UPPER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Jetmore Lake
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Buckner **Counties:** Hodgeman

HUC 8: 11030006 **HUC (10) 12:** (03) 01

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

Drainage Area: 32.2 square miles

Conservation Pool: Surface Area = 70 acres
Watershed/Lake Ratio: 294:1
Maximum Depth = 4.0 meters
Mean Depth = 1.7 meters
Storage Volume = 383 acre-feet
Estimated Retention Time = 0.65 years
Year Constructed = 1991

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

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

Impaired Use: All uses in Jetmore Lake are impaired to a degree by eutrophication.

Water Quality Criteria:

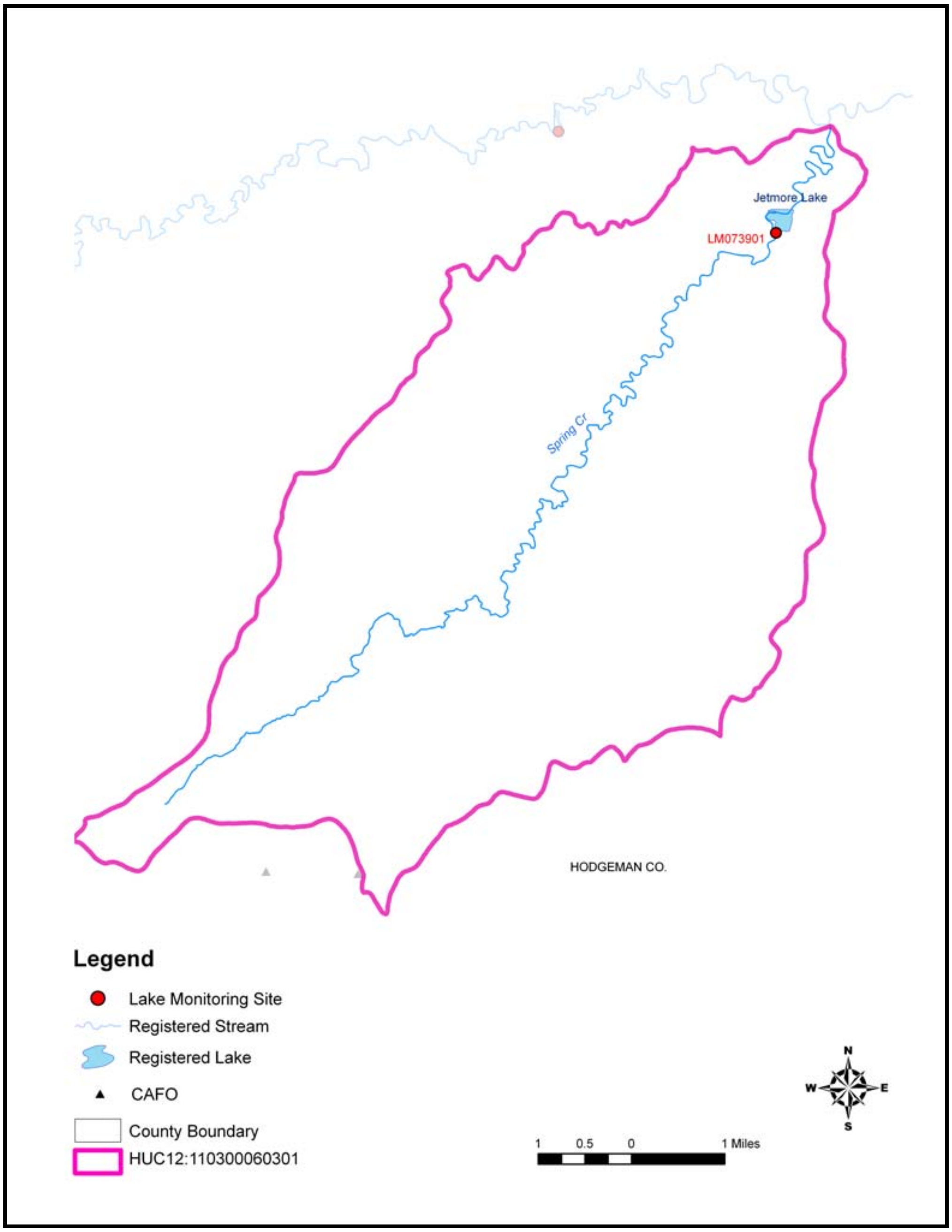
General – Narrative: Taste-producing and odor-producing substances of artificial origin shall not occur in surface waters at concentrations that interfere with the production of potable water by conventional water treatment processes, that impart an unpalatable flavor to edible aquatic or semiaquatic life or terrestrial wildlife, or that result in noticeable odors in the vicinity of surface waters (KAR 28-16-28e(b)(7).

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 (KAR 28-16-28e(c)(3)(D).

