MARAIS DES CYGNES BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody Assessment Unit: Bourbon County State Fishing Lake
Water Quality Impairment: Eutrophication bundled with Dissolved Oxygen and pH

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Marmaton **Counties:** Bourbon

HUC 8: 10290104 **HUC 11 (HUC 14):** 010 (020)

Drainage Area: Approximately 11.8 square miles

Conservation Pool: Area = 103 acres
Watershed/Lake Ratio: 61:1
Maximum Depth = 10.0 m
Mean Depth = 3.4 m
Estimated Retention Time = ~0.23 years
Year Constructed: 1957

Designated Uses: Primary Contact Recreation; Expected Aquatic Life Support; Domestic Water Supply; Food Procurement; Industrial Water Supply; Irrigation Use; Livestock Watering Use

2002, 2004, & 2006 303(d) Listing: Marais des Cygnes 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 (K.A.R. 28-16-28e(c)(2)(A)).

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 (K.A.R. 28-16-28e(c)(7)(A)).

The concentration of Dissolved Oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution.

Dissolved Oxygen (DO): 5.0 mg/L (K.A.R. 28-16-28e(d), Table 1g).

The pH range outside the zone of initial dilution: 6.5-8.5 (K.A.R 28-16-28e(d), Table 1g).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Fully Eutrophic, Trophic State Index = 55.93

The Trophic State Index (TSI) is derived from the chlorophyll *a* concentration (Chla). 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 condition is seen with chlorophyll *a* concentrations over 12 ppb and hypereutrophy occurs at levels over 30 ppb. The Carlson TSI derives from the chlorophyll *a* 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

Lake Chemistry Monitoring Sites: Station LM013301 in Bourbon County SFL (Figure 1).

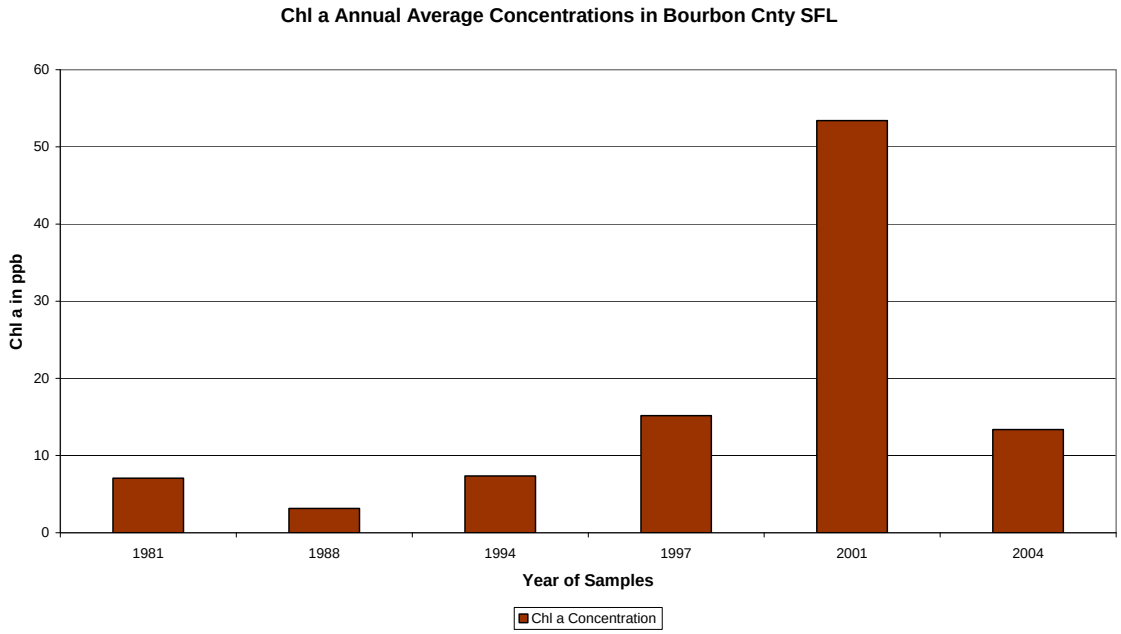
Period of Record Used: Six surveys conducted by KDHE in calendar years 1981, 1988, 1994, 1997, 2001 and 2004.

Stream Flow Record: Marmaton River (USGS Site 06917380, record period from 1980-2005) near the City of Marmaton was used to estimate flow conditions in the regional area of Bourbon County SFL.

Long-Term Hydrologic Conditions: Wolfpen Creek above Bourbon County State Fishing Lake has a median flow of 1.63 cfs and a 10% exceedance flow of 16.0 cfs. The estimated mean streamflow for Wolfpen Creek is 12.3 cfs, however there is essentially no flow in the stream at the 75% exceedance point.

Current Condition: Over the period of record, Bourbon County State Fishing Lake had chlorophyll *a* concentrations averaging 16.57 ppb. Chlorophyll *a* concentrations have significantly increased since 1994, reaching a maximum yearly average in 2001 of 53.4 ppb.

Figure 1. Annual Chlorophyll *a* Averages in Bourbon County SFL.

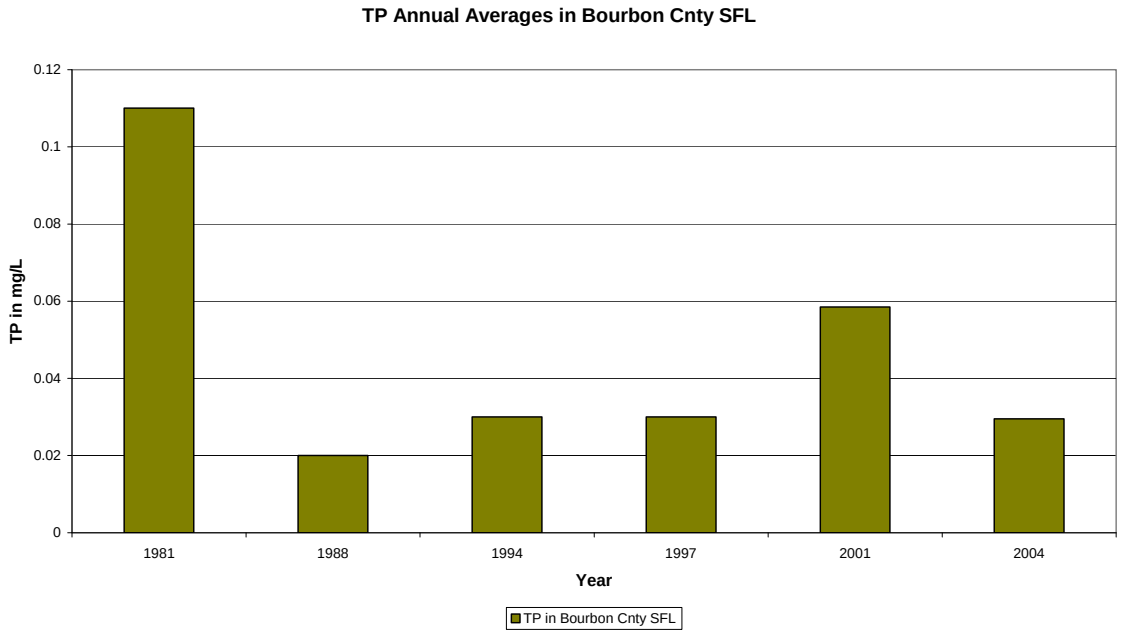


The ratio of total nitrogen and total phosphorus is a common ratio utilized to determine which of these nutrients is likely limiting plant growth in Kansas aquatic ecosystems (Dzialowski et al. 2005). Typically, lakes that are nitrogen limited have a water column TN:TP ratio < 10 (mass); lakes that are co-limited by nitrogen and phosphorus have a TN:TP ratio between 10 and 17; and lakes that are P limited have a water column TN:TP ratio > 17 (Smith, 1998). The total phosphorus concentrations for samples obtained at 0.5 meters or less average 46 ppb over the period of record. The total phosphorus concentrations observed over the period of record have generally been stable since 1988. The total nitrogen average concentration over the period of record is 0.67 mg/L, and is primarily influenced by the Kjeldahl Nitrogen content (average concentration of 0.63 mg/L). As displayed in Table 1, Nitrogen and Phosphorus display co-limiting ratios. However, the average of the yearly ratios indicate phosphorus has a strong influence on algal plant growth and is therefore a greater influence on lake condition rather than total nitrogen concentrations.

