	Diatoms	64	0.0	11,597	0.5
	Non-Motile Green Algae	141,743	92.5	2,126,143	87.7
	Unidentified Algae	0		0	
Total		153,178		2,424,930	

Table 14 (continued). Dante Lake Algae Abundance (cells / ml) and Biovolume (um^3/ml)

Date	Algae Group	cells/ml	%	µm^3/ml	%
14-Aug-00	Flagellated Algae	581	5.1	166,606	17.6
	Dinoflagellates	39	0.3	27,122	2.9
	Blue-Green Algae	775	6.8	2,325	0.2
	Diatoms	4,456	38.9	555,807	58.6
	Non-Motile Green Algae	5,618	48.9	196,053	20.7
	Unidentified Algae	0		0	
Total		11,469		947,913	
7-Sep-00	Flagellated Algae	1,221	18.4	175,948	25.8
	Dinoflagellates	0		0	
	Blue-Green Algae	4,069	61.4	179,032	26.2
	Diatoms	958	14.6	288,601	42.3
	Non-Motile Green Algae	384	5.6	38,972	5.7
	Unidentified Algae	0		0	
Total		6,632		682,553	
26-Sep-00	Flagellated Algae	17,244	30.7	1,407,164	31.1
	Dinoflagellates	0		0	
	Diatoms	4,864	8.7	1,896,853	41.9
	Blue-Green Algae	22,108	39.4	879,014	19.4
	Non-Motile Green Algae	11,939	21.3	344,883	7.6
	Unidentified Algae	0		0	
Total		56,155		4,527,914	
11-Oct-00	Flagellated Algae	13,713	58.4	985,293	60.1
	Dinoflagellates	102	0.4	71,104	4.3
	Diatoms	812	3.5	250,895	15.3
	Blue-Green Algae	7,110	30.3	296,910	18.1
	Non-Motile Green Algae	1,727	7.4	34,536	2.1
	Unidentified Algae	0		0	
Total		23,464		1,638,738	
9-Apr-01	Flagellated Algae	57,409	96.9	6,127,585	94.5
	Dinoflagellates	335	0.6	264,500	4.1
	Diatoms	165	0.3	55,860	0.9
	Blue-Green Algae	390	0.7	9,760	0.1
	Non-Motile Green Algae	160	0.3	4,000	0.1
	Unidentified Algae	800	1.3	24,000	0.4
Total		59,259		6,485,705	

Table 14 (continued). Dante Lake Algae Abundance (cells/ml) and Biovolume (µm^3/ml)

Date	Algae Group	cells / ml	%	µm^3/ml	%
3-May-01	Flagellated Algae	103,320	78.1	5,316,680	37.0
	Dinoflagellates	0		0	
	Diatoms	24,680	18.7	8,912,400	62.1
	Blue-Green Algae	160	0.1	3,200	0.0
	Non-Motile Green Algae	120	0.1	2,400	0.0
	Unidentified Algae	4,000	3.0	120,000	0.8
Total		132,280		14,354,680	

Blue-green algae, including nuisance species, were found to be less abundant than expected during the present investigation. Density of the most common species *Oscillatoria agardhii* ranged from 70 cells/ml to 38,102 cells/ml when it was present in the plankton, with a mean density of 9,294 cells/ml. Those are considered moderate populations for a highly eutrophic waterbody. Unaccountably, blue-greens were not collected on two dates during the first half of July (Table 15) when warm-water conditions are known to be favorable for growth of blue-green algae (Wetzel, 2001). Possibly, heavy runoff from summer rainstorms diluted or flushed these buoyant species from this small reservoir. An examination of rainfall data for the watershed covering June and July 2000 indicated the above scenario for explaining the absence of blue-greens was unlikely. Dante Lake in past years was quite capable of producing massive blue-green algae blooms during the summer months. On July 25, 1979, a heavy bloom of *Aphanizomenon flos-aquae* was reported at a density of 265,773 cells/ml that had a volume of 31,095,441 µm^3/ml (Koth, 1981). An even more intense summer blue-green bloom, this time consisting of *Oscillatoria agardhii*, was observed in Dante Lake on July 28, 1998 which had a density of 610,400 cells/ml and a biovolume estimated at 29,299,200 µm^3/ml (State Lake Assessment 1998). It was noted that 1979 and 1998 were years with above average rainfall in the watershed whereas during the present project (year 2000) rainfall yield was 3.6 inches below normal. Similarly, relatively few algae were reported in Dante Lake during 1989, a year of below average rainfall. These data suggest a direct relationship exists between the amount of rainfall, and by implication, runoff and nutrient loading to Dante Lake, and the occurrence of blue-green blooms in this small reservoir.

An exception to this trend was observed during algae assessment in 2002 when a heavy July blue-green bloom (*O. agardhii*) was observed similar to those present in summer of 1979 and 1998. Rainfall data indicated that 2002 was a dry year in the Lake Dante watershed with annual precipitation 5 inches below normal. However, 2001 was an unusually wet year (rainfall: 30.6 inches) and the resulting runoff together with considerable snowfall that winter, may have provided sufficient nutrient loading for the development of the large blue-green population that was present during the summer of 2002. No algae sampling was scheduled during 2001 after May, but April and early May 2001 samples disclosed large blooms of flagellated algae and diatoms following heavy spring rains and runoff (Table 14).

Threatened and Endangered Species

There are five threatened or endangered species documented for Charles Mix County. The US Fish and Wildlife Service lists whooping crane, bald eagle, pallid sturgeon, least tern and piping plover as endangered or threatened that could potentially be found in the project area. All of these, pallid sturgeon, piping plover, least tern and probably whooping crane and bald eagle may be associated primarily with the local reaches of the Missouri River some 15 miles from Dante Lake and its watershed. There is no habitat data specific to the project area presently available. None of the above five species were encountered during this study. However, care should be taken when conducting mitigation projects in the Dante Lake watershed due to its proximity to those areas in Charles Mix County where endangered or threatened species were reported.

Bald eagles typically prefer large trees for perching and roosting. As there are no confirmed sightings of bald eagles within the Dante Lake drainage, little impact to the species should occur. Any mitigation procedures that take place should avoid the destruction of large trees that may be used as eagle perches, particularly if an eagle is observed using the tree as a perch or roost.

Whooping cranes also have not been documented in the Dante Lake drainage. Sightings in the area are most likely during spring and fall migration. When roosting, cranes prefer wide, shallow open water areas such as flooded fields, marshes, reservoirs and rivers. Those types of habitat are scarce or lacking in the small (2844 acres) Dante Lake watershed. The preference of these large birds for isolation and avoidance of areas that are surrounded by tall trees, nearby hills or other visual obstructions makes it unlikely that they will be present in the small drainage that is mainly used as cropland interspersed with a number of farmsteads. Therefore, the cranes should not be negatively impacted by implementation of BMPs.

Fisheries

The most recently published fisheries survey was completed during July 2000. A copy of the South Dakota Department of Game, Fish and Parks fisheries survey for Dante Lake can be found in Appendix A.

The survey indicates there are only two common fish species presently inhabiting the lake, bluegill and black bullhead. There may be one or more scarce species present or some others that were not captured with the gear or short time span allotted for the survey (10-12 July 2000), such as largemouth bass and fathead minnows, respectively. Five years earlier a similar survey found six species residing in the lake. The standard method used to sample fish populations in Dante Lake consists of eight, ¾ inch frame nets set for 24 hours.

Bluegill had doubled their population since 1995 with a catch-per-unit effort (CPUE) of 182. Condition of the species was found to be good for a high density population with a relative weight value (Wr) of 95 (Appendix A). Dense weed beds in the shallows of the lake provide ideal habitat for bluegill. Bullhead may prefer more open, silty bottom substrate.

The black bullhead population remained low between the two most recent surveys with a CPUE of 2.3. Possibly, bullhead are in competition with bluegill for the available food supply, such as aquatic insects, that may be more abundant in the weedy shallows than in deeper water where low dissolved oxygen levels in bottom substrates during summer and winter may reduce benthic invertebrate populations.

The present management approach for Dante Lake consists of a plan for electrofishing to determine the prevalence of predator species. If predator densities are found to be low, supplemental stockings should be made to increase predation on bluegill. The last such stocking was made in 1990 with 250 northern pike.

In addition, the large bluegill population in Dante Lake may be used as an adult bluegill source for transfer to other lakes.

Aquatic Macrophyte Survey

Past documentation (1979) of macrophytes in this small reservoir indicated that emergent vegetation, mainly cattail and bulrush, covered approximately 95% of the shoreline. Submergent and floating-leaved aquatic vegetation consisted mainly of coontail (*Ceratophyllum demersum*) and four species of pondweed, *Potamogeton pusillus*, *P. foliosus*, *P. pectinatus*, and *P. nodosus* (Koth 1981). A 2000 GF&P fisheries survey reported submergent vegetation was heavy in the shallow areas, especially in the north half (inlet portion) of the lake (Appendix A).

An aquatic macrophyte survey of Dante Lake was conducted August 3, 2000, as part of this assessment project. The survey consisted of surveying the entire shoreline and identifying emergent and terrestrial plant species, and establishing 6 in-lake transects to quantify the submergent/floating plant community (Figures 9 and 10, Tables 15 and 16). Each transect had five survey points to evaluate the macrophyte community. Sampling at each survey point consisted of casting a grapple and identifying the plant species retained on the grapple.

The shoreline survey supported the finding of the 1979 investigation in that cattail and bulrush were the only aquatic emergent plants observed, with cattails more frequently encountered than bulrush during the present survey. Curled dock (*Rumex crispus*) and white sweet clover (*Melilotus alba*) were the only common, non-woody wetland plants recorded. Other vegetation common near the shoreline consisted mostly of trees, mainly Russian olive followed by elm and willow (Table 16).

Virtually all of the shallow near shore area, one to several feet deep around the periphery of the lake, consisted of beds of pondweed (mostly sago pondweed) except for a small portion next to the tributary inlet which was dominated by coontail (approx. 99%).

Only two submergent /floating plant species were identified in sampling from 29 survey points within 6 transects in Dante Lake on August 3, 2000. Lake-wide, coontail was found to be more common than sago pondweed in the deeper offshore areas of the lake (Table 17).

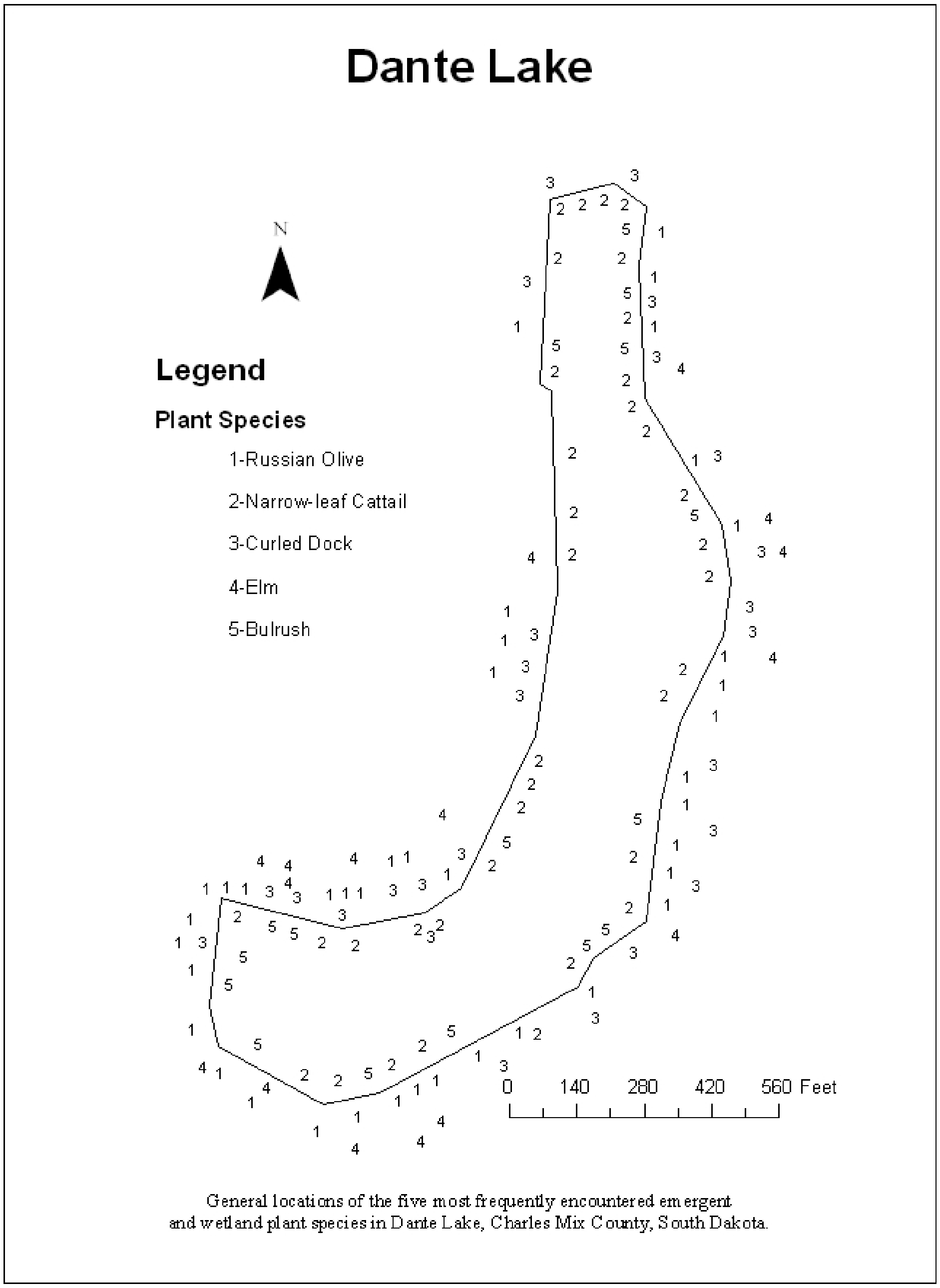

Figure 9. General locations of the five most frequently encountered emergent and wetland plant species in Dante Lake, Charles Mix County, South Dakota for 2000 through 2001.

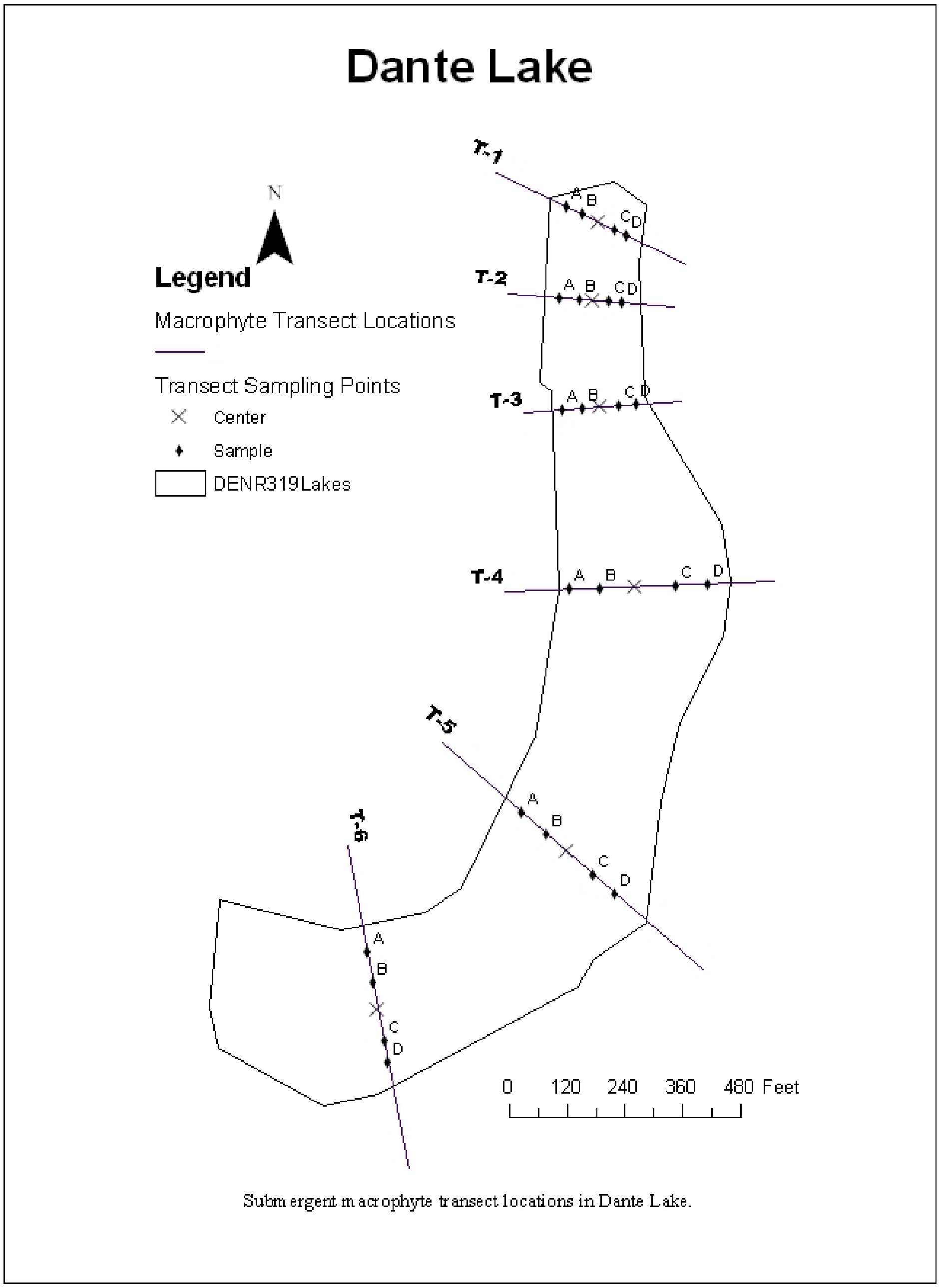

Figure 10. Submergent macrophyte transect locations in Dante Lake, Charles Mix County, South Dakota from 2000 through 2001.

In the first two transects, T-1 and T-2 near the north inlet, coontail was the predominant plant that was found in moderate to dense concentrations. Sago pondweed was present as a sparse population at those sites. The remaining four downstream transects contained scattered patches or floating mats of both species with no apparent pattern of distribution. Numbers of both taxa were mostly sparse, rarely approaching moderate densities. Since both plant species are capable of forming floating mats, it cannot be ascertained from the data available whether floating mats or submersed beds or both were sampled in offshore waters (Figure 10, Table 16).

Table 15. Macrophyte shoreline survey in Dante Lake, August 3, 2000.

ID. No.*	Common Name	Scientific Name	Relative Abundance**
Emergent / Wetland			
1	Russian Olive	Eleagnus angustifolia	37
2	Narrow-leaf Cattail	Typha angustifolia	33
3	Curled Dock	Rumex crispus	25
4	Elm	Ulmus sp	14
5	Bulrush	Scirpus sp.	13
6	White Sweet Clover	Melilotus alba	10
7	Willow	Salix sp.	10
8	Redcedar	Juniperus virginiana	5
9	River Bulrush	Scirpus fluviatilis	3
10	Smartweed	Polygonum sp.	2
11	Cottonwood	Populus sp.	2
Submergent / Floating			
12	Sago Pondweed	Potamogeton pectinatus	approx 95% of nearshore area
13	Coontail	Ceratophyllum demersum	approx 5% of nearshore area

*** see Figure 53**

**** Number of times recorded around the shoreline as single plants or groups**

Table 16. Dante Lake macrophyte survey transects for August 3, 2000.

	Point Depth (ft)	Secchi Depth (ft)	Transect Species	Transect Density*	Transect
1A	2.4	2.4	coontail	5	
“	“	“	sago pondweed	1	
1B	2.8	2.8	coontail	4	
“	“	“	sago pondweed	1	
Center T-1	2.0	2.0	coontail	5	
1C	2.9	2.9	coontail	5	
1D	3.5	3.5	coontail	4	
2A	5.5	4.5	coontail	4	
2B	6.0	6.0	coontail	3	
CenterT-2	6.6	5.9	coontail	3	
2C	6.0	6.0	coontail	2	
2D	4.8	4.8	coontail	4	
3A	8.1	4.1	none	0	
3B	8.8	4.7	sago pondweed	1	
CenterT-3	8.8	4.8	none	0	
3C	6.9	4.5	coontail	1	
“	“	“	sago pondweed	2	
3D	5.6	4.9	coontail	3	
4A	5.9	4.1	coontail	3	
4B	8.9	4.4	none	0	
CenterT-4	8.9	4.4	coontail	1	
4C	9.2	4.8	none	0	
4D	7.0	5.4	coontail	1	
5A	10.0	4.2	coontail	1	
“	“	“	sago pondweed	1	
5B	12.3	4.0	none	0	
CenterT-5	13.9	4.0	none	0	
5C	12.6	4.2	none	0	
5D	8.5	4.1	coontail	2	
“	“	“	sago pondweed	1	
6A	11.5	3.5	coontail	2	
“	“	“	sago pondweed	1	
Center T-6	data missing				
6B	16.4	4.0	none	0	
6C	16.4	3.9	none	0	
6D	10.2	4.1	coontail	1	
6D	10.2	4.1	sago pondweed	2	

***Transect Density: 1 = sparse 2 = scattered 3= moderate 4 = heavy 5 = dense**

OTHER MONITORING

Sediment Survey and Suspended Solids (TSS) Budget

Sedimentation continues to be one of the more destructive pollutants in South Dakota state lakes and streams. This impairment can cause an increase in internal phosphorus loading, decrease habitat availability for invertebrates and fish, decrease depth and thereby significantly shorten the useful life span of smaller lakes and reservoirs.

A sediment survey was completed for Dante Lake during January 2001. Sampling entailed drilling holes through the ice at 129 survey sites and recording the depth of the water column in each case (Figure 11). A long steel probe was pushed into the sediment at each site until solid substrate was encountered and the depth of the soft sediments was determined. The location of the sites was recorded by GPS (Global Positioning System).

