MISSOURI RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody Assessment Unit: Atchison County State Fishing Lake
Water Quality Impairment: Eutrophication bundled with pH

This TMDL serves as a revision for the Eutrophication portion of the existing Atchison County SFL Eutrophication/ Dissolved Oxygen / Aquatic Plants TMDL approved by EPA on August 28, 2001

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Independence-Sugar **County**: Atchison

HUC 8: 10240011 **HUC10** (HUC12): 02 (02)

Drainage Area: Approximately 3.41 square miles.

Conservation Pool: Surface Area = 75.5 acres
Watershed Ratio = 30:1
Maximum Depth = 10.0 meters
Mean Depth = 3.4 meters
Storage Volume = 746.8 acre-feet
Estimated Retention Time = 0.72 years
Mean Annual Precipitation = 33.3 inches
Mean Annual Evaporation = 44.0 inches
Annual Outflow = 1044 acre-feet

Ecoregion: Western Corn Belt Plains, Nebraska/Kansas Loess Hills (47h)

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

303(d) Listings: Atchison County State Fishing Lake pH: 2002, 2004, 2008, 2010, and 2012 Missouri River Basin Lakes. Eutrophication TMDL initially approved on August 28, 2001.

Impaired Use: All uses in Atchison County State Fishing Lake are impaired to a degree by eutrophication.

Water Quality Criteria: 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)(A)).

The introduction of plant nutrients into surface waters designated for domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(c)(3)(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 (KAR 28-16-28e(c)(7)(A)).

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

Figure 1. Atchison County State Fishing Lake base map. The watershed is delineated with the heavy black line and 10 foot contour lines are shown withn the watershed. (Image source: National Agricultural Imaging Program 2005 aerial photograph of the region)

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Hypereutrophic, Trophic Sate Index = 66.45 (1981-2011)
Hypereutrophic, Trophic State Index = 77.83 (2011)

The Trophic State Index (TSI) is derived from the chlorophyll *a* concentration. Trophic state assessments of potential alagal 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 12 ppb and hyperuetrophy 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 LM012601 in Atchison State Fishing Lake (Figure 1).

Period of Record Used: Seven surveys conducted by KDHE in calendar years 1981, 1987, 1997, 2001, 2004, 2008, and 2011.

Current Condition: Over the period of record, Atchison County SFL has a chlorophyll *a* concentration average of 50.57 µg/L, with a corresponding Trophic State Index (TSI) of 66.45. Chlorphyll *a* concentrations were measured in samples taken during a single sampling event in the summers of 1981, 1987, 1997, 2001, 2004, 2008, and 2011. As indicated in Figure 2, chlorophyll *a* concentrations range from a low of 13.7 µg/L in 1997 to a high of 123.7 µg/L in 2011 and have increased sharply the past decade.

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 phosphorus 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 66 µg/L for the sampling years of 1997, 2001, 2004, 2008, and 2011. The total phosphorus concentrations have steadily increased over these years. The total nitrogen concentration average for these same sampling years is 1.52 mg/L, and is primarily influence by the Kjeldahl Nitrogen content. With the exception of the 2001 sampling event, the lake is phosphorus limited and phosphorus has a strong influence on algal plant growth and lake condition rather than total nitrogen concentrations.

Table 1. Average Concentrations for sampling events in Atchison County SFL.

Sample Date	Chl a (µg/L)	TP (mg/L)	TN (mg/L)	TN:TP Ratio	Field pH	Temp (C)	Secchi Depth (m)
5/20/1981	16.55					15.2	
8/3/1987	44.05				8.15	33.5	
7/9/1997	13.7	0.0300	0.6565	21.88	8.2	28.5	1.20
7/9/2001	25.55	0.0595	0.2375	4.00	8.75	31.5	1.03
8/2/2004	56.55	0.0600	1.5125	25.21	8.72	28.5	0.91
6/30/2008	73.9	0.0635	1.6855	26.54	8.35	26	0.82
8/2/2011	123.71	0.1170	3.5180	30.01	9.16	32	0.49
Average	50.57	0.066	1.52	21.54	8.55	27.9	0.89

As seen in Table 1, water quality violations for pH with values greater than 8.5 were observed in 2001, 2004, and 2011. Chlorophyll *a* and nutrient concentrations were high during these years and likely influenced the pH within the lake as increasing algal communities commonly lead to an increase in the level of pH due to photosynthesis. Algal communities can be reduced through nutrient reduction leading to pH concentrations that fall within the water quality standard of 6.5 to 8.5.

Figure 2. Chlorophyll *a* concentrations in Atchison County SFL over the period of record.