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. Jetmore 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 contributing to eutrophication which could interfere with domestic water supply should the lake become an active source. The excessive nutrients are also impairing aquatic life use by supporting objectionable types and quantities of algae which also leads to impairment of contact recreation within Jetmore Lake. A chlorophyll *a* endpoint of 10 μg/L is assigned to address the domestic water supply use; however, all other uses will be met when the chlorophyll *a* endpoint of 10 μg/L is met.

Level of Eutrophication: Fully Eutrophic, Trophic State Index = 59.3

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:

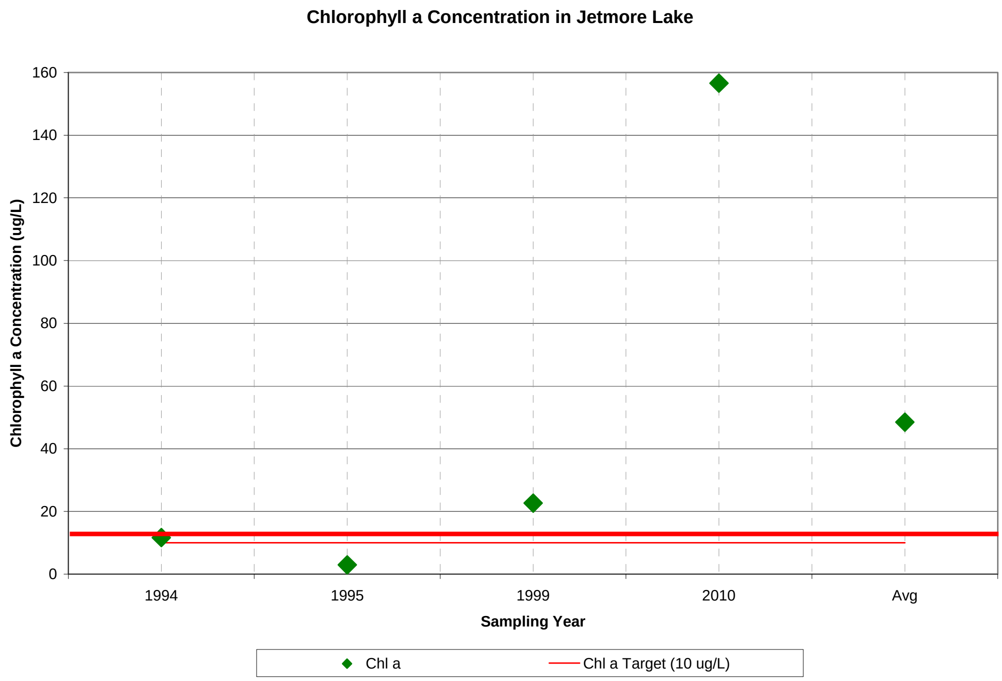
1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: 64

Lake Monitoring Sites: KDHE Station LM073901 at Jetmore Lake.
Period of Record: Four surveys conducted by KDHE during the summer of calendar years 1994, 1995, 1999, and 2010.

Long-Term Hydrologic Conditions: Spring Creek (CUSEGA segment 110300067) above Jetmore Lake is the only registered stream directly feeding the lake. There is not a flow gage on the stream and the USGS estimates mean flow as 1.00 cfs with a flow of 0.0 at 10, 25, 50, 75 and 90 percent flow exceedance and a 2 year peak flow of 468 cfs (Perry, 2004). CNET eutrophication modeling (Appendix A) generates a flow value of 0.93 cfs, based on the drainage area. According to the USGS Lake Hydro data, the mean runoff in the watershed is 0.50 inches/year; the mean precipitation in the watershed is 20.0 inches/year; the mean loss due to evaporation for the lake is 66.8 inches/year; and the calculated mean annual outflow for the lake is 586 acre feet/year.

Current Condition: Over the period of record, Jetmore Lake has chlorophyll *a* concentrations averaging 48.5 μg/L. Chlorophyll *a* concentrations are variable over the period of record ranging from a low value of 2.95 μg/L in 1995 to a high value of 157 μg/L in 2010 (Figure 2). Water quality data is limited for the lake as it went dry in 2002, began to refill in 2005 and in 2007 the lake level was high enough to begin restocking fish (McWhirt, 2011). KDHE sampling resumed in 2010, although it was limited to measurements for Chlorophyll *a* and Secchi depth only.

Figure 2. Chlorophyll *a* concentrations in Jetmore Lake during 1994-2010 sampling years.



The average Secchi depth in Jetmore Lake is 0.75 meters with a low reading of 0.50 meters in 1994, improving to 1.10 meters in 1995 and settling between 0.6 and 0.8 meters for the remainder of the period of record (Figure 3). Total phosphorus (TP) concentrations are available for 1994, 1995 and 1999 which averaged 34.6 μg/L, ranging from 11.3 μg/L in 1995 to 62.8 μg/L in 1999 (Figure 4). Total nitrogen concentrations are available for the sampling years of 1995 and 1999 with values of 1.25 mg/L and 1.05 mg/L, respectively. Turbidity in Jetmore Lake averaged 3.56 NTU with a range of 2.80 to 4.35 NTU, while total suspended solids ranged from 7.50 to 15.0 mg/L (Table 2).