Average sediment depth in Dante Lake was 2.3 feet. Sediment depths ranged from 0.5 to 5.0 feet, with the majority of the sediment in the upper one-half of the lake (Figure 11). Sediment volume was 25 acre-feet or approximately 74,076 tons. This represents about 11.4% of the original lake volume.

Table 5 shows that Dante Lake received an estimated 1,128 cubic feet (0.026 ac-ft) of sediment in the form of total suspended solids (TSS) from its single tributary during this project. The volume of sediment was calculated by converting the 69,071 kg total given in Table 5 into pounds and dividing the result by 135. One cubic foot of sediment weighs approximately 135 pounds (135 lb/ft3) (NRCS).

Table 17. Seasonal Loadings of Total Suspended Solids for Dante Creek to Dante Lake from 2000 through 2001.

Date Month/Year	Days	Sample Count	Volume (hm3)	Mass (kg)	Conc (ppb)	Percent Discharge
May-00	17	1	0.037	910	24,886	1.41%
Jun-00	30	1	0	0	2,767	0.00%
Jul-00	31	0	0	0	0	0.00%
Aug-00	31	1	0.072	1,917	26,716	2.74%
Sep-00	30	0	0	0	0	0.00%
Oct-00	31	0	0	0	0	0.00%
Nov-00	30	0	0	0	0	0.00%
Dec-00	31	0	0	0	0	0.00%
Jan-01	31	0	0	0	0	0.00%
Feb-01	28	0	0	0	0	0.00%
Mar-01	31	1	1.704	45,514	26,716	64.96%
Apr-01	30	4	0.772	19,883	25,741	29.43%
May-01	15	1	0.038	847	22,258	1.45%

Dante Lake Sediment Depth

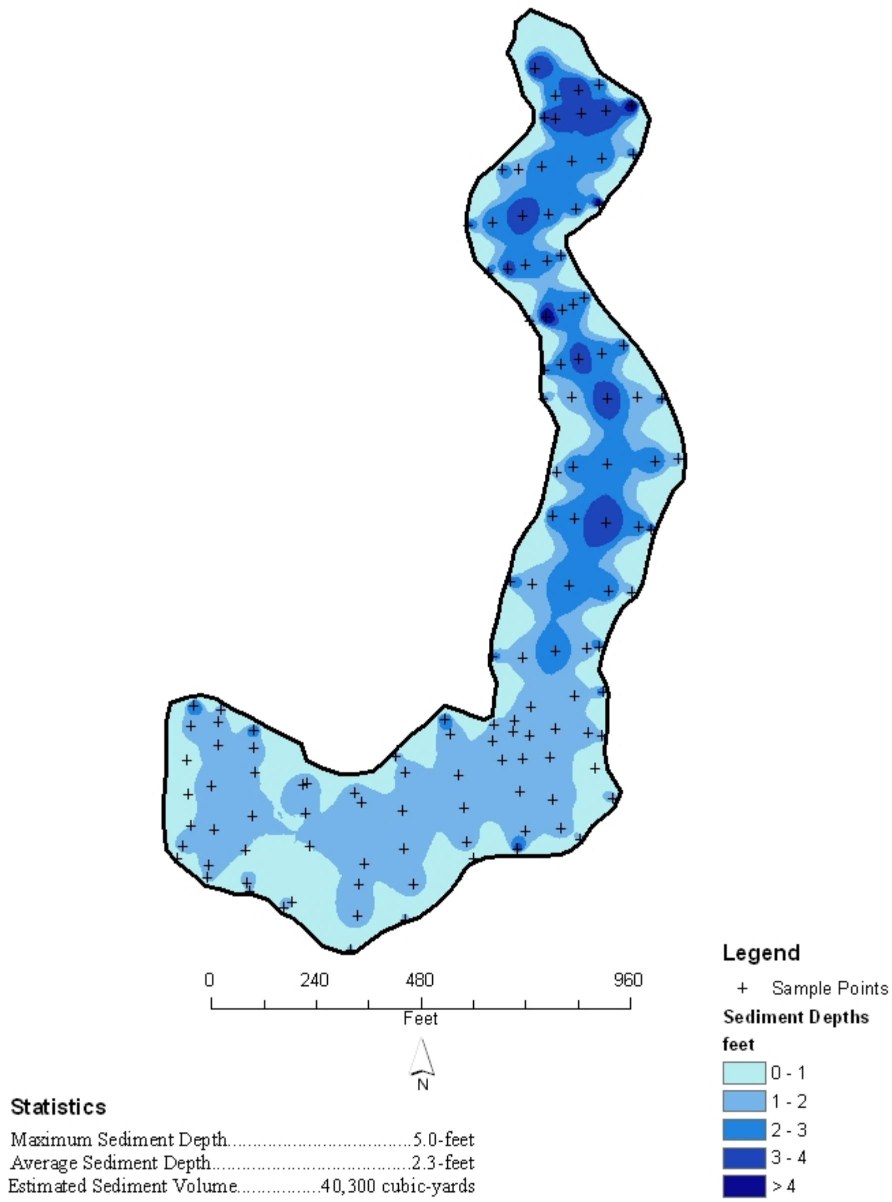

Figure 11. Dante Lake sediment depth for 2001.

The estimated volume of sediment retained by Dante Lake was 224.5 ft3 or 20% of the amount entering the reservoir. This volume amounts to only 0.005 ac-ft or less than one-hundredth of one percent of the volume of Dante Lake (193.5 ac-ft). That amount appears to pose no threat to the useful life of the reservoir for the foreseeable future.

Seasonal loadings of sediment (TSS) at Dante Lake occurred primarily during snowmelt and spring rain events in this investigation (Table 17). The spring months accounted for 97% of the sediment load that occurred during the project. A single summer rainstorm in August 2000 contributed the remaining 3%.

Elutriate Analysis

Elutriate samples are used to determine chemical contaminants in bottom sediment samples. In general, contaminants are composed of various metals, agricultural pesticides and herbicides (Table 18). A typical sample set is composed of sediment and a sample of the overlying water (receiving water). Receiving water is analyzed before being mixed with the sediment to detect existing contamination in the overlying water. The sediment and receiving water are then mixed for a predetermined amount of time and the homogenous sample is separated using a centrifuge. The water layer (elutriate sample) is extracted from the centrifuge test tube and analyzed for contaminants.

All water quality standards for toxic pollutants for human health and aquatic life values in South Dakota are based on beneficial use categories (ARSD 74:51:01). Samples for elutriate analysis were collected from a mid-lake site on June 18, 2002. The sediment sample was collected with a stainless steel Petite Ponar dredge and the receiving water sample was collected with a Van Dorn type sampler. Samples were preserved and transported to the laboratory at 40C.

Receiving water and elutriate samples collected from Dante Lake were analyzed at the South Dakota State Health Laboratory in Pierre. Lab results indicate both receiving water and elutriate samples were below laboratory detection limits for PCBs, herbicide and pesticide parameters and were relatively low or below detection limits for metals (Table 18). The elutriate (sediment) sample contained highly elevated concentrations of phosphorus and ammonia. This represents a considerable potential source of nutrients for the lake that could be activated during periods of prolonged lake stratification (in-lake nutrient recycling). Water hardness tests ($CaCO_3$) indicated Dante Lake has very hard water. Conductivity and dissolved solids concentration also indicated mineralized (moderately saline) waters.

Table 18. Dante Lake receiving water and elutriate chemical concentrations collected in June 2002.

Parameter	Receiving Water Dante Lake	Elutriate Sample Dante Lake	Actual in Sediment Dante Lake	Unit
COD	26.4	38.7	12.3	mg/L
Phosphorus, total	0.03	0.45	0.42	mg/L
TKN	1.02	5.83	4.81	mg/L
Hardness	1180	1160	-	mg/L
Nitrate	0.1	0.1	0	mg/L
Nitrite	<0.02	<0.02	<0.02	mg/L
Aluminum	8.1	<0.03	-	µg/L
Zinc	<2.0	4.4	>2.4	µg/L
Silver	<0.2	<0.2	<0.2	µg/L
Selenium	8.6	1.2	-7.4	µg/L
Nickel	7.6	3.3	-4.3	µg/L
Mercury, total	<0.1	<0.1	<0.1	µg/L
Lead	<0.1	<0.1	<0.1	µg/L
Copper	1.6	1.4	-0.2	µg/L
Cadmium	<0.2	<0.2	<0.2	µg/L
Arsenic	8.0	6.0	-2.0	µg/L
Ammonia	0.04	4.72	4.68	mg/L
Endosulfan II	< 0.500	< 0.500	< 0.500	µg/L
Atrazine	< 0.100	< 0.100	< 0.100	µg/L
Endrin	< 0.500	< 0.500	< 0.500	µg/L
Heptachlor	< 0.400	< 0.400	< 0.400	µg/L
Heptachlor Epoxide	< 0.500	< 0.500	< 0.500	µg/L
Methoxychlor	< 0.500	< 0.500	< 0.500	µg/L
Toxaphene	ND	ND	ND	-
Aldrin	< 0.500	< 0.500	< 0.500	µg/L
Dieldrin	< 0.500	< 0.500	< 0.500	µg/L
Aroclor 1016	< 0.100	< 0.100	< 0.100	µg/L
Aroclor 1221	< 0.100	< 0.100	< 0.100	µg/L
Aroclor 1232	< 0.100	< 0.100	< 0.100	µg/L
Aroclor 1242	< 0.100	< 0.100	< 0.100	µg/L
Aroclor 1248	< 0.100	< 0.100	< 0.100	µg/L
Aroclor 1254	< 0.100	< 0.100	< 0.100	µg/L
Aroclor 1260	< 0.100	< 0.100	< 0.100	µg/L
Diazinon	< 0.500	< 0.500	< 0.500	µg/L
DDD	< 0.500	< 0.500	< 0.500	µg/L
DDT	< 0.500	< 0.500	< 0.500	µg/L
DDE	< 0.500	< 0.500	< 0.500	µg/L
BETA BHC	< 0.500	< 0.500	< 0.500	µg/L
GAMMA BHC	< 0.500	< 0.500	< 0.500	µg/L
ALPHA BHC	< 0.500	< 0.500	< 0.500	µg/L

Annualized Agricultural Non Point Source Model (AnnAGNPS)

AnnAGNPS is a data intensive watershed model that routes sediment and nutrients through a watershed by utilizing land uses and topography. The watershed is broken up into cells of varying sizes based on topography. Each cell is then assigned a primary land use and soil type. Best Management Practices (BMPs) are then simulated by altering the land use in the individual cells and reductions are calculated at the outlet to the watershed.

The input data set for AnnAGNPS Pollutant Loading Model consists of 33 sections of data, which can be supplied by the user in a number of ways. This model execution utilized; digital elevation maps (DEMs) to determine cell and reach geometry, SSURGO soil layers to determine primary soil types and the associated NASIS data tables for each soils' properties, and primary land use based on remotely-sensed data obtained from the EROS data center. Impoundment data was obtained from analysis of the National Wetlands Inventory (NWI). Weather data was generated using a synthetic weather generator based on climate information from the closest stations. Mean annual precipitation for this watershed is about 21 inches.

It is important to note that these model results are based on 25 simulated years of data with precipitation ranging from 15 to 27 inches per year. None of these represent the project period, they are instead representations of what may typically occur on any given year, and when analyzed as a group provides a risk analysis for practices in the watershed.

The land use data used for this model was derived from LANDSAT imagery collected during the years 2000 and 2001. Analysis of this imagery was completed by the EROS Data Center and compiled into land use combinations for each cell. These combinations were derived by selecting the most prevalent land use in each cell for each year and then combined into a two year rotation. Table 19 indicates the land uses in the Dante Lake watershed. For the model purposes, approximately 69 percent of the land is cropped with an additional 26 percent used for pasture and rangeland. The remaining 6 percent are split between hay ground, urban (residential) and wetland areas.

Table 19. Dante Landuse Percentages

Landuse Type	Number of Cells	Percent of Watershed
Cropland	93	69%
Hay	4	3%
Rangeland	35	26%
Urban	1	1%
Wetland	1	1%

The LANDSAT data is estimated to be approximately 70 percent accurate on a given year. Approximately 30 percent of the land use combinations in the Dante watershed do not appear to be accurate (those with field validation advised in Table 20). Typical applications of the LANDSAT data would normally involve the project coordinator correcting these inaccuracies as well as refining the tillage practices typical for their watershed. The Dante Lake report is being completed after the completion of the project with very little available data on tillage, fertilizer, and land use practices. For this reason, there will be no correction step and the data will be used as is. Prior to any implementation activities in this watershed, refinement of this dataset is required to accurately depict actual conditions in this watershed and re-calculate reductions to provide accurate reduction percentages.

Initial critical cells for phosphorus were determined using simulated cell specific runoff values (lbs/acre), with threshold runoff values greater than one and two standard deviations above the mean. Sediment, nitrogen and phosphorus cells were analyzed and prioritized independently based on statistical characteristics. Cellular loading greater than two standard deviations above the mean for each category (sediment, nitrogen and phosphorus) received a priority ranking of one (1), loading cells greater than one but less than two standard deviation above the mean received a priority ranking of two (2) and cellular loading between one standard deviation and the mean received a priority three (3) ranking.

Priority critical cells for phosphorus in the Dante Lake watershed were based on AnnAGNPS modeling shown in Table 22. AnnAGNPS model identified approximately 1,145 acres of critical areas for phosphorus (nutrient of concern), or 40.9 percent of the entire Dante Lake watershed, based on the above criteria. Long-term monitoring suggest that Dante Lake has periodically had increased phosphorus concentrations resulting in elevated mean trophic state index (TSI) values above 65.00, exceeding the 2000 targeted lakes protocols for ecoregion 42.

Current data indicate that Dante Lake is meeting ecoregion 42 criteria; however, since the lake assessment occurred during a relatively dry period TSI values during wet periods were not well represented. Taking this into account nutrient reductions from the watershed will be needed to further reduce in-lake TSI values to meet targeting criteria during both wet and dry years.

There are 28 cells or 21 percent of these inaccurate combinations that can be attributed to two combinations, grass/corn and wheat/corn. Assuming that at least one of the two years is correct, several simulations were completed to show the effects of the inaccuracies. These simulations will be described further with the other simulations. For the remaining cells with apparently inaccurate combinations, the practices were alternated to minimize the effect any one mistake may have on the data. Typical tillage practices for the fields in the watershed are somewhat conservative; with an assumption that only one pass with a disk is used for most bean and corn crops immediately prior to planting.

Table 20. Field Type and Frequency for Dante Lake Watershed

Field Code	Field Verification.	Cells	2000	2001	Land use	Operation	Landuse Type	Percent Comp.	Percent Advised
101103	Advised	1	Grass	Beans	Grass/Beans	GdBc	Cropland	1%	
107104	Advised	2	Other Crop	Alfalfa	AGMHay	AGMHay	Hay	1%	
107102	Advised	4	Other Crop	Corn	Corn	dC	Cropland	3%	
103101	Advised	5	Beans	Grass	Bean/Grass	dBcG	Cropland	4%	30%
102101	Advised	7	Corn	Grass	Cor n/Grass	dCcG	Cropland	5%	
101102	Advised	8	Grass	Corn	Grass/Corn	GdCc	Cropland	6%	
101109	Advised	13	Grass	Wheat	Grass/Wheat	GdTc	Cropland	10%	
2323	None	1	High Int Ind.	High Int Ind.	Urban	Urban	Urban	1%	1%
104101	Optional	1	Alfalfa	Grass	AGMHay	AGMHay	Hay	1%	
101104	Optional	1	Grass	Alfalfa	AGMHay	AGMHay	Hay	1%	
92101	Optional	1	Wetland	Grass	Pasture/ Good	CRP	Rangeland	1%	
10792	Optional	1	Other Crop	Wetland	Wetland	WRP	Wetland	1%	
103103	Optional	3	Beans	Beans	Beans	dBc	Cropland	2%	69%
103102	Optional	15	Beans	Corn	Bean/Corn	dBdC	Cropland	11%	
102102	Optional	18	Corn	Corn	Corn	dCc	Cropland	13%	
102103	Optional	19	Corn	Beans	Corn/Bean	dCdB	Cropland	14%	
101101	Optional	34	Grass	Grass	Pasture	PastGood	Rangeland	25%	

A number of management scenarios or simulations were completed for the Dante Lake watershed. A comparison of the phosphorus, nitrogen and sediment loads at the outlet to the watershed is available in Table 21. Following the table each simulation is described in detail.

Table 21. Simulation average annual loads, values in pounds or tons per acre at the watershed outlet over 25 years

Simulation	#	Nitrogen Load (lbs/ac/yr)	Phosphorus Load (lbs/ac/yr)	Sediment Load (tons/ac/yr)
Current Crops/ Pastures Fair Condition	*	3.417	3.282	0.086
Current Crops/ Pastures Good Condition	1	3.272	3.203	0.085
Current Crops/ Pastures Poor Condition	2	3.801	3.442	0.088
Entire Watershed Pasture Good Condition	3	0.812	0.566	0.000
Entire Watershed as CRP	4	0.600	0.445	0.000
Wheat/Grass to Grass	5	3.306	3.127	0.084
Wheat/Grass to Wheat	6	3.716	3.795	0.093
Grass/Corn to Grass	7	3.150	3.152	0.083
Grass/Corn to Corn	8	3.989	4.203	0.101
Total Watershed Acres				**2,799.3**

*** = Current conditions**

Simulation number one consisted of current crops with pastures in good condition. This simulation was intended to represent the watershed with its current cropping practices as determined by the EROS dataset with pasturelands in good condition. This simulation was completed to simulate what might be expected if current cropping practices continue and grazing practices are followed that improve range condition to its best possible condition. This represents approximately a 2.4 percent reduction in total phosphorus loading (parameter of concern) and approximately a 1.2 percent reduction in sediment loading at the outlet of Dante Lake.

Table 22. Phosphorus priority acreage for Dante Lake watershed, Charles Mix County, South Dakota.

Phosphorus Priority	Acres	Percent
1	22.46	0.8
2	453.01	16.1
3	670.51	24.0
Total Priority Acreage	**1,145.98**	**40.9**
Total Watershed Acres	**2,799.30**	**100.0**

Simulation number two consisted of current crops with pastures in poor condition. This simulation was intended to represent the watershed with its current cropping practices as determined by the EROS dataset with pasturelands in poor condition. With the uncertainty of the actual range conditions in this watershed, it may be assumed for the purposes of this model that the current condition of the watershed lies somewhere between the values obtained for simulations 1 and 2.

Simulations three and four were intended to show what potential the watershed would have if it were managed in a natural state, assumed to be entirely a grassy plain with no cropland or urban development. The CRP management and pasture good conditions were both completed because they simulate different types of cover properties. The CRP run is more similar to what would be found in a native prairie, while the pasture good condition better represents what might be found in a tame grass pasture with non native species such as brome grass.

Comparing the values from simulations 3 and 4 to what was determined to be the current state of the watershed; it can be assumed that approximately 75.2 percent of the current nitrogen load, 82.8 percent of the phosphorus load, and 99 percent of the sediment load are the result of human activity. These percentages are NOT to be used as a TMDL goal, but are only a reference point from where the TMDL may begin development.

Simulations five through eight were completed to determine the potential changes in the watershed loadings as a result of land use combinations that are not expected to be correct. The LANDSAT imagery indicated that approximately 10 percent of the watershed was a wheat/grass combination, while 11 percent had a corn/grass combination. These two combinations account for over two-thirds of the land use combinations that had apparent errors. The cumulative effect of these errors is +/- 20 percent for the nitrogen load, +/- 25 percent for the phosphorus load, and +/- 15 percent for sediment load. Comparing the AnnAGNPS phosphorus modeled load (3.282 lbs/acre (9,186 lbs/yr) was 62.2 percent different from the measured load (1.240 lbs/acre (3,472 lbs/yr delivered). Sediment loading was assumed to be 0.086 tons/acre (241 tons/yr) from the model; the measured load was calculated to be 0.027 tons/acre/yr (76 tons/yr), 68.4 percent different. These inconsistencies are likely attributable to a combination of variables, soil nutrients and fertilizer/manure application; however, the modeled percent reductions for each modeled BMP were considered to be relatively stable and were used to estimate reductions (kg/acre) based on measured loads.

Potential reductions from the watershed are limited due to the completion of the modeling after the completion of the project with very little available data. It is likely that range management will have a very minimal effect on the loadings to Dante Lake, likely an estimated 2.4 percent for nutrients and 1.2 percent for sediment, based on simulations 1 and 2. The greatest potential reductions will be from cropland acres. With the uncertainty of fertilizer applications, riparian zone conditions along cropped acres, and tillage practices; any or all of these may be potential sources of reductions.

SD DENR recommends the following BMPs to reduce phosphorus loading 6.4 percent (474 kg/year) and sediment 4.6 percent (3.53 tons/year). Recommended BMPs consist of the implementation of grazing management to improve pasture conditions from fair condition to good condition, improve tillage practices and/or convert corn rotations to pasture reducing overall phosphorus loading to Dante Lake.

Quality Assurance Reporting

Three quality assurance and quality control (QA/QC) sample sets were collected throughout the 2000 and 2001 sampling periods for tributary sampling sites. However, there were no QA/QC samples collected for the in-lake sampling sites during this study. Standard chemical analysis was performed on all blank and replicate samples collected. Analyses followed both the tributary and in-lake standard routine chemical parameters for analysis and are listed in Tributary Monitoring section of this report and Table 23 for in-lake samples.

Replicate samples were compared to the original samples using the industrial statistic (%I). The value given is the absolute difference between the original and the replicate sample in percent. The equation used was:

Equation 1. Industrial statistic equation.

$$\%I = [(A-B) / (A+B)]*100$$

%I = Industrial Statistic
(A-B) = Absolute difference
(A+B) = Absolute sum

Blank samples were evaluated by calculating the mean and standard deviation of all blank samples for both tributary and in-lake samples. The criterion for compliance was that the standard deviation be less than the mean of all blank samples.

Table 23. Tributary quality assurance/quality control samples collected in Dante Creek, Charles Mix County, South Dakota from 2000 through 2001.