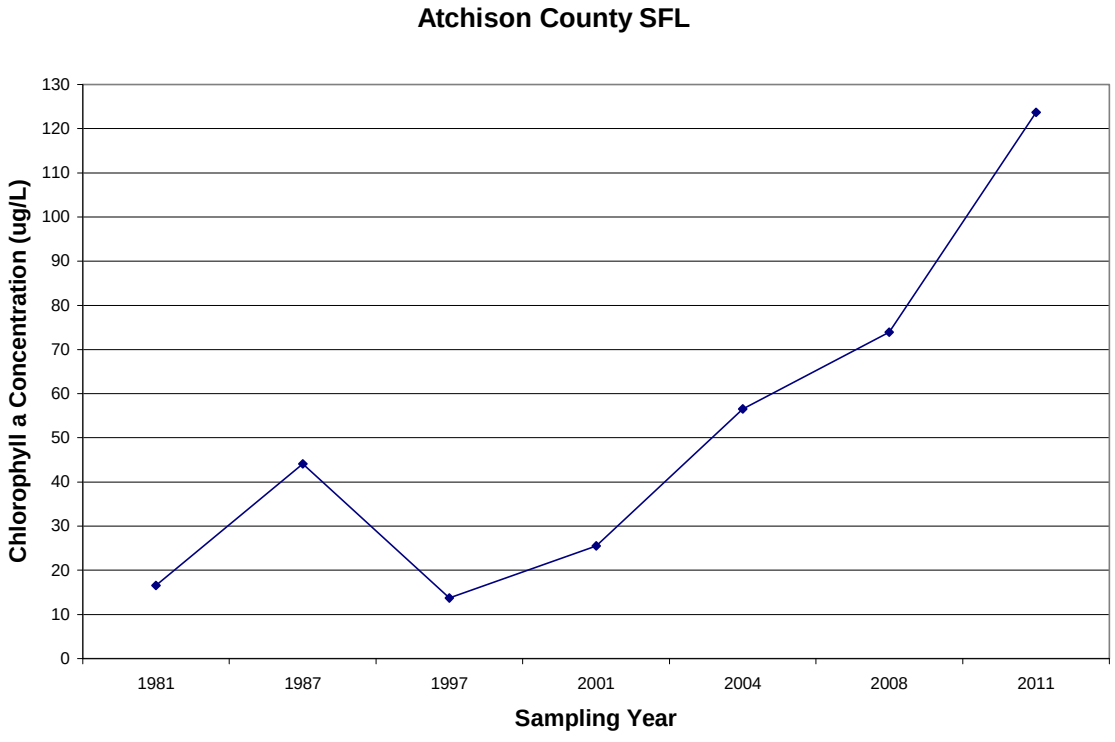


Figure 3. Total Phosphorus Concentrations from 1997-2011 in Atchison County SFL.

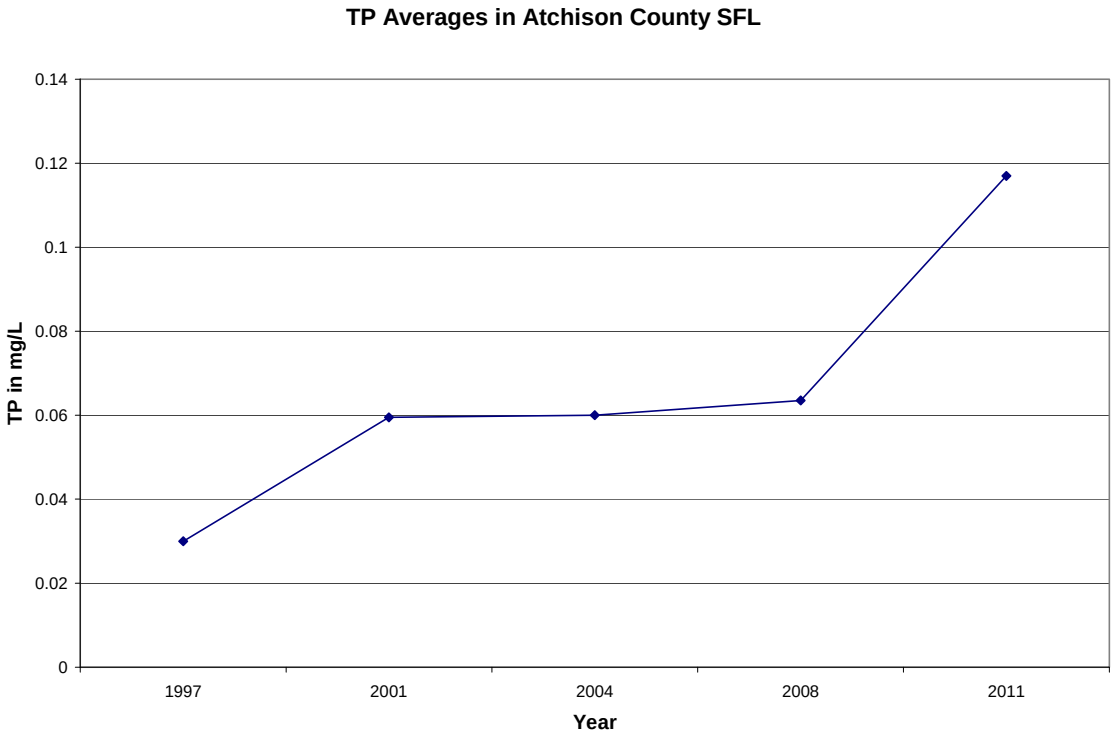


Figure 4. Field pH values in Atchison County SFL from 1987-2011.

