

**SOLOMON RIVER BASIN TOTAL MAXIMUM DAILY LOAD**

**Water Body: Sheridan County State Fishing Lake**  
**Water Quality Impairment: Eutrophication bundled with Dissolved Oxygen**

**Subbasin:** Upper South Fork Solomon

**County:** Sheridan

**HUC 8:** 10260013

**HUC 11 (HUC 14):** 020 (050)

**Ecoregion:** Central Great Plains, Rolling Plains and Breaks (27b)

**Drainage Area:** Approximately 6.3 square miles

**Conservation Pool:** Area = 35.6 acres  
Watershed Area: Lake Surface Area = 113:1  
Maximum Depth = 5.0 meters (16 feet)  
Mean Depth = 2.0 meters (6.6 feet)

**Designated Uses:** Primary and Secondary Contact Recreation, Expected Aquatic Life Support, Food Procurement

**Authority:** State (Kansas Department of Wildlife and Parks)

**2002 303(d) Listing:** Solomon River Basin Lakes

**Impaired Use:** All uses are impaired to a degree by eutrophication

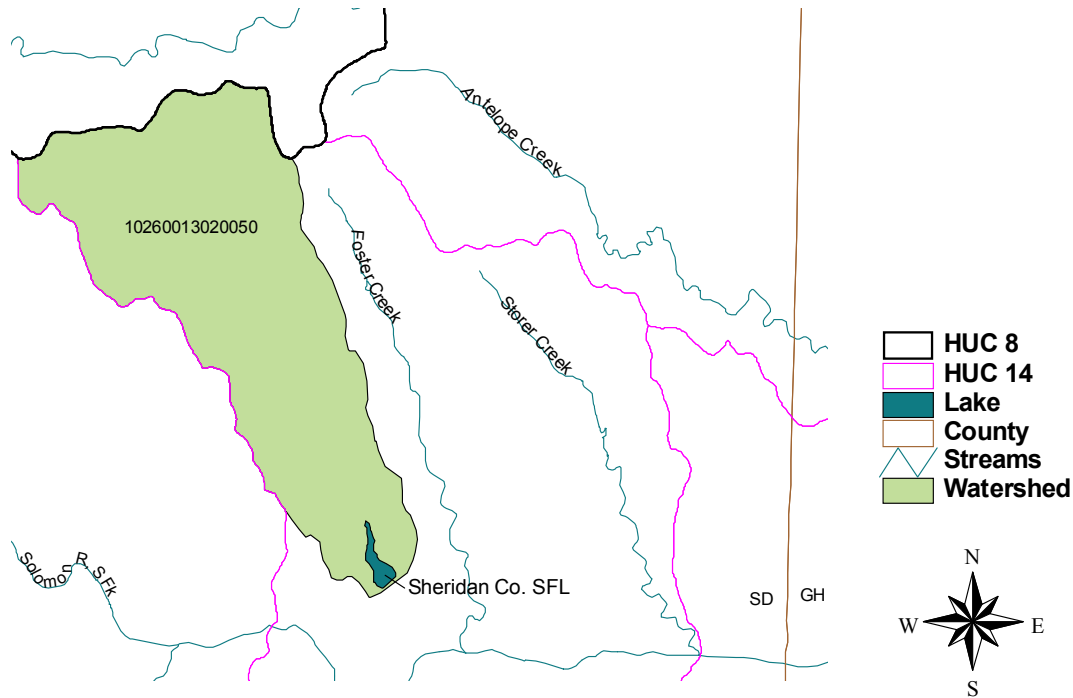
**Water Quality Standard:** Nutrients - Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life. (KAR 28-16-28e(c)(2)(B)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation. (KAR 28-16-28e(c)(7)(A)).