Table 1. Average Concentrations for sampling periods in Bourbon County SFL.

Sample Date	**Chl *a* (ppb)**	**TP (mg/L)**	**TN (mg/L)**	**TN:TP Ratio**	**pH**	**Temp C**	**Secchi Depth m**
8/11/81	7.05	0.11			8	27.8	
8/8/88	3.14	0.02			8.38	31	
7/19/94	7.35	0.03	1.17	39	8.17		
6/9/97	15.15	0.03	0.23	7.63	7.82	24	
8/13/01	53.4	0.0585	0.89	15.27	8.69	29.75	0.76
7/26/04	13.35	0.0295	0.39	13.43	7.23	25.75	1.92
All (≤ 0.5m) Data Avg.	**16.57**	**0.046**	**0.67**	**18.79**	**8.06**	**27.63**	**1.34**

Figure 2. Annual Total Phosphorus Averages in Bourbon County SFL.



As observed in Table 2, Bourbon County SFL displays the following described characteristics based on the most recent sampling event. Non-algal turbidity (NAT) values < 4 m^{-1} indicate there are very low levels of suspended silt and /or clay. The light availability in the mixed layer is expressed as Z*NAT in Table 2. The depth of the mixed layer in meters (Z) multiplied by the NAT value indicates there is abundant light within the mixed layer of the lake and potentially a high response by algae to nutrient inputs when this value is <3. The partitioning of light extinction between algae and non-algal turbidity is expressed as Chla*SD (Chlorophyll *a* * secchi depth) in Table 2. Inorganic turbidity is not responsible for light extinction in the water column and there is a strong algal response to changes in nutrient levels when this value is > 16. An index of chlorophyll *a* / total phosphorus was used to evaluate algal use of the phosphorus supply and is displayed and calculated in Table 2 as Chla/TP. There is a limited response by algae to phosphorus if the index values are less than 0.13, suggesting nitrogen, light or other factors may be more important. If values are greater than 0.4, a strong algal response to changes in phosphorus is likely. The current condition of the average chlorophyll *a* concentration and the average total phosphorus concentration within Bourbon County SFL yields an index value of 0.453, where algal response is influenced by variations in the phosphorus concentrations. However, the average condition over the period of record yields a value of 0.36, indicating a moderate response by algae to phosphorus levels. The light availability in the mixed layer for a given surface light is represented as Z/SD. Values <3 indicate that light availability is high in the mixed zone and there is a high probability of strong algal responses to changes in nutrient levels. The "shading" column in Table 2 represents the shading in the water column due to algae and inorganic turbidity and is calculated by multiplying the mean lake depth (in meters) by the calculated light attenuation coefficient (derived from secchi depth and chlorophyll *a* data). Values < 16 indicate that self-shading of algae does not significantly impede

productivity. It must be noted that the shading metric is most applicable to lakes with maximum depths of less than 5 meters. (Scheffer, 1998).

Table 2. Limiting factor determinations for Bourbon County SFL surveyed during 2004. NAT= non-algal turbidity, TN/TP = nitrogen-to-phosphorus ratio, Z= depth of mixed layer, Chla = chlorophyll-a, and SD= Secchi depth. Shading = calculated light attenuation coefficient times mean lake depth (Carney, 2004).

Period	TN/TP	NAT	Z*NAT	Chla*SD	Chla/TP	Z/SD	Shading	Factor
Current-2004	13.43	0.187	0.622	25.63	0.453	1.732	4.20	P>N
All Data	18.79	0.332	1.12	22.20	0.360	2.54		P>N

Figure 3. Multivariate TSI comparison chart of Bourbon County SFL for 2001 and 2004.

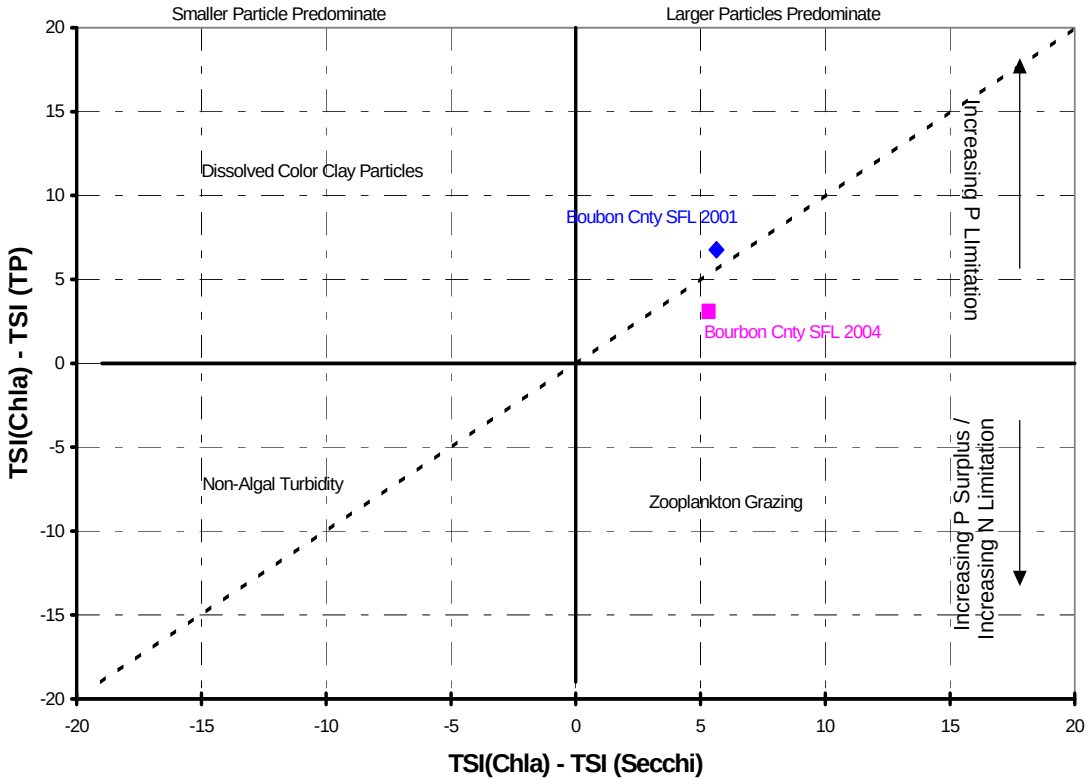


Figure 3 summarizes the current trophic conditions at Bourbon County SFL using a multivariate TSI comparison chart for data obtained in 2001 and 2004. These were the only two years secchi depths were obtained. Points above TSI(Chla) – TSI(TP), where