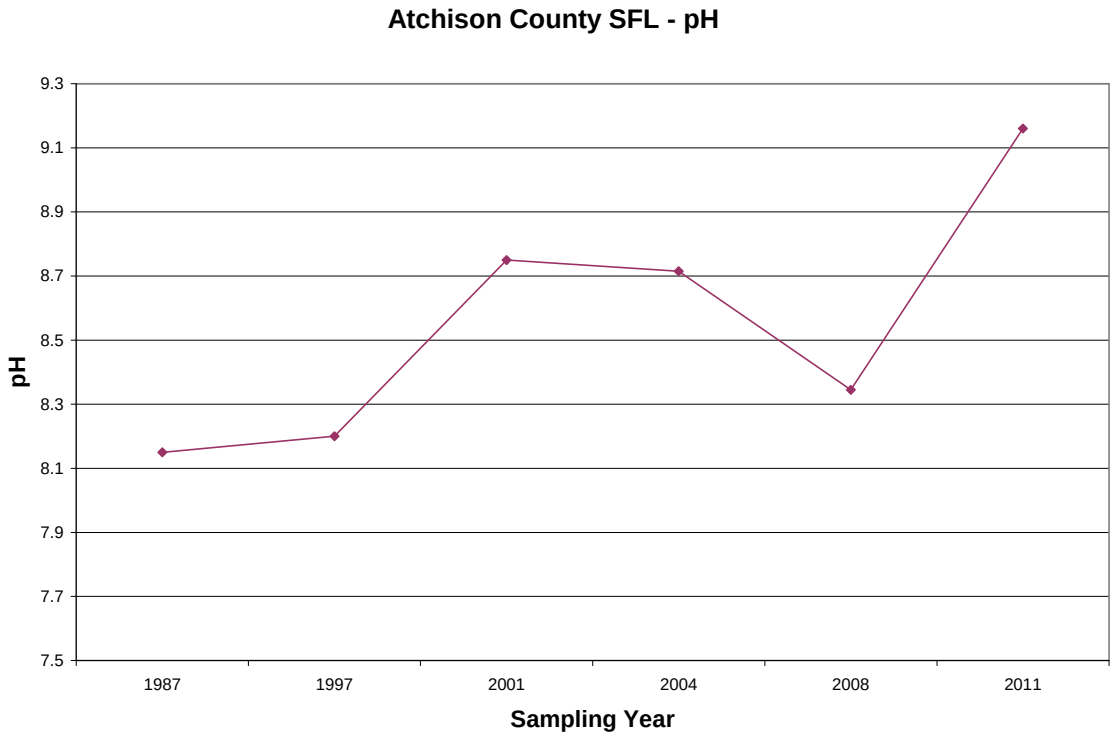


Table 2 lists the six metrics measuring the roles of light and nutrients in Atchison County SFL. Non-algal turbidity (NAT) values <0.4m^{-1} indicates there are very low levels of suspended silt and/or clay. The values between 0.4 and 1.0m^{-1} indicates inorganic turbidity assumes greater influence on water clarity but would not assume a significant limiting role until values exceed 1.0m^{-1}.

The depth of the mixed layer in meters (Z) multiplied by the NAT value assesses light availability in the mixed layer. 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 less than 3. Values greater than 6 would indicate the opposite.

The partitioning of light extinction between algae and non-algal turbidity is expressed as chl-*a**SD (chlorophyll *a* * Secchi Depth). 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 greater than 16. Values less than 6 indicate that inorganic turbidity is primarily responsible for light extinction in the water column and there is a weak algal response to changes in nutrient levels.

Values of algal use of phosphorus supply (Chl-*a*/TP) that are greater than 0.4 indicate a strong algal response to changes in phosphorus levels, where values less than 0.13 indicate a limited response by algae to phosphorus.

The light availability in the mixed layer for a given surface light is represented as Zmix/SD. Values less than 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. Values > 6 indicate the opposite.

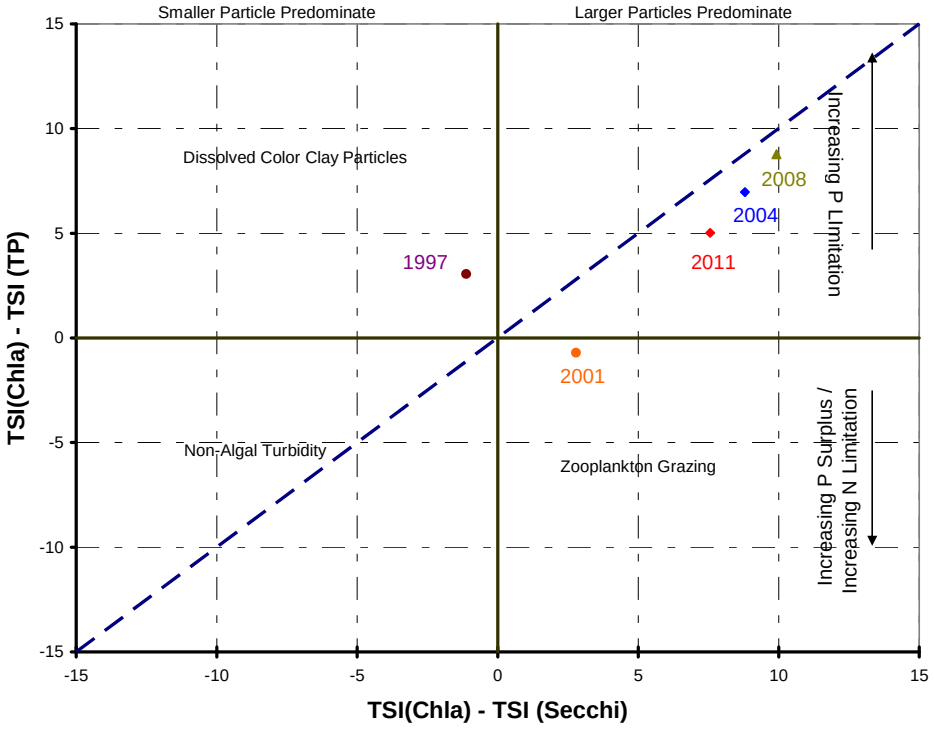
The above metrics indicate that Atchison County State Fishing Lake has very low levels of suspended silt and there is a strong response to algae to nutrient inputs, particularly to changes in phosphorus levels.