Dissolved Oxygen: 5 mg/L (KAR 28-16-28e(c)(2)(A))

Figure 1

## Sheridan Co. SFL TMDL Reference Map



## 2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

**Level of Eutrophication:** Hypereutrophic, Trophic State Index = 65.91

**Monitoring Sites:** Station 069401 in Sheridan Co. SFL (Figure 1).

**Period of Record Used:** Three surveys during 1991 - 2000.  
One chlorophyll a sample in 1989

**Current Condition:** In 1989, the chlorophyll a concentration was  $10.1 \mu\text{g/L}$ , and the Secchi disc depth was 1.5 meters. From the three surveys in 1991 through 2000, Sheridan Co. SFL had chlorophyll a concentrations averaging  $36.7 \mu\text{g/L}$ , a Total Phosphorus concentration of  $93 \mu\text{g/L}$ , a Total Kjeldahl Nitrogen concentration of  $1.26 \text{ mg/L}$ , and a nitrate concentration of  $0.04 \text{ mg/L}$  (Appendix A). The Secchi disc depth averaged 0.6 meter. Light was indicated to be the primary limiting factor due to clay turbidity (Appendix B). Nitrogen was a secondary limiting factor. The chlorophyll a to total phosphorus yield was moderate.

The Trophic State Index is derived from the chlorophyll a concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll a concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll a concentrations over 7  $\mu\text{g/l}$  and hypereutrophy occurs at levels over 30  $\mu\text{g/l}$ . The Carlson TSI, derives from the chlorophyll concentrations and scales the trophic state as follows:

1. Oligotrophic            TSI < 40
2. Mesotrophic            TSI: 40 - 49.99
3. Slightly Eutrophic    TSI: 50 - 54.99
4. Fully Eutrophic        TSI: 55 - 59.99
5. Very Eutrophic        TSI: 60 - 63.99
6. Hypereutrophic        TSI:  $\geq$  64

**Dissolved Oxygen Samples from Sheridan Co. SFL**

<b>Date</b>	<b>Depth (meter)</b>	<b>Dissolved Oxygen (mg/L)</b>
7/16/91	00.0	7.8
7/16/91	00.5	7.8
7/16/91	01.0	7.8
7/16/91	02.0	7.7
7/16/91	03.0	7.7
7/16/91	04.0	<b>1.4</b>
6/18/96	00.0	12.0
6/18/96	00.5	13.3
6/18/96	01.0	11.4
6/18/96	02.0	5.6
6/18/96	03.0	<b>0.8</b>
6/18/96	04.0	<b>0.1</b>
6/18/96	04.5	<b>0.1</b>
8/15/00	00.0	7.3
8/15/00	00.5	7.4
8/15/00	01.0	5.6
8/15/00	02.0	<b>4.6</b>
8/15/00	03.0	<b>4.5</b>
8/15/00	04.0	<b>3.3</b>
8/15/00	04.5	<b>3.0</b>

Decomposition of plant material has lowered the dissolved oxygen concentrations in the lake. The dissolved oxygen concentrations decreased with increased depth. (See above table). At the surface, the average concentration was 9.0 mg/L, a sufficient amount of dissolved oxygen for aquatic life support. However, at 3 meters, the concentration drops to 4.3 mg/L.

**Interim Endpoints of Water Quality (Implied Load Capacity) at Sheridan Co. SFL over 2008 - 2012:**

In order to improve the trophic condition of the lake from its current Hypereutrophic status, the desired endpoint will be to maintain summer chlorophyll a concentrations below 12  $\mu\text{g/L}$ .

Achievement of this endpoint should also result in dissolved oxygen concentrations above 5 mg/L.