TSI(Chla) is greater than TSI(TP), indicate situations where phosphorus is limiting chlorophyll *a*, points below would conclude the opposite. TSI(Chla) – TSI(SD) is plotted on the horizontal axis, showing that if the Secchi depth (SD) trophic index is greater than the chlorophyll *a* trophic index, than large organic materials dominate by zooplankton grazing. Transparency would be dominated by non-algal factors such as color or inorganic turbidity if the Secchi depth index were less than the chlorophyll *a* index. Points near the diagonal line occur in turbid situations where phosphorus is bound to clay particles and therefore turbidity values are closely associated with phosphorus concentrations. For the years plotted in Figure 3, Bourbon County SFL is clear and primarily limited by phosphorus. According to the 2004 KDHE Lake and Wetland Monitoring Program Annual Report, the algal communities in Bourbon County SFL comprise of 51% blue-green algae, 36% green algae, and 13% diatoms based on the percent composition of the total cell count.

Water quality standard violations for both dissolved oxygen (DO) and pH were observed only in 2001. DO concentrations over the period of record are summarized in **Table 3**, **Figure 4,** and **Figure 5**. The 2001 detections are responsible for the DO and pH listings for this lake. The DO violations were detected at the 2 and 3-meter deep sampling points. DO concentrations were significantly higher during this same sampling event at depths of 1 meter or less. In 2001, the observed chlorophyll *a* concentration was highest over the period of record and the nutrient concentrations were all greater than the average conditions for the lake. These conditions influenced the pH and DO concentrations within the lake at that time. Increasing algal communities within a lake will lead to decreasing DO concentrations as the production of organic matter is consumed by bacteria, and will additionally cause the pH levels to rise through photosynthesis. Algal communities can be reduced through nutrient reduction. The most current data collected in 2004 had the lowest overall DO average for all samples collected at 3 meters and less.

Figure 4. Dissolved Oxygen average concentrations in Bourbon County SFL.

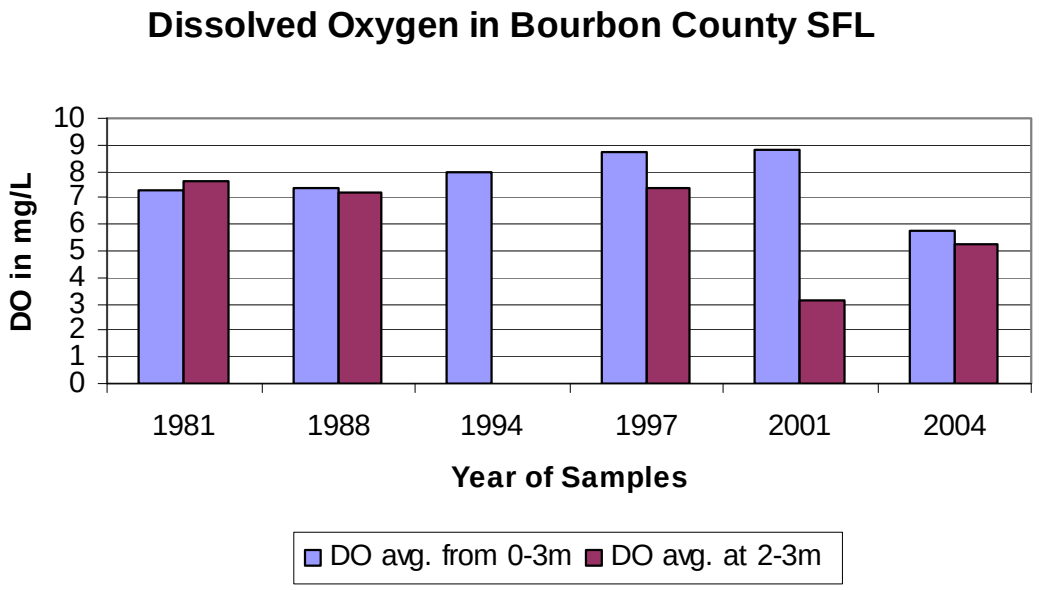


Table 3. Dissolved Oxygen Samples (mg/L) by Depth in Bourbon County SFL

Date	0.0 m	~ 0.5 m	~ 1.0 m	~ 2.0 m	~ 3.0 m	All 0-3.0m Avg.
8/11/81	7.2		7.2 (0.9m)	7 (1.8m)	7.6 (2.7m)	7.25
8/8/88	7.5	7.4	7.4	7.2	7.2	7.34
7/19/94	8					8
6/9/97	9.8	9.7	9.5	8.9	5.8	8.74
8/13/01	12.8	13	12	4.5	1.7	8.8
7/26/04	6.6	6.3	5.6	5.3	5.2	5.8
Average	**8.65**	**9.1**	**8.34**	**6.58**	**5.5**	**7.66**

Figure 5. Dissolved Oxygen Concentrations for each sample at Bourbon Country SFL.