Table 2. Limiting factor determinations for Atchison County SFL from 1997-2011. NAT= non-algal turbidity; TN:TP = nitrogen to phosphorus ratio; Z = depth of mixed layer; Chl*a* = chlorophyll-*a*; and SD = secchi depth. (Carney, 1997, 2001, 2004, and 2008)

Sampling Year	TN:TP	NAT	Z*NAT	Chl*a**SD	Chl*a*/TP	Z/SD	Factor	Chl*a*
1997	21.88	0.49	0.49	16.44	0.46	2	P	13.7
2001	4.00	0.33	0.8	26.32	0.43	2.34	N	25.55
2004	25.21	<0.01	<0.01	51.46	0.943	3.88	P	56.55
2008	26.54	<0.01	<0.01	60.6	1.164	4.18	P	73.9
2011	30.01	<0.01	<0.01	60.6	1.057	6.94	P	123.71

Another method for evaluating limiting factors is the TSI deviation metrics. Figure 5 summarized the current trophic conditions at Atchison County SFL using a multivariate TSI comparison chart for data obtained in 1997, 2001, 2004, 2008, and 2011. 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 Sechi 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 4, Atchison County SFL is primarily limited by phosphorus with the exception of the 2001 sampling event.

Figure 5. Multivariate TSI comparison chart of Atchison County SFL for 1997, 2001, 2004, 2008, and 2011.



Other Parameter Relationships: Within Atchison County SFL there are positive relationships between chlorophyll *a* and; phosphorus, total suspended solids (TSS), turbidity, pH, and total nitrogen as seen in Figure 6. There are negative relationships between chlorophyll *a* and secchi depth and non-algal turbidity. As seen in Figure 7, within the lake there are positive relationships between pH and: temperature, phosphorus, TSS, turbidity, chlorophyll *a*, and total nitrogen.

Figure 6. Relationship between chlorophyll *a* and: TP, TSS, Turbididty, pH, Secchi, TN, and NAT in Atchison County SFL.

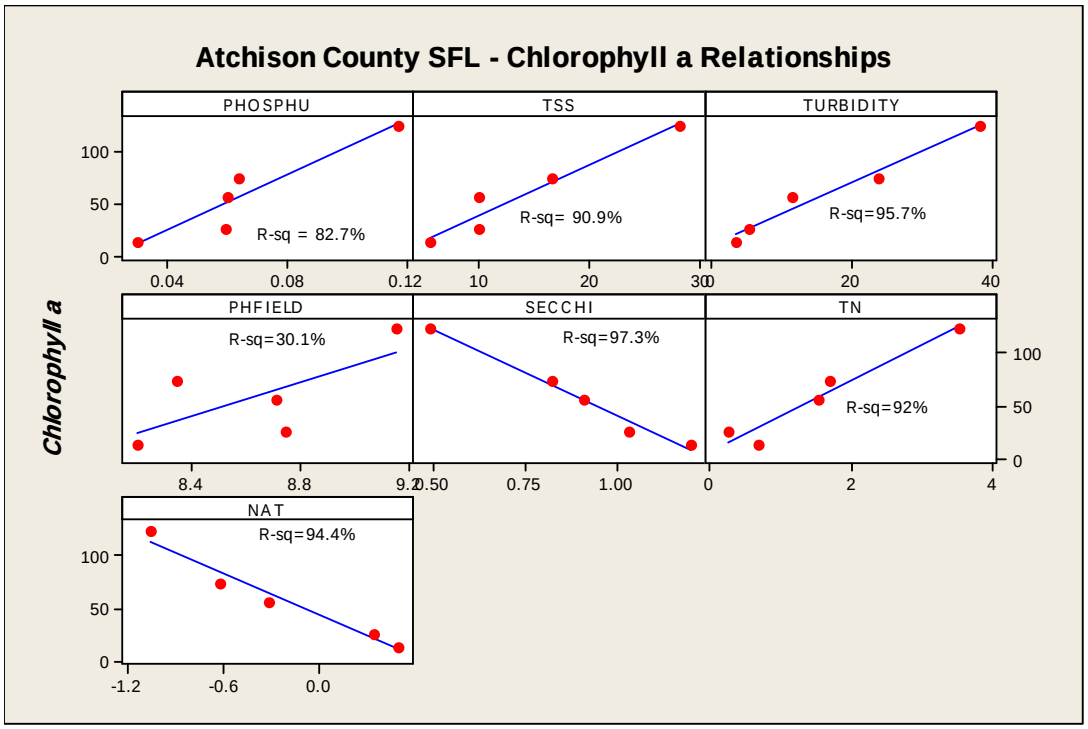
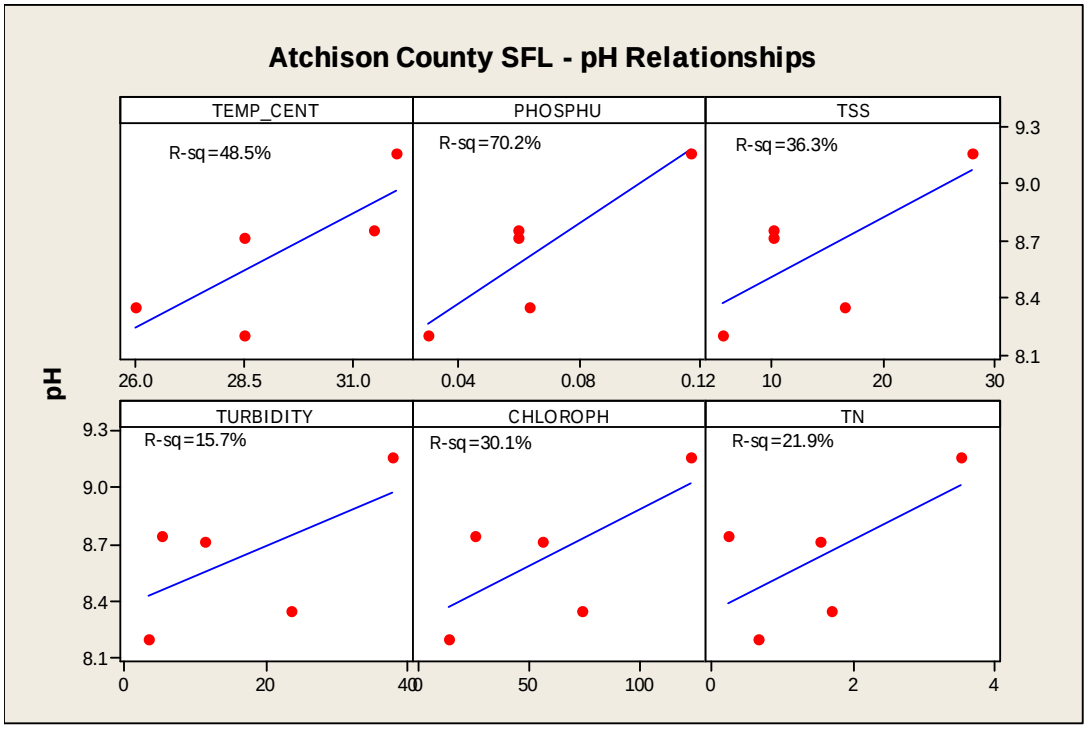