SITE	DATE	TIME	Fecal Coliform Bacteria (#Colonies/100 ml)	E. coli (#Colonies/100 ml)	Alkalinity (mg/L)	Total Solids (mg/L)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Volatile Total Suspended Solids (mg/L)
Blank	5/18/2000	945	5	0	6	14	13	1	0.01	0.1	0.11	0.21	0.003	0.010	0.50
Blank	6/1/2000	803	5	0	6	16	16	1	0.01	0.1	0.11	0.21	0.001	0.001	0.50
Blank	4/4/2001	1005	5	0	6	10	9	1	0.02	0.1	0.36	0.46	0.002	0.002	1.00
		SD	0	0	0	3.06	3.51	0.00	0.01	0.00	0.15	0.15	0.00	0.00	0.29
		Mean	5	0	6	13.33	12.67	1.00	0.01	0.10	0.19	0.29	0.00	0.00	0.67
DLT-2	5/18/2000	920	8800		163	2844	2780	64	0.01	0.5	1.75	2.25	0.324	0.176	12
Replicate	5/18/2000	950	5900		171	2955	2853	102	0.03	0.5	1.15	1.65	0.34	0.167	20
		1.60%	**19.73%**		2.40%	1.91%	1.30%	**22.89%**	**50.00%**	0.00%	**20.69%**	**15.38%**	2.41%	2.62%	**25.00%**
DLT-2	6/1/2000	801	900		333	4676	4662	14	0.01	0.05	0.94	0.99	0.196	0.043	4
Replicate	6/1/2000	802	590		330	4675	4615	60	0.01	0.05	1.01	1.06	0.085	0.036	5
		0.06%	**20.81%**		0.45%	0.01%	0.51%	**62.16%**	0.00%	0.00%	3.59%	3.41%	**39.50%**	8.86%	**11.11%**
DLO-1	4/4/2001	917	5	2	117	1619	1609	10	0.25	0.8	1.16	1.96	0.266	0.134	5
Replicate	4/4/2001	1000	5	2	119	1629	1618	11	0.24	0.8	1.39	2.19	0.258	0.132	6
		4.33%	0.00%	0.00%	0.85%	0.31%	0.28%	4.76%	2.04%	0.00%	9.02%	5.54%	1.53%	0.75%	9.09%

Three tributary quality assurance/quality control samples were collected for tributary monitoring sites during this study. Sixteen total tributary samples were collected in Dante Lake for an overall quality assurance/quality control percentage of 18.7 percent. Six tributary replicate sample parameters (volatile total suspended solids, total suspended solids, ammonia, TKN, Total Nitrogen, fecal coliform bacteria and total phosphorus) had industrial statistics (%I) greater than 10 percent (absolute percent) on at least one sampling date. Volatile total suspended solids and total suspended solids concentrations can vary considerably because of variations in sample collection. Fecal coliform colony counts often vary due to variations in bacterial growth on incubated media and temperature. All other replicate parameter samples were within 10 percent from the original samples (Table 23).

All blank quality assurance/quality control chemical parameters samples were in compliance with respect to criterion proposed previously (Table 23).

Monitoring Summary and Recommendations

Monitoring Summary

Tributary Recommendations

Tributary recommendations are based on best professional judgment and AnnAGNPS Best Management Practices (BMPs). All reductions were modeled using water quality and/or AnnAGNPS data collected during this study. Generalized crop management modeling estimated approximately a 6.4 percent reduction in phosphorus loading to Dante Lake based on 2000 and 2001 AnnAGNPS and assessment loading data.

Additional BMPs (streambank stabilization, cattle restrictions, alternative watering, grazing management, fertilizer reduction, etc.) should be considered and implemented in the Dante Lake watershed to further reduce sediment and nutrient loads to Date Lake and are represented in the TMDL calculation as part of the implicit margin of safety (MOS). Implementing any additional BMPs will help ensure TMDL attainability in the Dante Lake watershed. Any implementation project undertaken in this watershed should be combined with other Charles Mix County implementation projects.

In-lake Recommendations

The in-lake recommendation is based on Best Management Practices and best professional judgment and should be considered only after all tributary BMPs have been implemented to attain long-term success. Reductions were estimated or calculated using water quality and/or BATHTUB modeling data collected during this study. Reduction percentages given in Table 24 are the expected percent reduction in in-lake nutrients based on 2000 through 2001 data.

Aluminum Sulfate Treatment (Alum)

Alum treatment uses an aluminum sulfate slurry that, when applied to water, creates an aluminum hydroxide precipitate (floc). The aluminum hydroxide (Al_3O_2) floc removes phosphorus and suspended solids, both organic and inorganic, from the water column by reacting with the assimilated phosphorus to create aluminum phosphate that settles to the bottom. By collecting and settling out suspended particles including algae, alum leaves the lake noticeably clearer (improving Secchi depth). Once on the bottom of the lake, the floc forms a layer that acts as a phosphorus barrier by combining with phosphorus as it is released from the sediment. The aluminum phosphate compound will not release phosphorus to the water column unless disturbed (Sweetwater, 2000).

The treatment can be effective for up to ten years and is dependent upon the amount of alum applied, total suspended solids sedimentation rate and external phosphorus loading. Welch and Cooke (1995) studied lakes treated with alum and found that phosphorus concentrations were reduced from 30 percent to 90 percent after application. If long-term disturbance and tributary loadings are significantly reduced, a significant reduction in in-lake phosphorus is estimated based upon in-lake concentrations prior to application. The percent reductions for alum treatment in Table 24 were calculated using a conservative percent reduction in in-lake phosphorus concentrations.

Table 24. Estimated reduction percentages using BATHTUB for in-lake alum treatment, Best Management Practices for Dante Lake, Charles Mix County, South Dakota in 2000 and 2001.

		Percent TSI Parameter Reduction (BATHTUB)		
In-lake Best Management Practice	**In-lake Phosphorus Reduction**	**Secchi**	**Chlorophyll-a**	**Phosphorus**
Alum Treatment	30%	0	0	7.2

1 = Percent TSI reduction was estimated using predicted tributary TSI values based on BATHTUB modeling.

Implementing an alum treatment in Dante Lake to further reduce in-lake phosphorus is represented in the TMDL calculation as part of the implicit margin of safety (MOS). Implementing any additional in-lake BMPs will help ensure TMDL attainability in the Dante Lake watershed. Other in-lake BMPs should be considered to augment tributary mitigation to produce an overall positive impact on Dante Lake over time.

Mechanical Aeration

Instillation of a lake aeration system is recommended for use especially in the summer months (June thru September) to break up stratification and increase conversion of organic matter improving dissolved oxygen concentrations throughout the lake. Mechanical aeration is needed to meet the TMDL goal for dissolved oxygen ($\geq$ 5.0 mg/L) when phosphorus and algae concentrations become low due to limited runoff. A mechanical aerator is recommended and should be considered to improve overall water quality in Dante Lake.

Targeted Reduction and TMDL

An estimated 6.4 percent modeled phosphorus reduction based on AnnAGNPS watershed modeling is expected based on converting wheat/grass and corn/grass fields to grass and improving grazing management in pastures in fair condition to good conditions especially in pastures adjacent to Dante Creek. These reductions are based on EROS Landsat landuse data coverage using 2-year crop rotations.

Targeted reductions for specific parameters and mean TSI values were modeled using the BATHTUB reduction model. All reductions were modeled or calculated using water quality and/or AnnAGNPS data collected during this study. Parameter-specific and mean TSI values were plotted on beneficial use categories and are shown in Figure 12 and Figure 13. Tributary and in-lake TSI reductions were based on Best Management Practices and best professional judgment. The Margin of Safety (MOS) for phosphorus is implicit. Implicit in that all modeled reduction estimations for tributary BMPs were calculated using extremely conservative reduction values/percentages and any additional tributary BMPs (not modeled) implemented would be incorporated into the TMDL equation as an implicit margin of safety.

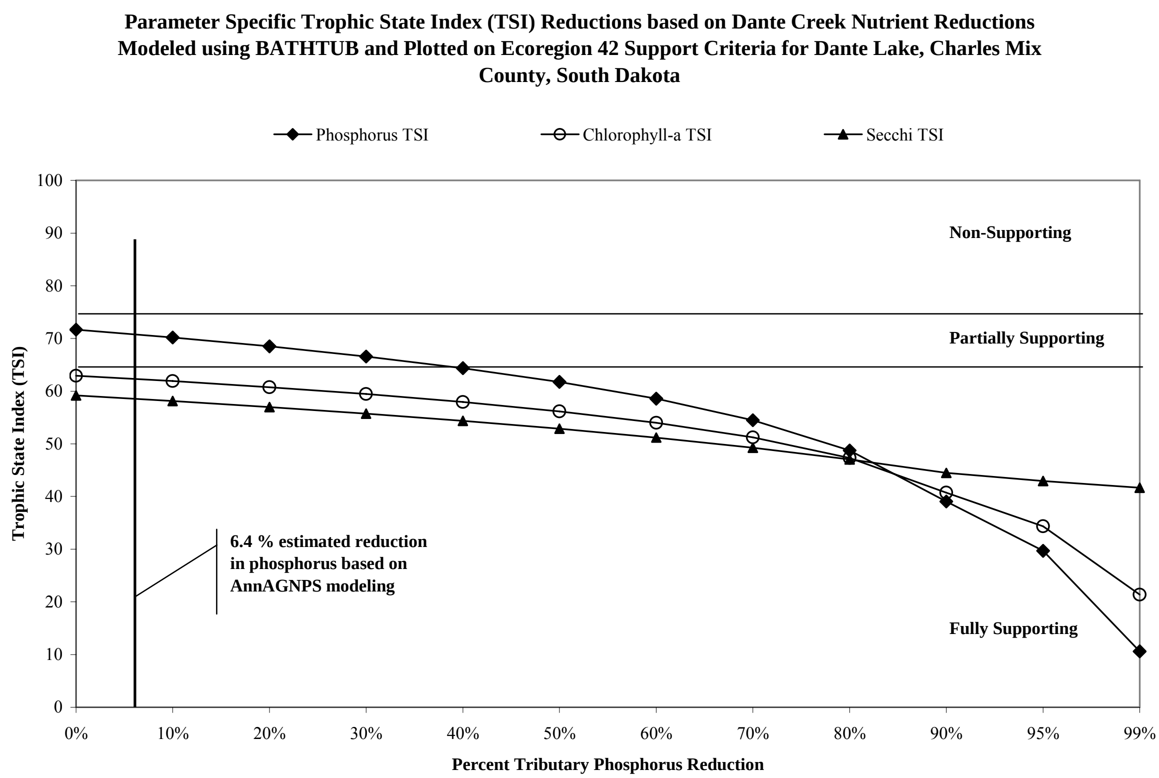

Figure 12. TMDL-predicted parameter specific Trophic State Index (TSI) reductions using the BATHTUB reduction model based on tributary BMPs reductions by beneficial use categories for Dante Lake, Charles Mix County, South Dakota using 2000 and 2001 data.

Based upon 2000 and 2001 modeled data, phosphorus TSI (71.69) was partially supporting while Secchi TSI (59.19) and chlorophyll-a TSI values (62.94) were fully supporting based on previously defined beneficial use criteria (Figure 12).

The target criteria are 70.76 for phosphorus, 62.30 for chlorophyll-a and 58.53 for Secchi visibility (Table 25). SD DENR-recommended targets for specific TSI parameters for Dante Lake were based on AnnAGNPS modeled attainability. Reductions should improve phosphorus TSI by 1.30 percent, chlorophyll-a TSI by 1.01 percent and Secchi TSI by 1.11 percent, which will improve in-lake water quality. To reach these goals, tributary total phosphorus loads will have to be reduced by 6.4 percent (AnnAGNPS derived reduction). Long-term tributary and in-lake monitoring should be conducted during and after implementation to evaluate BMPs' effectiveness and determine if in-lake TSI targets have been met. SD DENR will continue to monitor Dante Lake as part of the statewide lakes assessment project.

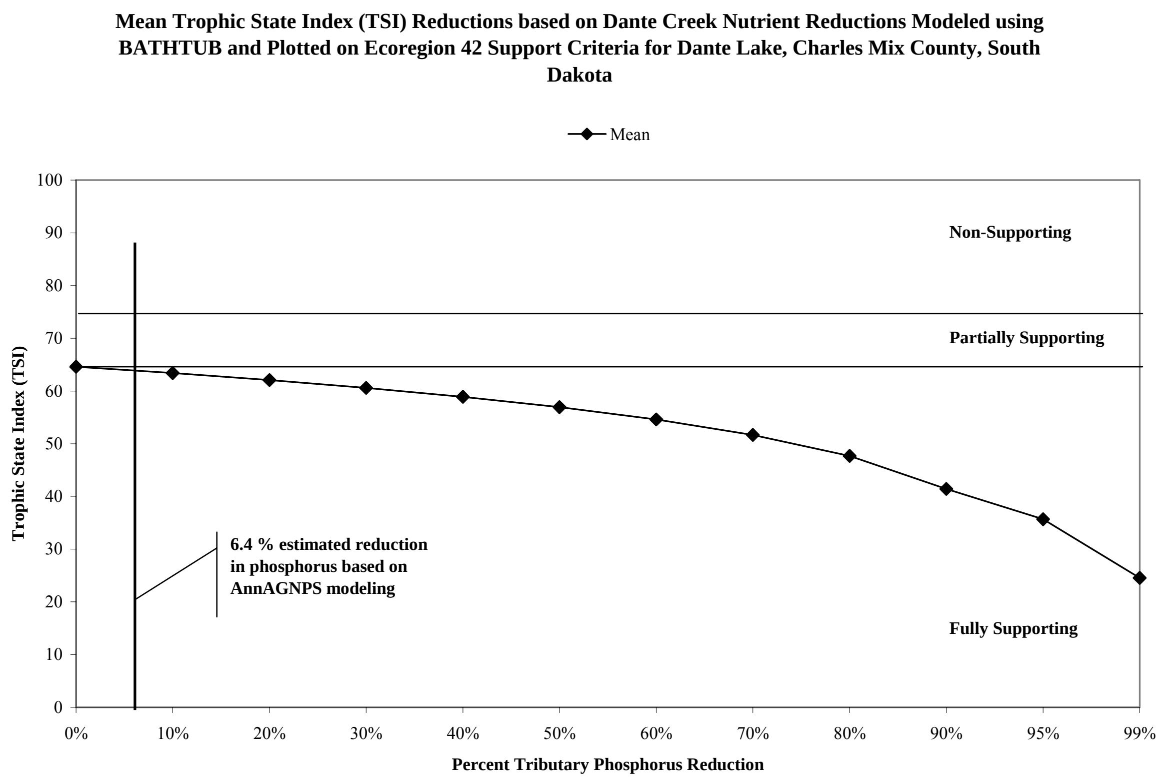

Figure 13. TMDL-predicted mean Trophic State Index (TSI) reduction using the BATHTUB reduction model based on tributary BMPs reductions ranked by Ecoregion 42 beneficial use categories for Dante Lake, Charles Mix County, South Dakota based on 2000 and 2001 data.

The average TSI values for phosphorus, chlorophyll-a and Secchi combined as modeled using BATHTUB (Table 25 (64.61)) is in the fully supporting category (Figure 13). The recommended target for an average TSI value in Dante Lake is 63.86 (Table 25 and Table 26). Implementing tributary BMPs on selected cropped areas and improving grazing management in the watershed should decrease the in-lake mean TSI value approximately 1.16 percent which will continue to fully support Ecoregion 42 beneficial use criteria (mean TSI ≤ 65.00).

If an in-lake alum treatment is considered, all tributary BMPs should be in place and implemented before alum treatment begins to attain maximum benefit. In-lake BMPs may improve phosphorus TSI values (an estimated 7.2 percent, based on modeled (BATHTUB) in-lake TSI reductions); however, the Total Maximum Daily Load (TMDL) is based on attainable tributary BMP reductions using conservative targeted reduction estimates. Similarly, the instillation of a mechanical aeration device in Dante Lake will improve overall in-lake water quality and maintain surface water dissolved oxygen concentrations above 5.00 mg/L. There was little evidence of major phosphorus load from in-lake sediments.

An appropriate TMDL for total phosphorus in Dante Lake is 1,474 kg/yr based on measured load, producing a mean TSI of 63.86 (Table 26 and Equation 2).

Mean TSI values should be reduced by 1.16 percent based on modeled tributary BMPs. In-lake BMPs (alum treatment (implicit margin of safety) may be implemented to achieve additional reductions (estimated approximately 7.2 percent) after tributary BMPs are implemented to achieve maximum benefit. In-lake BMPs were taken into account through the implicit margin of safety.

Table 25. Current, targeted and percent reduction for parameter specific and mean TSI values using BATHTUB based on 2000 and 2001 data for Dante Lake, Charles Mix County, South Dakota.

TSI Parameter	2000 -2001 Estimated TSI Values (BATHTUB)	TMDL Targeted TSI Value	Percent TSI Reduction
Total Phosphorus	71.69	70.76	1.30
Chlorophyll-a	62.94	62.30	1.01
Secchi	59.19	58.53	1.11
Average	64.61	63.86	1.16

Table 26. Total phosphorus TMDL target loading for Dante Lake, Charles Mix County, South Dakota from 2000 through 2001.

Parameter	Best Management Practice	Margin of Safety	TMDL[1]
Total Phosphorus	Tributary and In-lake BMPs	Implicit (conservative estimations)	Total Phosphorus TSI 70.76 (1,474 kg/year) (Mean TSI 63.86)

1 = Calculated based on 2000 and 2001 in-lake and tributary loading/concentration data

Equation 2. Total phosphorus TMDL equation for Dante Lake, Charles Mix County, South Dakota based on 2000 through 2001 data.

Component	Maximum Load
Waste Load Allocation (WLA):	0 (kg/yr)
+ Load Allocation (LA)	1,474 (kg/yr)
+ Margin of Safety:	Implicit
TMDL[1]	**1,474 (kg/yr)**

1 = Represents a total phosphorus tributary measured load reduction of approximately 6.4 percent, based on AnnAGNPS BMP attainability.

In concert with recommended tributary and in-lake BMPs to reduce in-lake phosphorus concentrations improving TSI values and dissolved oxygen concentrations, a mechanical aerator should be installed to assure attainment of the dissolved oxygen standard or goal.

Public Involvement and Coordination

Public involvement and coordination were the responsibility of South Central Water Development District. As local sponsor for the project, the district was responsible for issuing press releases and/or news bulletins. The project was discussed at monthly meetings of the South Central Water Development District Board, which is also a public setting where the public is invited to attend.

South Central Water Development District was the appropriate lead project sponsor for this project. The Development District was important to this project because of its working relationship with the stakeholders within the watershed.

State Agencies

Because the South Dakota Department of Environment and Natural Resources (SD DENR) is the statewide pollution control agency, it was the appropriate lead state agency for this project. SD DENR is responsible for tracking Section 319 funds and state and local match for federal funding. The Department (SD DENR) is also responsible for coordination and data collection for all assessment and implementation projects throughout the State of South Dakota.

South Dakota Game, Fish and Parks (SD GF&P) provided current and long-term fisheries data, reports and endangered species list (Heritage List) for Dante Lake. SD GF&P should be contacted and consulted during the planning and implementation phases of this project.

Federal Agencies

Natural Resources Conservation Service (NRCS) provided office space and technical assistance for the project. NRCS is the contact for local landowners involved with conservation plans and practices. NRCS needs to be involved up-front during all phases of the implementation process.

The United States Environmental Protection Agency (US EPA) provided financial assistance for the project. The US EPA provided $141,929 of Section 319 funds to cover project costs for the South Central Lakes Watershed Assessment project in which the Dante Lake watershed was assessed. EPA will also review and approve this assessment and TMDL.

The United States Fish and Wildlife Service (US FWS) did not provide financial or technical assistance during the assessment project. However, they should be contacted prior to the implementation project regarding their role in the implementation of the TMDL and the potential impact on any endangered species (consultation process).

Local Governments, Industry, Environmental, and Other Groups; Public-at-Large

South Central Water Development District within the Dante Lake watershed took a leading role in the planning and implementation of this project. This was evident during the assessment phase and becomes more important during the implementation phase when conservation practices need to be implemented with local landowners.

Other Sources of Funds

The South Central Lakes Watershed Assessment project was funded with Section 319 and local funds.

Funding Category	Source	Total
EPA Section 319 Funds	US EPA	$141,929.00
State Funds	Local	$37,887.50
Local Match	Local	$37,887.50
Total Budget		**$217,704.00**

Aspects of the Project That Did Not Go Well

One portion of the project that provided some difficulty was AGNPS data collection and modeling. During the project local coordinators were to collect all required AGNPS data to model the watershed; however, after the project ended much of the data was still not collected. With the project ended, a decision was made to change the watershed model from AGNPS to an updated annualized version (AnnAGNPS). This change required different data requirements and a steep learning curve to transition from AGNPS to AnnAGNPS. This increased the modeling and analysis time required for relating AnnAGNPS data to water quality monitoring data.

Future Activity Recommendations

Currently, Dante Lake is meeting ecoregional-based beneficial use evaluation criteria (fully supporting, mean TSI $\leq$ 65.00) based on AnnAGNPS modeling, BMPs and watershed phosphorus reduction attainability. Long-term data suggest in-lake TSI values vary depending upon rainfall patterns. Data also indicate lower dissolved oxygen concentrations in the summer months ($\leq$ 5.0 mg/L), especially in drier years. Implementing recommended tributary and in-lake BMPs for phosphorus to reduce in-lake TSI values should improve dissolved oxygen concentrations by reducing the amount of organic matter delivered to Dante Lake. The addition of a mechanical aeration for operation during periods of low surface dissolved oxygen concentrations will provide oxygen (air) to the hypolimnion breaking up stratification and increase the conversion of organic matter improving dissolved oxygen concentrations throughout the lake. Another benefit of hypolimnetic aeration should be improved dissolved oxygen profiles especially during the summer months increasing available fish habitat. Any realized reductions in tributary loading will also improve Dante Lake TSI values and dissolved oxygen concentrations.