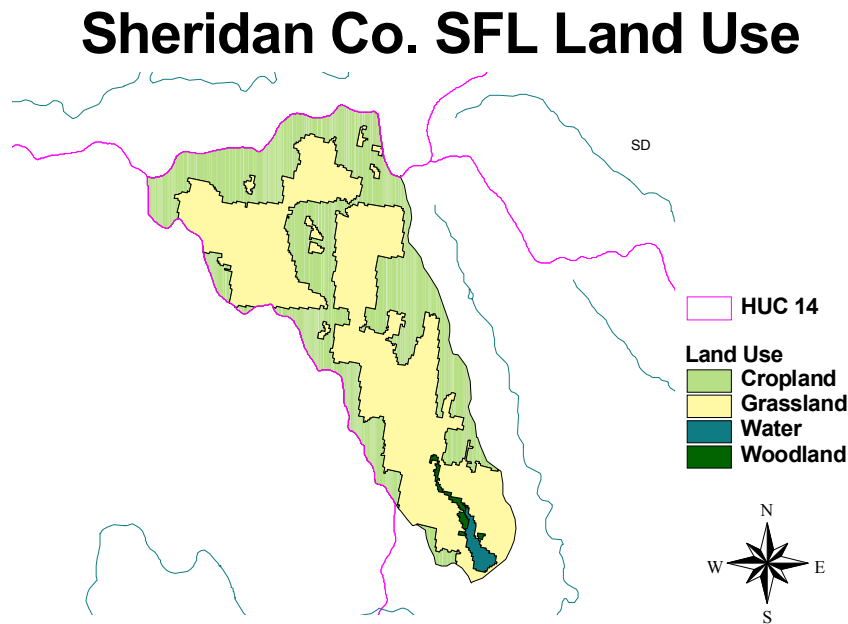
Total Nitrogen concentration in the lake should be maintained below 0.62 mg/L. A regression of 2000 - 2001 lake data and 1997 - 2000 wetland data was used to determine the current, in-lake nitrogen concentration and to calculate how much of a nutrient reduction was need to meet water quality standards.

Current Condition and Reductions for Sheridan Co. SFL

Parameter	Current Condition	TMDL	Percent Reduction
Total Phosphorus Load (lb/year)	510.1	63.8	87 %
Total Phosphorus Concentration ( $\mu\text{g/L}$ )	93	28	70 %
Chlorophyll a ( $\mu\text{g/L}$ )	36.7	< 12	67 %
Total Nitrogen Concentration (mg/L)	1.30	< 0.62	52 %
Dissolved Oxygen (mg/L) at 3 meters	4.3	> 5.0	16 % Increase

3. SOURCE INVENTORY AND ASSESSMENT

Figure 2



**Land Use:** The watershed around Sheridan Co. SFL has a low-to-moderate potential for nonpoint source pollutants. An annual phosphorus load of 510.1 pounds per year is necessary to correspond to the concentrations seen in the lake.

One source of phosphorus and nitrogen within Sheridan Co. SFL

is probably runoff from agricultural lands where phosphorus and nitrogen have been applied. Land use coverage analysis indicates that 43.8% of the watershed is cropland (Figure 2).

Phosphorus and nitrogen from animal waste are a contributing factor. Fifty-four percent of land around the lake is grassland. Waste from animals grazing in the grassland may be adding to the load. Livestock waste management systems are not located within the watershed.

No towns and thus no municipal wastewater treatment plants are located within the Sheridan Co. SFL watershed. The average population density in the watershed is 1.3 people per square mile. A potential source is septic systems located around the lake. Failing septic systems can be a significant source of nutrients. The Sheridan County has 540 septic systems, accounting for 41% of the sewage systems present in the county.

**Contributing Runoff:** The watershed's average soil permeability is 1.5 inches/hour according to NRCS STATSGO database. About 76.1% of the watershed produces runoff even under relatively low (1.5"/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 4.3% of this watershed, chiefly along the stream channels.

**Background Levels:** The atmospheric phosphorus and geological formations (i.e., soil and bedrock) may contribute to phosphorus loads. Nutrients from wildlife waste are another contributing factor.

#### **4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY**

While light is the limiting factor in Sheridan Co. SFL, Total Phosphorus is allocated under this TMDL, because a phosphorus reduction will have a large effect on the managing the algal community. The Load Capacity is 63.8 pounds per year of phosphorus and was calculated using the CNET model. More detailed assessment of sources and confirmation of the trophic state of the lake must be completed before detailed allocations can be made. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction. Because of atmospheric deposition, initial allocations of nitrogen will be based on a proportional decrease in nitrogen between the current condition and the desired endpoint.

**Point Sources:** A current Wasteload Allocation of zero is established by this TMDL because of the lack of point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers.