Figure 7. Relationship between pH and: temperature, TP, TSS, Turbidity, chlorophyll *a*, and TN



Interim Endpoints of Water Quality (Implied Load Capacity) at Atchison County State Fishing Lake: The ultimate endpoint of the TMDL is to achieve the Kansas Water Quality Standards to fully support all designated uses of Atchison County State Fishing Lake**.** 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 ug/L, with the initial reductions focused on phosphorus loading to the lake. Reductions in phosphorus loading will address the accelerated succession of aquatic biota and the development of objectionable concentrations of algae and algae by-products as determined by the chlorophyll a concentrations in the lake. KDHE established chlorophyll *a* target values in the 303(d) listing methodology for lakes, with the chlorophyll *a* target of 12 ug/L for lakes with a designated use of primary contact recreation, but are not active public water supply lakes. The chlorophyll *a* endpoint of 12 µg/L will also ensure long-term protection to fully support Primary Contact Recreation within the lake. If Atchinson County SFL becomes an active or reserve municipal water supply, as determined by the addition of a point of diversion for municipal use, a use attainability analysis will be conducted to ascertain if the 12 µg/L endpoint adequately supports such use in the lake. Achievement of this endpoint should also result in pH values between 6.5 and 8.5. Improving the trophic conditions of the lake should resolve the pH impairment since this impairment has a good relationship with chlorophyll *a* and phosphorus concentrations. The reduction of chlorophyll *a* will lower photosynthesis rates within Atchison County SFL, which in effect will lower the pH of the lake.

This TMDL applies across all flow conditions effectively addressing the critical condition brought about by high flow events when nutrient loading in the lake occurs at exaggerated rates. Seasonal variation has been incorporated in this TMDL since the peaks of algal growth occur in the summer months.

Based on the CNET reservoir eutrophication model (see Appendix A), the total phosphorus concentrations must be reduced by 55% to achieve a phosphorus load reduction of 69%. The TMDL as established through the CNET model is detailed in Table 3.

Table 3. Current conditions and reductions for Atchison County SFL.

Parameter	Current Condition	TMDL	Percent Reduction
Total Phosphorus Annual Load (lbs/year)	1431	444	69%
Total Phosphorus Daily Load (lbs/day)*	10.5	3.26	69%
Total Phosphorus Concentration (ug/L)	66	30	55%
Chlorophyll a Concentration (ug/L)	50.6	<12	76%
pH	8.55	6.5-8.5	12%