Current data indicate that a 6.4 percent reduction in total phosphorus can be achieved in this watershed to meet the TMDL goal of 1,474 kg/yr total phosphorus for a mean in-lake TSI of 63.86. The recommended reductions will improve compliance with South Dakota's narrative criteria and the designated beneficial uses of the watershed, specifically, warmwater permanent fish life propagation water, immersion recreation water, limited contact recreation water, fish and wildlife propagation, recreation, and stock watering water. The installation of a mechanical aeration device in concert with implementation of tributary and in-lake BMPs will meet warmwater permanent fish life propagation and immersion recreation numeric standards for dissolved oxygen ($\geq$ 5.0 mg/L) throughout the year. Based on data from this assessment, a phase II implementation project should be designed and initiated in this watershed to achieve these goals.

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Appendix A

Dante Lake Fisheries Report

SOUTH

DAKOTA

FISHERIES

STATEWIDE FISHERIES SURVEYS, 2000
SURVEY OF PUBLIC WATERS
Part 1
Lakes – Region II

South Dakota
Department of
Game, Fish and Parks
Wildlife Division
Joe Foss Building
Pierre, South Dakota 57501-3182

Annual Report
No. 01-16

SOUTH DAKOTA STATEWIDE FISHERIES SURVEY

2102 - F-21-R-33

Name: Dante Lake **County:** Charles Mix
Legal Description: Sections 4 & 9, Township 95, Range 62
Location From Nearest Town: 2 miles N, ½ mile E of Dante

Date of Present Survey: July 10-12, 2000
Date Last Surveyed: June 19-21, 1995
Most Recent Lake Management Plan: F-21-R-27 **Date:** 1993
Management Classification: Warm Water Permanent
Contour Mapped: yes **Date:** 1973

Primary Species: (game and forage)
Bluegill

Secondary and Other Species:
Black Bullhead

PHYSICAL CHARACTERISTICS

Surface Area: 18.7 acres **Watershed:** 1,900 acres
Maximum Depth: 23 feet **Mean Depth:** 11 feet
Lake Elevation at Survey (from known benchmark): -2 feet

1. Describe ownership of lake and adjacent lakeshore property:

The South Dakota Department of Game, Fish and Parks owns the south half of Dante Lake; the north half of the lake has easements to the State of South Dakota, as does an additional eight acres on in the watershed which the silt retention dam is located.

2. Describe watershed condition and percentages of land use:

The entire watershed of Dante Lake is privately owned. Land use is mainly agricultural with cultivated cropland comprising of 78%, pasture and hay land 20%, and 2% roads and residences.

3. Describe aquatic vegetative condition:

Submergent vegetation is heavy in the shallow areas, especially in the north half of the lake.

4. Describe pollution problems:

The major pollution concern is a result of the deteriorated condition of the watershed, which allows heavy siltation to enter the lake reducing water volume and promoting a hyper-eutrophic state.

5. **Describe condition of all structures, i.e. spillway, level regulators, boat ramps, etc.:**

The spillway and dam grade are in good condition. The boat ramp, while serviceable, does need some gravel on the approach to the top of the ramp.

CHEMICAL DATA

1. **Describe general water quality characteristics:**

Water quality characteristics at Dante Lake were analyzed in the field on July 10, 2000 with a HACH water quality test kit. Results are on Table 1.

2. **Thermocline:** yes **Location from surface:** 10 feet

3. **Secchi disc reading:** 9 feet

4. **Stations for water chemistry located on attached map:** yes

Table 1. Water chemistry results from Dante Lake, Charles Mix County, July 10, 2000.

Station number	Depth feet	Temp F	DO PPM	CO2 PPM	ALK MG\L	Hardness MG\L	pH
1	Surface	83	7.4	56	123	1694	8.5
1	18	66	0	218	361	1631	7.5

BIOLOGICAL DATA

Methods:

1. **Describe fish collection methods and show sampling locations by gear type on the lake map.**

Four, 3/4 inch frame nets were set into Dante Lake on July 10-12, 2000. Fish indices were calculated using Winfin computer program. Results of the survey are listed on the following tables.

Results and Discussion:

1. **Tables listing species, number, size, etc. of fish.**

Table 2. Total catch of eight, 24 hour, 3/4 inch frame nets at Dante Lake, Charles Mix County, July 10-12, 2000.

Spec	No.	Low 80% CI	Mean CPUE	Up 80% CI	Low 90% CI	PSD	Up 90% CI	Low 90% CI	Stock Mean Wr	Up 90% CI
BLB	18	1.2	2.3	3.3	68	83	99	86.5	88.7	90.9
BLG	1458	143.2	182.3	221.3	95	98	100	94.3	95.0	95.8

2. **Brief narrative describing status of fish sampled, make reference to the tables.**

Two species were sampled in Dante Lake; bluegill and black bullhead. The last survey was in 1995 when six species were sampled.

Bluegill have doubled in density since 1995 with a CPUE of 182.3, PSD was 98 with an RSD-P of 4. Condition was good for such a high density population with a Wr of 95.

The black bullhead population remains low with a CPUE of 2.3 and a PSD of 83. Though no largemouth bass were sampled, it would appear that a predatory fish is keeping bullheads in check.

RECOMMENDATIONS

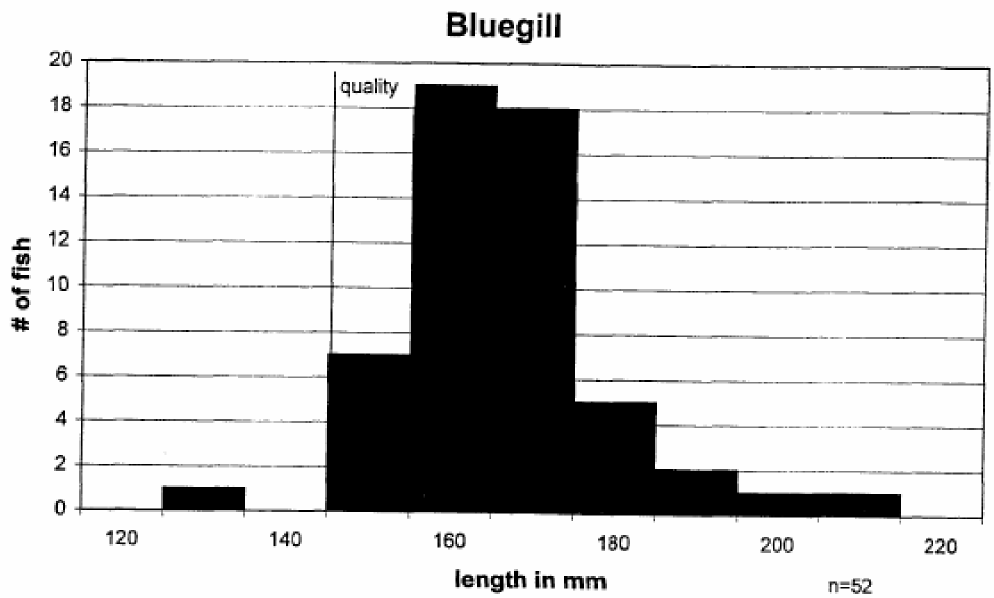
Describe management approach.

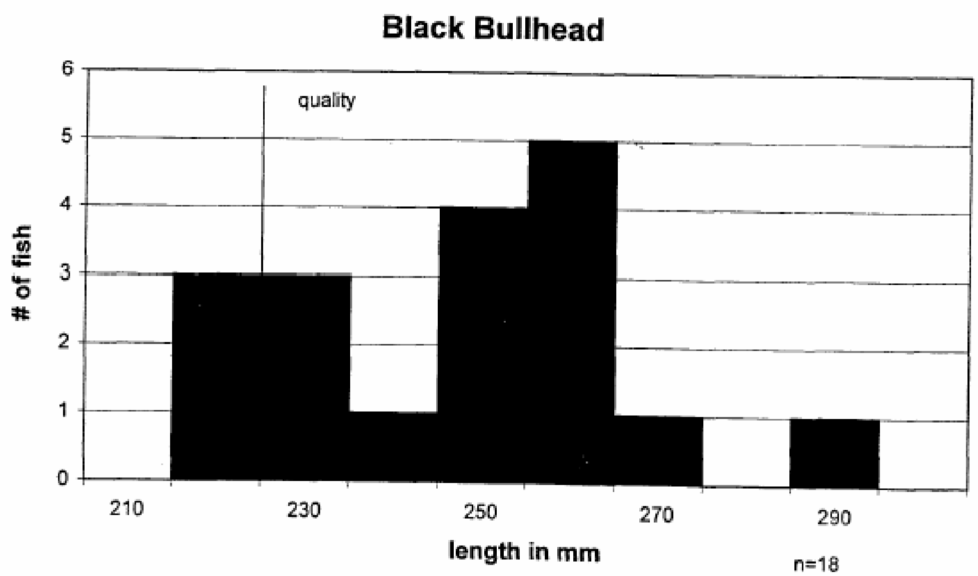
1. Dante Lake should be electrofished as soon as possible. If densities are low, supplemental stockings should be made to increase predation on bluegill.
2. Use Dante Lake as an adult bluegill source for transfer to other lakes.

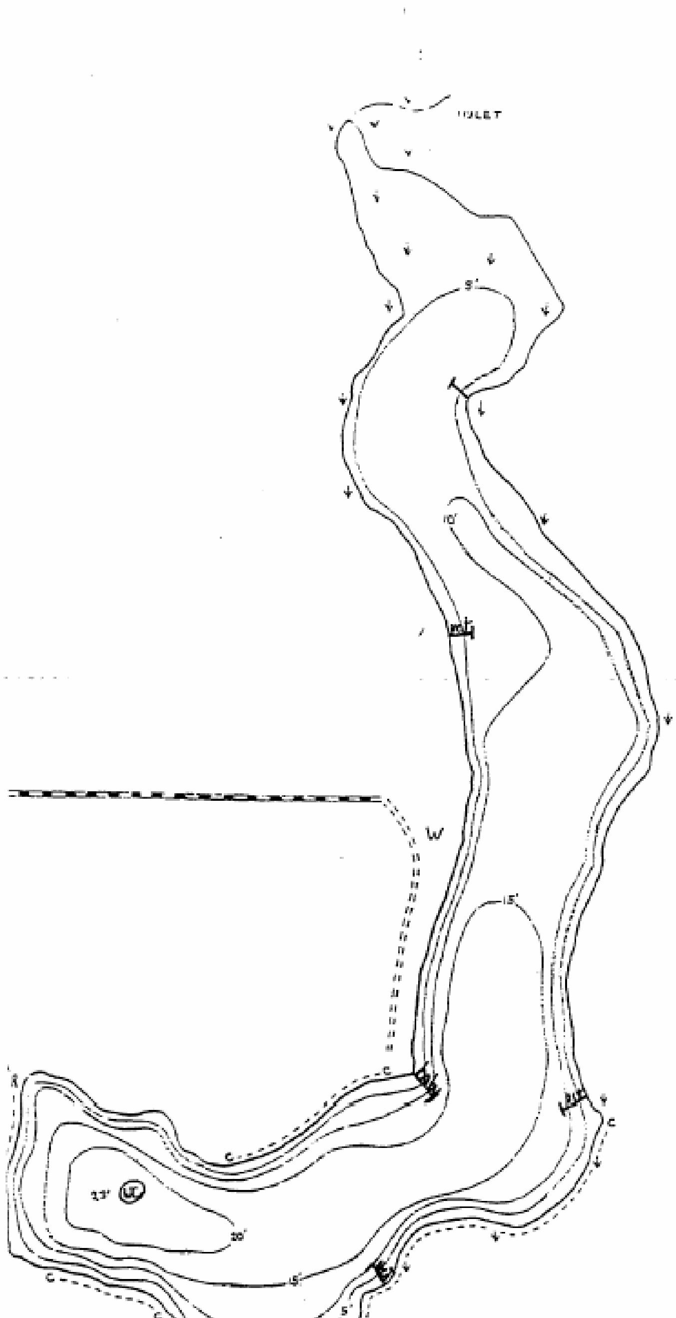
Stocking record for Dante Lake, Charles Mix County, 2000.

YEAR	NUMBER	SPECIES	SIZE
1990	250	NOP	ADT

Dante Lake


Bluegill
quality
# of fish
20
18
16
14
12
10
8
6
4
2
0
120
140
160
180
200
220
length in mm
n=52


Black Bullhead
quality
# of fish
6
5
4
3
2
1
0
210
230
250
270
290
length in mm
n=18



GL

SYMBOLS

SHORELINE
DEPTH CONTOUR
ROADS
HARD SURFACE
GRAVEL
TRAIL
BENCHMARK — — BM
MARSH
GRAZING LAND — GL
CROPLAND — — CL
WOODED — — W
PARTIALLY WOODED — — PW
CUTBANK C — — — C
ROCKY SHORELINE R — — — R
SANDY SHORELINE S — — — S
GRAVELLY SHORELINE G — — — G
PUBLIC ACCESS — — PA
BRIDGE
BUILDINGS

0 165 330
Scale in Feet

SOUTH DAKOTA
DEPARTMENT OF GAME, FISH AND PARK
LAKE DANTE
CHARLES MIX COUNTY

SECTION 4, 9—TWP 95N—RGE 62W
B.M: SPILLWAY (10 INCHES BELOW FULL)
PLANIMETERED ACREAGE: 18
MILES OF SHORELINE: .7

PLANIMETERED LAKE ACREAGE	
ACRES GREATER THAN 5 FEET	
ACRES GREATER THAN 10 FEET	
ACRES GREATER THAN 15 FEET	
ACRES GREATER THAN 20 FEET	
TOTAL ACRE FEET	
AVERAGE DEPTH	10

Appendix B

Dante Lake Stage/ Discharge Relationship

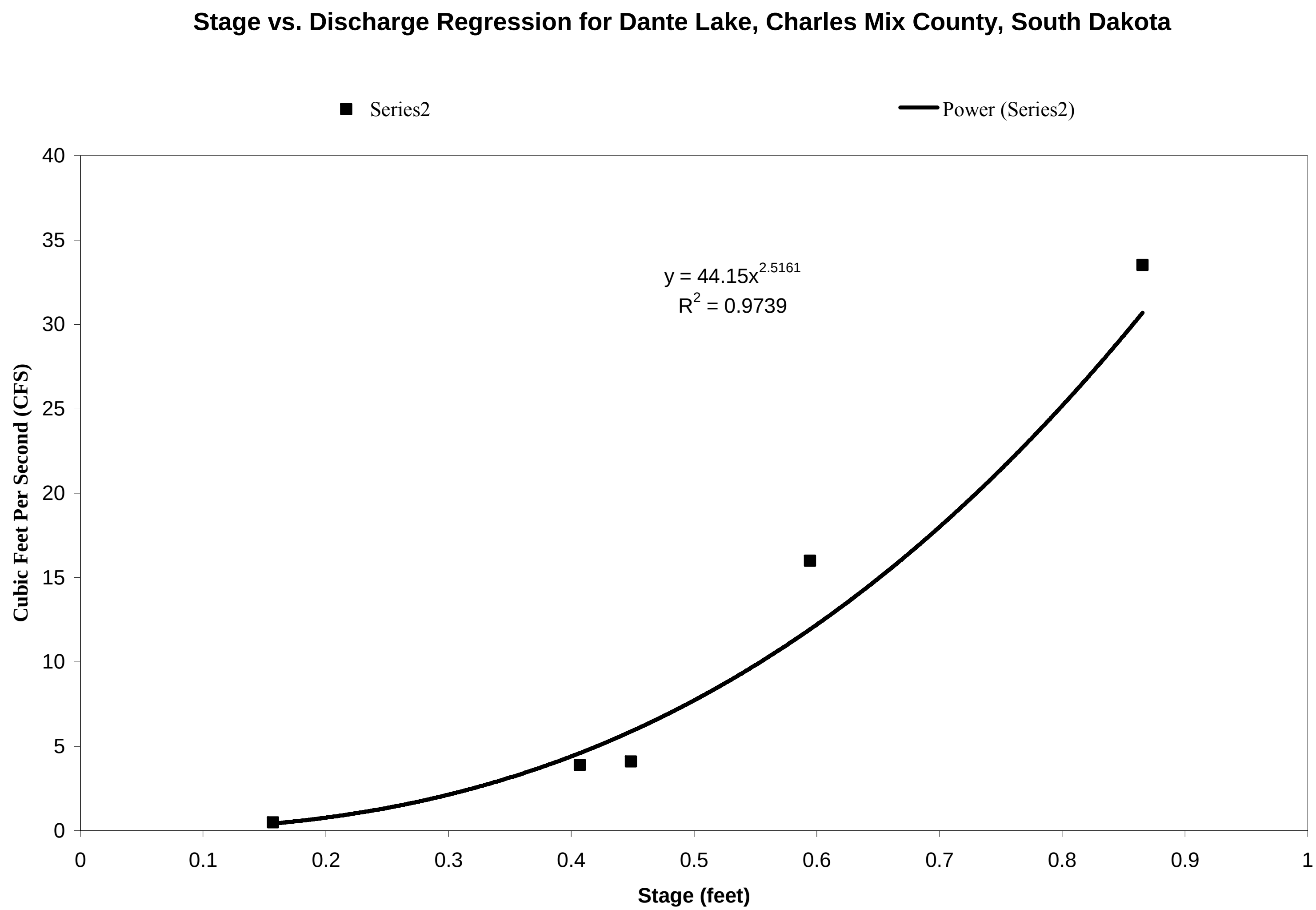


Figure B-1. DLT-2 Stage Discharge relationship.

Appendix C

Tributary and In-lake Data Tables for Dante Lake

Table C-1. Dante Lake Tributary Data for 2000 through 2001

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	SITE	DATE	TIME	Air Temp	Cond.	DO	pH	W. Temp	Turb.	Fecal Coli	Alk	T. Solids	Sus. Solids	Ammonia	Nitrate	TKN	TN	IN	T. Phos.	T DIS P	VTSS	TDS	E-COLI
2	DLO-1	4/4/2001	917	12.4	1084	13.05	8.63	2.76	10.8	10	117	1619	10	0.25	0.8	1.16	1.96	1.05	0.266	0.134	5		2
3	DL0-1	4/9/2001	1309	16	1629	10.29	8.1	9.42	9.6	10	148	2334	13	0.02	0.9	1.22	2.12	0.92	0.192	0.082	4		1
4	DLO-1	4/17/2001	1005	9	2012	7.85	8.43	9.62	6.1	10	160	2707	11	0.02	0.5	1.27	1.77	0.52	0.15	0.057	6		1
5	DLO-1	4/19/2001	720	9	1943	12.75	8.18	8.14	6.6	10	163	2703	8	0.02	0.3	1.32	1.62	0.32	0.148	0.039	6		4.1
6	DLO-1	4/24/2001	1015	13	1081	11.5	8.11	6.05	31.6	2800	111	1435	30	0.15	0.5	0.87	1.37	0.65	0.326	0.214	10		2420
7	DLO-1	4/30/2001	826	15	1321	12.6	8.06	15.12	9.4	10	119	1446	10	0.02	0.1	1.16	1.26	0.12	0.229	0.115	8		26.2
8	DLT-2	5/18/2000	920	9	2633	8.77	7.83	11.13	74	8800	163	2844	64	0.01	0.5	1.75			0.324	0.176	12	2597	
9	DLT-2	5/24/2000	1117	22.75	3964	8.76	7.63	12.88		220	302	4675	16	0.01	0.05	0.61			0.054	0.02	2	4340	
10	DLT-2	6/1/2000	801	15						900	333	4676	14	0.01	0.05	0.94			0.196	0.043	4	4498	
11	DLT-2	8/8/2000	645	18.3						20000	67	1172	35	0.14	0.7	1.48			0.459	0.307	12		
12	DLT-2	3/22/2001	1120	10			7.13	0.43	22.3	10	109	811	23	1.17	1.2	2.25			0.743	0.64	7		23.1
13	DLT-2	4/4/2001	1035	12.4	1615	16.5	8.11	3.85	7.88	50	208	2554	6	0.14	2.1	0.36			0.225	0.209	2		39.9
14	DLT-2	4/9/2001	1340	17	1554	7.76	7.96	12.8	14.6	90	188	1952	10	0.09	1.7	1.07			0.48	0.422	4		152
15	DLT-2	4/24/2001	1047	14	1079	10.5	7.88	8.45	16.4	2700	136	1321	10	0.02	1	0.61			0.462	0.414	4		2420
16	DLT-2	4/30/2001	906	16	2482	12.22	7.61	13.99	3.8	60	239	3210	2	0.02	0.2	0.62			0.05	0.036	1		57.3
17	DLT-2	5/10/2001	1003	14	2678	11.35	7.44	13.42	19.8	10	264	1031	6	0.02	0.1	0.97			0.151	0.125	4		32.8