**Nonpoint Sources:** Water quality violations are partially due to nonpoint source pollutants. Background levels may be attributed to atmospheric deposition and geological sources. The

assessment suggests that cropland and animal waste contribute to the elevated total phosphorus concentrations in the lake. Generally a Load Allocation of 57.4 pounds of total phosphorus per year, leading to an 87% reduction, is necessary to reach the endpoint. A proportional decrease of 47% in nitrogen loading will allow the total nitrogen endpoint to be achieved.

**Defined Margin of Safety:** The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus load and the chlorophyll a endpoint. Therefore, the margin of safety will be 6.4 pounds per year of total phosphorus taken from the load capacity subtracted to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. For nitrogen, the margin of safety will be an additional 5% reduction in nitrogen to ensure that the endpoint is reached.

**State Water Plan Implementation Priority:** Because Sheridan Co. SFL is a state managed fishing lake, this TMDL will be a Medium Priority for implementation.

**Unified Watershed Assessment Priority Ranking:** Sheridan Co. SFL lies within the Upper South Fork Solomon (HUC 8: 10260013) with a priority ranking of 69 (Low Priority for restoration).

**Priority HUC 11s:** The HUC 11 (020) encompasses all of the Sheridan Co. SFL watershed and thus should take priority.

## 5. IMPLEMENTATION

### Desired Implementation Activities

There is a very good potential that agricultural best management practices will allow full use support to take place in Sheridan Co. SFL. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure application to land.

### Implementation Programs Guidance

#### Fisheries Management - KDWP

- a. Assist evaluation in-lake or near-lake potential sources of nutrients to lake.
- b. Advise county on applicable lake management techniques which may reduce nutrient loading and cycling in lake.

**Nonpoint Source Pollution Technical Assistance - KDHE**

- a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management
- b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.
- c. Provide technical assistance on nutrient management in vicinity of streams.
- d. Update and implement nutrient and sediment abatement strategies.
- e. Develop a Watershed Restoration and Protection Strategy for HUC 10260013.

**Water Resource Cost Share Nonpoint Source Pollution Control Program - SCC**

- a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands.
- b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.

**Riparian Protection Program - SCC**

- a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
- b. Develop riparian restoration projects.
- c. Promote wetland construction to assimilate nutrient loadings.

**Buffer Initiative Program - SCC**

- a. Install grass buffer strips near streams.
- b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

**Extension Outreach and Technical Assistance - Kansas State University**

- a. Continue to educate residents and landowners about nonpoint source pollution.
- b. Educate agricultural producers on sediment, nutrient, and pasture management.
- c. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
- d. Provide technical assistance on livestock waste management systems and nutrient management plans.
- e. Provide technical assistance on buffer strip design and minimizing cropland runoff.
- f. Encourage annual soil testing to determine capacity of field to hold phosphorus.

**Time Frame for Implementation:** Water quality improvement activities are encouraged at the local level prior to 2008. Funding for installing lake pollution reduction practices should be allocated within the lake drainage after the year 2008. Evaluation of nutrient sources to lake and identification of potential management techniques should occur prior to 2008.

**Targeted Participants:** Primary participants for implementation will be agricultural producers within the drainage of the lake. Initial work in 2008 should include local assessments by conservation district personnel and county extension agents to locate within the lake drainage:

1. Total row crop acreage
2. Cultivation alongside lake
3. Drainage alongside or through animal feeding lots
4. Livestock use of riparian areas
5. Fields with manure applications

**Milestone for 2008:** The year 2008 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from Sheridan Co. SFL should indicate probable sources of nutrients and plans in place to initiate implementation.

**Delivery Agents:** The primary delivery agents for program participation will be the Kansas Department of Wildlife and Parks. Producer outreach and awareness will be delivered by Kansas State Extension.

**Reasonable Assurances:**

**Authorities:** The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.
2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.
3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.
4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.
5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*.
6. The *Kansas Water Plan* and the Solomon Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

**Funding:** The State Water Plan Fund annually generates \$16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the



Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Medium Priority consideration.

**Effectiveness:** Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming and installation of buffer strips within the watersheds cited in this TMDL.

## **6. MONITORING**

Additional data, to further determine source loading and mean summer lake trophic condition, would be of value prior to 2008. Further sampling and evaluation should occur once before 2008 and once between 2008 and 2012.

