UPPER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: (Veterans) Memorial Park Lake
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Walnut Creek **County:** Barton

HUC 8: 11030008 **HUC (10) 12:** (03) 06

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

Drainage Area: 0.98 square miles

Conservation Pool: Surface Area = 13 acres
Watershed/Lake Ratio: 48:1
Maximum Depth = 4.0 meters
Mean Depth = 1.7 meters
Storage Volume = 71.1 acre-feet
Mean Annual Discharge = 90.7 acre-feet
Estimated Retention Time = 0.78 years
Mean Annual Precipitation = 23.3 inches
Mean Annual Evaporation = 62.8 inches

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

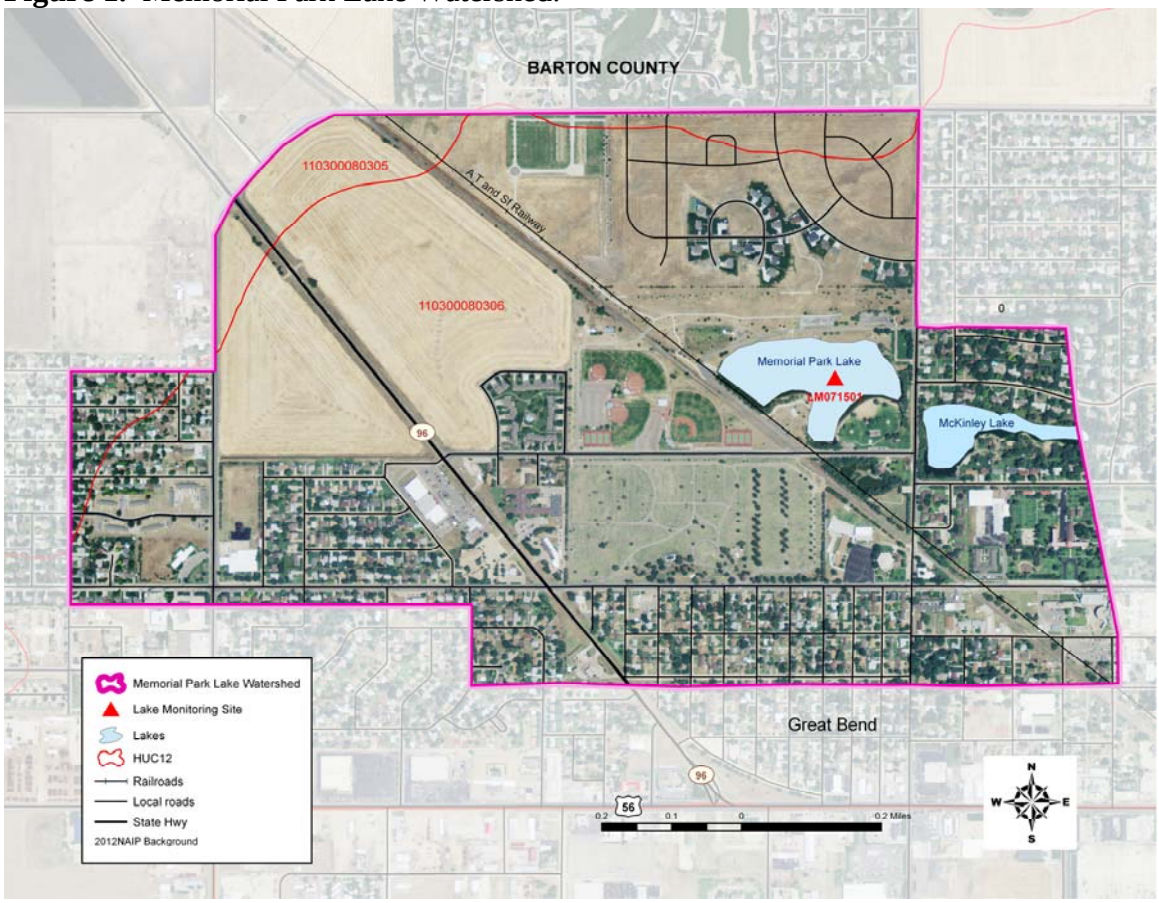
303(d) Listings: Memorial Park Lake Eutrophication: 2002, 2004, 2008, 2010, 2012; Kansas Upper Arkansas River Basin Lakes.

Impaired Use: All uses in Memorial Park 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 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)).

Figure 1. Memorial Park Lake Watershed.



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2012 303(d): Excessive nutrients are not being controlled and are thus impairing aquatic life use and contributing to eutrophication which is impairing aquatic life use by supporting objectionable types and quantities of algae which also leads to impairment of contact recreation within Memorial Park Lake. Memorial Park Lake has no municipal water rights attached to its storage; it is not being used for domestic water supply, nor is it planned as a reserve for a municipal water supply. The chlorophyll *a* endpoint of 12 µg/L is appropriate to protect the immediate uses of aquatic life support and contact recreation in Memorial Park Lake. Should the lake serve as a domestic or municipal water supply in the future, as evidenced by the installation of a point of diversion within the lake, a subsequent use attainability analysis will be conducted to ascertain if the 12 µg/L endpoint adequately supports such use in the lake.

Level of Eutrophication: Hypereutrophic, Trophic State Index = 71.7

The Trophic State Index (TSI) is derived from the chlorophyll *a* concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll *a*,

nutrient levels, and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll *a* 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:

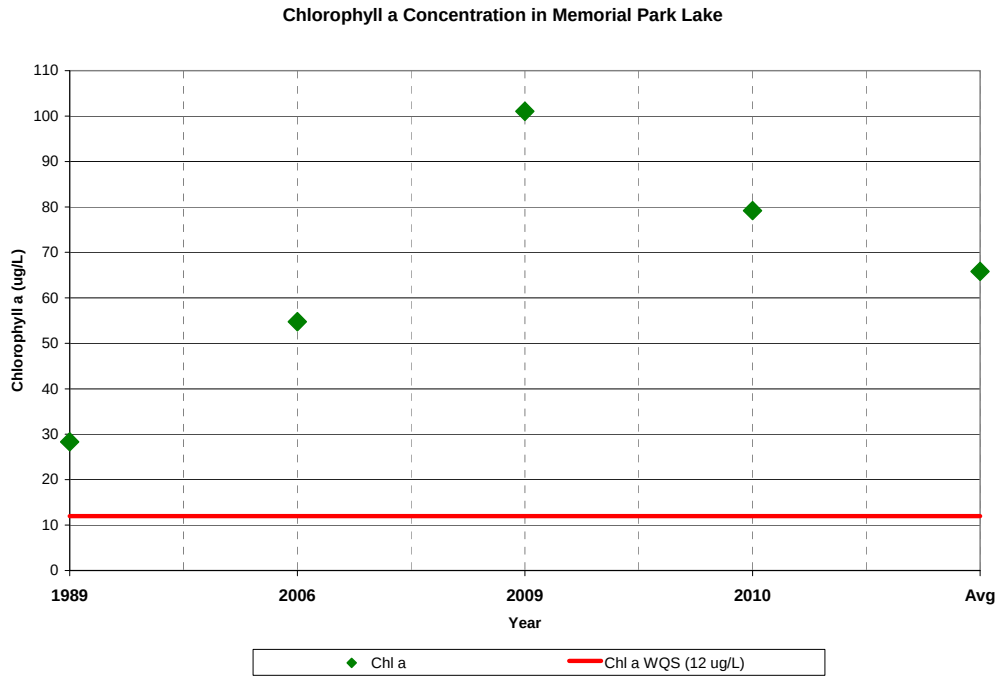
1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: 64