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

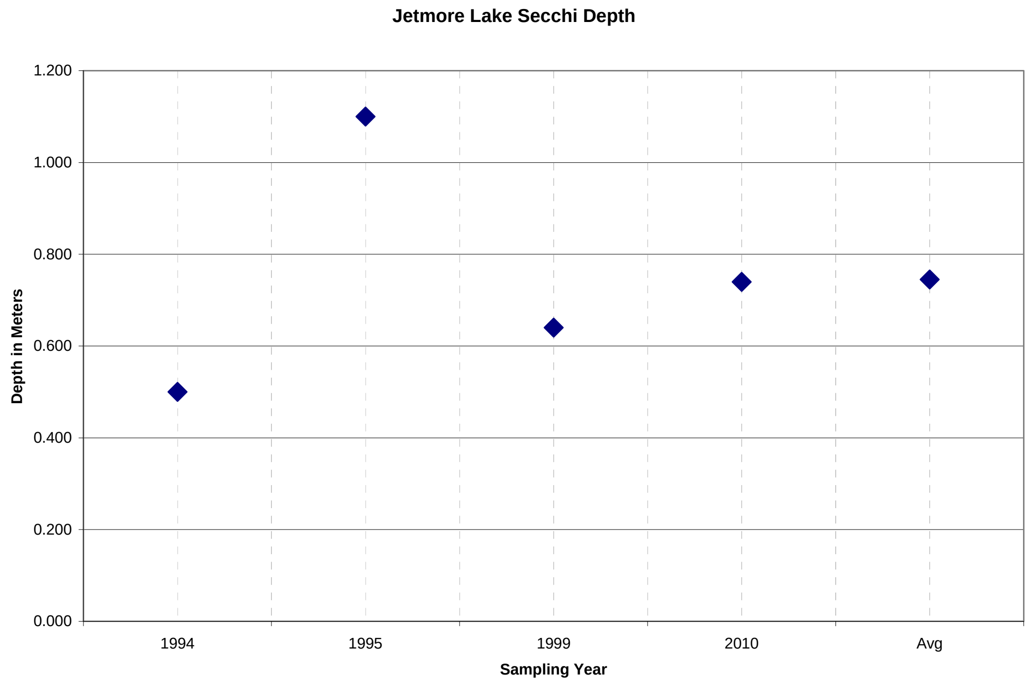
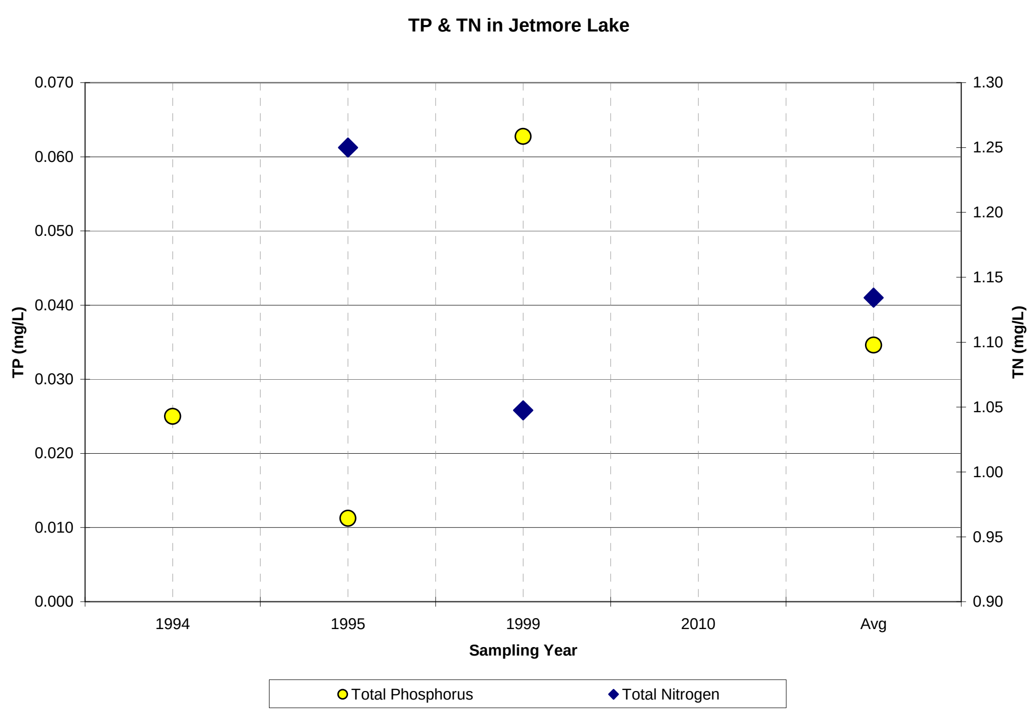


Figure 4. Average Total Phosphorus and Total Nitrogen concentration by sampling date.