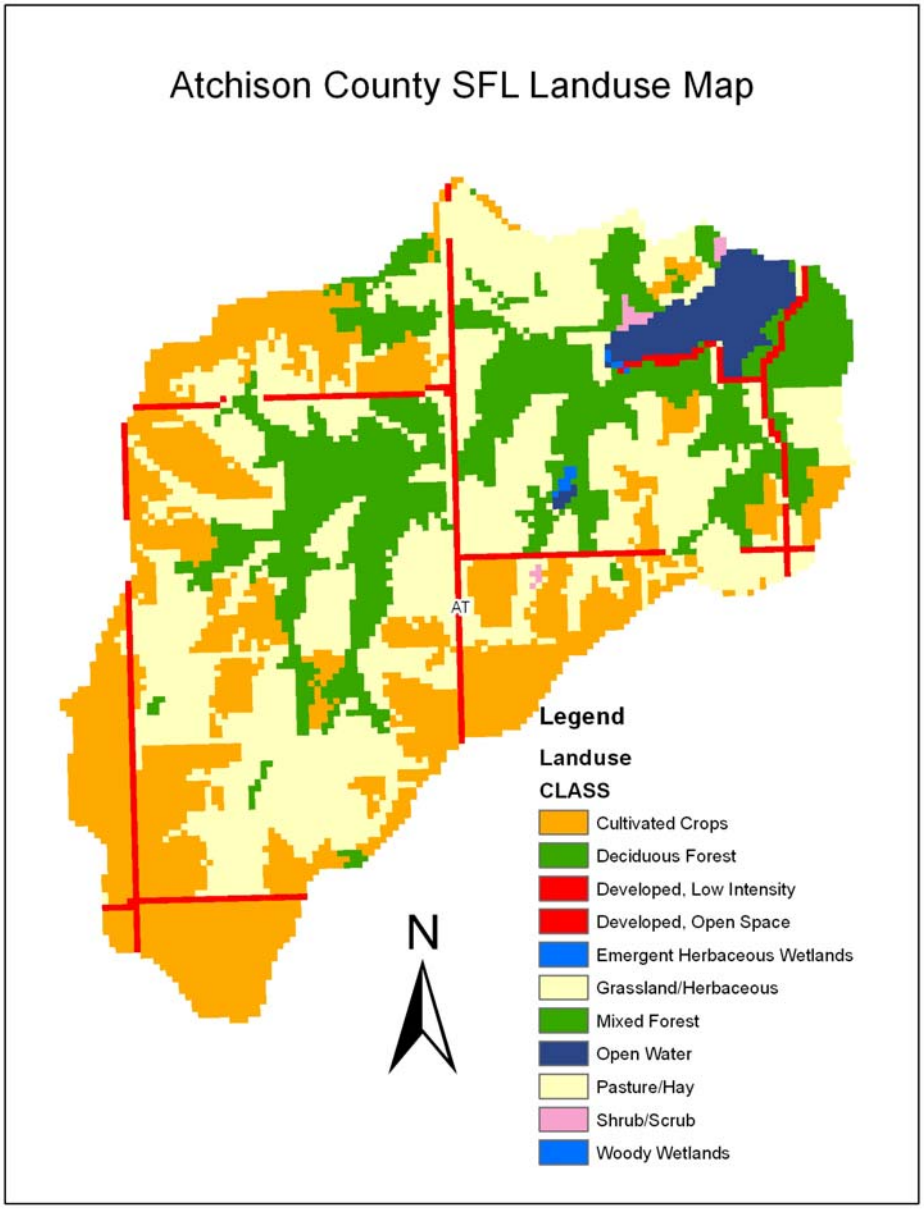
3. SOURCE INVENTORY

Land Use: The predominant land cover in the watershed around Atchison County SFL includes grassland (39.2%), cropland (30.6%) and forest/woodland (23.1%) according to the 2001 National Land Cover Data. Table 4 details the respective land cover acres with the corresponding landuse percentages for the entire watershed. As seen in Figure 8, the landuse map details the location of the corresponding landuses within the watershed.

Table 4. Landuse acres and percentages in the Atchison County SFL watershed (2001, NLCD).

Landuse	Acres	Percentage
Grassland	855.1	39.2 %
Cropland	666.5	30.6 %
Forest/Woodland	503.1	23.1 %
Developed	83.6	3.8 %
Open Water	68.9	3.2 %
Wetland	3.11	0.1 %

Figure 8. Atchison County SFL Landuse Map.



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

Livestock: There are no 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 Atchison County SFL. According to the 2011 Kansas Farm Facts there are 28,000 head of cattle in Atchison County.

Nonpoint Sources: Due to the lack of point sources in the watershed the impairment within the Atchison County SFL watershed is attributed to nonpoint sources. Phosphorus within the watershed may be attributed to fertilizer or manure application to the agricultural lands.

The Kansas Biological Survey (KBS) conducted a study of runoff in the Atchison County SFL watershed during 2002. Nutrient concentrations were documented ranging from <0.1 mg/l to 6.5 mg/l TP, and 0.76 mg/l to 5.9 mg/l TN. Since the watershed lacks point sources, the dominant mechanism for phosphorus entry into the lake is sediment, and the high levels recorded by KBS suggest that significant sediment movement is occurring during runoff events.

Contributing Runoff: The watershed of Atchison State Fishing Lake has a mean soil permeability value of 0.57 inches/hour, ranging from 0.01 to 1.29 inches/hour according to the NRCS STATSGO database. According to a USGS open-file report (Juracek, 2000), the threshold soil permeability values that represents very high, high, moderate, low, very low, and extremely low rainfall intensity, were set at 3.43, 2.86, 2.29, 1.71, 1.14, and 0.57" / hour respectively. The lower rainfall intensities generally occur more frequently than the higher rainfall intensities. The higher soil-permeability thresholds imply a more intense storm during which areas with higher soil permeability may potentially contribute runoff. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than the soil permeability. As soil profiles become saturated, excess overland flow is produced. The entire watershed has a low soil permeability value, which will produce runoff with rainfall events that produce 1.29 inches/hour of rain. Runoff generated from cropland and grassland likely contribute to the siltation impairment within Atchison SFL.

Population and On-Site Waste Systems: According to the 2010 U.S. Census block information there are less than 25 people residing in census blocks within the Atchison County SFL watershed. The population within the watershed likely utilizes septic systems. Nutrient loading contribution from failing on-site septic systems may occur if a system fails and is located near the lake or near streams entering the lake. If the on-site septic systems are in working order and not located near drainage to the lake then on-site waste systems are not a source contributing to the impairments in the watershed.

Internal Loading: The previously mentioned KBS study also examined sediment cores taken from the lake bottom to determine nutrient loading rates. They reported 33 mg PO_{4-} /sq. meter/day. Undissolved nutrients bound to suspended solids in the inflow to Atchison County SFL are potentially significant sources of nutrients that may endure in the sediment layer until they are removed by dredging. Internal nutrients can undergo remineralization and resuspension and may be a continuing source of nutrients in Atchison County SFL.

Other Sources: The Kansas Department of Wildlife and Parks maintains a series of fish feeders in Atchison County SFL. They annually add 6000 lbs. of fish food, corresponding to an annual estimated phosphorus load of 60 lbs.