Lake Monitoring Sites: KDHE Station LM071501 at Memorial Park Lake.
Period of Record: Four surveys conducted by KDHE during the calendar years 1989, 2006, 2009, and 2010.

Long-Term Hydrologic Conditions: There are no streams directly feeding Memorial Park Lake. CNET eutrophication modeling (Appendix A) generates a total inflow value of 113 acre-feet per year, based on drainage area. The lake watershed encompasses a significant portion of the City of Great Bend as Memorial Park Lake also receives substantial stormwater discharge during storm events. According to the USGS Lake Hydro data, the mean runoff in the watershed is 1.77 inches/year; the mean precipitation in the watershed is 23.3 inches/year; the mean loss due to evaporation for the lake is 62.8 inches/year; and the calculated mean annual outflow for the lake is 42.6 acre feet/year.

Current Condition: Over the period of record, Memorial Park Lake has chlorophyll *a* concentrations averaging 65.8 μg/L. Chlorophyll *a* concentrations have been increasing since the 1989 sampling with a high value of 101 μg/L recorded in 2009 (Figure 2).

Figure 2. Chlorophyll *a* concentrations in Memorial Park Lake for the period of record.



The average Secchi depth in Memorial Park Lake is 0.50 meters with the highest reading measured in 1989 at 0.69 meters and a low reading of 0.36 meters in 2009 (Figure 3). Total phosphorus (TP), total nitrogen (TN), turbidity and total suspended solids (TSS) data is only available for 2006 and 2009 (Table 1). TP, TN and TSS concentrations are comparable between the two years while turbidity increased dramatically between 2006 and 2009 and is likely a reflection of the increase in chlorophyll *a* from 54.8 µg/L in 2006 to 101 µg/L in 2009.

Figure 3. Secchi Depth at Memorial Park Lake for the period of record.

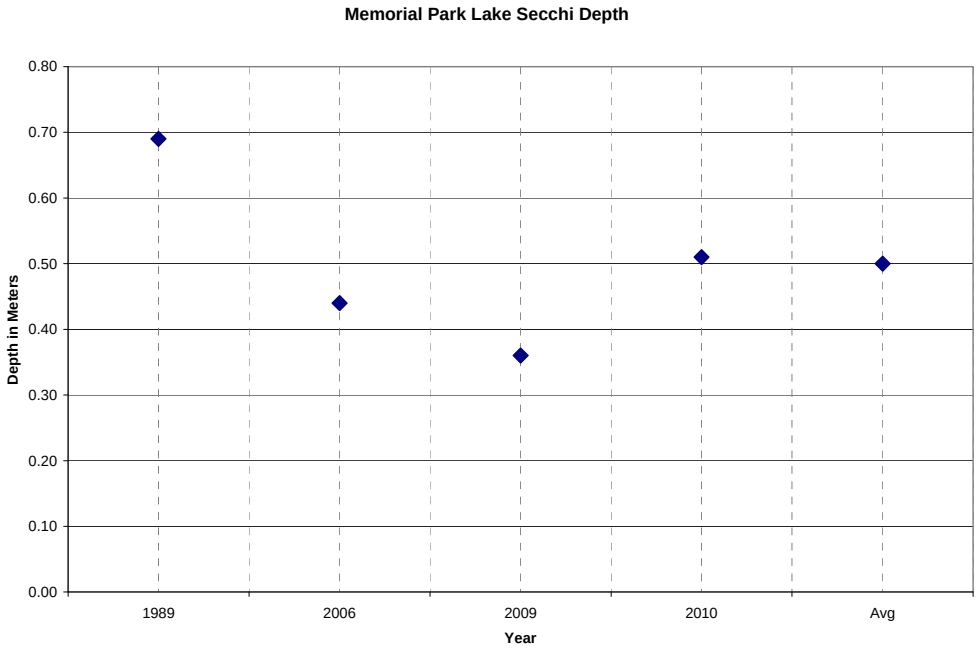


Table 1. Concentration averages for Memorial Park Lake for the period of record.

Sampling Year	Chl-a (μg/L)	TN (mg/L)	TP (mg/L)	TN:TP ratio	Secchi Depth (m)	Turbidity (NTU)	TSS (mg/L)
1989	28.3	*	*	*	0.690	*	*
2006	54.8	2.68	0.171	15.7	0.440	11.3	29.0
2009	101	2.63	0.141	18.7	0.360	39.9	23.0
2010	79.2	*	*	*	0.510	*	*
Average	*65.8*	*2.66*	*0.156*	*17.2*	*0.500*	*30.4*	*26.0*

* Data not available.

The ratio of total nitrogen and total phosphorus has been used to determine which of these nutrients is most likely limiting plant growth in Kansas aquatic ecosystems. Generally, lakes that are nitrogen limited have water column TN:TP ratios < 8 (mass); lakes that are co-limited by nitrogen and phosphorus have water column TN:TP ratios between 9 and 21; and lakes that are phosphorus limited have water column TN:TP ratios > 29 (Dzialowski et al., 2005). Total phosphorus and total nitrogen data is only available for 2006 and 2009 resulting in TN:TP ratios of 15.7 and 18.7, respectively, pointing to phosphorus/nitrogen co-limitation (Table 1).

Table 2 lists the six metrics that measure the roles of light and nutrients in Memorial Park Lake. 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 $1.0m^{-1}$ indicate inorganic turbidity assumes greater influence on water clarity but would not assume a significant limiting role until values exceed $1.0m^{-1}$.

Table 2. Memorial Park Lake limiting factor metrics.