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 1995 and 1999 resulting in TN:TP ratios of 111 and 16.7, respectively, pointing to phosphorus as the limiting nutrient in Jetmore Lake (Table 1).

Table 1. Concentration averages for Jetmore 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)
1994	11.7	*	0.0250	*	0.500	3.50	*
1995	2.95	1.25	0.0113	111	1.10	2.80	7.50
1999	22.7	1.05	0.0628	16.7	0.640	4.35	15.0
2010	157	*	*	*	0.740	*	*
Average	*25.6*	*1.13*	*0.0346*	*52.2*	*0.745*	*3.56*	*11.3*

* Data not available.

Table 2 lists the six metrics that measure the roles of light and nutrients in Jetmore 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. Jetmore 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**	
1994	1.71	No Data Available	5.83	0.488	No Data Available	No Data Available	11.7
1995	0.835	No Data Available	3.25	0.334	No Data Available	No Data Available	2.95
1999	1.00	2.05	14.5	0.368	3.22	3.84	22.7
2010	-2.56	No Data Available	116	No Data Available	No Data Available	No Data Available	157

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.

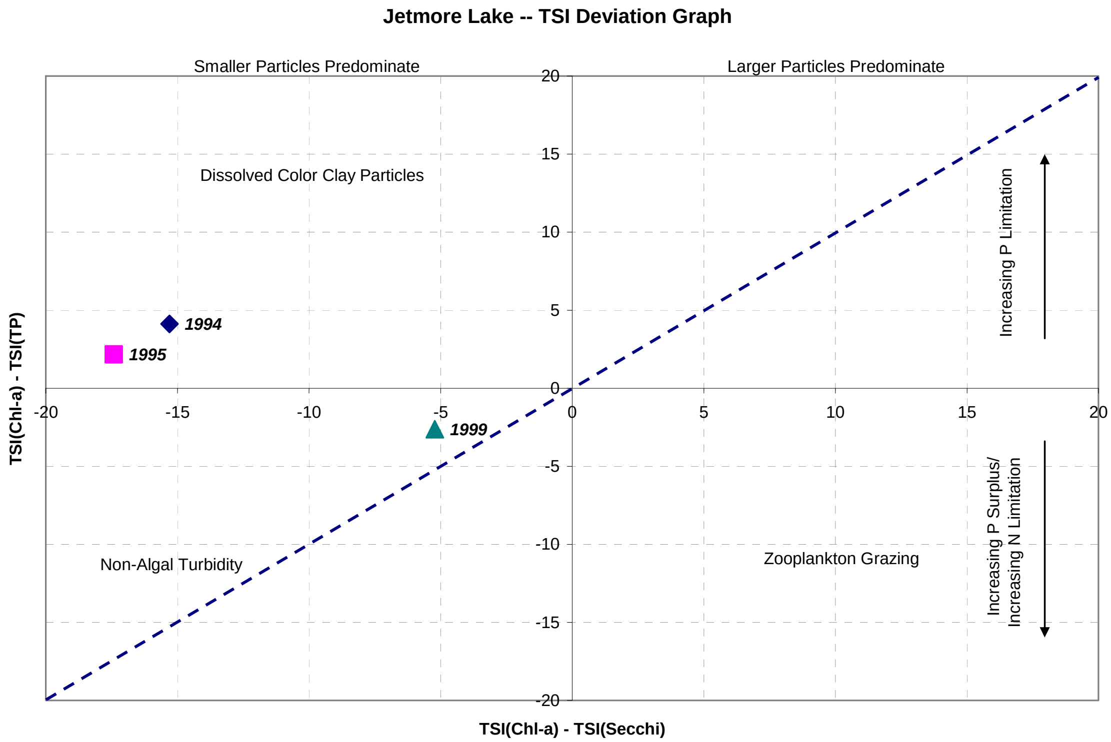
The light availability in the mixed layer for a given surface light is represented as Zmix/SD. Values less than 3 indicate that light availability is high in the mixed zone and there is a high probability of strong algal responses to changes in nutrient levels.

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).

Although the available data is limited, the above metrics indicate that to some degree inorganic turbidity is impairing light availability causing the algal response to nutrient inputs to be moderate. Self shading of algae in Jetmore Lake does not appear to be impeding algal productivity.