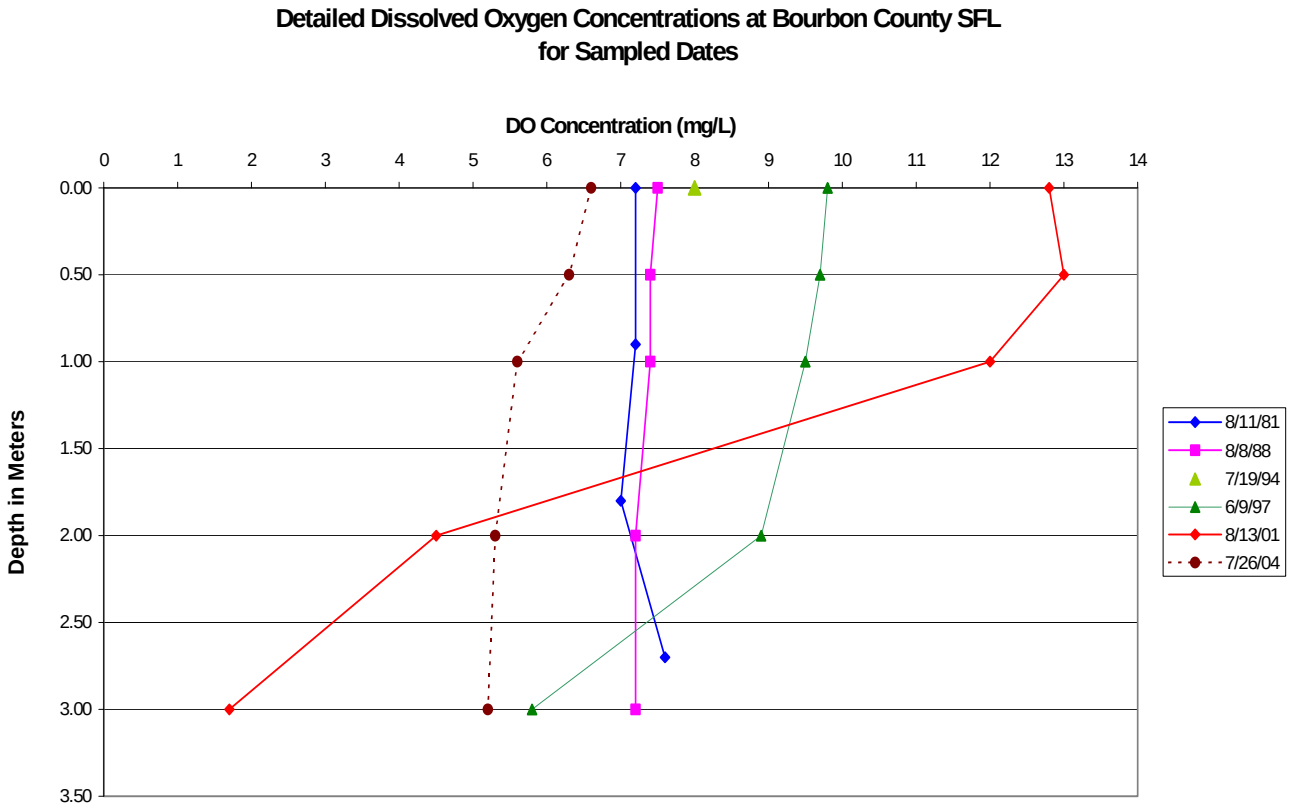
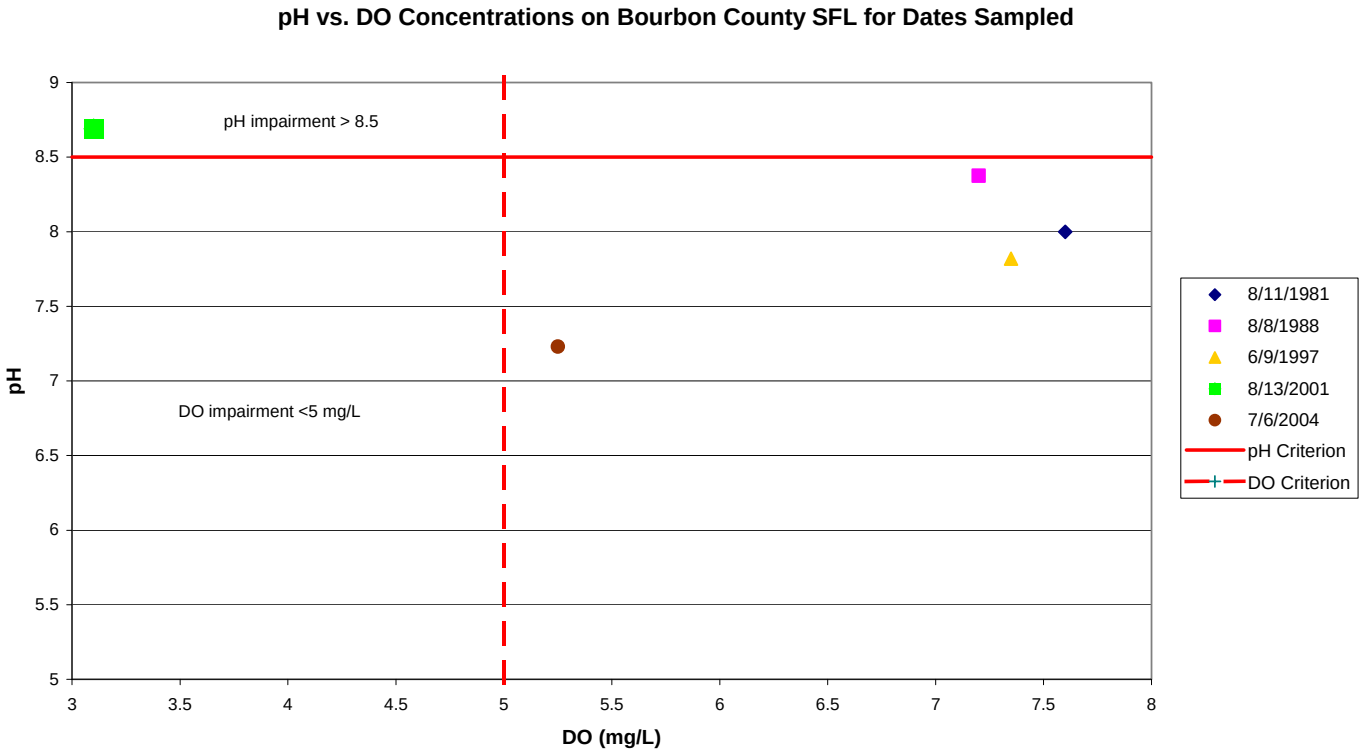


Figure 6. pH vs Dissolved Oxygen Average Concentrations at 2-3m for dates sampled.



Regional Precipitation: Average annual rainfall totals for Chanute, KS are approximately 40 inches per year. Daily rainfall data for the sampling years of 1997, 2001, and 2004 indicates the year of 2001 was the driest of the three years. Rainfall amounts for the 45-day period prior to the sampling date indicates that 2001 also received the least amount of days of rain during this period, with one of those days accounting for the largest rainfall event within the 45-day period for the three years of data (**Table 4**). This suggests that water levels in the region were low in 2001, and a significant runoff event occurred during the 45-day period prior the lake being sampled.

Table 4. Summary of Rainfall Data from the Chanute Weather Station for a 45-day period prior to the sampling date.

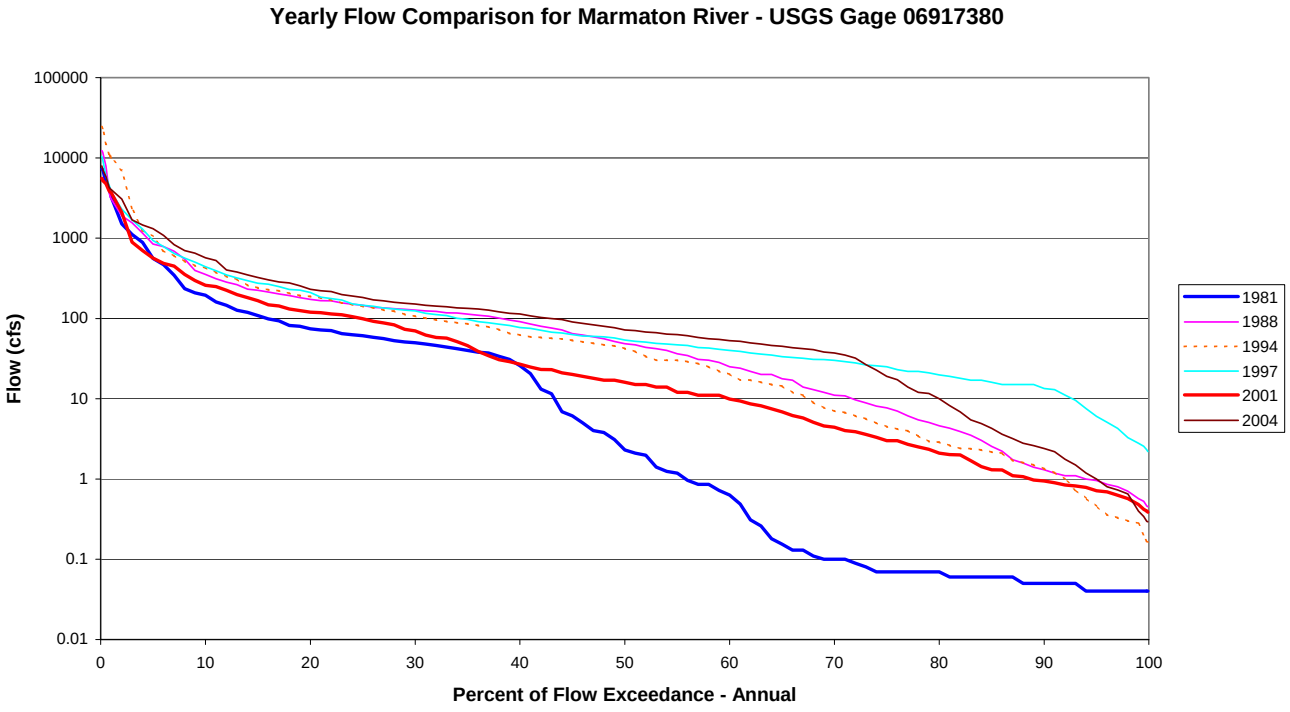
Sampling Date	45-Day Rainfall Total (inches)	Number of Days Rain recorded in the 45-Days	Maximum 24 Hour Rainfall (inches) during 45-Day Period
June 9, 1997	3.76	15	0.77
August 13, 2001	3.63	9	1.85
July 26, 2004	9.99	24	1.56