Sampling Year	Non-algal Turbidity	Light Availability in the Mixed Layer	Partitioning of Light Extinction between Algae & Non-algal Turbidity	Algal use of Phosphorus Supply	Light Availability in the Mixed Layer for a Given Surface Light	Shading in Water Column due to Algae and Inorganic Turbidity	Chl-*a* (μg/L)
	NAT	**Zmix*NAT**	**Chl-a*SD**	**Chl-a/TP**	**Zmix/SD**	**Shading**	
1989	0.742	1.22	19.5	No Data Available	2.39	3.22	28.3
2006	0.904	1.49	24.1	0.320	3.75	4.55	54.8
2009	0.252	0.415	36.4	0.717	4.58	6.17	101
2010	-0.019	-0.0310	40.4	No Data Available	3.24	4.97	79.2

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.

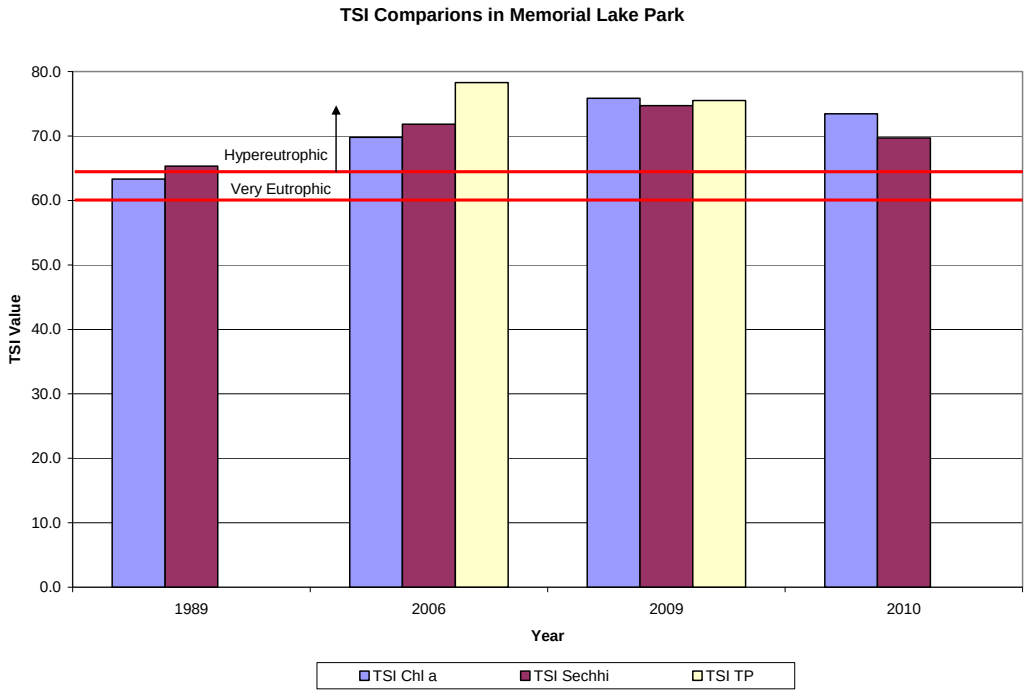
The light availability in the mixed layer for a given surface light is represented as Zmix/SD. Values less than 3 indicate that light availability is high in the mixed zone and there is a high probability of strong algal responses to changes in nutrient levels.

Shading values less than 16 indicate that self-shading of algae does not significantly impede productivity. This metric is most applicable to lakes with maximum depths of less than 5 meters (Carney, 2004).

The above metrics indicate that there are low levels of inorganic turbidity and abundant light within the mixed layer in Memorial Park Lake allowing for a strong algal response to nutrient inputs. Self shading due to algal growth does not appear to be impeding algal growth in the lake.

TSI values for Memorial Park Lake (Figure 4) show the lake has been in a very eutrophic to hypereutrophic state for the period of record.

Figure 4. Memorial Park Lake Carlson Trophic State Indices (TP TSI not available for 1989 & 2010).



The median trophic conditions within Memorial Park Lake compared to Federal lakes in the state are summarized in Table 3. The trophic indicator values within Memorial Park Lake fail to meet any of the benchmarks established for the Federal Lakes, the Central Great Plains Lakes or the Kansas Lakes.

Table 3. Median trophic indicator values of Memorial Park Lake in comparison with federal lakes and draft nutrient benchmarks in Kansas. The nutrient benchmarks were derived from 47-58 lakes and reservoirs, based on the data collected between 1985-2002 (Dodds et al., 2006).

Trophic Indicator	Memorial Park Lake	Federal Lake	Central Great Plains	Statewide Benchmark
Secchi Depth (cm)	48	95	117	129
TN (µg/L)	2643	903	695	625
TP (µg/L)	156	76	44	23
Chlorophyll *a* (µg/L)	66	12	11	8

Algal Communities: In August 2010, KDHE issued a Public Health Warning for Memorial Park Lake due to excessive blue-green algae, or cyanobacteria blooms. Subsequent sampling and analysis for blue-green algae by KDHE's Lake and Wetland Monitoring Program staff revealed blue-green algae cell counts above the warning level of 100,000 cells/mL (WHO, 1999) through the spring of 2011 (Figure 5) with one exception occurring on November 3, 2010 when the sampling occurred after a high intensity rainfall runoff event. A break down of the type of cyanobacteria that were

counted during KDHE's analysis are shown in Figure 6 and shows that as the *Aphanizomenon* count decreased in the fall of 2010, *Planktothrix* began to thrive. This shift in the algae population is reflected in Figure 7 as *Planktothrix* is a microcystin producing species of cyanobacteria where *Aphanizomenon* is not.

Figure 5. Blue-Green Algae cell count for August 1, 2010 through April 4, 2010. Note: x-axis is in terms of the month/week the lake was sampled.