Another method for evaluating limiting factors is the TSI deviation metrics. Figure 5 (Multivariate Deviation Graph) summarizes the current trophic conditions at Jetmore Lake using a multivariate TSI comparison chart for the period of record. Where TSI(Chl-a) is greater than TSI(TP), the situation indicates phosphorus is limiting chlorophyll *a*, whereas negative values indicate turbidity limits chlorophyll *a.* Where TSI(Chl-a)-TSI(SD) is plotted on the horizontal axis, if the Secchi depth (SD) trophic index is less than the chlorophyll *a* trophic index, then there is dominant zooplankton grazing. Transparency would be dominated by non-algal factors such as color or inorganic turbidity if the Secchi depth index were more 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.

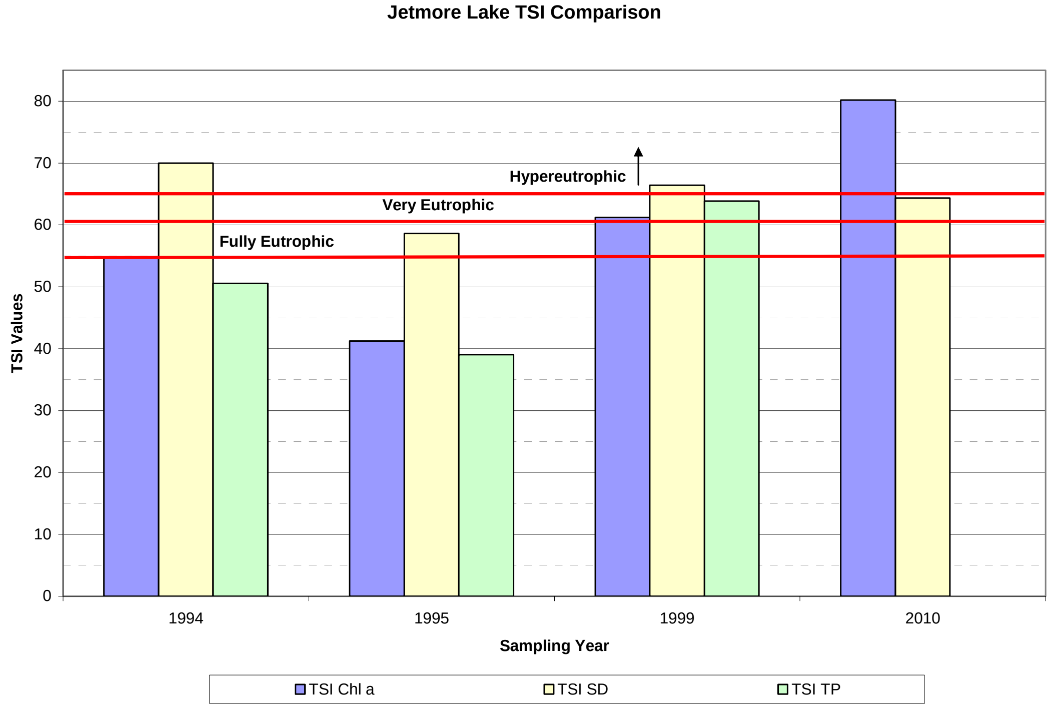
Figure 5. Multivariate TSI comparison chart for Jetmore Lake.



With limited data, the multivariate TSI comparison chart in Figure 5 indicates that phosphorus and inorganic turbidity are limiting chlorophyll *a* concentrations in Jetmore Lake.

The Carlson Trophic State Indices for Chlorophyll *a*, Secchi depth and total phosphorus in Jetmore Lake (Figure 6) show the lake's trophic condition has deteriorated since 1995 and reached a hypereutrophic state in 2010.

Figure 6. Jetmore Lake Trophic State Indices (TP TSI not available for 2010).



The median trophic conditions within Jetmore Lake compared to Federal lakes in the state are summarized in Table 3. The trophic indicator value for total phosphorus within Jetmore Lake meets the Statewide, Central Great Plain and Federal Benchmarks. All other trophic indicator values, however, fail to meet any of the benchmarks.

Table 3. Median trophic indicator values of Jetmore 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	Jetmore Lake	Federal Lake	Central Great Plains	Statewide Benchmark
Secchi Depth (cm)	69	95	117	129
TN (µg/L)	1140	903	695	625
TP (µg/L)	25	76	44	23
Chlorophyll *a* (µg/L)	17	12	11	8