Regional Stream Flow: Stream flow records along the Marmaton River were examined to further evaluate the hydrological conditions of the regional area of Bourbon County SFL. As indicated in **Figure 7**, flow values in 2001 were significantly less than flow values for other sampling years, with the exception of data from 1981. The median flow condition in 2001 was 16 cfs at USGS gaging station 06917380 (**Table 5**). Streamflow data from 2001 also identifies a significant runoff event during the 45-day period prior the lake being sampled. The runoff event yielded a recorded daily flow average of 2,260 cfs on July 27, 2001, where flows progressively dissipated to a daily flow average of 3.6 cfs on August 13, 2001. Data from 1981 indicates there were 161 days of the year that the Marmaton River had flows less than 1 cfs, with the majority of these occurring during the colder months. The data from 1981 generally implies that it was an extremely dry year.

Table 5. Selected annual flow conditions on the Marmaton River at USGS Gaging Station 06917380 for years Bourbon County SFL was sampled.

Sample Year	Annual Flow Avg. (cfs)	Median Flow (cfs)
1981	154	2.3
1988	255	48.5
1994	451	42
1997	260	54
2001	168	16
2004	287	72

Figure 7. Annual Flow comparisons for Marmaton River near Marmaton, KS.



Fish Population: Bourbon County SFL offers sport fishing opportunities throughout the year. According to the Kansas Department of Wildlife and Parks fish survey, the number of adult fish Captured Per Unit time Effort (CPUE) shows that sight-feeding bass have been generally increasing since 1991. In the past couple of years, the bluegill population has steadily increased as well. Crappie and walleye populations have remained fairly steady over the period of record as indicated in **Figure 8**. Bottom-feeding fish tend to fluctuate between years with good gizzard shad populations for years with less populated channel catfish, and the opposite with some years having strong channel catfish populations and much lower gizzard shad populations. The Kansas Department of Wildlife and Parks notes that levels in the lake have been lowered for fish management on occasion.

Figure 8. Number of sight-feeding fish Captured per Unit Time Effort (CPUE) by the Kansas Department of Wildlife Parks.

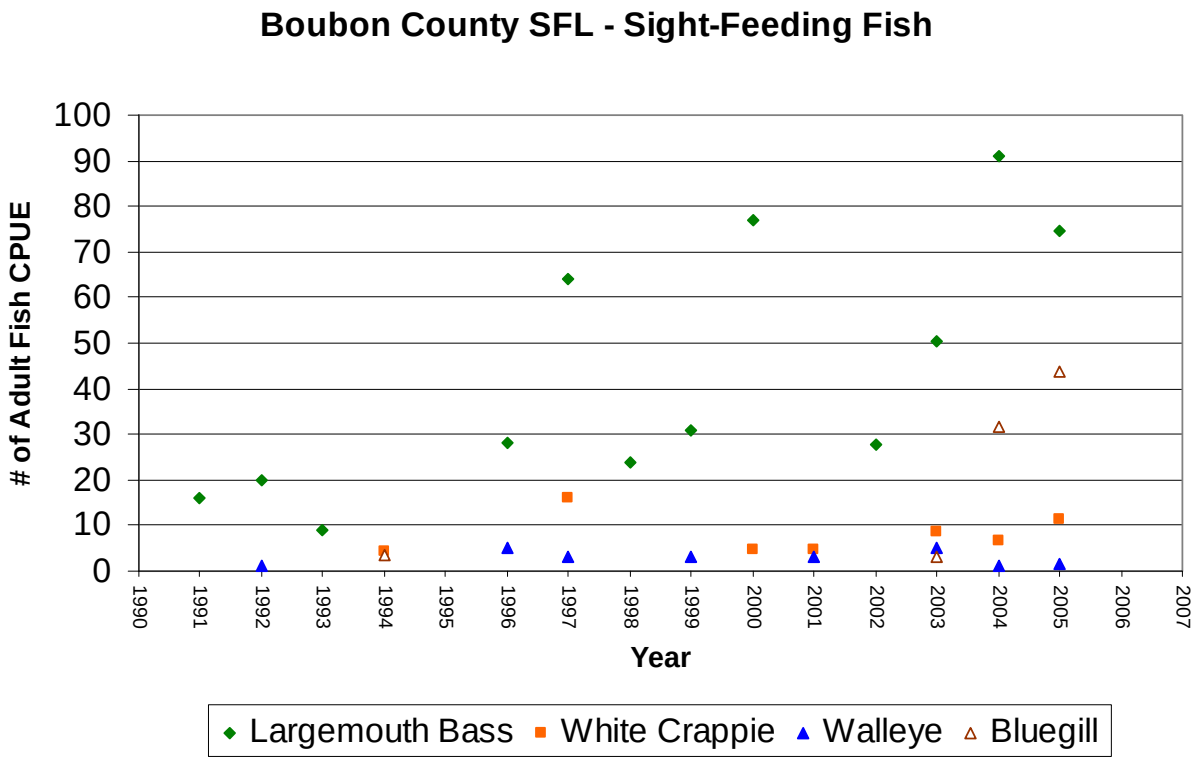
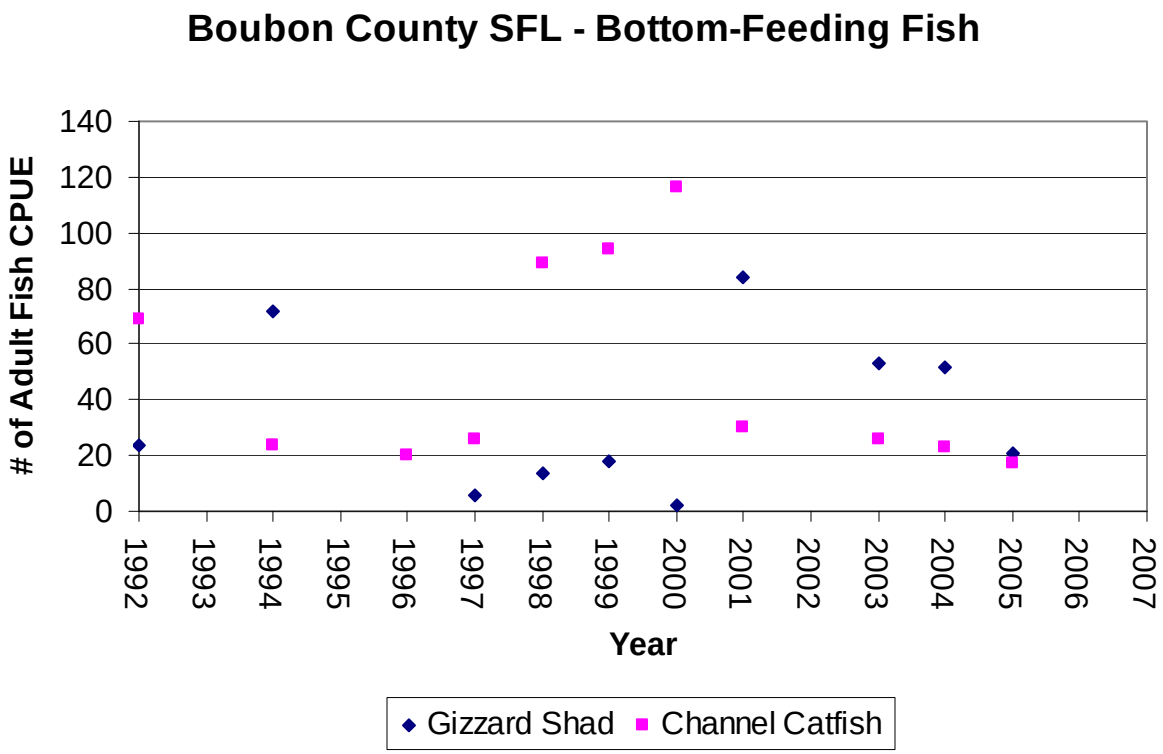