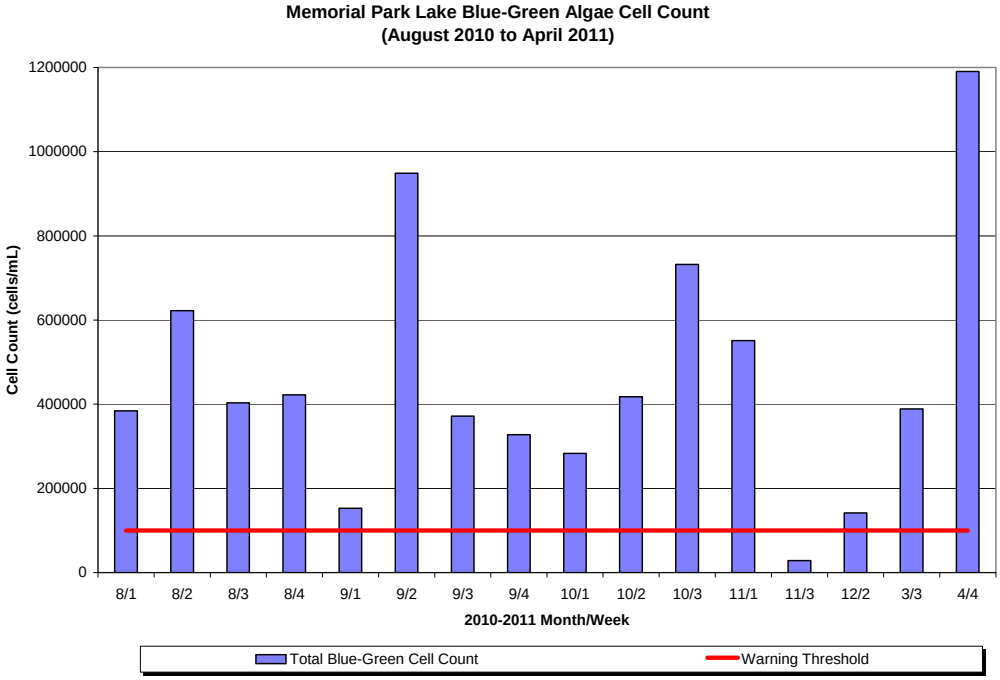


Figure 6. Cyanobacteria species shift in Memorial Park Lake, August 2010 through April 2011. Note: x-axis is in terms of the month/week the lake was sampled.

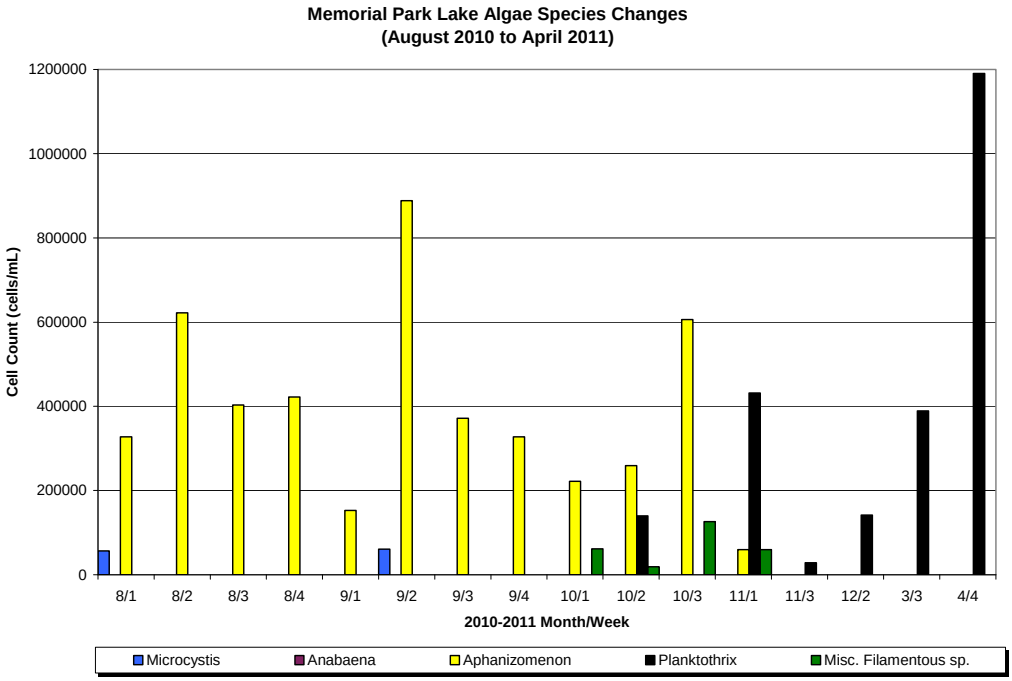
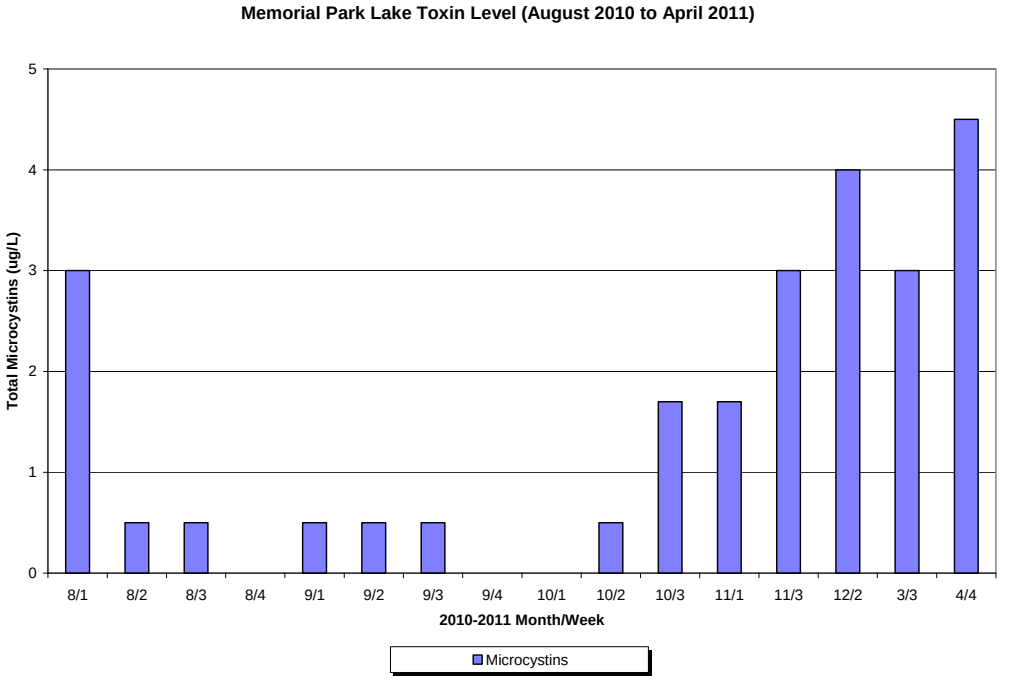


Figure 7. Microcystin levels in Memorial Park Lake, August 2010 through April 2011. Note: x-axis is in terms of the month/week the lake was sampled.