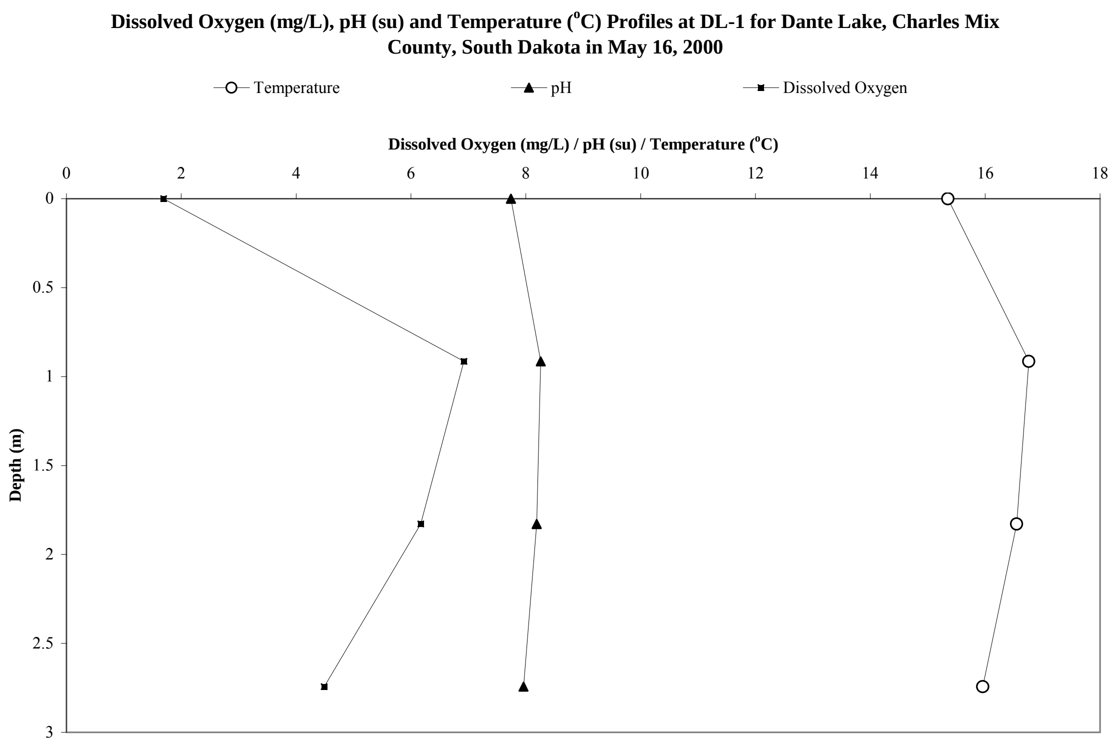
Table C-2. Dante Lake In-lake Data for 2000 through 2001

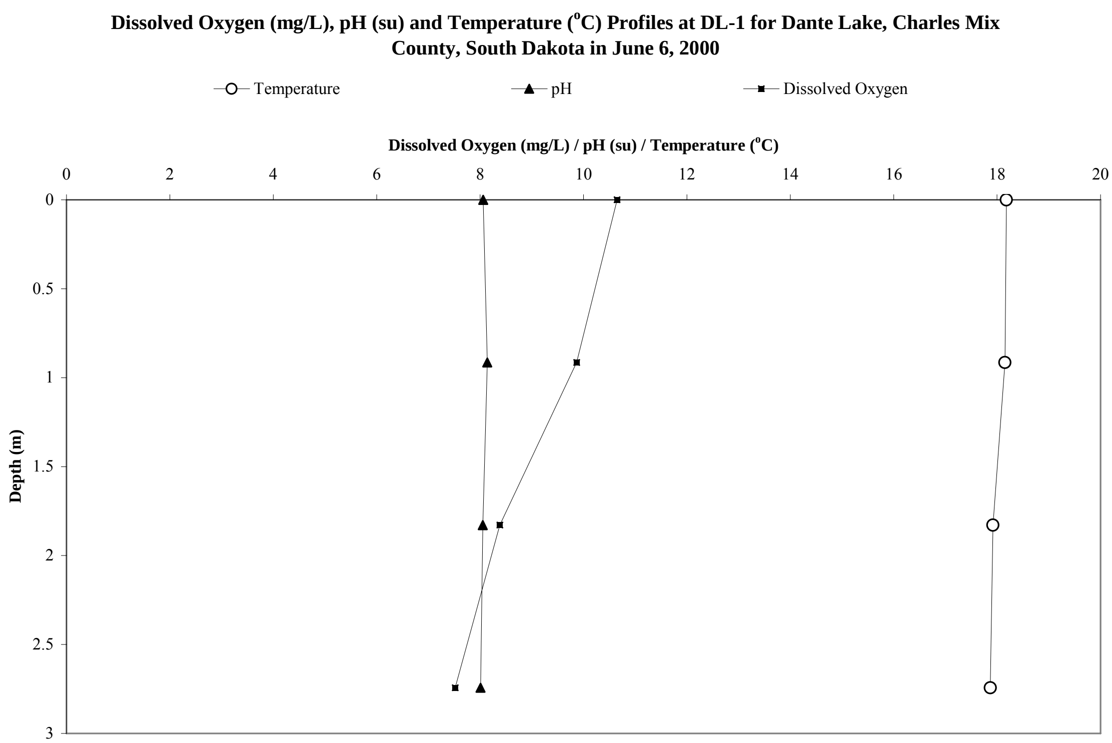
SITE	DATE	TIME	Air Temp	Cond.	DO	pH	Sample type	TEMP	DEPTH	TURB.	SECCHI	Secchi (M)	Secchi TSI	T Depth	Fecal Coli.	Alk. M	Alk. P	T. Solids	Sus. Solids	Ammonia	Nitrate	TKN	T. Phos.	TP TSI	TDP	VTSS	TDS	E-COLI	Chlo a	Chloro TSI
DL-1	5/16/2000	920	20		7.21	8.29	GRAB	16.87	S		1.7	0.51816	69.49	10.5	5	158	0	3107	13	0.01	0.05	2.5	0.128	74.15	0.017	7	2934		38.15	75.32
DL-1	5/16/2000	920	20		1.69	7.74	GRAB	15.35	B						5	159	0	3114	16	0.01	0.05	2.17	0.099		0.011	9	2949			
DL-1	5/16/2000	920	20		6.92	8.26	GRAB	16.76	3																					
DL-1	5/16/2000	920	20		6.17	8.19	GRAB	16.55	6																					
DL-1	5/16/2000	920	20		4.49	7.96	GRAB	15.96	9																					
DL-1	6/6/2000	1026	26		10.65	8.06	GRAB(A,C)	18.18	S	15.6	2	0.6096	67.14	10.5															21.93	69.89
DL-1	6/6/2000	1026	26		9.87	8.14	GRAB(A,C)	18.15	3	14.3																				
DL-1	6/6/2000	1026	26	2934	8.38	8.05	GRAB(A,C)	17.92	6	15																				
DL-1	6/6/2000	1026	26	2930	7.52	8.01	GRAB(A,C)	17.87	9	16.2																				
DL-1	6/6/2000	1026	26	2928	7.32	8	GRAB(A,C)	17.82	B	16.4																				
DL-1	6/19/2000	920	21	3244	5.05	7.74	GRAB	20.49	S	12.9	2.9	0.88392	61.78	10		145	0	3165	11	0.14	0.1	1.61	0.088	68.74	0.02	6	2991		12.62	64.47
DL-1	6/19/2000	920	21	3241	4.69	7.78	GRAB	20.45	B	14.8						146	0	3156	13	0.14	0.1	1.96	0.105		0.019	7	3013			
DL-1	6/19/2000	920	21	3243	4.9	7.79	GRAB	20.5	3	12.4																				
DL-1	6/19/2000	920	21	3243	4.83	7.79	GRAB	20.49	6	12.1																				
DL-1	7/6/2000	1000	25.53	3510	3.53	7.99	GRAB(A,C)	25.69	S	1.7	10.3	3.13944	43.49	10.3															0.7	36.10
DL-1	7/6/2000	1000	25.53	3501	3.38	7.97	GRAB(A,C)	25.63	3	1.2																				
DL-1	7/6/2000	1000	25.53	3495	3.26	7.95	GRAB(A,C)	25.53	B	1.5																				
DL-1	7/6/2000	1000	25.53	3243	0.36	7.8	GRAB(A,C)	22.02	B	7.5																				
DL-1	7/17/2000	818	19	3858	4.64	8	GRAB	25.8	S	14	5.5	1.6764	52.55	10.25	10	134	0	3267	11	0.12	0.1	1.29	0.055	61.96	0.029	7			9.29	61.47
DL-1	7/17/2000	818	19	3857	4.25	8.1	GRAB	25.82	3	13.9																				
DL-1	7/17/2000	818	19	3857	4.15	8.13	GRAB	25.81	6	13.8																				
DL-1	7/17/2000	818	19	3858	3.92	8.13	GRAB	25.77	B	13.9																				
DL-1	7/31/2000	910	20.5	3675	11.33	8	GRAB(A,C)	26.06	S	18.3	2.5	0.762	63.92	9.8															9.45	61.63
DL-1	7/31/2000	910	20.5	3670	11.8	8.18	GRAB(A,C)	26.01	3	18.1																				
DL-1	7/31/2000	910	20.5	3602	5.79	7.73	GRAB(A,C)	25.02	6	21.6																				
DL-1	7/31/2000	910	20.5	3443	5.72	7.57	GRAB(A,C)	23.06	B	14																				
DL-1	8/14/2000	1140	21	3182	4	7.8	GRAB	26.92	S	16	4.5	1.3716	55.44	9.2	10	110	0	3310	8	0.08	0.1	2.24	0.048	60.00	0.015	2			4.01	53.22
DL-1	8/14/2000	1140	21	3177	3.88	7.79	GRAB	26.82	3	15.9																				
DL-1	8/14/2000	1140	21	3172	3.8	7.79	GRAB	26.73	6	16																				
DL-1	8/14/2000	1140	21	3164	3.56	7.77	GRAB	26.61	B	17.9																				
DL-1	9/7/2000	1124	22	3339	3.62	7.75	GRAB(A,C)	21.84	S	16.1	4.1	1.24968	56.78	9.7															2.72	49.42
DL-1	9/7/2000	1124	22	3339	3.37	7.68	GRAB(A,C)	21.82	3	15.9																				
DL-1	9/7/2000	1124	22	3334	3.27	7.64	GRAB(A,C)	21.73	6	15.8																				
DL-1	9/7/2000	1124	22	3326	2.73	7.58	GRAB(A,C)	21.59	B	16.6																				
DL-1	9/26/2000	1038	18	2825	12.12	8.31	GRAB	13.31	S	15	2.8	0.85344	62.29	9.3	10	123	0	3366	13	0.56	0.1	2.1	0.088	68.74	0.011	9			31.72	73.51
DL-1	9/26/2000	1038	18		11.59		GRAB	13.06	3																					
DL-1	9/26/2000	1038	18		10		GRAB	12.96	6																					
DL-1	9/26/2000	1038	18	2762	8.47	7.72	GRAB	12.38	B	15																				
DL-1	10/11/2000	1210	15.54		8.35	8.44	GRAB(A,C)	9.54	S	22	2.45	0.74676	64.21	8.9																
DL-1	10/11/2000	1210	15.54		8.16		GRAB(A,C)	9.41	3																					
DL-1	10/11/2000	1210	15.54		8.09		GRAB(A,C)	9.4	6																					
DL-1	10/11/2000	1210	15.54		8.03	8.32	GRAB(A,C)	9.37	B	23.5																				
DL-1	10/25/2000	1200	13.5	2974	10.12	8.06	GRAB	14.52	S	15.4	3.9	1.18872	57.51	8.5	10	128	0	3424	8	0.36	0.1	1.86	0.077	66.82	0.02					
DL-1	10/25/2000	1200	13.5	2967	9.76	8.05	GRAB	14.44	B	15.9																				
DL-1	4/9/2001	1140	18	1568	9.75	8.39	GRAB	7.71	S	11	2	0.6096	67.14	11.7	10	149	0	2343	14	0.02	0.9	1.24	0.199	80.52	0.084	7		3.1	53.19	78.58
DL-1	4/9/2001	1140	18		9.91		GRAB	7.52	3																					
DL-1	4/9/2001	1140	18		9.55		GRAB	7.01	6																					
DL-1	4/9/2001	1140	18		3.61		GRAB	4.61	9																					
DL-1	4/9/2001	1140	18	2119	1.07	7.51	GRAB	3.67	B	6																				
DL-1	5/3/2001	1010	12	1370	13.29	8.8	GRAB	15.57	S	10.8	2.7	0.82296	62.81	11.8	10	122	2	1486	8	0.27	0.1	1.17	0.222	82.09	0.083	3		1	82.7	70.97
DL-1	5/3/2001	1010	12		13.32		GRAB	15.56	3																					
DL-1	5/3/2001	1010	12		13.01		GRAB	15.49	6																					
DL-1	5/3/2001	1010	12		5.88		GRAB	12.51	9																					
DL-1	5/3/2001	1010	12	1301	5.32	7.9	GRAB	8.58	B	8.2																				
DL-2	4/9/2001	1200	18	1582	10.41	8.02	GRAB	8.29	S	11.6	2	0.6096	67.14	20.9	10	177	0	3920	10	1.12	0.1	2.56	0.156	77.00	0.122	2		2		
DL-2	4/9/2001	1200	18		7.93		GRAB	6.9	3																					
DL-2	4/9/2001	1200	18		7.82		GRAB	6.13	6																					
DL-2	4/9/2001	1200	18		7.58		GRAB	6.13	9																					
DL-2	4/9/2001	1200	18		3.06		GRAB	3.19	12																					
DL-2	4/9/2001	1200	18		1.79		GRAB	3.21	15																					
DL-2	4/9/2001	1200	18		0.3		GRAB	3.6	18																					
DL-2	4/9/2001	1200	18	2162	0.28	7.3	GRAB	4.02	B	7.6																				

Appendix D

Dante Lake Temperature, pH and Conductivity Profiles

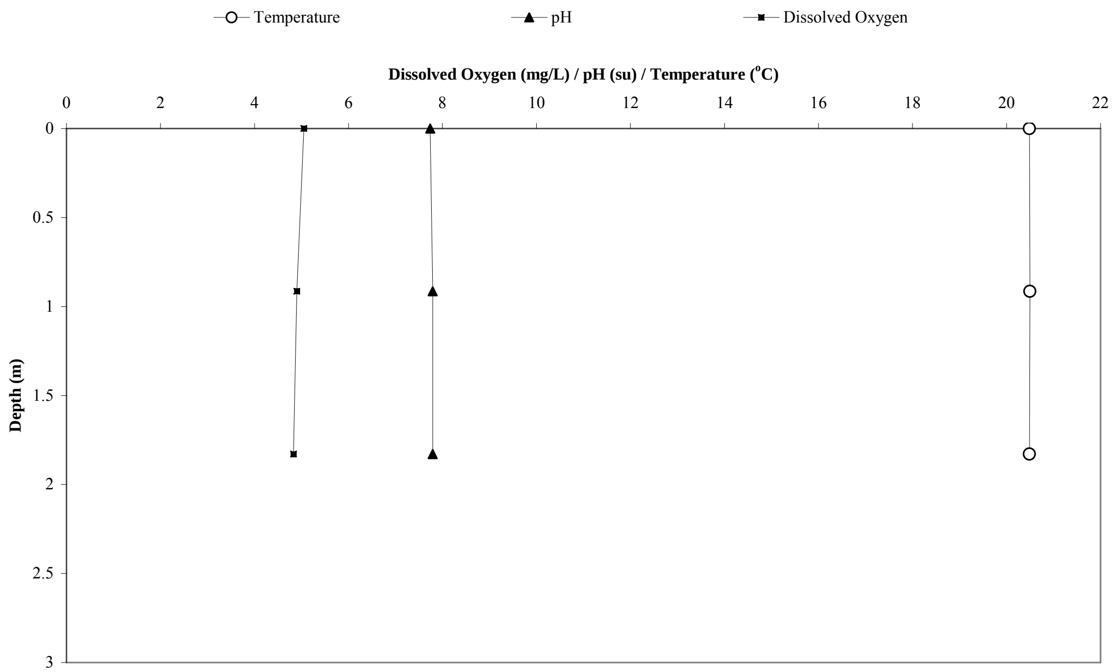
Dante Lake Profiles (DL-1)



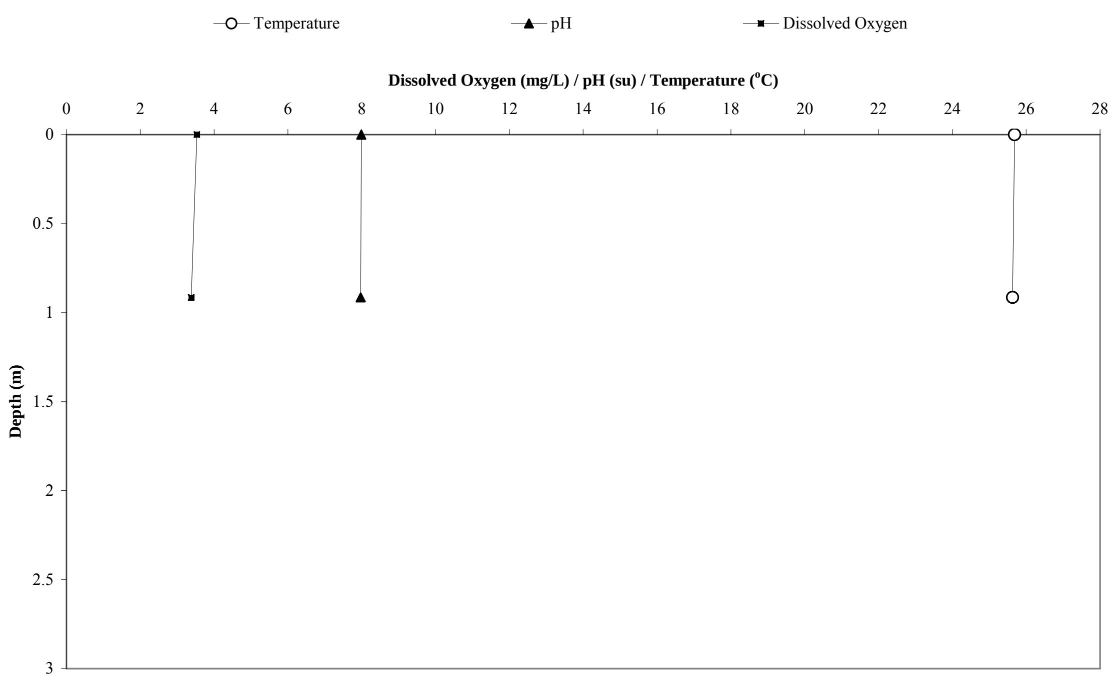


Dante Lake Profiles (DL-1)

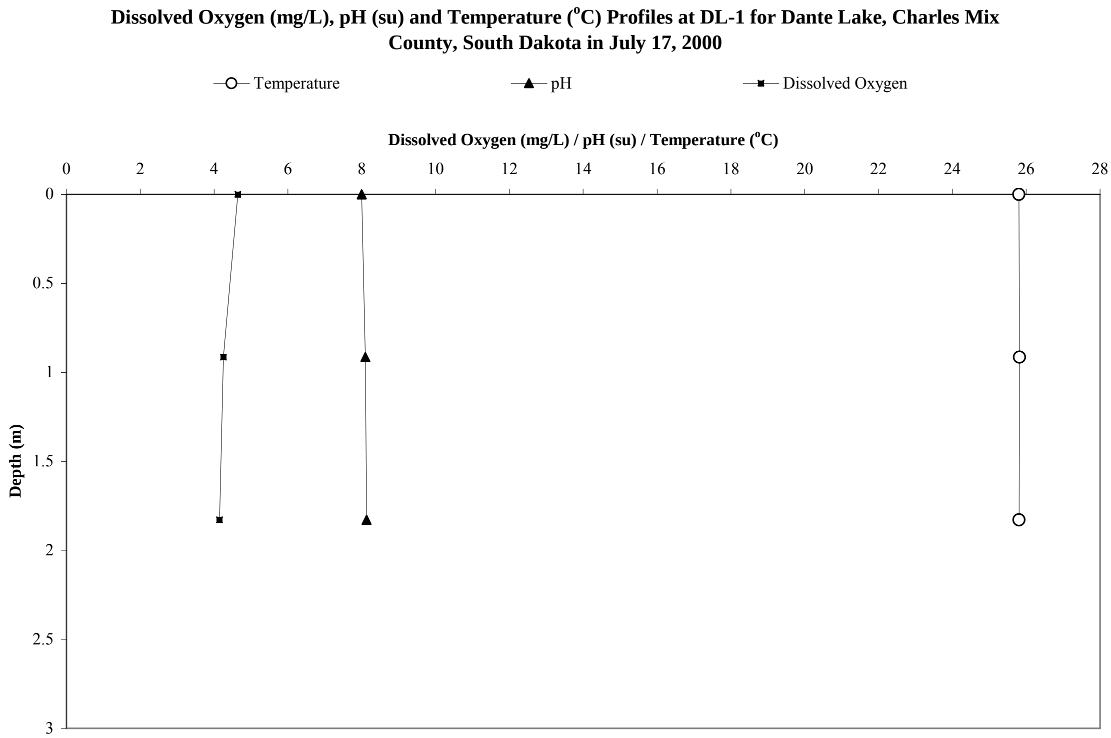
Dissolved Oxygen (mg/L), pH (su) and Temperature (°C) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in June 19, 2000

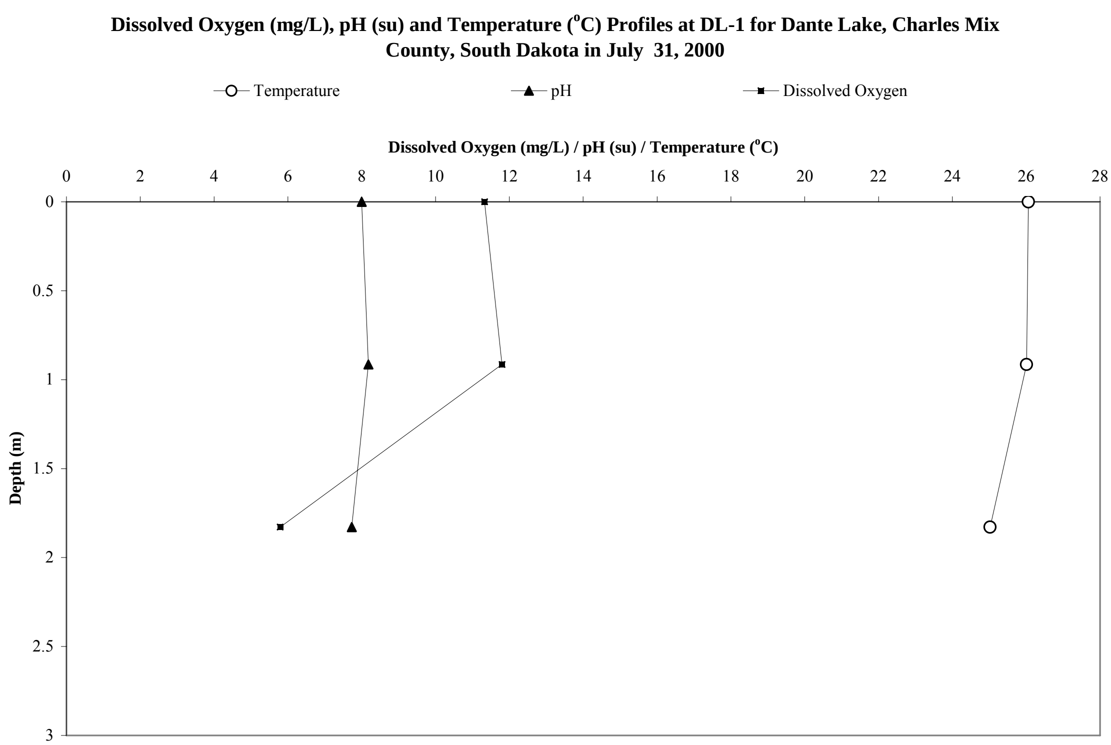


Dissolved Oxygen (mg/L), pH (su) and Temperature (°C) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in July 6, 2000