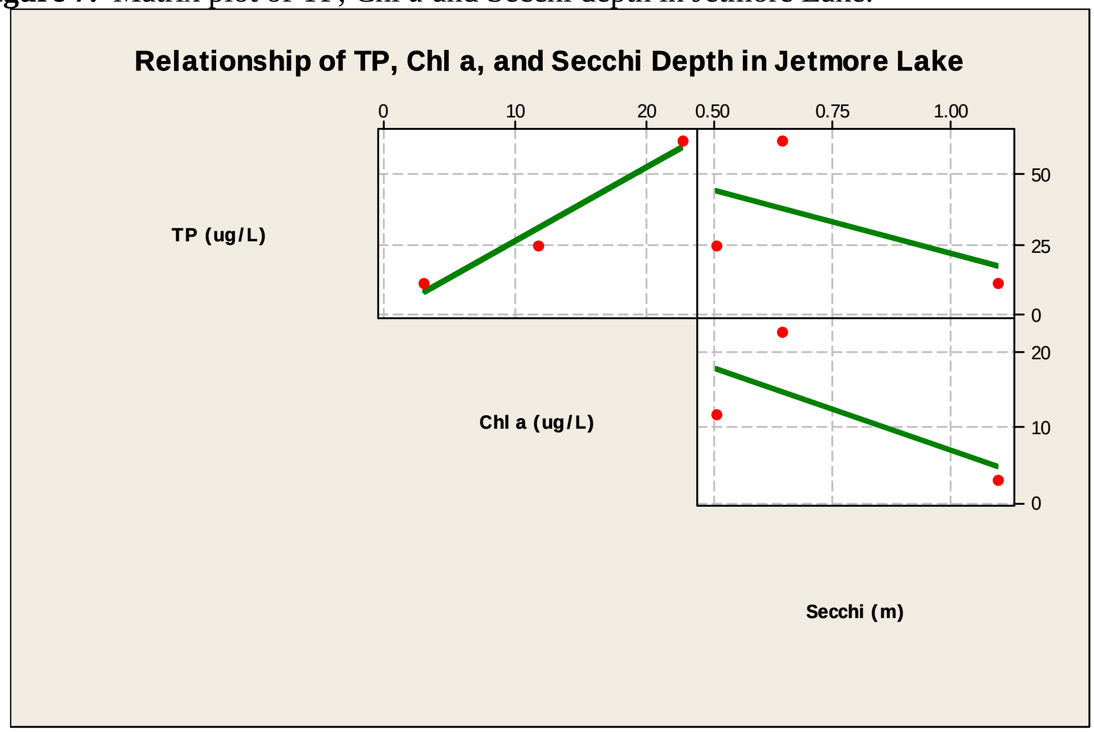
Algal Communities: Algal community data is limited to the 1995 and 1999 sampling years and, as seen in table 4, there was an increase in total cell count that is reflected in the chlorophyll *a* level. Blue-green algae also appear in 1999 where there were none seen in the 1995 sampling.

Table 4. Algal communities observed in Jetmore Lake during KDHE sampling years.

Sampling Date	Total Cell Count cells/mL	Percent Composition				Chl-*a* μg/L
		Green	Blue-Green	Diatom	Other	
1995	6300	88	0	8	4	2.95
1999	11529	66	29	0	5	22.7

Relationships: Although the data are limited, Figure 7 indicates a strong relationship between total phosphorus, chlorophyll *a* and Secchi depth in Jetmore Lake (Figure 7).

Figure 7. Matrix plot of TP, Chl *a* and Secchi depth in Jetmore Lake.



Stream Data: There is not a KDHE monitoring station or USGS Gaging station associated with Spring Creek above Jetmore Lake. The USGS estimates a mean flow of 1.00 cfs, a flow of 0.0 cfs at 10, 25, 50, 75 and 90 percent flow exceedance and a 2 year peak flow of 468 cfs (Perry, 2004).

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

In order to improve the trophic condition of Jetmore Lake from its current Fully Eutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* average concentrations below 10 μg/L, 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. The chlorophyll *a* endpoint of 10 μg/L is the statewide goal for lakes serving as public water supplies which will also ensure long-term protection to fully support Primary Contact Recreation and Aquatic Life within the lake. Based on the CNET reservoir eutrophication model (Appendix A), the total phosphorus concentration entering the lake must be reduced by 70%. With this reduction, the endpoint for Jetmore Lake will be met. This reduction at the inflow to Jetmore Lake will result in a 53% reduction of total phosphorus, and an 80% reduction of Chlorophyll *a* within the lake (Table 5). 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 Jetmore Lake utilized in the model input was based on data from KDHE station LM073901 for the period of record. In lake total phosphorus concentration was based on a regression of the TSI values for TP and chlorophyll *a* and using the resulting equation TSI(TP)=1.1817*TSI(chlorophyll *a*)-10.733 a current lake concentration of 88.2 μg/L was estimated. Water quality data for Spring Creek was estimated by calibrating the stream total phosphorus concentration input in CNET to the current lake mean phosphorus concentration of 82.8 μg/L resulting in an estimated total phosphorus concentration in Spring Creek of 225 μg/L before reductions (Appendix A).

Table 5. Jetmore Lake current average condition and TMDL based on CNET.