Desired Endpoints of Water Quality (Implied Load Capacity) in Memorial Park Lake:

In order to improve the trophic condition of Memorial Park Lake from its current hypereutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* average concentrations below 12 μg/L, which corresponds to a Carlson Trophic State Index of 55, with the reductions focused on phosphorus loading. 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. A chlorophyll *a* endpoint of 12 μg/L will also ensure long-term protection to fully support Primary Contact Recreation within the lake. If and when Memorial Park Lake becomes an active or reserve municipal water supply, as determined by the addition of a point of diversion, a use attainability analysis will be conducted to ascertain if the12 μg/L endpoint adequately supports such use in the lake.

Based on the CNET reservoir eutrophication model (Appendix A), the total phosphorus entering the lake must be reduced by 93%. With this reduction, the endpoint for Memorial Park Lake will be met. This reduction at the inflow to Memorial Park Lake will result in a 82% reduction of total phosphorus and an 82% reduction of chlorophyll *a* within the lake (Table 4). Achievement of the endpoint indicates loads are within the loading capacity of the lake, the water quality standards are attained, and full support of the designated uses of the lake has been achieved. Seasonal variation has been incorporated in this TMDL since the peaks of algal growth occur in the summer months. The current average condition for Memorial Park Lake utilized in the model input was based on data from KDHE station LM071501. Water quality data for the inflow into Memorial Park Lake was estimated by calibrating the stream total phosphorus concentration input in CNET to the current lake mean phosphorus concentration of 156 μg/L resulting in an estimated total phosphorus concentration in the runoff entering Memorial Park Lake of 557 μg/L before reductions (Appendix A).

Table 4. Memorial Park Lake current average condition and TMDL based on CNET.

	Current Avg. Condition	**TMDL**	**Percent Reduction**
Total Phosphorus – Annual Load (lbs/year)	141	9.673	93%
Total Phosphorus – Daily Load* (lbs/day)	1.03	0.0711	93%
Total Phosphorus – Lake Concentration (μg/L)	156	27.8	82%
Chlorophyll *a* Concentration (μg/L)	65.8	12.0	82%

*See Appendix B for Daily Load Calculations

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There is stormwater discharge (MS4) permit that falls in to the Memorial Park Lake watershed that requires the implementation of best management practices in order to attenuate the discharge of pollutants into the Great Bend stormwater discharge system's receiving streams and lakes (Table 5). Currently, stormwater discharge is conveyed directly to Memorial Park Lake via pipes and channels during rain events.

Table 5. NPDES Permits in the Memorial Park Lake watershed.

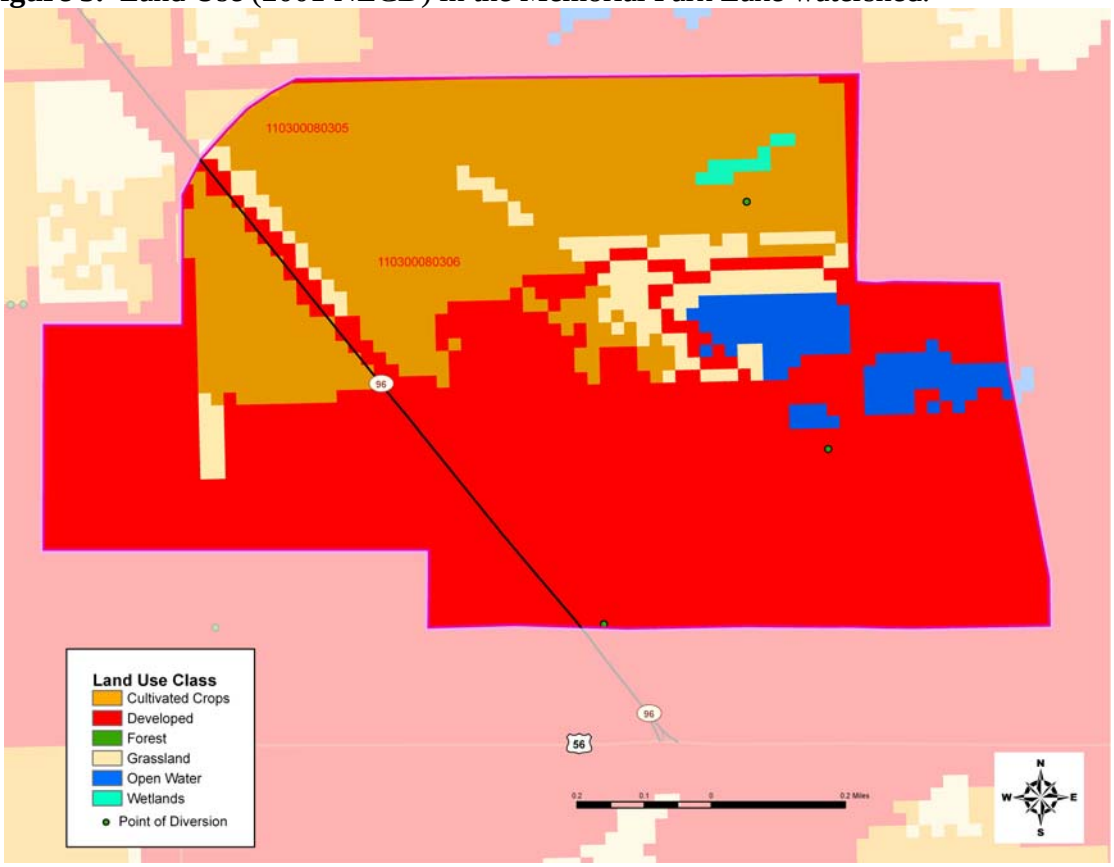
Permitee	NPDES Permit #	State Permit #	Type	Expiration Date
City of Great Bend	KSR044007	M-UA16-SN01	Stormwater	September 30, 2009*

*Permit pending

Livestock Waste Management Systems: There are no active permitted or certified confined animal feeding operations (CAFOs) in the Memorial Park Lake watershed. However, according to USDA National Agricultural Statistics Service, on January 1, 2010, cattle inventory for Barton County was 105,000 head.

Land Use: The predominant land use in the Memorial Park watershed is developed land (59%) and cultivated crops (32%) according to the 2001 National Land Cover Data. Together they account for 91% of the total land area in the watershed with the remaining land comprised of open water (4%) and grassland (5%) (Figure 5). Fertilizer runoff from cropland adjacent to the lake and from domestic lawns in the watershed are likely contributors to the phosphorus loading in the lake.

Figure 5. Land Use (2001 NLCD) in the Memorial Park Lake watershed.