Background: Leaf litter and wastes derived from natural wildlife may add to the nutrient load of Atchison SFL. Atmospheric and geological formations (i.e. soil and bedrock) may also contribute to the nutrient loads. The suspension of sediment and nutrients may be influenced by the wind and bottom feeding fish, which may also re-suspend sediment and contribute to available nutrients in the lake. Fish feeding operations additionally contribute variably seasonal loads to the nutrient load within the lake.

4. ALLOCATIONS OF POLLUTANT REDUCTION RESPONSIBILITY

Phosphorus is the limiting nutrient in Atchison County SFL and allocated under this TMDL. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction.

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 predominantly due to nonpoint source pollutants. Background levels may be attributed to nutrient recycling and leaf liter. 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. A load allocation of 399.6 lbs/year of total phosphorus, accounting for a 70% reduction, is necessary to reach the TMDL endpoint. The calculated daily load allocation (see Appendix B) is 2.93 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 44.4 lbs/year, or 0.33 lbs/day (see Appendix B), of total phosphorus.

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

Unified Watershed Assessment Priority Ranking: The Atchison County SFL watershed lies within the Independence-Sugar Subbasin (HUC8: 10240011) with a priority ranking of 25 (Medium Priority for restoration).

5. IMPLEMENTATION

Desired Implementation Activities: There is a very good potential that agricultural best management practices will improve the condition of Atchison 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. Incorporate the provisions of this TMDL into the Missouri Basin WRAPS.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – KDA Division of Conservation

a. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.
b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.
c. Re-evaluate nonpoint source pollution control methods.

Riparian Protection Program – KDA Division of Conservation

a. Establish, protect or re-establish 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 – KDA Division of Conservation

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 2013-2018.

Targeted Participants: Primary participants for implementation of best management practices will be agricultural producers within the drainage of the lake.

Milestone for 2017: The year 2017 will be the next time TMDL development and revision will occur in the Missouri River Basin. At that point in time, sample data from Atchison County SFL will be reexamined to confirm the impaired status of the lake. Should impairment remain, more aggressive techniques will be examined to remove potential sources of sediment and nutrients from the lake.

Delivery Agents: The primary delivery agents for program participation will be the Atchison County Conservation District for programs of the Kansas Department of Wildlife and Parks. Producer outreach and awareness will be delivered by Kansas State Extension. The Kansas Department of Health and Environment shall continue to monitor lake conditions.

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.A.R. 28-16-69 through 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

3. 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.

4. 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.

5. 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.

6. 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.

7. K.S.A. 32-807 authorizes the Kansas Department of Wildlife and Parks to manage lake resources.

8. The *Kansas Water Plan* and the Missouri River 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 pollution 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 watershed and water resources of highest priority. Typically, the state

allocates at least 50% of the fund to programs supporting water quality protection and restoration through the WRAPS program. This watershed and its TMDL are a **Medium** Priority consideration for funding.

Effectiveness: The key to success will be widespread utilization and maintenance of conservation farming and proper livestock waste management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue sampling Atchison 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 the 303(d) listing will be evaluated in 2022. Atchison County SFL should be scheduled for sampling in 2014, 2017, and 2020.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Missouri 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 Missouri Basin and these specific TMDLs. This TMDL was presented for comments at the Missouri WRAPS meeting on April 25, 2013 in Troy.

Public Hearing: Public comments for this TMDL were held open from May 4 through June 7, 2013. A public hearing on this TMDL was held on May 23, 2013 in Ottawa.

Basin Advisory Committee: The Missouri Basin Advisory Committee met to discuss these TMDLs on September 13, 2012 in Hiawatha and on April 9, 2013 in Atchison.

Milestone Evaluation: In 2017, evaluation will be made as to any implementation of management practices to minimize stormwater 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 303(d) Delisting: Atchison County SFL will be evaluated for delisting under Section 303(d), based on the monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022-303(d) 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 2014 which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendations of this TMDL will be considered in the *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2012-2020.

Rev October 31, 2013

References:

Carney, E.. 2006; *Chlorophyll a Prediction Models*. Kansas Department of Health and Environment, Topeka, KS.

Carney, E.. 1997, 2001, 2004, 2008; *Lake and Wetland Monitoring Program Annual Report*. Kansas Department of Health and Environment, Topeka, KS.

Dodds, W.K., 2002. Freshwater Ecology Concepts and Environmental Applications. Academic Press, San Diego.

Dzialowski, A.R., S.H. Wang, N.C. Lim, W.W. Spotts and D.G. Huggins. 2005; Nutrient Limitation of Phytoplankton Growth in Central Plains Reservoirs, USA; Journal of Plankton Research; 27 (6):587-595.

Juracek, K.E., 2000. Soils – Potential Runoff. U.S.Geological Survey Open-File Report 00-253.

Kansas Biological Survey. 2005. Predicting the effects of watershed management on the eutrophication of reservoirs in the central plains: an integrated modeling approach. KBS Publication No. 123. University of Kansas.

Kansas Department of Health and Environment, 2008. Missouri River Basin Total Maximum Daily Load. Atchison County State Fishing Lake, Siltation.

National Agricultural Statistics Service. Kansas Farm Facts 2011. Accessed on August 8, 2012 at: http://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/Annual_Statistical_Bulletin/ff2011.pdf .

Smith, V.H. 1998. Cultural Eutrophication of Inland, Estuarine, and Coastal Waters. In: M.L. Pace and P.M. Groffman (eds.), Limitation and frontiers in ecosystem science. Springer-Verlag, New York, NY. P 7-49.

Appendix A – CNET Eutrophication Model for Bourbon County SFL.