Figure 9. Number of bottom-feeding fish Captured per Unit Time Effort (CPUE) by the Kansas Department of Wildlife and Parks.



Interim Endpoints of Water Quality (Implied Load Capacity) at Bourbon County SFL:

In order to improve the trophic condition of the lake from its current Fully Eutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* concentrations below 12 µg/L, with the initial reductions focused on phosphorus loadings to the lake. Achievement of this endpoint should also result in pH values between 6.5 and 8.5 and dissolved oxygen concentrations above 5 mg/L. Improving the trophic condition of the lake should resolve the pH and DO impairment since this impairment was observed in 2001 when the chlorophyll *a* concentration within the lake was at its maximum observed concentration through the sampling years and the nutrient concentrations (TP & TN) were above their average concentrations. The reduction of chlorophyll *a* will lower photosynthesis rates within Bourbon County Lake. Higher photosynthesis rates cause pH levels to rise over 8.5 and lowers production of organic matter that consumes oxygen at lower depths of the lake.

Based on the CNET reservoir eutrophication model (see Appendix A), the total phosphorus concentrations must be reduced by 30% to achieve a phosphorus load reduction of 30%.

Table 6. Current Conditions and Reductions for Bourbon County SFL

Parameter	**Current Condition**	**TMDL**	**Percent Reduction**
Total Phosphorus Annual Load (lb/year)	6093	4244	30%
Total Phosphorus Daily Load (lbs/day)*	56.3	39.3	30%
Total Phosphorus Concentration (µg/L)	46	32.2	30%
Chlorophyll a (µg/L)	16.57	< 12	28%
Dissolved Oxygen (mg/L)	5.8	> 5.0	0%
pH	8.06	6.5 - 8.5	0%

* - See Appendix B for Daily Load Calculation

3. SOURCE INVENTORY AND ASSESSMENT

Land Use: The predominant land cover in the watershed around Bourbon County SFL includes grasslands, pasture, and hay, of which 60% is Tallgrass Prairie and 30% comprises pasture and hay. Based on land cover, there is a moderate potential for nonpoint source pollutants.

There is not any permitted or registered confined animal feeding operations (CAFOs) located within the watershed. Smaller animal feeding operations with less than 300 animal units may be operating within the watershed. Animal waste from any facility with livestock may add to the phosphorus load going into Bourbon County SFL. According to the 2005-2006 Kansas Agricultural Farm Facts, there are 30,300 and 59,300 head of cattle in Allen and Bourbon Counties respectively.

A secondary source of phosphorus within the Bourbon County SFL watershed may be attributed to fertilizer or manure application to the agricultural lands within the watershed. Though there is only approximately 1% of the land cover in cultivated crops according to the land use coverage assessment of the watershed, there will be some variability between other crops being planted in future years where pasture and hay are indicated on the map (see **Figure 10**).

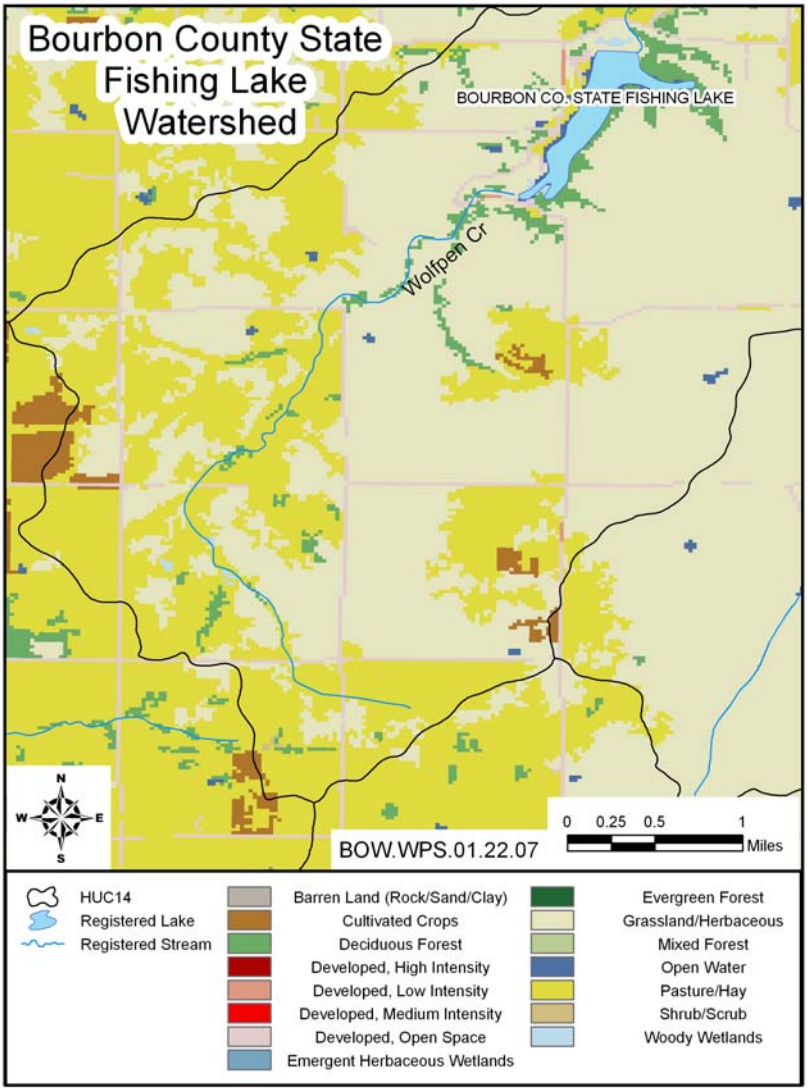
Because this is a rural agricultural area, it can be assumed that all of the farmhouses in the watershed are not connected to public sewer systems. Failing on-site septic systems may contribute significant nutrient loadings and aggravate eutrophication problems. According to the 1990 census, there are 2,430 septic systems in Bourbon County and 1,492 septic systems in Allen County. According to the KDHE Lake surveying team, there are several residences located just west of the lake, however these are not directly next to the lake and the potential that they may have failing septic systems is presumably low since it was noted that these appeared to be constructed more recently.