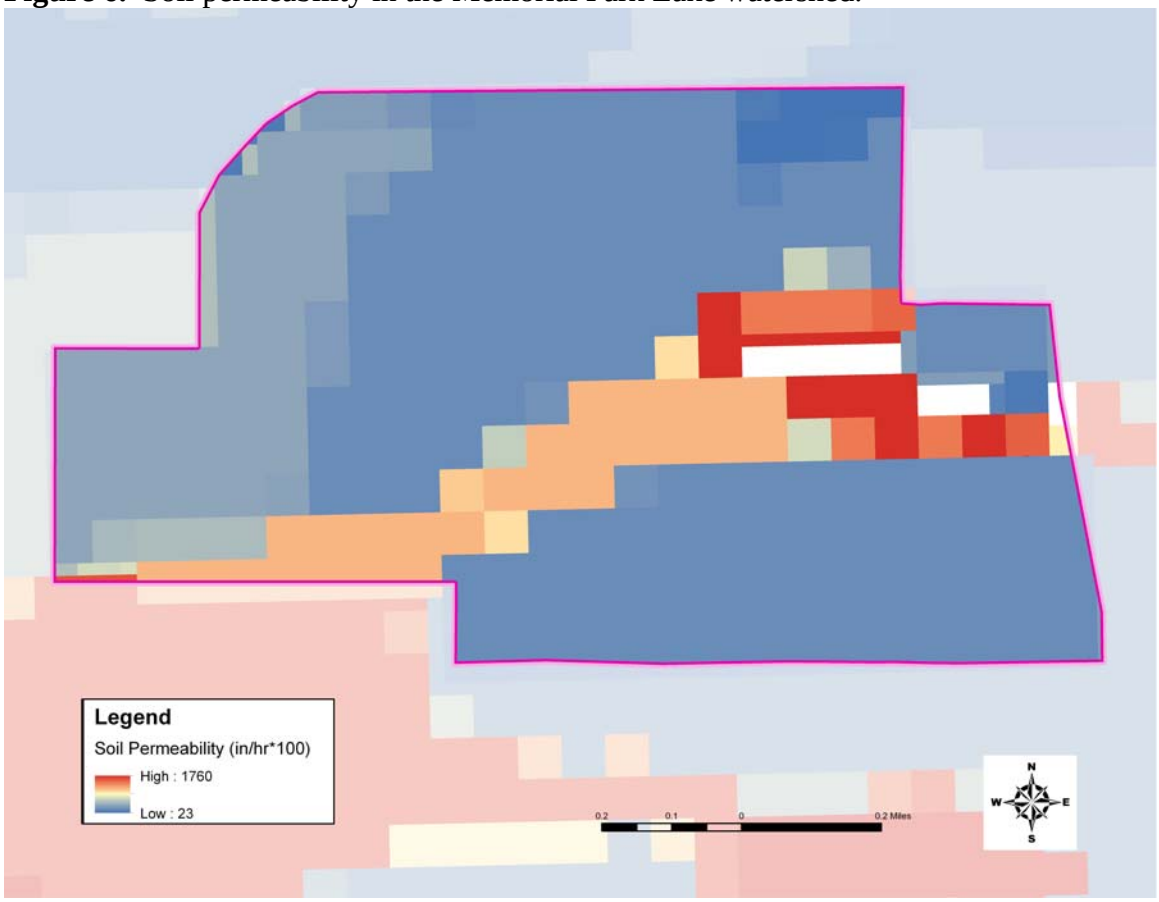
Unique Points of Diversion: The Memorial Park Lake watershed contains three unique points of diversion that are made up of a water right and point of diversion combination. Two points are for municipal use, one groundwater and one surface water, and one point is a groundwater right for dewatering use. Combined they are allocated to use 577 acre-feet of water annually (Figure 5).

On-Site Waste Systems: According to the 2010 U.S Census, the total population of Great Bend was 15,995 with the population in the Memorial Park Lake watershed at 1,745 people for a population density for of 1,781 people/mi^2. The 2010 U.S. Census registered a 4.2% increase in the population of Great Bend over the 2000 census. 1990 census data estimate 20% of households in Barton County utilize septic or other on-site systems. However, the Memorial Park Lake watershed is located within the city limits of Great Bend and is serviced by the City of Great Bend utilities division making it unlikely that failing septic systems are contributing to the eutrophication impairment in the lake.

Contributing Runoff: The watershed of Memorial Park Lake has a mean soil permeability value of 2.78 inches/hour, ranging from 0.23 inches/hour to 17.6 inches/hour according to NRCS STATSGO database (Figure 6). 26% of the watershed has soil permeability of 1.29 inches/hour or less generating runoff during very low to low rainfall intensities while 26% of the watershed has a soil permeability of 7.26 inches/hour

which typically generates runoff under very high intensity rainfall events. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values are set at 3.43 inches/hour for very high, 2.86 inches/hour for high, 2.29 inches/hour for moderate, 1.71 inches/hour for low, 1.14 inches/hour for very low, and 0.57 inches/hour for extremely low soil-permeability. Runoff is primarily generated as infiltration excess when rainfall intensities are greater than soil permeability. As the watershed's soil profile becomes saturated, excess overland flow is produced.

Figure 6. Soil permeability in the Memorial Park Lake watershed.



Background and Natural Sources: There is a significant resident goose population on and near Memorial Park Lake. Geese may contribute nutrients through fecal deposits in the lake and along the shoreline. Although much of the nutrient load from the geese may settle to the lake bottom as part of the sediment deposition, anaerobic conditions in shallow areas of the lake or re-suspension during times of turnover may introduce available nutrients into the water column. Maintaining deterrents around the lake, such as silhouettes or high grass at the water's edge, may discourage and disperse geese from overloading areas of the lake. Some nutrient loading as organic forms may occur in the fall as a result of leaf litter and macrophyte senescence.

Atmospheric deposition from geological formations may also contribute to nutrient loads. The suspension of sediment and nutrients may be influenced by the wind. Because

Memorial Park Lake is a small lake, nutrient cycling of the sediment is likely contributing available nutrients to the lake for algal uptake.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Although 2006 and 2009 sampling data indicate a nitrogen/phosphorus co-limitation in Memorial Park Lake, this TMDL will focus on reducing the amount of total phosphorus entering the lake in order to achieve the endpoint. The general inventory of sources within the drainage area of the lake indicates load reductions should be focused on loads associated with stormwater discharge practices and animal waste around the lake. Because of atmospheric deposition, the allocation of phosphorus will include a proportional decrease in phosphorus between the current condition and the desired endpoint.

Nonpoint Sources: The assessment suggests that fertilizer applied to cropland and lawns in the watershed combined with stormwater delivery are the main contributors to the hypereutrophic state of the lake. These loads, however, are applied to the Great Bend stormwater (MS4) permit making the Other Nonpoint Source Load Allocation zero and the TMDL's Total Phosphorus Load Allocation equal to the Atmospheric Load Allocation (Table 6).