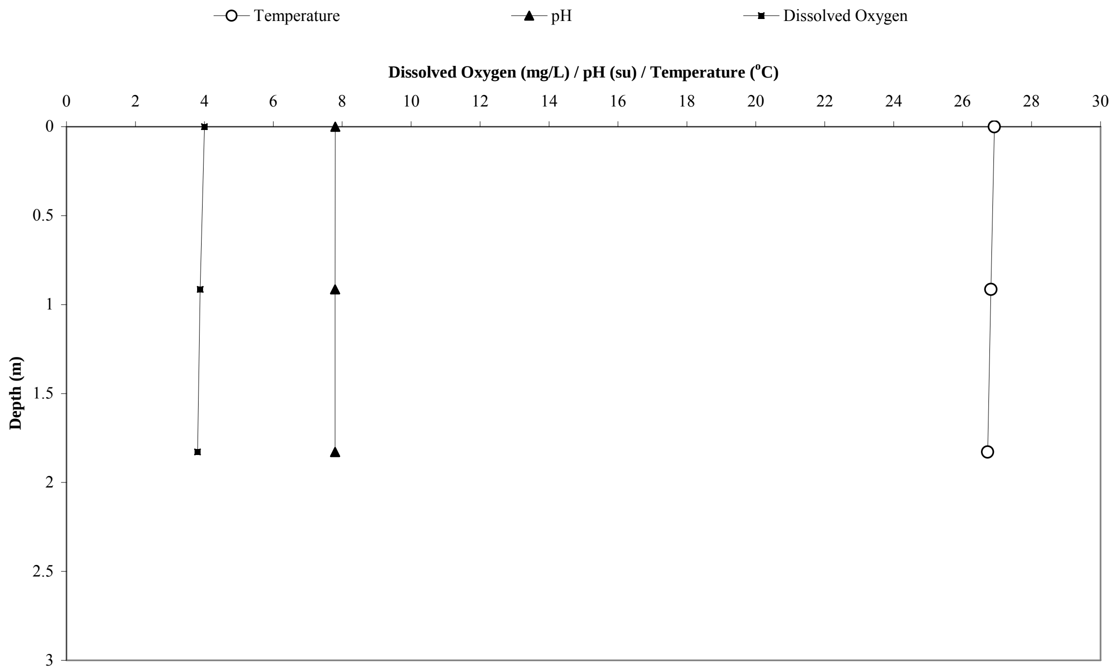
Dante Lake Profiles (DL-1)



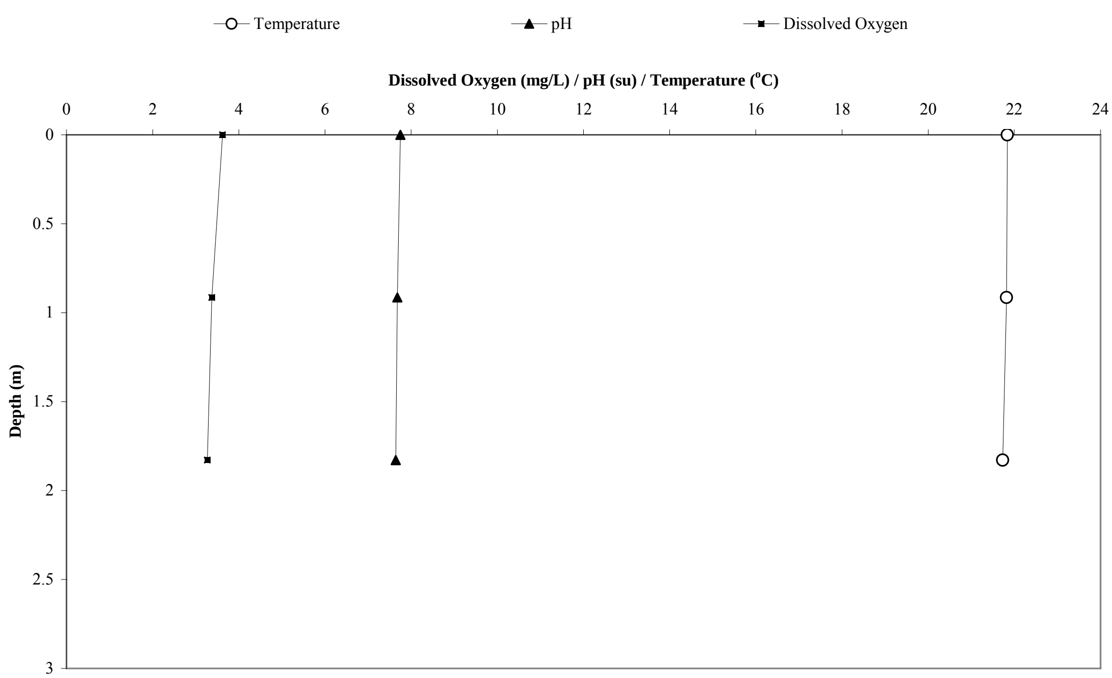


Dante Lake Profiles (DL-1)

Dissolved Oxygen (mg/L), pH (su) and Temperature (^oC) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in August 14, 2000

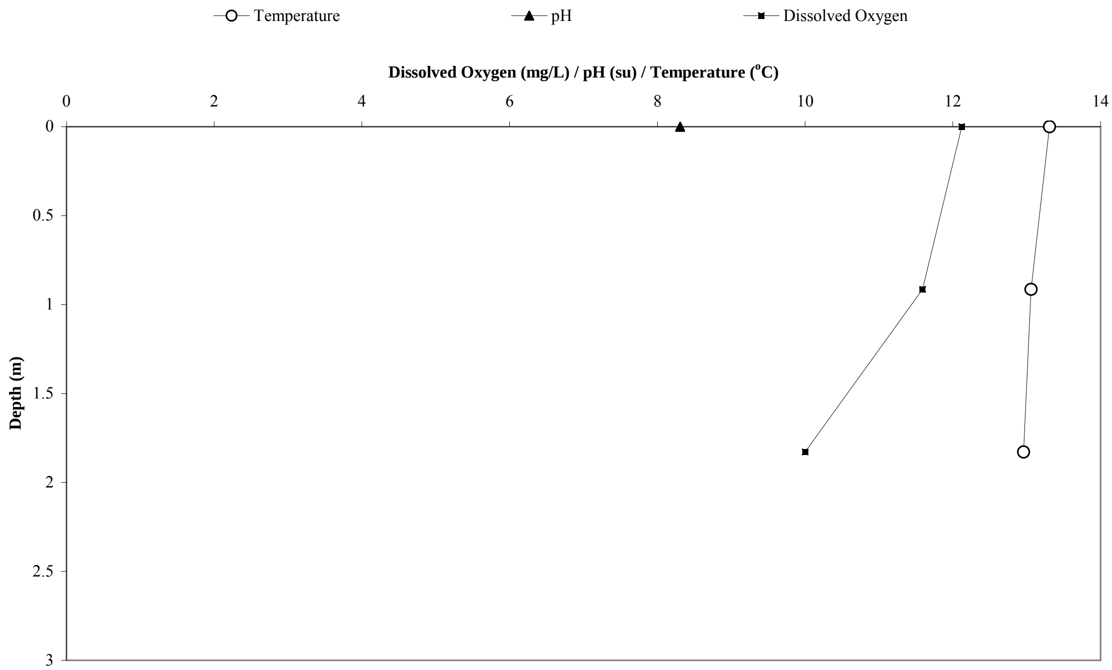


Dissolved Oxygen (mg/L), pH (su) and Temperature (^oC) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in September 7, 2000

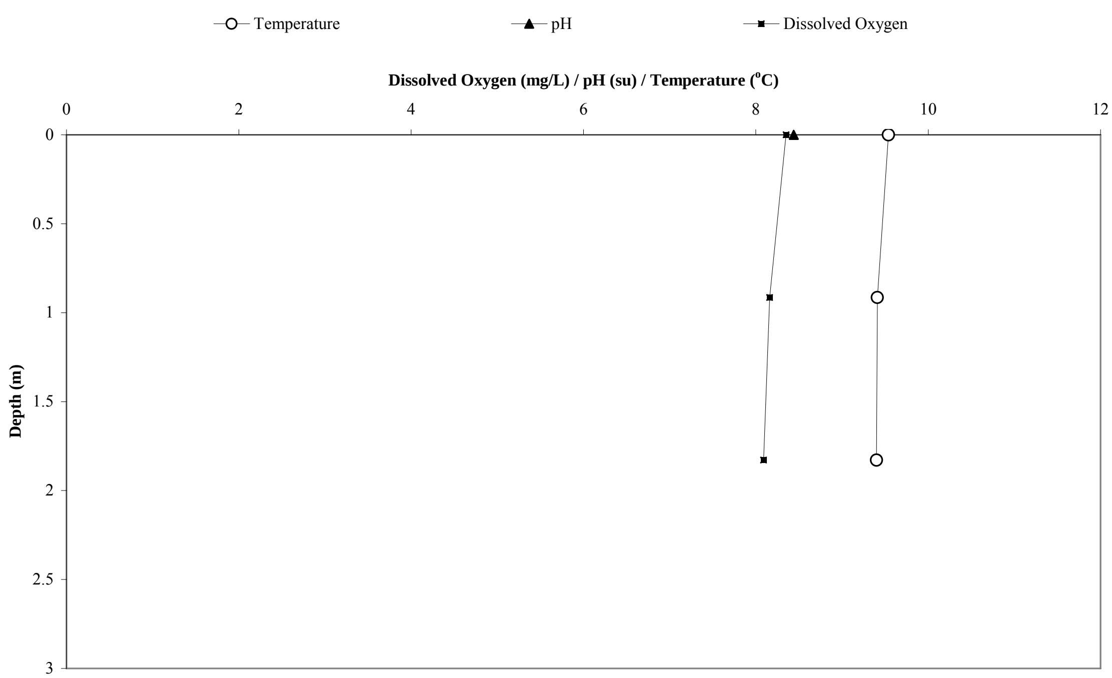


Dante Lake Profiles (DL-1)

Dissolved Oxygen (mg/L), pH (su) and Temperature (°C) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in September 26, 2000

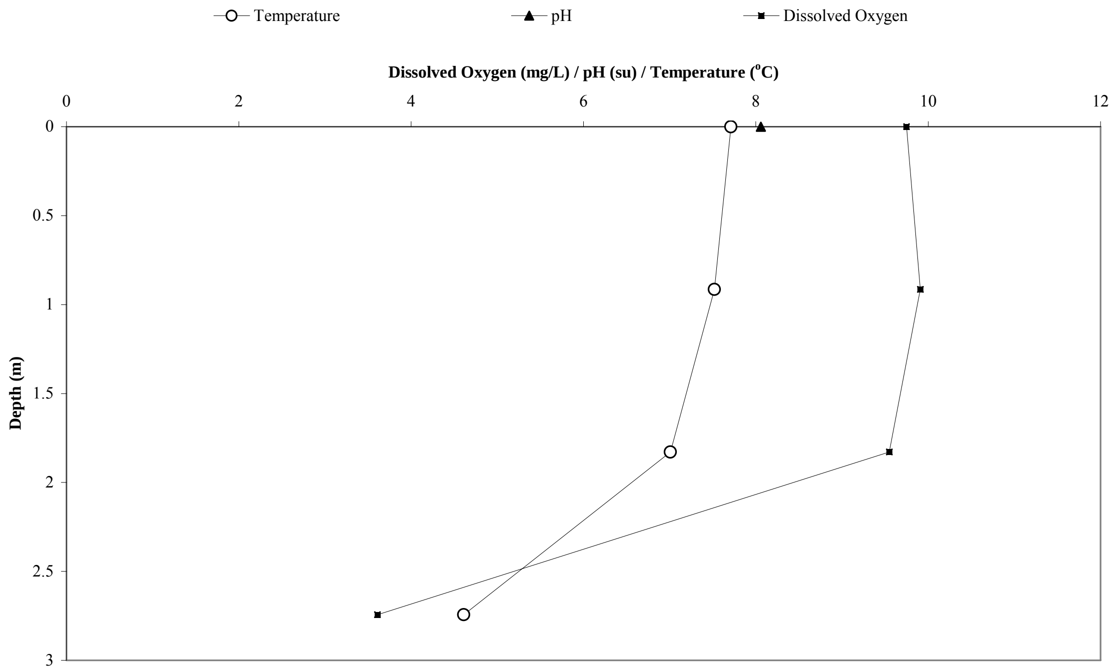


Dissolved Oxygen (mg/L), pH (su) and Temperature (°C) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in October 11, 2000

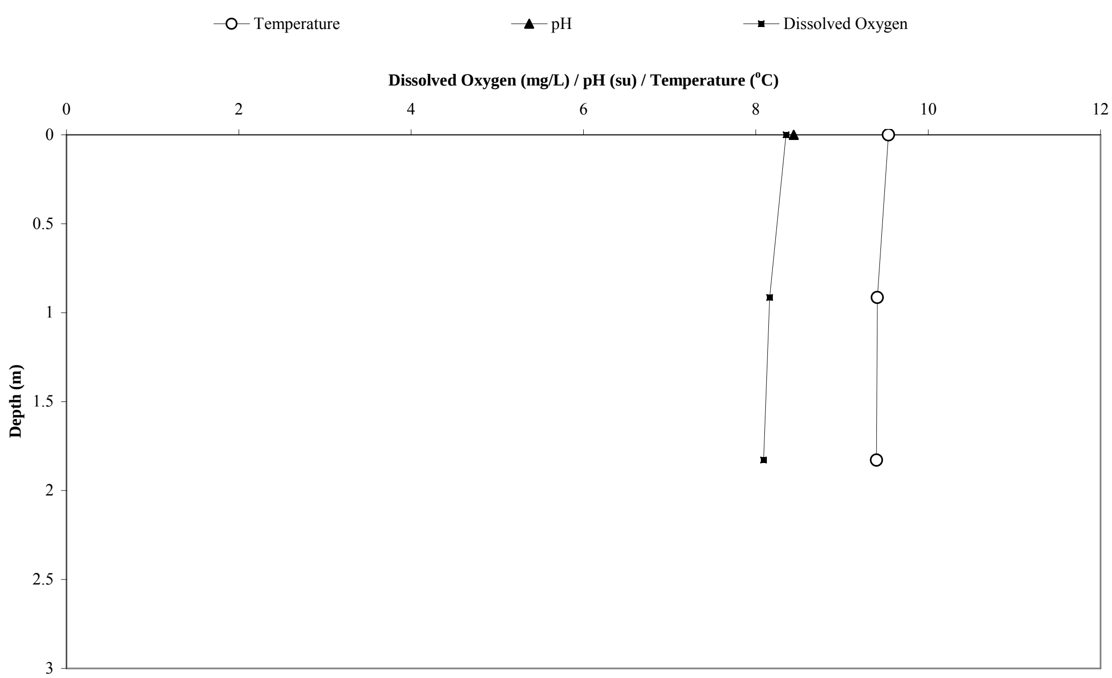


Dante Lake Profiles (DL-1)

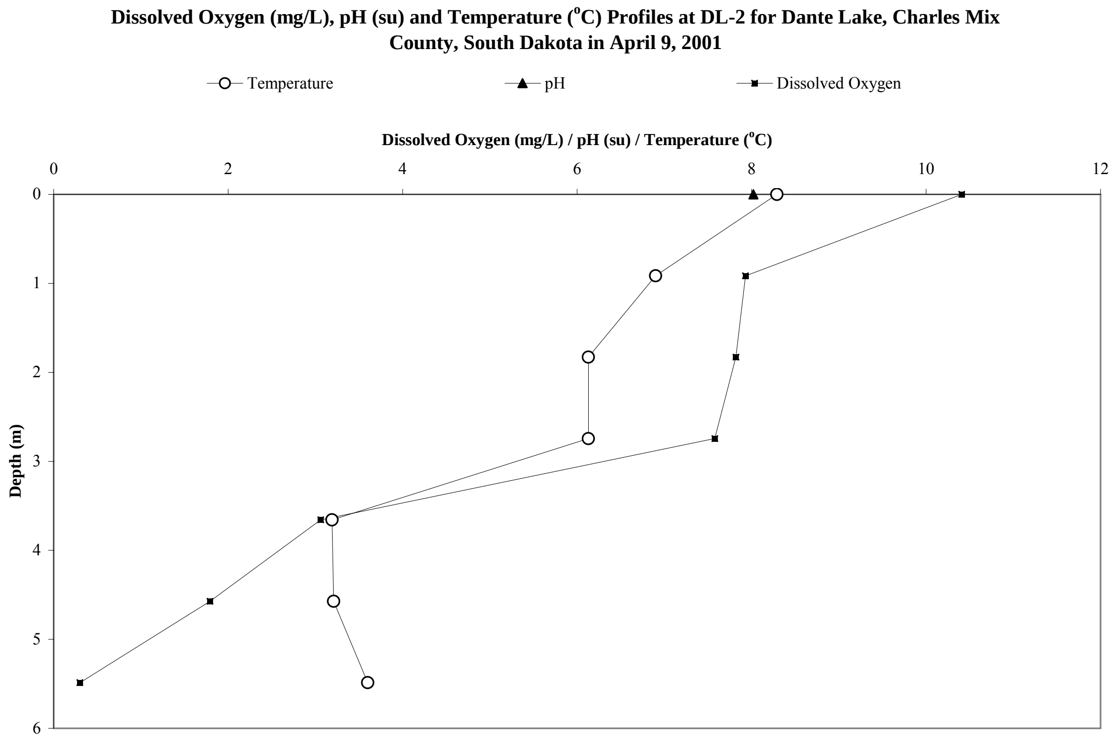
Dissolved Oxygen (mg/L), pH (su) and Temperature (^oC) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in April 9, 2001



Dissolved Oxygen (mg/L), pH (su) and Temperature (^oC) Profiles at DL-1 for Dante Lake, Charles Mix County, South Dakota in May 3, 2001



Dante Lake Profiles (DL-2)



Appendix E

TMDL Summary Document

TOTAL MAXIMUM DAILY LOAD EVALUATION

For

TOTAL PHOSPHORUS

In

DANTE LAKE

DANTE CREEK WATERSHED

(HUC 10170101)

CHARLES MIX COUNTY, SOUTH DAKOTA

**SOUTH DAKOTA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES**

JANUARY, 2006

Dante Lake Total Maximum Daily Load **January 2006**

Waterbody Type:	Lake (Impounded)
303(d) Listing Parameter:	TSI and Dissolved Oxygen
Designated Uses:	Recreation, Warmwater permanent aquatic life
Size of Waterbody:	18.7 acres
Size of Watershed:	2,799 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Trophic State Index (TSI)
Analytical Approach:	AnnAGNPS, BATHTUB, FLUX
Location:	HUC Code: 10170101
Goal:	
Trophic State Index (TSI)	6.4 % reduction in total phosphorus load (101 kg)
Dissolved Oxygen (DO)	Summer dissolved oxygen concentrations $\geq$ 5 mg/L
Target:	
Trophic State Index (TSI)	Total phosphorus TSI = 70.76; mean TSI = 63.86

Objective:

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Dante Lake is an 18.7-acre man-made impoundment located in Charles Mix County, South Dakota. The 1998 South Dakota 303(d) Waterbody List (page 22), 2002 South Dakota 303(d) Waterbody List (page 29) and the 2004 Integrated Report (The 2004 South Dakota Integrated Report for Surface Water Quality Assessment (page 128) identified Dante Lake for TMDL development for TSI (SD DENR, 1998, SD DENR, 2002 and SD DENR, 2004).

The damming of Dante Creek 2 miles north of Dante, SD, created the lake, which has an average depth of 11 feet (3.4 meters) and 0.70 mile (1.1 km) of shoreline. The lake currently has a maximum depth of 23 feet (7.0 m), holds 194 acre-feet of water, and sporadically stratifies during the summer when runoff . The outlet for the lake empties into Choteau Creek, which eventually reaches the Missouri River above Lewis and Clark Lake.