NPDES: There are no NPDES permitted facilities within the watershed.

Contributing Runoff: The watershed of Bourbon County SFL has a mean soil permeability value of 0.81 inches/hour, ranging from 0.01 inches/hour to 1.29 inches/hour according to NRCS STATSGO database. About 79% of the watershed has a permeability value less than 1.14 inches/hour, of which 24% has a value less than 0.57 inches/hour, which contributes to runoff during very low rainfall intensity events. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced.

Background: Deciduous forest comprises about 3% of the land cover in the watershed; leaf litter and wastes derived from natural wildlife may add to the nutrient load. Atmospheric and geological formations (i.e. soil and bedrock) may also contribute to the nutrient loads. Fish feeding stations add an insignificant amount of nutrients to the load.

Figure 10. Land Use Cover and watershed boundary for Bourbon County SFL.



4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Phosphorus and Nitrogen are co-limiting nutrients in Bourbon County SFL, however phosphorus is predominately limiting and is therefore allocated under this TMDL. The general inventory of sources within the drainage area of the lake indicates load reductions should be focused on nonpoint source runoff contributions attributed to smaller livestock facilities and fertilizer applicators.

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 sources be proposed in the watershed and discharge into the impaired segments, the current wasteload

allocations 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 predominantly due to nonpoint source pollutants. Background levels may be attributed to nutrient recycling and leaf litter. The assessment suggests that runoff transporting nutrient loads associated with animal wastes and cultivated crops where fertilizer has been applied, to include pasture and hay, contribute to the elevated phosphorus concentrations in the lake. The Kansas Department of Wildlife and Parks lowers the levels of the lake on occasion for fishery management purposes. The lowering of the lake may add to the fluctuations in dissolved oxygen and pH observed in the lake. A Load Allocation of 3,820 lbs/year of total phosphorus, accounting for a 37% reduction, is necessary to reach the TMDL endpoint. The daily load allocation is calculated in Appendix B and is 35.4 lbs/day of total phosphorus.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus loads and the chlorophyll *a* endpoint. Therefore, the margin of safety will be 10% of the original calculated total phosphorus load allocation, which has been subtracted from the assigned load allocation to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety is 424 lbs/year of total phosphorus.

State Water Plan Implementation Priority: This TMDL will be a Medium Priority for implementation.

Unified Watershed Assessment Priority Ranking: The Bourbon County SFL watershed lies within the Marmaton River Subbasin (HUC 8: 10290104) with a priority ranking of 17 (High Priority for restoration work).

Priority HUC 11s: The HUC 11 encompasses the entire watershed and thus should take priority.

5. IMPLEMENTATION

Desired Implementation Activities:
There is a very good potential that agricultural best management practices will improve the condition of Bourbon County SFL. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cultivated cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams and drainage channels in the watershed.

4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure land applications and runoff potential.
6. Adequately manage fertilizer utilization in the watershed and implement runoff control measures.

Implementation Program Guidance:

Fisheries Management – KDWP

1. Assist evaluation in-lake or near-lake potential sources of nutrients to lakes.
2. Apply 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 the establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management for livestock facilities in the watershed.
d. Guide federal programs such as the Environmental Quality Improvement Program, which are dedicated to priority subbasins through the Unified Watershed Assessment, to priority watersheds and stream segments within those subbasins identified by this TMDL.
e. Assess conditions and evaluate implementation priority through the Marais des Cygnes Basin WRAPS in 2012.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.
c. Provide sediment control practices to minimize erosion and sediment and nutrient transport.
d. Re-evaluate nonpoint source pollution control methods.

Riparian Protection Program – SCC

a. Establish, protect or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects

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

Time Frame for Implementation: Continued monitoring over the years from 2008-2012.

Targeted Participants: Primary participants for implementation will be agricultural producers who are within the drainage of the lake and the Kansas Department of Wildlife and Parks. A detailed assessment of sources conducted over 2008-2012 should include local assessments by conservation district personnel and county extension agents to survey, locate, and assess the following within the lake drainage area:

1. Total row crop acreage
2. Cultivation alongside lake
3. Livestock use of riparian areas
4. Fields with manure applications

Milestone for 2012: The year 2012 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from Bourbon County SFL will be reexamined to confirm the impaired status of the lake. Should the case of impairment remain, source assessment, allocation, and implementation activities will ensue.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Wildlife and Parks. The Kansas State University Extension Service will deliver producer outreach and awareness.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants and to assure allocations of pollutants to point and nonpoint sources can be attained.

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*, including selected Watershed Restoration and Protection Strategies.

6. The *Kansas Water Plan* and the Marais des Cygnes 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 Low Priority consideration for funding.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities. The key to

success will be widespread utilization of conservation farming and proper livestock waste management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue sampling Bourbon County SFL once every three or four years in order to assess the impairment that drives this TMDL. Based on the sampling results, the priority status of 303(d) listing will be evaluated in 2012. Should impairment status be verified, the desired endpoints under this TMDL will be refined and call for more intensive sampling to be conducted over the period 2013-2017 to assess progress in this TMDL's implementation.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Marais des Cygnes Basin have been held since 2001. An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs in the Marais des Cygnes Basin and these specific TMDLs.

Public Hearing: A Public Hearing on these Marais des Cygnes Basin TMDLs was held in Ft. Scott on May 31, 2007.

Basin Advisory Committee: The Marais des Cygnes Basin Advisory Committee met to discuss these TMDLs on June 22, 2006 in Pomona, November 29, 2006 in Williamsburg, December 18, 2006 in Ft. Scott, January 30, 2007 in Ottawa, March 13, 2007 in Ft. Scott and May 17, 2007 in Ottawa.

Milestone Evaluation: In 2012, evaluation will be made as to implementation of management practices to minimize the nonpoint source runoff contributing to this impairment. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2012.

Consideration for 303d Delisting: Bourbon County SFL will be evaluated for delisting under Section 303d, based on the monitoring data over 2008-2015. Therefore, the decision for delisting will come about in the preparation of the 2016 303d list. Should modifications be made to the applicable water quality criteria during the 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 would come in 2007, 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 the *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2008-2015.

Revised November 26, 2007

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Appendix A – CNET Eutrophication Model for Bourbon County SFL.