Point Sources: A wasteload allocation is assigned to the Great Bend stormwater discharge (MS4) permit for phosphorus under this TMDL (Table 6). It was determined that 100% of the Memorial Park Lake watershed is within the city limits of Great Bend; consequently, 100% of the Total Phosphorus Wasteload Allocation is allocated to the Great Bend MS4 permit.

Table 6. Memorial Park Lake TMDL

Description	Allocations (lbs/year)	Allocations (lbs/day)*
Total Phosphorus Atmospheric Nonpoint Load Allocation	1.166	0.00857
Total Phosphorus Other Nonpoint Source Load Allocation	0	0
Total Load Allocation	1.166	0.00857
Total Phosphorus Wasteload Allocation	7.54	0.0554
Total Phosphorus Margin of Safety	0.967	0.00711
Total Phosphorus TMDL	9.673	0.0711

*See Appendix B for Daily Load Calculations

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 is explicitly set at 10% of the original calculated total phosphorus loading capacity, which compensates for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety is expressed in Table 5.

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

Unified Watershed Assessment Priority Ranking: This watershed lies within the Lower Walnut Creek Subbasin (HUC 8: 11030008) which is classified as Category II (Watershed Meeting Goals, Including Those Needing Action to Sustain Water Quality).

Priority HUC 12: The entire watershed is within HUC 12: 110300080306.

5. IMPLEMENTATION

Desired Implementation Activities: There is some potential that urban and agricultural best management practices will improve the condition of Memorial Park Lake.

Some of the recommended urban practices are as follows:

1. Educate watershed residents on appropriate lawn fertilizer application.
2. Install grass buffer strips along drainage channels in the watershed.
3. Promote proper management of construction sites to minimize sediment and nutrient runoff.
4. Investigate feasibility of installing a storm water wetland in the watershed to aid in the removal of nutrients.
5. Promote installation of porous and concrete grid pavement in the watershed.

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. Promote and adopt continuous no-till cultivation to increase the amount of water infiltration and minimize cropland soil erosion and nutrient transports.
4. Install grass buffer strips along streams and drainage channels in the watershed.
5. Reduce activities within riparian areas.
6. Implement nutrient management plans to manage manure land applications and runoff potential.
7. Adequately manage fertilizer utilization in the watershed and implement runoff control measures.

Implementation Program Guidance:

Watershed Management Program – KDHE

a. Support selected Section 319 project activities including demonstration projects and outreach efforts dealing with erosion and sediment control and nutrient management.

b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management in the vicinity of streams.

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.

NPDES – MS4 – KDHE

a. Encourage the City of Great Bend to retrofit media filters and wetland channels along flow paths of stormwater coming from developed areas east and south of the lake.
b. Support construction of retention ponds and wetland basins to reduce particulate phosphorus, organic nitrogen and nitrates from stormwater.
c. Promote good housekeeping in developed areas near the lake, inlcudng street sweeping and prudent fertilizer use on lawns in residential areas.
d. Establish monitoring of nutrients in east and south arms of lake, focusing on concentrations arriving at lake after rainfall events.

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 nutrients.

Time Frame for Implementation: Initial implementation will proceed over the years from 2012-2020. Additional implementation may be required over 2021-2030 to achieve the endpoints of this TMDL.

Targeted Participants: Primary participants for implementation will be residents and stakeholders within the Memorial Park Lake watershed and the City of Great Bend Department of Public Works. A detailed assessment of sources conducted over 2012-2013 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 and fertilizer application rates,
2. Cultivation alongside lake,
3. Livestock use of riparian areas,
4. Fields with manure applications.

Milestone for 2016: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks the next cycle of 303(d) activities in the Upper Arkansas Basin. At that point in time, sample data from Memorial Park Lake will be reexamined to assess improved conditions in the lake. Should the impairment remain adjustments to source assessment, allocation, and implementation activities may begin.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment, the City of Great Bend Department of Public Works, the Kansas Department of Agriculture – Division of Conservation, the Natural Resources Conservation Service, the Kansas State University Extension Service, and the Barton County Conservation District. Producer outreach and awareness will be delivered by Kansas State University Extension Office.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants and to assure allocations of pollutant 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.A.R. 28-16-69 to 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

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. The Kansas Water Plan and the Upper Arkansas 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.

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

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. Additionally, $2 million has been allocated between the State Water Plan Fund and EPA 319 funds to support implementation of Watershed Restoration and Protection Strategies. 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. Detention ponds and wetland basins have also been proven effective in reducing nutrient loads in stormwater. The key to success will be widespread utilization of conservation farming, proper livestock waste management and proper stormwater management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue to sample Memorial Park Lake monthly for algae until the blue-green algae blooms subside and the public health advisory is lifted. KDHE will also

continue its 3-year sampling schedule in order to assess the trophic state of Memorial Park Lake. Based on the sampling results, the 303(d) listing will be evaluated in 2022. Should impairment status continue, the desired endpoints under this TMDL will be refined and more intensive sampling will be conducted over the period 2021-2030 to assess progress in this implementation.

7. FEEDBACK

Public Notice: An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Upper Arkansas Basin.

Public Hearing: A Public Hearing was held on September 20th, 2012 in Garden City to receive comments on this TMDL. None were received throughout the August 20, 2012 through September 26, 2012 comment period.

Basin Advisory Committee: The Upper Arkansas River Basin Advisory Committee met to discuss these TMDLs on April 4th, 2012 in Jetmore and September 20th 2012 in Garden City.

Milestone Evaluation: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks a future cycle of 303(d) activities in the Upper Arkansas Basin. At that point in time, sample data from Memorial Park Lake will be reexamined to assess improved conditions in the lake. Should the impairment remain, adjustments to source assessment, allocation, and implementation activities may occur.

Consideration for 303d Delisting: Memorial Park Lake will be evaluated for delisting under Section 303d, based on the monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022-303d 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 might 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 2012. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2012-2021.

Developed 12/19/12

References

Carney, E. 2006, 2009. Lake and Wetland Monitoring Program Annual Report/ Summary. Kansas Department of Health and Environment.

Chorus, Ingrid, Jamie Bartram, ed. Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management. New York: WHO, 1999.

Dodds W.K., E. Carney, and R.T. Angelo, 2006. Determining ecoregional reference conditions for nutrient, Secchi depth and chlorophyll *a* in Kansas lakes and reservoirs. Lake and Reservoir Management 22(2): 151-159.

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.

International Stormwater BMP Database. 2010. International Stormwater Best Management Practices Database, Pollutant Category Summary: Nutrients.