	Current Avg. Condition	**TMDL**	**Percent Reduction**
Total Phosphorus – Annual Load (lbs/year)	419.1	125.5	70%
Total Phosphorus – Daily Load* (lbs/day)	4.34	1.30	70%
Total Phosphorus – Lake Concentration (μg/L)	88.2	41.2	53%
Chlorophyll *a* Concentration (μg/L)	49.2	10	80%

*See Appendix B for Daily Load Calculations

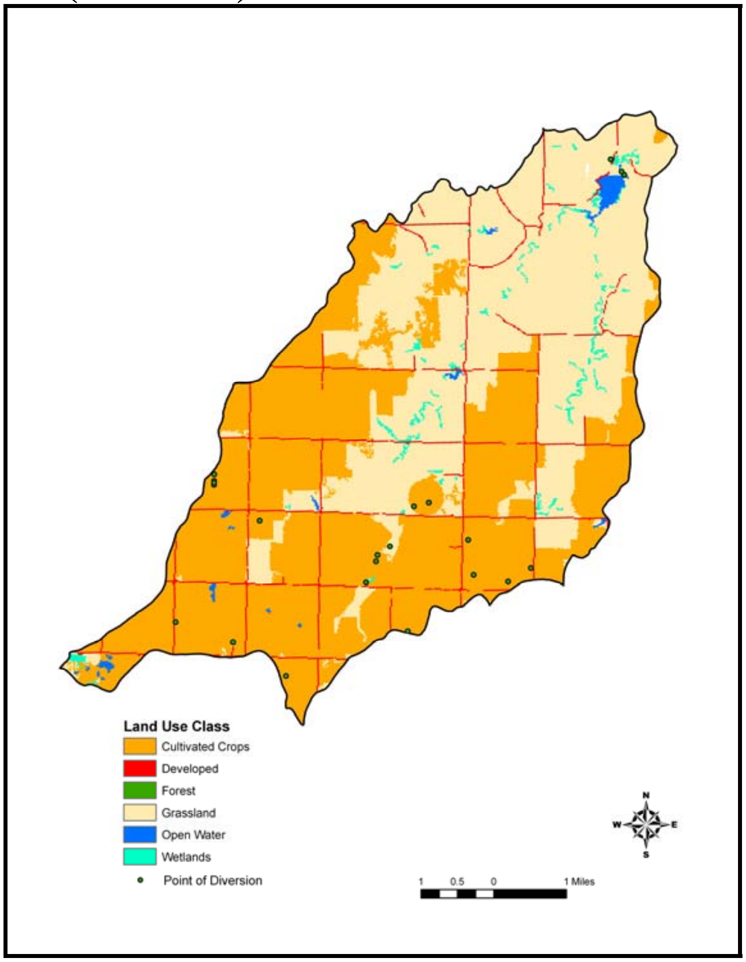
3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There are no NPDES permitted facilities in the Jetmore Lake watershed.

Livestock Waste Management Systems: There are no active permitted or certified confined animal feeding operations (CAFOs) in the Jetmore Lake watershed. However, according to USDA National Agricultural Statistics Service, on January 1, 2010, cattle inventory for Hodgeman County was 75,000 head.

Land Use: The predominant land uses in the Jetmore Lake watershed are cultivated cropland (52.0%) and grassland (43.2) according to the 2001 National Land Cover Data. Together they account for 95.3% of the total land area in the watershed with the remaining land area composed of developed space (2.9%), wetlands (1.2%) and open water (0.70%).

Figure 8. Land Use (2001 NLCD) & Points of Diversion in the Jetmore Lake watershed.



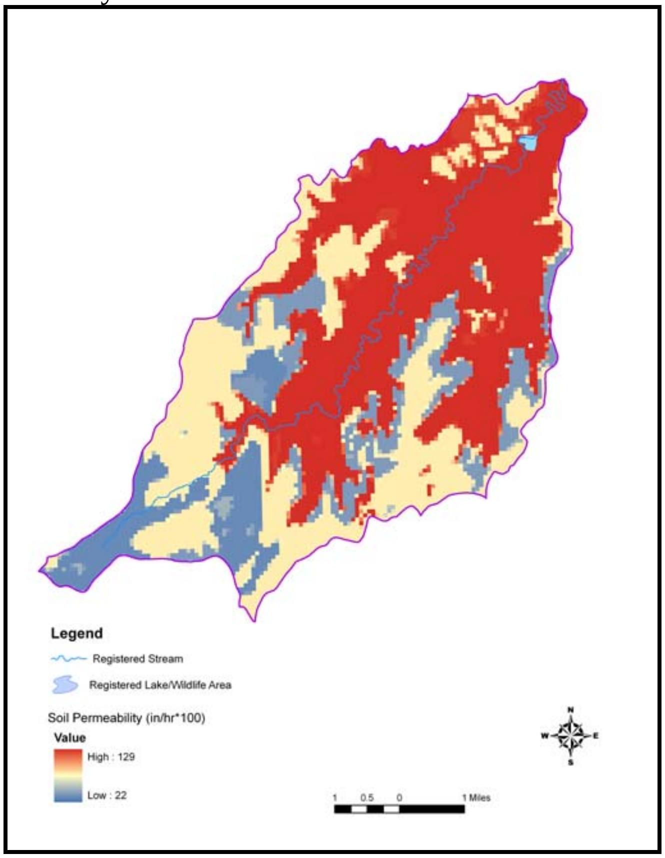
Points of Diversion: There are 475 unique points of diversion in Hodgeman County with 22 of them falling into the Jetmore Lake watershed (Figure 8). Combined, the water rights are authorized to use 4,337 acre-feet of water annually. Eighteen of the water rights are groundwater rights to be used for irrigation and two of the rights are for municipal use: a surface water right owned by the Kansas Water Office and a ground water right owned by the City of Jetmore. Of the remaining two points, one is a surface water right to be used for recreation and the other is a groundwater right to be used for livestock watering.