Input for CNET Model

Parameter	**Value Input into CNET Model**
Drainage Area (km^2)	30.56
Precipitation (m/yr)	1.03
Evaporation (m/yr)	1.23
Unit Runoff (m/yr)	0.25
Surface Area (km^2)	0.417
Mean Depth (m)	10.0
Depth of Mixed Layer (m)	3.39
Depth of Hypolimnion (m)	1.35
Observed Phosphorus (ppb)	46
Observed Chlorophyl *a* (ppb)	16.57
Observed Secchi Disc Depth	1.34

Output from CNET Model

Parameter	**Output from CNET Model**
Load Capacity (LC)*	4244 lbs/year
Waste Load Allocations (WLA)	0 lbs/year
Atmospheric Air Deposition (LA)	38 lbs/ year
Other Nonpoint (LA)	3782 lbs/year
Total Load Allocation (LA)	3820 lbs/year
Margin of Safety (MOS)	424 lbs/year

* - LC=WLA + LA + MOS

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE -> **Bourbon County SFL** Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...		Latitude	37
Drainage Area	km2	30.56	30.56
Precipitation	m/yr	1.03	1.03
Evaporation	m/yr	1.23	1.23
Unit Runoff	m/yr	0.25	0.25
Stream Total P Conc.	ppb	360	250
Stream Ortho P Conc.	ppb	0	0
Atmospheric Total P Load	kg/km2-yr	46	46
Atmospheric Ortho P Load	kg/km2-yr	0	0
POINT SOURCE CHARACTERISTICS...			
Flow	hm3/yr	0	0.0
Total P Conc	ppb	0	0.0
Ortho P Conc	ppb	0	0
RESERVOIR CHARACTERISTICS...			
Surface Area	km2	0.417	0.417
Max Depth	m	10	10
Mean Depth	m	3.4	3.4
Non-Algal Turbidity	1/m	0.33	0.33
Mean Depth of Mixed Layer	m	3.39	3.39
Mean Depth of Hypolimnion	m	1.35	1.35
Observed Phosphorus	ppb	46	46.0
Observed Chl-a	ppb	16.57	16.6
Observed Secchi	meters	1.34	1.34
MODEL PARAMETERS...			
BATHTUB Total P Model Number	(1-8)	1	1
BATHTUB Total P Model Name		AVAIL P	
BATHTUB Chl-a Model Number	(2,4,5)	2	2
BATHTUB Chl-a Model Name		P L Q	
Beta = 1/S vs. C Slope	m2/mg	0.045037	0.045037
P Decay Calibration (normally =1)		1	1
Chlorophyll-a Calib (normally = 1)		1	1
Chla Temporal Coef. of Var.		0.35	0.35
Chla Nuisance Criterion	ppb	12	12
WATER BALANCE...			
Precipitation Flow	hm3/yr	0.43	0.43
NonPoint Flow	hm3/yr	7.64	7.64
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	8.07	8.07
Evaporation	hm3/yr	0.51	0.51
Outflow	hm3/yr	7.56	7.56

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	10	10
NonPoint Load	kg/yr	633	439
Point Load	kg/yr	0	0
Total Load	kg/yr	642	449
Sedimentation	kg/yr	294	178
Outflow	kg/yr	348	271
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.458	0.397
Mean Phosphorus	ppb	46.0	35.8
Mean Chlorophyll-a	ppb	13.9	11.8
Algal Nuisance Frequency	%	59.7	40.8
Mean Secchi Depth	meters	1.05	1.16
Hypol. Oxygen Depletion A	mg/m2-d	894.7	823.2
Hypol. Oxygen Depletion V	mg/m3-d	662.8	609.8
Organic Nitrogen	ppb	498.7	450.1
Non Ortho Phosphorus	ppb	28.5	24.7
Chl-a x Secchi	mg/m2	14.5	13.7
Principal Component 1	-	2.50	2.39
Principal Component 2	-	0.92	0.90

	Observed	Pred	Target
Carlson TSI P	59.4	59.4	55.8
Carlson TSI Chl-a	58.2	56.4	54.8
Carlson TSI Secchi	55.8	59.4	57.8

OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	1.28
Chlorophyll-a		1.19	1.41
Secchi		1.28	1.15
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		0.00	0.92
Chlorophyll-a		0.65	1.26
Secchi		0.91	0.52

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	1.4178	1.4178
Residence Time	yrs	0.1876	0.1876
Overflow Rate	m/yr	18.1	18.1
Total P Availability Factor		1	1
Ortho P Availability Factor		1.93	1.93
Inflow Ortho P/Total P		0.000	0.000
Inflow P Conc	ppb	85.0	59.4
P Reaction Rate - Mods		1.6	1.1
P Reaction Rate - Model 2		#DIV/0!	#DIV/0!
P Reaction Rate - Model 3		1.6	1.1
1-Rp Model 1 - Avail P		0.542	0.603
1-Rp Model 2 - Decay Rate		#DIV/0!	#DIV/0!
1-Rp Model 3 - 2nd Order Fixed		0.538	0.599
1-Rp Model 4 - Canfield & Bach		0.568	0.619
1-Rp Model 5 - Vollenweider 19		0.698	0.698
1-Rp Model 6 - First Order Dec		0.842	0.842
1-Rp Model 7 - First Order Set		0.948	0.948
1-Rp Model 8 - 2nd Order Tp Or		0.542	0.603
1-Rp - Used		0.542	0.603
Reservoir P Conc	ppb	46.0	35.8
Gp		0.720	0.720
Bp	ppb	38.9	27.6
Chla vs. P, Turb, Flush	2	13.9	11.8
Chla vs. P Linear	4	12.9	10.0
Chla vs. P 1.46	5	21.7	15.0
Chla Used	ppb	13.9	11.8
m1 - Nuisance Freq Calc.		2.6	2.4
z		-0.245	0.232
v		0.387	0.388
w		0.925	0.928
x		0.403	0.408

ORTHO P LOADS...			
Precipitation	kg/yr	0	0
NonPoint	kg/yr	0	0
Point	kg/yr	0	0
Total	kg/yr	0	0
Total	#/year	0	0

TOTAL P LOADS...			
BAF Override (KS)	OrP %		
0.5	0%	19	19
0.23	0%	2750	1910
0.8	0%	0	0
		2770	1929
		6093	4244

Appendix B – Conversion to Daily Loads as Regulated by EPA Region VII

The TMDL has estimated annual average loads for TN and TP that if achieved should meet the water quality targets. A recent court decision often referred to as the "Anacostia decision" has dictated that TMDLs include a "daily" load (Friend of the Earth, Inc v. EPA, et al.).

Expressing this TMDL in daily time steps could be misleading to imply a daily response to a daily load. It is important to recognize that the growing season mean chlorophyll *a* is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response.

To translate long term averages to maximum daily load values, EPA Region 7 has suggested the approach describe in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001)(TSD).

Maximum Daily Load (MDL) = (Long-Term Average Load) * $e^{[Z\sigma-0.5\sigma^2]}$

where $\sigma^2 = \ln(CV^2+1)$

CV = Coefficient of variation = Standard Deviation / Mean

Z = 2.326 for 99th percentile probability basis

LTA= Long Term Average
LA= Load Allocation
MOS= Margin of Safety

Parameter	LTA	CV	$e^{[Z\sigma-0.5\sigma^2]}$	MDL	LA	MOS (10%)
TP	4244 lbs/yr	0.66	3.37	39.3 lbs/day	35.4 lbs/day	3.9 lbs/day

Maximum Daily Load Calculation

Annual TP Load = 4244 lbs/yr

Maximum Daily TP Load = $[(4244 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.6013)-0.5*(0.6013)^2]}$
= 39.3 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TP MOS = 424 lbs/yr

Daily TP MOS = $[(424 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.6013)-0.5*(0.6013)^2]}$
= 3.92 lbs/day

Source- *Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001)*