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

Kansas Water Office, 2002. Population Estimates & Projections by Selected Year. Accessed May 16, 2011. http://www.kwo.org/Reports%20%26%20Publications/Population_table5.pdf

National Agricultural Statistics Service. April 21, 2011. State and County Data. http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats_1.0/index.asp

WIMAS Query. Kansas Geological Survey. April 21, 2011. http://hercules.kgs.ku.edu/geohydro/wimas/query_setup.cfm

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Appendix A – CNET Eutrophication Model for Memorial Park Lake.
Input for CNET Model

Parameter	**Value Input into CNET Model**
Drainage Area (km^2)	2.53
Precipitation (m/yr)	0.59
Evaporation (m/yr)	1.59
Unit Runoff (m/yr)	0.045
Surface Area (km^2)	0.053
Mean Depth (m)	1.70
Depth of Mixed Layer (m)	1.69
Depth of Hypolimnion (m)	0.62
Observed Phosphorus (ppb)	156
Observed Chlorophyl *a* (ppb)	65.8
Observed Secchi Disc Depth	0.50

Output from CNET Model

Parameter	**Output from CNET Model**
Load Capacity (LC)*	9.67 lbs/year
Waste Load Allocations (WLA)	7.53 lbs/year
Atmospheric Air Deposition (LA)	1.17 lbs/year
Other Nonpoint (LA)	0 lbs/year
Total Load Allocation (LA)	1.17 lbs/year
Margin of Safety (MOS)	0.967 lbs/year

*LC=WLA + LA + MOS

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE -> **Memorial Park Lake** Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...		Latitude	38.34
Drainage Area	km2	2.53	2.53
Precipitation	m/yr	0.59	0.59
Evaporation	m/yr	1.59	1.59
Unit Runoff	m/yr	0.045	0.045
Stream Total P Conc.	ppb	557	34
Stream Ortho P Conc.	ppb	111.4	6.8
Atmospheric Total P Load	kg/km2-yr	10	10
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	0.053	0.0526
Max Depth	m	4	4
Mean Depth	m	1.7	1.7
Non-Algal Turbidity	1/m	0.36	0.48
Mean Depth of Mixed Layer	m	1.7	1.69
Mean Depth of Hypolimnion	m	0.62	0.62
Observed Phosphorus	ppb	156	27.7
Observed Chl-a	ppb	65.8	12.0
Observed Secchi	meters	0.50	1.29
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	0.030395	0.064599
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	0.03	0.03
NonPoint Flow	hm3/yr	0.11	0.11
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	0.14	0.14
Evaporation	hm3/yr	0.08	0.08
Outflow	hm3/yr	0.06	0.06

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	0	0
NonPoint Load	kg/yr	39	2
Point Load	kg/yr	0	0
Total Load	kg/yr	39	3
Sedimentation	kg/yr	30	1
Outflow	kg/yr	10	2
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.757	0.357
Mean Phosphorus	ppb	156.0	27.8
Mean Chlorophyll-a	ppb	60.7	11.9
Algal Nuisance Frequency	%	100.0	42.6
Mean Secchi Depth	meters	0.45	0.80
Hypol. Oxygen Depletion A	mg/m2-d	1870.3	829.6
Hypol. Oxygen Depletion V	mg/m3-d	3016.6	1338.0
Organic Nitrogen	ppb	1568.7	465.6
Non Ortho Phosphorus	ppb	112.5	28.5
Chl-a x Secchi	mg/m2	27.5	9.5
Principal Component 1	-	3.56	2.53
Principal Component 2	-	1.07	0.78
	Observed	Pred	Target
Carlson TSI P	77.0	77.0	52.1
Carlson TSI Chl-a	71.7	70.9	54.9
Carlson TSI Secchi	70.0	71.4	63.2
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	1.00
Chlorophyll-a		1.08	1.00
Secchi		1.10	1.61
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		0.00	-0.01
Chlorophyll-a		0.30	0.02
Secchi		0.36	1.76

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	0.08942	0.08942
Residence Time	yrs	1.4599	1.4599
Overflow Rate	m/yr	1.2	1.2
Total P Availability Factor		1	1
Ortho P Availability Factor		1.93	1.93
Inflow Ortho P/Total P		0.198	0.176
Inflow P Conc	ppb	642.1	43.2
P Reaction Rate - Mods 1		12.8	0.9
P Reaction Rate - Model 2		21.3	1.6
P Reaction Rate - Model 3		93.7	6.3
1-Rp Model 1 - Avail P		0.243	0.643
1-Rp Model 2 - Decay Rate		0.194	0.536
1-Rp Model 3 - 2nd Order Fixed		0.098	0.327
1-Rp Model 4 - Canfield & Bachm		0.147	0.458
1-Rp Model 5 - Vollenweider 197		0.453	0.453
1-Rp Model 6 - First Order Deca		0.407	0.407
1-Rp Model 7 - First Order Sett		0.538	0.538
1-Rp Model 8 - 2nd Order Tp Onl		0.243	0.643
1-Rp - Used		0.243	0.643
Reservoir P Conc	ppb	156.0	27.8
Gp		0.326	0.326
Bp	ppb	207.0	19.5
Chla vs. P, Turb, Flush:	2	60.7	11.9
Chla vs. P Linear	4	43.7	7.8
Chla vs. P 1.46	5	128.9	10.4
Chla Used	ppb	60.7	11.9
ml - Nuisance Freq Calc.		4.0	2.4
z		-4.458	0.187
v		0.000	0.392
w		0.403	0.941
x		0.000	0.426

ORTHO P LOADS...

Precipitation	kg/yr	0	0
NonPoint	kg/yr	13	1
Point	kg/yr	0	0
Total	kg/yr	13	1
Total	#/year	28	2

TOTAL P LOADS...

BAF Override (KS)	OrP %		
0.5	0%	0.53	0.53
0.23	20%	63.41	3.87
0.8	0%	0.00	0.00
		63.94	4.40
		140.67	9.67

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

The TMDL has estimated annual average loads for 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 lbs/year	CV	$e^{[Z\sigma-0.5\sigma^2]}$	MDL lbs/day	Atm LA lbs/day	Waste LA lbs/day	NonPoint LA lbs/day	MOS (10%) lbs/day
TP	9.67	0.5	2.68	0.0711	0.00857	0.0554	0	0.00711

Maximum Daily Load Calculation
Annual TP Load = 9.67 lbs/yr

Maximum Daily TP Load = [(9.67 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 0.0711 lbs/day

Margin of Safety (MOS) for Daily Load
Annual TP MOS = .967 lbs/yr

Daily TP MOS = [(0.967 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 0.00711 lbs/day

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