Input for CNET Model

Parameter	**Value Input into CNET Model**
Drainage Area (km^2)	8.83
Precipitation (m/yr)	0.845
Evaporation (m/yr)	1.12
Unit Runoff (m/yr)	0.17
Surface Area (km^2)	0.31
Mean Depth (m)	10.0
Depth of Mixed Layer (m)	3.4
Observed Phosphorus (ppb)	66
Observed Chlorophyl *a* (ppb)	50.6
Observed Secchi Disc Depth	0.89

Output from CNET Model

Parameter	**Output from CNET Model**
Load Capacity (LC)*	444 lbs/year
Waste Load Allocations (WLA)	0 lbs/year
Atmospheric Air Deposition (LA)	30.8 lbs/ year
Other Nonpoint (LA)	368.8 lbs/year
Total Load Allocation (LA)	399.6 lbs/year
Margin of Safety (MOS)	44.4 lbs/year

* - LC=WLA + LA + MOS

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE ->

Atchison Cnty SFL

Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...		Latitude	37
Drainage Area	km2	8.83	8.83
Precipitation	m/yr	0.845	0.845
Evaporation	m/yr	1.12	1.12
Unit Runoff	m/yr	0.17	0.17
Stream Total P Conc.	ppb	390	125
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	0.31	0.31
Max Depth	m	10	10
Mean Depth	m	3.4	3.4
Non-Algal Turbidity	1/m	0.08	0.53
Mean Depth of Mixed Layer	m	3.39	3.39
Mean Depth of Hypolimnion	m	1.35	1.35
Observed Phosphorus	ppb	66	30.0
Observed Chl-a	ppb	50.6	12.0
Observed Secchi	meters	0.89	1.20
MODEL PARAMETERS...			
BATHTUB Total P Model Number	(1-8)	7	7
BATHTUB Total P Model Name		SETTLING	
BATHTUB Chl-a Model Number	(2,4,5)	5	5
BATHTUB Chl-a Model Name		JONES	
Beta = 1/S vs. C Slope	m2/mg	0.022205	0.069444
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	0.26	0.26
NonPoint Flow	hm3/yr	1.50	1.50
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	1.76	1.76
Evaporation	hm3/yr	0.35	0.35
Outflow	hm3/yr	1.42	1.42

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	7	7
NonPoint Load	kg/yr	135	43
Point Load	kg/yr	0	0
Total Load	kg/yr	142	50
Sedimentation	kg/yr	25	9
Outflow	kg/yr	116	41
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.180	0.180
Mean Phosphorus	ppb	82.2	29.1
Mean Chlorophyll-a	ppb	50.6	11.1
Algal Nuisance Frequency	%	100.0	34.8
Mean Secchi Depth	meters	0.83	0.77
Hypol. Oxygen Depletion A	mg/m2-d	1706.5	800.8
Hypol. Oxygen Depletion V	mg/m3-d	1264.1	593.2
Organic Nitrogen	ppb	1315.8	450.7
Non Ortho Phosphorus	ppb	87.8	28.3
Chl-a x Secchi	mg/m2	42.0	8.5
Principal Component 1	-	3.25	2.51
Principal Component 2	-	1.22	0.75
	Observed	Pred	Target
Carlson TSI P	64.6	67.8	52.8
Carlson TSI Chl-a	69.1	69.1	54.3
Carlson TSI Secchi	61.7	62.7	63.8
OBSERVED / PREDICTED RATIOS...			
Phosphorus		0.80	1.03
Chlorophyll-a		1.00	1.08
Secchi		1.07	1.56
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		-0.81	0.11
Chlorophyll-a		0.00	0.28
Secchi		0.25	1.65

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	1.054	1.054
Residence Time	yrs	0.7444	0.7444
Overflow Rate	m/yr	4.6	4.6
Total P Availability Factor		1	1
Ortho P Availability Factor		0	0
Inflow Ortho P/Total P		0.000	0.000
Inflow P Conc	ppb	100.1	35.5
P Reaction Rate - Mods		3.2	1.1
P Reaction Rate - Model 2		#DIV/0!	#DIV/0!
P Reaction Rate - Model 3		7.5	2.6
1-Rp Model 1 - Avail P		0.422	0.594
1-Rp Model 2 - Decay Rate		#DIV/0!	#DIV/0!
1-Rp Model 3 - 2nd Order Fixed		0.305	0.454
1-Rp Model 4 - Canfield & Bach		0.404	0.555
1-Rp Model 5 - Vollenweider 19		0.537	0.537
1-Rp Model 6 - First Order Dec		0.573	0.573
1-Rp Model 7 - First Order Set		0.820	0.820
1-Rp Model 8 - 2nd Order Tp Or		0.422	0.594
1-Rp - Used		0.820	0.820
Reservoir P Conc	ppb	82.2	29.1
Gp		0.663	0.663
Bp	ppb	86.0	20.8
Chla vs. P, Turb, Flush	2	36.0	7.9
Chla vs. P Linear	4	23.0	8.2
Chla vs. P 1.46	5	50.6	11.1
Chla Used	ppb	50.6	11.1
ml - Nuisance Freq Calc.		3.9	2.3
z		-3.934	0.389
v		0.000	0.370
w		0.433	0.885
x		0.000	0.348

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%	14	14
0.23	0%	585	188
0.8	0%	0	0
		600	202
		1319	444

CNET

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	444 lbs/yr	0.5	2.68	3.26 lbs/day	2.93 lbs/day	0.33 lbs/day

Maximum Daily Load Calculation

Annual TP Load = 444 lbs/yr

Maximum Daily TP Load = $[(444 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.6013)-0.5*(0.6013)^2]}$
= 3.26 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TP MOS = 44 lbs/yr

Daily TP MOS = $[(44 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.6013)-0.5*(0.6013)^2]}$
= 0.33 lbs/day

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