## **7. FEEDBACK**

**Public Meetings:** Public meetings to discuss TMDLs in the Solomon Basin were held January 7 and March 3, 2003 in Stockton. An active Internet Web site was established at <http://www.kdhe.state.ks.us/tmdl/> to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Solomon Basin.

**Public Hearing:** A Public Hearing on the TMDLs of the Solomon Basin was held in Stockton on June 2, 2003.

**Basin Advisory Committee:** The Solomon Basin Advisory Committee met to discuss the TMDLs in the basin on October 3, 2002, January 7, March 3, and June 2, 2003.

**Milestone Evaluation:** In 2008, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of Sheridan Co. SFL. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

**Consideration for 303(d) Delisting:** The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2008-2012. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

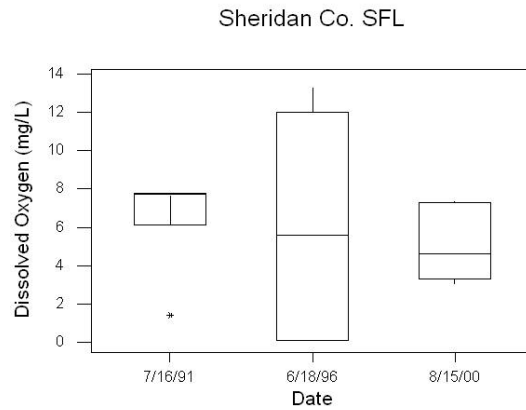
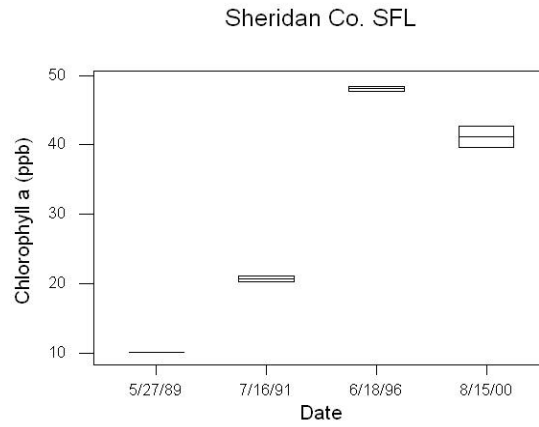
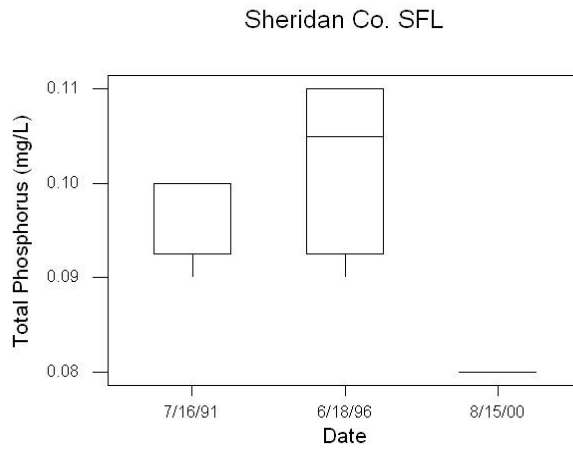
**Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process:** Under the current version of the Continuing Planning

Process, the next anticipated revision will come in 2004 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2004-2008.