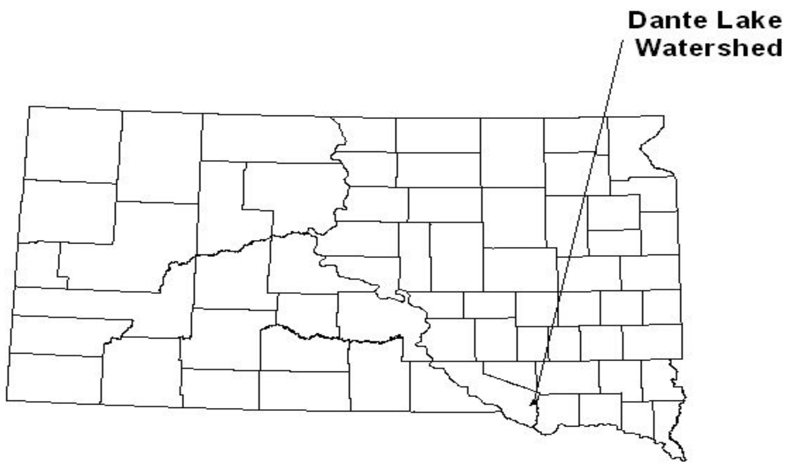


Figure 1. Location of Dante Lake Watershed in South Dakota

Problem Identification

Dante Creek is the primary tributary to Dante Lake and drains a watershed of mostly cropland with some intermixed grazing lands. Winter feeding areas for livestock may be present in the watershed. The stream carries nutrient loads, which degrade water quality in the lake and cause increased eutrophication. During the assessment, dissolved oxygen concentrations were below beneficial use based water quality standards during the summer. Sporadic instances of low dissolved oxygen concentrations in the summertime was attributed to in-lake stratification creating low total phosphorus concentrations in the epilimnion resulting in extremely low algal densities and low during the summer of 2000. Additional impairments are a result of grazing along the tributary, lake, fertilization and tillage. To alleviate sporadic low dissolved oxygen concentrations in Dante Lake, SD DENR recommends the installation of a hypolimnetic aeration system to increase in-lake dissolved oxygen concentrations the increase the conversion of organic matter in Dante Lake and expanding fish habitat.

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Dante Lake has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations. Along with these assigned uses are narrative and numeric criteria that define the desired water quality of the lake. These criteria must be maintained for the lake to satisfy its assigned beneficial uses, which are listed below:

Warmwater permanent fish life propagation;
Immersion recreation;
Limited contact recreation and;
Fish and wildlife propagation, recreation and stock watering

Individual parameters, including the lake's Trophic State Index (TSI) (Carlson, 1977) value, determine the support of beneficial uses and compliance with standards. A gradual increase in fertility of the water due to nutrients washing into the lake from external sources is a sign of the eutrophication process.

Dante Lake is identified in the 2004 South Dakota Integrated Report for Surface Water Quality Assessment as non-supporting its aquatic life beneficial use. This support was determined through comparison of its trophic state to other lakes in ecoregion 42.

South Dakota has several applicable narrative standards that may be applied to the undesired eutrophication of lakes and streams. Administrative Rules of South Dakota Article 74:51 contains language that prohibits the existence of materials causing pollutants to form, visible pollutants, taste and odor producing materials, and nuisance aquatic life.

If adequate numeric criteria are not available, the South Dakota Department of Environment and Natural Resources (SD DENR) uses surrogate measures. To assess the trophic status of a lake, SD DENR uses the mean TSI which incorporates Secchi depth, chlorophyll *a* concentrations and phosphorus concentrations. SD DENR has developed a protocol that establishes desired TSI levels for lakes based on an ecoregion approach. This protocol was used to assess impairment and determine a numeric TSI target for Dante Lake.

Dante Lake currently has a mean TSI of 64.61, which is indicative of higher levels of primary productivity and has sporadic instances of low dissolved oxygen concentrations during the summer. Surface water dissolved oxygen concentrations were attributed to low densities of algae during the summer. Sporadic low dissolved oxygen concentrations will be taken care of by the installation of a SD DENR recommended hypolimnetic aeration system. Installation of the aeration system will meet South Dakota surface water quality standards for dissolved oxygen ($\geq$ 5.00 mg/L) in Dante Lake. Assessment monitoring indicates that the primary cause of the high productivity is phosphorus loads from the watershed and at the lake itself most likely from livestock, fertilization, tillage and soil erosion from cropland and stream banks.

The numeric target, established to improve the trophic state of Dante Lake, is a growing season average TSI of 63.86. The current state of the lake is close enough to remove the lake from the impaired list; however there is a desire in the watershed to improve the lake in addition to a number of mitigation practices that will result in improved water quality to Dante Lake and Choteau Creek. Practices that will prove beneficial include cropland and livestock grazing management, riparian restoration, stabilization of eroding stream banks, buffer strip planting, and restricting cattle access to the tributary and lake by providing outlying watering facilities.

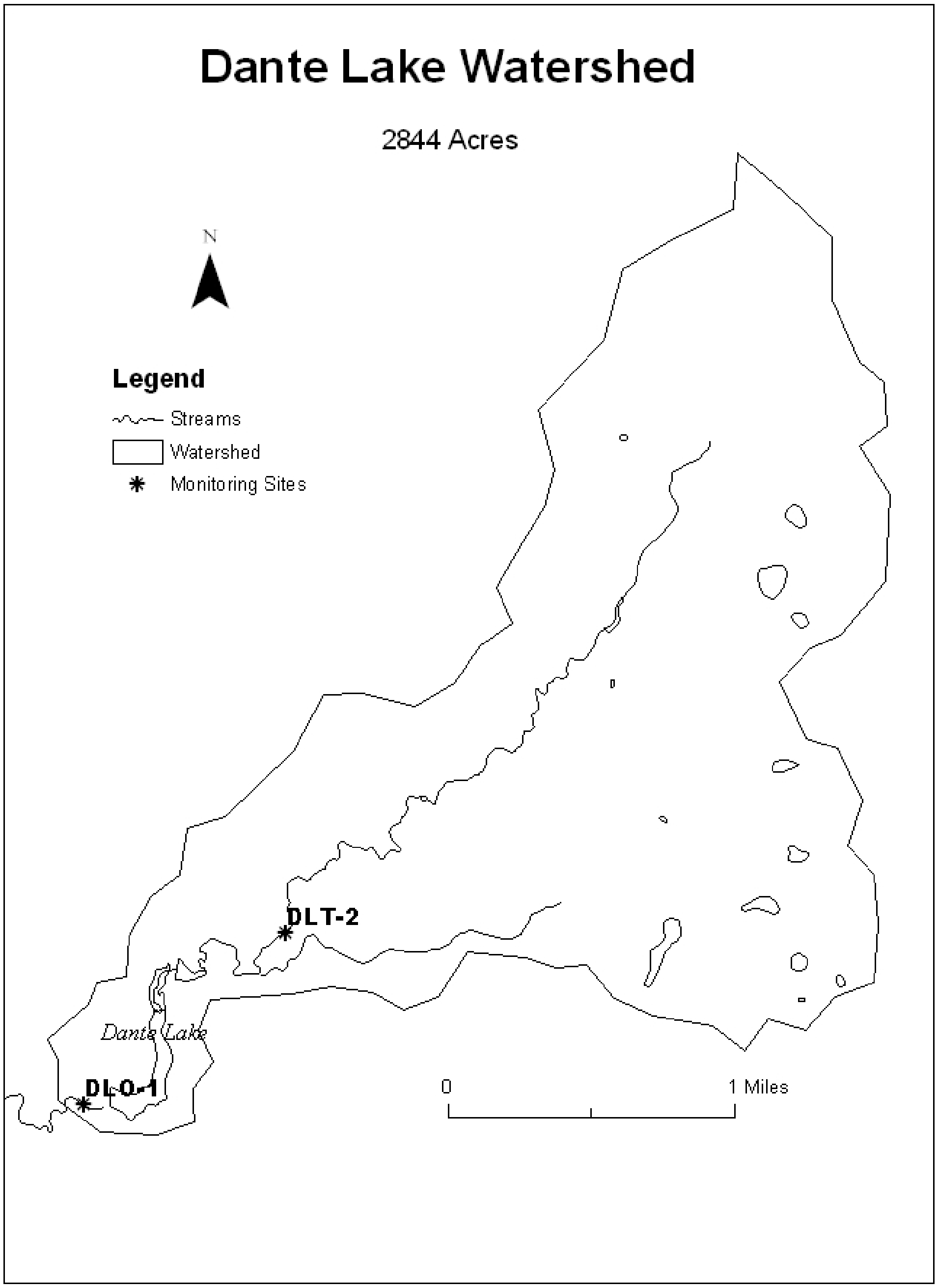


Figure 2. Dante Lake and Dante Creek Watershed

Pollutant Assessment

Point Sources

There are no point sources of pollutants of concern in this watershed.

Nonpoint Sources/ Background Sources

Dante Lake receives an estimated load of 1,575 kg of phosphorus on an annual basis based on measured loads collected from current assessment data. As a result of the lakes nearly full support of its beneficial uses, any restoration efforts completed should result in attainment of full support. Attainment of full support will be accomplished through phosphorus load reductions of 6.4 percent. Phosphorus reductions from the watershed of 6.4 percent or more would result in a TSI shift sufficient to reach full support of beneficial uses; however it would not restore the number of boat accessible acres in the lake to improve that beneficial use.

Linkage Analysis

Water quality data was collected from four monitoring sites within Dante Lake and Dante Creek watershed. Samples collected at each site were collected according to South Dakota's Standard Operating Procedures for Field Samplers. Water samples were sent to the State Health Laboratory in Pierre for analysis. Quality Assurance/Quality Control samples were supposed to be collected on 10% of the samples according to South Dakota's EPA approved Clean Lakes Quality Assurance/Quality Control Plan. Replicate samples were collected but blank samples were not. Details concerning water sampling techniques, analysis, and quality control are addressed on pages 9-48 of the assessment final report.

In addition to water quality monitoring, data was collected to complete a watershed landuse model. The Annualized Agriculture Nonpoint Pollution Source (AnnAGNPS) model was used to provide comparative values for each of the land uses and animal feeding operations located in the watershed. See the AnnAGNPS section of the final report, pages 53-57.

The impacts of phosphorus reductions on the condition of Dante Lake were calculated using BATHTUB, an Army Corps of Engineers model. It is recommended that managed grazing, fertilization and cropland management implemented in priority one and two critical phosphorus cells in the Dante Lake watershed (6.4 percent phosphorus reduction for all BMPs) will maintain the TSI to full support.

Nutrients, especially phosphorus, have been shown to increase eutrophication in lakes and reservoirs throughout the country increasing oxygen depletion caused by decomposition of algae and aquatic plants (Carpenter et al., 1998). Carpenter et al. (1998) and Bertram (1993) also indicate that reductions in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Nurnberg (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 AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg also developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes (UT DWQ, 2006). Dante Lake's morphological characteristics are well within those Nurnberg used to develop regression models (Nurnberg ranges: $\bar{z}$ mean depth (m), 1.8 – 200; A_o lake surface area (hectares), 1.0 – $8.2*10^6$ and $\bar{z} / A_o^{0.5}$ (m/km^2), 0.14 – 48.1; Dante values: $\bar{z}$ (m), 3.2; A_o (hectares), 7.6 and $\bar{z} / A_o^{0.5}$ (m/km^2), 11.6) which support SD DENR conclusions that nutrients affect dissolved oxygen concentrations and algal populations in Dante Lake. This view is also supported by Carpenter et al. (1998). Thus reduction in nutrient (phosphorus) loads to the lake will improve dissolved oxygen concentrations and overall water quality in Dante Lake. South Dakota's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waterbodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen)**.** The addition of a hypolimnetic aeration system to Dante Lake will eliminate sporadic violations in in-lake dissolved oxygen concentrations.

TMDL and Allocations

TMDL for Phosphorus

	0 kg/yr	(WLA)
+	1,474 kg/yr	(LA)
+	Implicit	(MOS)
	1,474 kg/yr	(TMDL)

Represents a 6.4 percent reduction in total phosphorus

Wasteload Allocations (WLAs)

There are no point sources of pollutants of concern in this watershed. Therefore, the "wasteload allocation" component of these TMDLs is considered a zero value. The TMDLs are considered wholly included within the "load allocation" component of the equation.

Load Allocations (LAs)

A 6.4 percent reduction in the phosphorus load to Dante Lake may be obtained through the improvement of grazing management and the specific crop cells identified in the AnnAGNPS section of the final report reducing the annual load from 1,575 kg/yr to 1,474 kg/yr of phosphorus. The load allocation was determined based on initial measured from assessment data.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, Dante Lake samples were separated into spring (March-May), summer (June-August), fall (September-November), and winter (December-February) collection periods.

Margin of Safety

Implementation of best management practices based on conservative BMP reductions in the Dante Lake watershed will result in an implicit margin of safety for loading reductions.

Critical Conditions

The impairments to Dante Lake are most severe during the summer. This is the result of warm water temperatures and low surface water phosphorus concentrations due to in-lake stratification, reduced algal growth contributing to surface water DO levels all impacting periods of peak recreational use of the lake. Low surface dissolved oxygen levels were observed in Dante Lake during the summer of 2000. SD DENR recommends the installation of a hypolimnetic aeration system to meet the water quality standards throughout the year. SD DENR will continue to monitor/sample Dante Lake in 2006 and beyond monitor in-lake profiles surface water and dissolved oxygen concentrations.

Follow-Up Monitoring

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to beneficial uses occurs. Dante Lake will also be monitored annually as a part of the South Dakota Statewide Lakes Assessment program to monitor TSI values and dissolved oxygen concentrations to provide additional monitoring data to track and re-evaluate in-lake responses to BMP implementations ensuring that the lake continues to support its beneficial uses.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

Charles Mix County Conservation District Board Meetings

Douglas County Conservation District Board Meetings

Individual contact with residents in the watershed.

South Central Water Development District

South Dakota Department of Game, Fish and Parks

The findings from these public meetings and comments have been taken into consideration in development of the Dante Lake TMDL.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET- SUITE 300
DENVER, CO 80202-2466
Phone 800-227-8917
http://www.epa.gov/region08

Implementation Plan

The South Dakota DENR is working with the Charles Mix County Conservation District and the Charles Mix County NRCS office to initiate an implementation project to include Dante Lake.

September 27, 2006

Ref: 8EPR-EP

Steven M. Pirner, Secretary
Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Dante Lake
Turkey Ridge Creek

Dear Mr. Pirner:

We have completed our review, and have received Endangered Species Act Section 7 concurrence from the U.S. Fish and Wildlife Service, on the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq*.), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1).

Based on our review, we feel the separate elements of the TMDLs listed in the enclosed table adequately address the pollutants of concern as given in the table, taking into consideration seasonal variation and a margin of safety. In the enclosed table, we have distinguished between TMDLs developed under Section 303(d)(1) *vs.* Section 303(d)(3) of the Clean Water Act. Section 303(d)(1) TMDLs are those for waterbodies that are water quality limited for the pollutant(s) of concern. The determination of whether a particular TMDL is (d)(1) or (d)(3) is made on a waterbody-by-waterbody and pollutant-by-pollutant basis.

Some of the TMDLs designated on the enclosed table as Section 303(d)(1) TMDLs, as distinguished from Section 303(d)(3) TMDLs, may be for waters not found on the current state 303(d) waterbody list. EPA understands that such waters would have been included on

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the list had the state been aware, at the time the list was compiled, of the information developed in the context of calculating these TMDLs. This information demonstrates that the non-listed water is in fact a water quality limited segment in need of a TMDL. The state need not include these waters that have such TMDLs associated with them on its next Section 303(d) list for the pollutant covered by the TMDL.

Thank you for your submittal. If you have any questions concerning this approval, feel free to contact Vernon Berry of my staff at 303-312-6234.

Sincerely,

Original signed by Max H. Dodson

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and
Remediation

Enclosures

ENCLOSURE 1

APPROVED TMDLS

Waterbody Name*	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	Section 303(d)1 or 303(d)3 TMDL	Supporting Documentation (not an exhaustive list of supporting documents)
Dante Lake*	Phosphorous	Maintain a mean annual TSI at or below 63.86	1,474 kg/yr total phosphorous (6.4% reduction in average annual total phosphorous loads)	Section 303(d)(1)	■ Phase I Watershed Assessment and TMDL Final Report, Dante Lake, Charles Mix County, South Dakota (SD DENR, January 2006)
	Dissolved Oxygen	Dissolved Oxygen ≥ 5.0 mg/L.	It is anticipated that meeting the phosphorous load reduction target will result in the dissolved oxygen target being met.**	Section 303(d)(1)	
Turkey Ridge Creek	Fecal Coliform	Fecal coliform ≤ 2000 cfu/100mL	2.27×10^{12} cfu/day (during high flow from May 1 to Sept. 30; 95% reduction in average annual, high flow fecal coliform loads)	Section 303(d)(1)	■ Watershed Assessment Final Report, Turkey Ridge Creek, Turner County, South Dakota (SD DENR, July 2005)

* An asterisk indicates the waterbody has been included on the State's Section 303(d) list of waterbodies in need of TMDLs.

** 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.

Appendix F

Public Comments and Responses to the Dante Lake Assessment Report and TMDL Summary Document

Public Notice Comments

EPA Region VIII TMDL Review Form

Document Name:	Dante Lake
Submitted by:	Gene Stueven, SD DENR
Date Received:	April 17, 2006
Review Date:	May 19, 2006
Reviewer:	Vern Berry, EPA
Formal or Informal Review?	Informal – Public Notice

This document provides a standard format for EPA Region 8 to provide comments to the South Dakota Department of Environment and Natural Resources on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

Water Quality Impairment Status
Water Quality Standards
Water Quality Targets
Significant Sources
Technical Analysis
Margin of Safety and Seasonality
Total Maximum Daily Load
Allocation
Public Participation
Monitoring Strategy
Restoration Strategy
Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Water Quality Impairment Status

Criterion Description – Water Quality Impairment Status
TMDL documents must include a description of the listed water quality impairments. While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Dante Lake is a 18.7 acre man-made impoundment on Dante Creek. It is located in the Choteau Creek watershed of the Missouri River Basin, Charles Mix County, South Dakota. It is listed on SD's 2004 303(d) list as impaired for trophic state index (TSI) due to nonpoint sources and is ranked as priority 1 (i.e., high priority) for TMDL development. The watershed drains predominantly agricultural land. Approximately 78% of the landuse is cropland, 20% is rangeland and pasture, and 2% is roads and residences in the watershed. The mean TSI during the period of the project assessment was 63.8, and the dissolved oxygen standards were not met. Dante Lake is not currently meeting its designated beneficial use for warmwater permanent fish life propagation.

2. Water Quality Standards

Criterion Description – Water Quality Standards
The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Dante Lake is impaired for dissolved oxygen and TSI. TSI is a surrogate measure used to determine whether the narrative standards are being met. South Dakota has applicable narrative standards that may be applied to the undesirable eutrophication of lakes. Data from Dante

Lake indicates problems with nutrient enrichment and nuisance algal blooms, which are typical signs of the eutrophication process. The narrative standards being implemented in this TMDL are:

"Materials which produce nuisance aquatic life may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair a beneficial use or create a human health problem." (See ARSD §74:51:01:09)

"All waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities." (See ARSD §74:51:01:12)

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

Other applicable water quality standards are included on pages 20 and 21 of the assessment report.

3. Water Quality Targets

Criterion Description – Water Quality Targets

Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must 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 TMDL target. For pollutants with narrative standards, the narrative standard must 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 targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Water quality targets for this TMDL are based on interpretation of narrative provisions found in State water quality standards. In May 2000, SD DENR published *Ecoregion Targeting for Impaired Lakes in South Dakota*. This document proposed ecoregion-specific targeted Trophic State Index (TSI) values based on beneficial uses. EPA approved the use of these ecoregion-specific targets to evaluate lakes using beneficial use categories. In South Dakota algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. SD DENR considers several algal species 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.

Dante Lake currently has a mean TSI of 64.6. Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that a 4% reduction in the total phosphorous loading from the watershed would be necessary to meet the ecoregion-based beneficial use TSI target of less than 65. This target will fully support its beneficial uses.

The water quality targets used in this TMDL are: **maintain a mean annual TSI $\leq$ 63.8; dissolved oxygen $\geq$ 5.0 mg/L.**

4. Significant Sources

Criterion Description – Significant Sources
TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can 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 can be employed so long as the approach is clearly defined in the document.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL identifies the major sources of phosphorous as coming from nonpoint source agricultural landuses within the watershed. In particular, a loading analysis was done for nutrients and sediment considering various agricultural land use and land management factors. Cropland and pastureland are the primary sources identified. Approximately 78% of the landuse is cropland and 20% is rangeland and pasture in the watershed.

5. Technical Analysis

Criterion Description – Technical Analysis

TMDLs must be supported by an appropriate level of technical analysis**.** It applies to **<u>all</u>** of the components of a TMDL document. It is vitally important that the technical basis for **<u>all</u>** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.

☐ Satisfies Criterion
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☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
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SUMMARY – The technical analysis addresses the needed phosphorous reduction to achieve the desired water quality. The TMDL recommends a 6.4% reduction in average annual total phosphorous loads to Dante Lake. Based on the loads measured during the period of the assessment the total phosphorous load should be 1,474 kg/yr to achieve the desired TSI target. This reduction is based in large part on the BATHTUB mathematical modeling of the Lake and its predicted response to nutrient load reductions.

The FLUX model was used to develop nutrient and sediment loadings for the Dante Lake inlet and outlet sites. This information was used to derive export coefficients for nutrients and sediment to target areas within the watershed with excessive loads of these pollutants.

The Annualized Agricultural Non-Point Source Model (AnnAGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The nutrient loading source analysis, that was used to identify necessary controls in the watershed, was based on the identification of targeted or “critical” cells. Cells that produce phosphorous loads greater than two standard deviations over the mean for the watershed were determined to be priority 1, and cells producing loads greater than one standard deviation over the mean were determined to be priority 2. The initial load reductions under this TMDL will be achieved through controls on the critical cells within the watershed to improve pasture conditions, improve tillage practices and/or convert corn rotations to pasture.

Improvements in the dissolved oxygen concentration of the lake can be achieved through hypolimnetic aeration (i.e., mechanical aeration), and through reduction of organic loading to the lake as a result of proposed BMP implementation.

COMMENTS - The linkage between reduction of organic loading (i.e., nutrients) and improvements in the in-lake DO concentrations should be strengthened by adding additional linkage language similar to what UT DEQ has used recently:

Addendum for the linkage betwecn lake/reservoir oxygen depletion and nutrients for East Canyon Reservoir, Minersville Reservoir, Kents Lake, LaRaron Reservoir, Mantua Reservoir and Puffer Lake.

The purpose of this addendum is to provide a definitive linkage between nutrient loads to Utah lakes/reservoirs and indirect oxygen depletions that occur as a result of excess blue-green algae blooms. This linkage will be used to further support and gain complete approval for the recently (April 2000) submitted TMDL's for Scofield Reservoir, East Canyon Reservoir, Mantua Reservoir, Minersville Reservoir, LeBaron Reservoir, Puffer Lake, and Kents Lake.