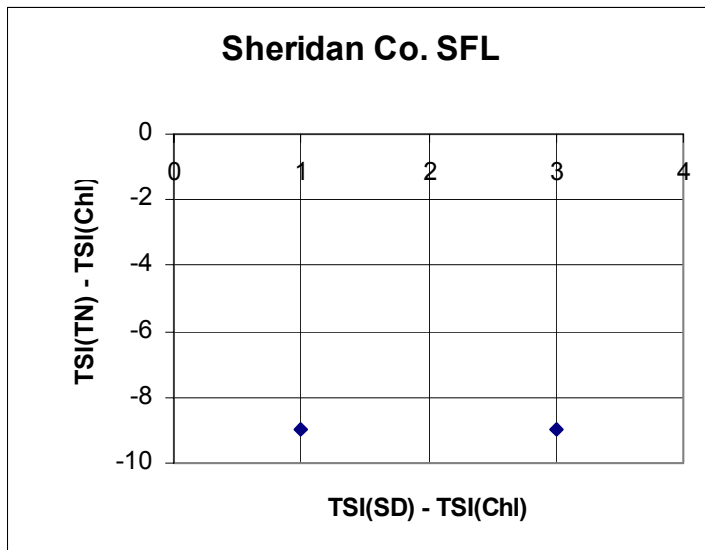
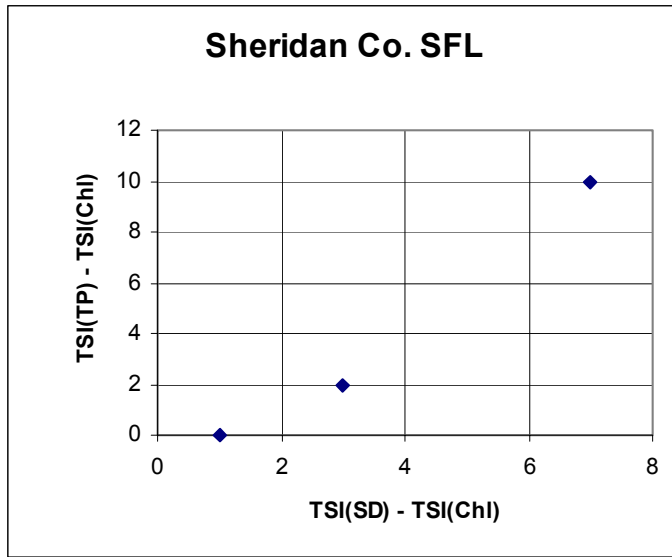
### **Bibliography**

Liscek, Bonnie C. Methodology Used in Kansas Lake TMDLs [web page] Jul. 2001;  
<http://www.kdhe.state.ks.us/tmdl/eutro.htm> [Accessed 30 September 2002].

# Appendix A - Boxplots



## Appendix B - Trophic State Index Plots



The Trophic State Index plots indicate that light is the primary limiting factor, due to clay turbidity. This is inferred by examining the relationship between the TSI(SD) - TSI(Chl) and TSI(TP)-TSI(Chl). The deviation of chlorophyll from the sediment load indicates the degree of light penetration, while the difference between chlorophyll and phosphorus indicates the level of phosphorus limitation. Therefore, if the final plot is in the first quadrant, it shows that the transparency of the water is impaired due to the presence of small particles, and that phosphorus does not limit algae growth. The positive slope of the graph also indicates a correlation between phosphorus and transparency which is found when phosphorus is bound to non algal particles. The relationship between the TSI(SD) - TSI(Chl) and TSI(TN)-TSI(Chl) indicates that nitrogen may be a secondary limiting factor.

**Appendix C - Input for CNET Model**

<b>Parameter</b>	<b>Value Input into CNET Model</b>
<b>Drainage Area (km<sup>2</sup>)</b>	16.3
<b>Precipitation (m/yr)</b>	0.52
<b>Evaporation (m/yr)</b>	1.52
<b>Unit Runoff (m/yr)</b>	0.02
<b>Surface Area (km<sup>2</sup>)</b>	0.14
<b>Mean Depth (m)</b>	2
<b>Depth of Mixed Layer (m)</b>	2.0
<b>Depth of Hypolimnion (m)</b>	0.6
<b>Observed Phosphorus (ppb)</b>	93.3
<b>Observed Chlorophyl-a (ppb)</b>	36.7
<b>Observed Secchi Disc Depth (m)</b>	0.6

**Output from CNET Model**

<b>Parameter</b>	<b>Output from CNET Model</b>
<b>Load Capacity (LC)*</b>	<b>63.8 lb/yr</b>
<b>Waste Load Allocation (WLA)</b>	<b>0 lb/yr</b>
<b>Load Allocation (LA)</b>	<b>57.4 lb/yr</b>
<b>Margin of Safety (MOS)</b>	<b>6.4 lb/yr</b>

\*LC = WLA + LA + MOS

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