In a review of scientific literature, Carpenter et al. (1998), has shown that non-point sources of phosphorous (P) has lead to eutrophic conditions for many lake/reservoirs across the U.S. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic p1ants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Although, the rates of recovery are variable among lakes/reservoirs. This supports the Division of Water Quality's (DWQ) viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, the concern is that this process rakes a significant amount of time (5-15 years).

In Lake Erie, heavy loading of phosphorous has impacted the lake severely. Monitoring and research from the 1960's has shown that depressed hypolimnctic DO levels were responsible for large fish kills and large mats of decaying algae. Binationa1 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 P reduction, but this was expected (See http://www.epa.gov/glnpo/lakeerie/dostory.html).

Nurnberg (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 AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg (1996) developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. The DWQ has calculated rnorphometric parameters such as surface area (A_o), mean depth (z), and the ratio of mean depth to surface area ($z/A_o^{0.5}$) for the concerned lakes and reservoirs in Utah (see Table 1).

The results show that these parameters are within the range of lakes used by Nurnberg. Because of this we feel confident that Nurnberg's empirical nutrient-oxygen relationship holds true for Utah lakes and reservoirs. We are also convinced that prescribed BMP's will reduce external loading of nutrients to the lakes/reservoirs which will reduce algae blooms and therefore increase oxygen levels over time. In addition Nurnberg rejects absolute DO as a trophic state metric (e.g., see page 442, Nurnberg (1996) in particular for an observation that there are many oligotrophic lakes with zero DO). Numbers presents other variables and metrics that would predict trophic status which we are relying on besides DO, itself. It is the compilation of all these indicators that will allow for complete evaluation of the lake health and achievement of water quality standards. Included with this document are other papers by Nurnberg to support our rationale.

Utah's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waterbodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen). However, if after treatment of sources and a sufficient period for recovery (10+ years) dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. However, in-lake treatments should not be implemented without control of nutrient sources within the watershed. This view is also supported by Carpenter et al. (1998).

Table 1. Morphometry data for Utah lakes and reservoirs.

Lake	**Nurnberg Range**	**Mantua**	**Scofield**	**East Canyon**	**Minersville**	**Kent Lake**	**Lebaron**	**Puffer**
z (m)	1.8 – 200	4.27	7.9	23	8.1	6.2	3.23	4.5
A_o(hectars)	5 – 6.2 10^6	224	1139	277	400	19.4	9.47	26.3
$z/A_o^{0.5}$ (m/km^2)	0.14 – 48.1	2.85	2.34	13.81	4.05	8.77	10.49	8.77

Response: The following text was added to the in-lake dissolved oxygen and linkage analysis sections of the assessment report and TMDL.

Nutrients, especially phosphorus, have been shown to increase eutrophication in lakes and reservoirs throughout the country increasing oxygen depletion caused by decomposition of algae and aquatic plants (Carpenter et al., 1998). Carpenter et al. (1998) and Bertram (1993) also indicate that reductions in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Nurnberg (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 AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg also developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes (UT DWQ, 2006). Dante Lake's morphological characteristics are well within those Nurnberg used to develop regression models (Nurnberg ranges: $\bar{z}$ mean depth (m), 1.8 – 200; A_o lake surface area (hectares), 1.0 – $8.2*10^6$ and $\bar{z} / A_o^{0.5}$ (m/km^2), 0.14 – 48.1; Dante values: $\bar{z}$ (m), 3.2; A_o (hectares), 7.6 and $\bar{z} / A_o^{0.5}$ (m/km^2), 11.6) which support SD DENR conclusions that nutrients affect dissolved oxygen concentrations and algal populations in Dante Lake. This view is also supported by Carpenter et al. (1998). Thus reduction in nutrient (phosphorus) loads to the lake will improve dissolved oxygen concentrations and overall water quality in Dante Lake. South Dakota's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waterbodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen).

However, if after treatment of sources and a sufficient period of time for recovery (10+ years) dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. Lower dissolved oxygen concentrations in the summer months, especially in dry years, may require the addition of a mechanical aeration for operation during periods of low surface dissolved oxygen concentrations. Adding oxygen (air) to the hypolimnion will break up stratification and increase conversion of organic matter improving dissolved oxygen concentrations throughout the lake profile. Two lakes in South Dakota, Stockade Lake in Custer County and Lake Waggoner in Haakon County, have or have had aeration systems installed to breakup stratification to improve water quality. Stockade Lake aeration system was put into service in 1999 and operates only during the summer months during thermal stratification. SD GF&P monitoring results indicate aeration during the summer did not allow the lake to stratify improving the dissolved oxygen profile increasing fish habitat during the summer. Improved water quality especially dissolved oxygen concentrations has been observed in Stockade Lake in resent years and based on SD GF&P monitoring data and current SD DENR statewide lake assessment data (SD GF&P, 2004, SD GF&P, 2005, SD GF&P, 2005a and SD DENR, 1996). In 2006, SD DENR proposed a change in listing criteria based on TSI (Trophic State Index) parameters based on Secchi and chlorophyll-a TSI values and grouped by fishery classifications. Using this criteria, the 2006 Integrated Report indicates that Stockade Lake be de-listed as fully meeting the modified lake listing criteria. Waggoner Lake installed a mechanical aeration system in the mid 1990's to breakup thermal stratification and improve drinking water taste. This system operated during the summer months through 2002 when the City of Philip switched its drinking water source from Waggoner Lake to West River/Lyman Jones rural water. A mechanical aerator is recommended and should be considered to improve the overall water quality in Dante Lake. Dante Lake is a small (18.7 acre) lake and a good candidate for an aeration system which should improve sporadic low dissolved oxygen concentrations observed in the summer months during this assessment.

Margin of Safety and Seasonality

Criterion Description – Margin of Safety/Seasonality

A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.

Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs , targets, and allocations.

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SUMMARY – A margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, more BMPs were specified than are necessary to meet the targets, and ongoing monitoring has been proposed to assure water quality goals are achieved. 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.

7. TMDL

Criterion Description – Total Maximum Daily Load *TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR. 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.*

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SUMMARY – The TMDL established for Dante Lake is a 1,474 kg/yr total phosphorus load to the lake (6.4% reduction in annual total phosphorus load). This is the “measured load” which is based on the flow and concentration data collected during the period of the assessment. The annual loading will vary from year-to-year; therefore, this TMDL is considered a long term average percent reduction in phosphorous loading.

8. Allocation

Criterion Description – Allocation

TMDLs apportion responsibility for taking actions or allocate 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 dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources.

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).

Allocating load reductions to specific sources is generally the most contentious and politically sensitive component of the TMDL process. It is also the step in the process where management direction is provided to actually achieve the desired load reductions. In many ways, it is a prioritization of restoration activities that need to occur to restore water quality. For these reasons, every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles.

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SUMMARY – This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Dante Lake. The allocation for the TMDL is a "load allocation" attributed to nonpoint sources. There are no significant point source contributions in this watershed. The source allocations for phosphorous are assigned to runoff from cropland and range/pastureland. There is a desire to move forward with controls in the areas of the basin where there is confidence that phosphorous reductions can be achieved through modifications to critical cells within the watershed.

9. Public Participation

Criterion Description – Public Participation

The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should 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 review, a copy of the comments received by the state should be also submitted to EPA..

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SUMMARY – The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process. In particular, the State has encouraged participation through public meetings in the watershed, individual contact with residents in the watershed, and will include widespread solicitation of comments on the draft TMDL when it is public noticed. The draft TMDL will also be posted on the Internet to solicit comments during the public notice period. The level of public participation is found to be adequate.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy

TMDLs may have significant uncertainty associated with 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 documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

At a minimum, the monitoring strategy should:
Articulate the monitoring hypothesis and explain how the monitoring plan will test it.
Address the relationships between the monitoring plan and the various components of the TMDL (targets, sources, allocations, etc.).
Explain any assumptions used.
Describe monitoring methods.
Define monitoring locations and frequencies, and list the responsible parties.

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SUMMARY – Dante Lake will continue to be monitored through the statewide lake assessment project. Post-implementation monitoring will be necessary to assure the TMDLs for phosphorous and dissolved oxygen have been reached and maintenance of the beneficial use occurs, and because the long term average TSI and phosphorous loading may be higher than was recorded during this assessment.

11. Restoration Strategy

Criterion Description – Restoration Strategy

At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. 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.

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SUMMARY – The South Dakota DENR is working with the local conservation district to develop a plan for an implementation project for Dante Lake. The implementation of various best management practices throughout the watershed is expected to meet or exceed the WQ and TMDL targets/goals. This includes conversion of a portion of the wheat/grass and corn/grass fields to grass and installation of a lake aeration system for use during the summer months. Mechanical aeration is needed to meet the TMDL goal for dissolved oxygen. Additional BMPs that could be implemented if necessary include streambank stabilization, cattle restrictions, alternative watering, grazing management, fertilizer reduction and in-lake treatment with aluminum sulfate.

12. Endangered Species Act Compliance

Criterion Description – Endangered Species Act Compliance

EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act ("ESA"). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with FWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.

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SUMMARY – EPA will request ESA Section 7 concurrence from the FWS for this TMDL.

13. Miscellaneous Comments/Questions

Final Approval Comments

EPA REGION VIII TMDL REVIEW FORM

Document Name:	**Dante Lake**
Submitted by:	**Gene Stueven, SD DENR**
Date Received:	**April 17, 2006**
Review Date:	**May 19, 2006**
Reviewer:	**Vern Berry, EPA**
Formal or Informal Review?	**Informal – Public Notice**

This document provides a standard format for EPA Region 8 to provide comments to the South Dakota Department of Environment and Natural Resources on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy
12. Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Water Quality Impairment Status

Criterion Description – Water Quality Impairment Status
TMDL documents must include a description of the listed water quality impairments. While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.

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SUMMARY – Dante Lake is a 18.7 acre man-made impoundment on Dante Creek. It is located in the Choteau Creek watershed of the Missouri River Basin, Charles Mix County, South Dakota. It is listed on SD's 2004 303(d) list as impaired for trophic state index (TSI) due to nonpoint sources and is ranked as priority 1 (i.e., high priority) for TMDL development. The watershed drains predominantly agricultural land. Approximately 78% of the landuse is cropland, 20% is rangeland and pasture, and 2% is roads and residences in the watershed. The mean TSI during the period of the project assessment was 63.8, and the dissolved oxygen standards were not met. Dante Lake is not currently meeting its designated beneficial use for warmwater permanent fish life propagation.

2. Water Quality Standards

Criterion Description – Water Quality Standards
The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.

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SUMMARY – Dante Lake is impaired for dissolved oxygen and TSI. TSI is a surrogate measure used to determine whether the narrative standards are being met. South Dakota has applicable narrative standards that may be applied to the undesirable eutrophication of lakes. Data from Dante Lake indicates problems with nutrient enrichment and nuisance algal blooms, which are typical signs of the eutrophication process. The narrative standards being implemented in this TMDL are:

“*Materials which produce nuisance aquatic life may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair a beneficial use or create a human health problem.*” (See ARSD §74:51:01:09)

“*All waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities.*” (See ARSD §74:51:01:12)

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

Other applicable water quality standards are included on pages 20 and 21 of the assessment report.

3. Water Quality Targets

Criterion Description – Water Quality Targets

Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must 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 TMDL target. For pollutants with narrative standards, the narrative standard must 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 targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

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SUMMARY – Water quality targets for this TMDL are based on interpretation of narrative provisions found in State water quality standards. In May 2000, SD DENR published *Ecoregion Targeting for Impaired Lakes in South Dakota*. This document proposed ecoregion-specific targeted Trophic State Index (TSI) values based on beneficial uses. EPA approved the use of these ecoregion-specific targets to evaluate lakes using beneficial use categories. In South Dakota algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. SD DENR considers several algal species 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.

Dante Lake currently has a mean TSI of 64.6. Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that a 4% reduction in the total phosphorous loading from the watershed would be necessary to meet the ecoregion-based beneficial use TSI target of less than 65. This target will fully support its beneficial uses.

The water quality targets used in this TMDL are: **maintain a mean annual TSI ≤ 63.8; dissolved oxygen ≥ 5.0 mg/L.**

4. Significant Sources

Criterion Description – Significant Sources

TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can 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 can be employed so long as the approach is clearly defined in the document.

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5. Technical Analysis

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TMDLs must be supported by an appropriate level of technical analysis. *It 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. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.*

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COMMENTS - The linkage between reduction of organic loading (i.e., nutrients) and improvements in the in-lake DO concentrations should be strengthened by adding additional linkage language similar to what UT DEQ has used recently:

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The purpose of this addendum is to provide a definitive linkage between nutrient loads to Utah lakes/reservoirs and indirect oxygen depletions that occur as a result of excess blue-green algae blooms. This linkage will be used to further support and gain complete approval for the recently (April 2000) submitted TMDL's for Scofield Reservoir, East Canyon Reservoir, Mantua Reservoir, Minersville Reservoir, LeBaron Reservoir, Puffer Lake, and Kents Lake.

In a review of scientific literature, Carpenter et al. (1998), has shown that non-point sources of phosphorous (P) has lead to eutrophic conditions for many lake/reservoirs across the U.S. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic p1ants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Although, the rates of recovery are variable among lakes/reservoirs. This supports the Division of Water Quality's (DWQ) viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, the concern is that this process rakes a significant amount of time (5-15 years).

In Lake Erie, heavy loading of phosphorous has impacted the lake severely. Monitoring and research from the 1960's has shown that depressed hypolimnctic DO levels were responsible for large fish kills and large mats of decaying algae. Binationa1 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 P reduction, but this was expected (See http://www.epa.gov/glnpo/lakeerie/dostory.html).

Nurnberg (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 AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg (1996) developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. The DWQ has calculated rnorphometric parameters such as surface area (A_o), mean depth (z), and the ratio of mean depth to surface area ($z/A_o^{0.5}$) for the concerned lakes and reservoirs in Utah (see Table 1).

The results show that these parameters are within the range of lakes used by Nurnberg. Because of this we feel confident that Nurnberg's empirical nutrient-oxygen relationship holds true for Utah lakes and reservoirs. We are also convinced that prescribed BMP's will reduce external loading of nutrients to the lakes/reservoirs which will reduce algae blooms and therefore increase oxygen levels over time. In addition Nurnberg rejects absolute DO as a trophic state metric (e.g., see page 442, Nurnberg (1996) in particular for an observation that there are many oligotrophic lakes with zero DO). Numbers presents other variables and metrics that would predict trophic status which we are relying on besides DO, itself. It is the compilation of all these indicators that will allow for complete evaluation of the lake health and achievement of water quality standards. Included with this document are other papers by Nurnberg to support our rationale.

Utah's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waterbodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen). However, if after treatment of sources and a sufficient period for recovery (10+ years) dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. However, in-lake treatments should not be implemented without control of nutrient sources within the watershed. This view is also supported by Carpenter et al. (1998).

Table 1. Morphometry data for Utah lakes and reservoirs.

Lake	Nurnberg Range	Mantua	Scofield	East Canyon	Minersville	Kents Lake	Lebaron	Puffer
z (m)	1.8 – 200	4.27	7.9	23	8.1	6.2	3.23	4.5
A_o (hectars)	5 – 6.2 10^6	224	1139	277	400	19.4	9.47	26.3
$z/A_o^{0.5}$ (m/km^2)	0.14 – 48.1	2.85	2.34	13.81	4.05	8.77	10.49	8.77

Response: The following text was added to the in-lake dissolved oxygen and linkage analysis sections of the assessment report and TMDL.

Nutrients, especially phosphorus, have been shown to increase eutrophication in lakes and reservoirs throughout the country increasing oxygen depletion caused by decomposition of algae and aquatic plants (Carpenter et al., 1998). Carpenter et al. (1998) and Bertram (1993) also indicate that reductions in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Nurnberg (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 AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg also developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes (UT DWQ, 2006). Dante Lake's morphological characteristics are well within those Nurnberg used to develop regression models

(Nurnberg ranges: $\bar{z}$ mean depth (m), 1.8 – 200; A_o lake surface area (hectares), 1.0 – $8.2*10^6$ and $\bar{z} / A_o^{0.5}$ (m/km^2), 0.14 – 48.1; Dante values: $\bar{z}$ (m), 3.2; A_o (hectares), 7.6 and $\bar{z} / A_o^{0.5}$ (m/km^2), 11.6) which support SD DENR conclusions that nutrients affect dissolved oxygen concentrations and algal populations in Dante Lake. This view is also supported by Carpenter et al. (1998). Thus reduction in nutrient (phosphorus) loads to the lake will improve dissolved oxygen concentrations and overall water quality in Dante Lake. South Dakota's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waterbodies is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen).

However, if after treatment of sources and a sufficient period of time for recovery (10+ years) dissolved oxygen concentrations are not improving, than in-lake treatments may be investigated and implemented. Lower dissolved oxygen concentrations in the summer months, especially in dry years, may require the addition of a mechanical aeration for operation during periods of low surface dissolved oxygen concentrations. Adding oxygen (air) to the hypolimnion will break up stratification and increase conversion of organic matter improving dissolved oxygen concentrations throughout the lake profile. Two lakes in South Dakota, Stockade Lake in Custer County and Lake Waggoner in Haakon County, have or have had aeration systems installed to breakup stratification to improve water quality. Stockade Lake aeration system was put into service in 1999 and operates only during the summer months during thermal stratification. SD GF&P monitoring results indicate aeration during the summer did not allow the lake to stratify improving the dissolved oxygen profile increasing fish habitat during the summer. Improved water quality especially dissolved oxygen concentrations has been observed in Stockade Lake in resent years and based on SD GF&P monitoring data and current SD DENR statewide lake assessment data (SD GF&P, 2004, SD GF&P, 2005, SD GF&P, 2005a and SD DENR, 1996). In 2006, SD DENR proposed a change in listing criteria based on TSI (Trophic State Index) parameters based on Secchi and chlorophyll-a TSI values and grouped by fishery classifications. Using this criteria, the 2006 Integrated Report indicates that Stockade Lake be de-listed as fully meeting the modified lake listing criteria. Waggoner Lake installed a mechanical aeration system in the mid 1990's to breakup thermal stratification and improve drinking water taste. This system operated during the summer months through 2002 when the City of Philip switched its drinking water source from Waggoner Lake to West River/Lyman Jones rural water. A mechanical aerator is recommended and should be considered to improve the overall water quality in Dante Lake. Dante Lake is a small (18.7 acre) lake and a good candidate for an aeration system which should improve sporadic low dissolved oxygen concentrations observed in the summer months during this assessment.

. Margin of Safety and Seasonality

Criterion Description – Margin of Safety/Seasonality

A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.

Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs , targets, and allocations.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – A margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, more BMPs were specified than are necessary to meet the targets, and ongoing monitoring has been proposed to assure water quality goals are achieved. 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.

7. TMDL

Criterion Description – Total Maximum Daily Load

TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR. 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL established for Dante Lake is a 1,474 kg/yr total phosphorus load to the lake (6.4% reduction in annual total phosphorus load). This is the “measured load” which is based on the flow and concentration data collected during the period of the assessment. The annual loading will vary from year-to-year; therefore, this TMDL is considered a long term average percent reduction in phosphorous loading.

8. Allocation

Criterion Description – Allocation

TMDLs apportion responsibility for taking actions or allocate 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 dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources.

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).

Allocating load reductions to specific sources is generally the most contentious and politically sensitive component of the TMDL process. It is also the step in the process where management direction is provided to actually achieve the desired load reductions. In many ways, it is a prioritization of restoration activities that need to occur to restore water quality. For these reasons, every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Dante Lake. The allocation for the TMDL is a “load allocation” attributed to nonpoint sources. There are no significant point source contributions in this watershed. The source allocations for phosphorous are assigned to runoff from cropland and range/pastureland. There is a desire to move forward with controls in the areas of the basin where there is confidence that phosphorous reductions can be achieved through modifications to critical cells within the watershed.

9. Public Participation

Criterion Description – Public Participation

The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should 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 review, a copy of the comments received by the state should be also submitted to EPA..

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process. In particular, the State has encouraged participation through public meetings in the watershed, individual contact with residents in the watershed, and will include widespread solicitation of comments on the draft TMDL when it is public noticed. The draft TMDL will also be posted on the Internet to solicit comments during the public notice period. The level of public participation is found to be adequate.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy

TMDLs may have significant uncertainty associated with 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 documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

At a minimum, the monitoring strategy should:

- *Articulate the monitoring hypothesis and explain how the monitoring plan will test it.*
- *Address the relationships between the monitoring plan and the various components of the TMDL (targets, sources, allocations, etc.).*
- *Explain any assumptions used.*
- *Describe monitoring methods.*
- *Define monitoring locations and frequencies, and list the responsible parties.*

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Dante Lake will continue to be monitored through the statewide lake assessment project. Post-implementation monitoring will be necessary to assure the TMDLs for phosphorous and dissolved oxygen have been reached and maintenance of the beneficial use occurs, and because the long term average TSI and phosphorous loading may be higher than was recorded during this assessment.

11. Restoration Strategy

Criterion Description – Restoration Strategy

At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. 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.

- ☐ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The South Dakota DENR is working with the local conservation district to develop a plan for an implementation project for Dante Lake. The implementation of various best management practices throughout the watershed is expected to meet or exceed the WQ and TMDL targets/goals. This includes conversion of a portion of the wheat/grass and corn/grass fields to grass and installation of a lake aeration system for use during the summer months. Mechanical aeration is needed to meet the TMDL goal for dissolved oxygen. Additional BMPs that could be implemented if necessary include streambank stabilization, cattle restrictions, alternative watering, grazing management, fertilizer reduction and in-lake treatment with aluminum sulfate.

12. Endangered Species Act Compliance

Criterion Description – Endangered Species Act Compliance

EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act ("ESA"). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with FWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.

- ☐ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – EPA will request ESA Section 7 concurrence from the FWS for this TMDL.

13. Miscellaneous Comments/Questions

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