On-Site Waste Systems: The Jetmore Lake watershed is a rural agricultural area and, based on the1990 census data, about 48% of households in Hodgeman County utilize septic or other on-site systems. Failing on-site septic systems may contribute significant nutrient loadings and aggravate eutrophication problems if in proximity to the lake.

Contributing Runoff: The watershed of Jetmore Lake has a mean soil permeability value of 0.95 inches/hour, ranging from 0.22 inches/hour to 1.29 inches/hour according to NRCS STATSGO database (Figure 9). Most of the watershed is considered to have very low to low soil permeability with 24% of the watershed having a permeability of 0.81 inches/hour and 58% of the watershed has a permeability of 1.29 inches/hour.

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 9. Soil permeability in the Jetmore Lake watershed.



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

The limited data indicate total phosphorus is limiting the production of algal growth in Jetmore Lake; therefore, total phosphorus will be 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 fertilizer applicators and smaller livestock facilities. Because of atmospheric deposition, the allocation of phosphorus will include a proportional decrease in phosphorus between the current condition and the desired endpoint (Table 6).

Point Sources: A current Wasteload Allocation of zero is assigned for phosphorus under this TMDL because of the lack of point sources in the watershed. Should future sources be proposed in the watershed, 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: The assessment suggests that cropland and animal waste contribute to the very eutrophic state of the lake. The eutrophic state of the lake has also been aggravated by the lake being at a reduced level for approximately 36 months due to lack of inflow. Load reductions should be focused on nonpoint source runoff contributions attributed to the livestock facilities and fertilizer applicators within the watershed. Using the CNET reservoir eutrophication modeling worksheet (Appendix A), a loading capacity of 112.9 lbs/year of total phosphorus entering the lake, accounting for a 73% reduction, was found to be necessary to reach the endpoint (Table 6).

Table 6. Jetmore Lake Eutrophication (Total Phosphorus) TMDL

Description	Allocations (lbs/year)	Allocations (lbs/day)*
Total Phosphorus Atmospheric Load	6.23	0.06
Total Phosphorus Wasteload	0	0
Total Phosphorus Nonpoint Source Load	112.9	1.17
Total Phosphorus Margin of Safety	12.5	0.13
Total Phosphorus TMDL	125.5	1.30

*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 6.

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

Unified Watershed Assessment Priority Ranking: This watershed lies within the Buckner Subbasin (HUC 8: 11030006) with a priority ranking of 28 (Medium Priority for restoration work).

Priority HUC 12: The entire watershed is within HUC 12: 110300060301.

5. IMPLEMENTATION

Desired Implementation Activities: There is a very good potential that agricultural best management practices will improve the condition of Jetmore Lake. 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.

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 by happenstance over the years 2012-2016. Focused implementation may be required over 2017-2021 to achieve the endpoints of this TMDL.

Targeted Participants: Primary participants for implementation will be agricultural producers and stakeholders within the Jetmore Lake watershed. 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 Jetmore 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.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment, the Kansas Department of Agriculture – Division of Conservation, the Natural Resources Conservation Service, the Kansas State University Extension Service, the Hodgeman County Conservation District and the Upper Arkansas Basin WRAPS teams. 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. 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 its 3-year sampling schedule in order to assess the trophic state of Jetmore 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 2021-2025 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 Jetmore 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: Jetmore 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 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 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 10/24/12

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Appendix A – CNET Eutrophication Model for Jetmore Lake.
Input for CNET Model

Parameter	Value Input into CNET Model
Drainage Area (km^2)	83.4
Precipitation (m/yr)	0.51
Evaporation (m/yr)	1.7
Unit Runoff (m/yr)	0.01
Surface Area (km^2)	0.283
Mean Depth (m)	1.7
Depth of Mixed Layer (m)	1.69
Depth of Hypolimnion (m)	0.62
Observed Phosphorus (ppb)	88.3
Observed Chlorophyl *a (*ppb)	48.5
Observed Secchi Disc Depth	0.75

Output from CNET Model

Parameter	Output from CNET Model
Load Capacity (LC)*	125.5 lbs/year
Waste Load Allocations (WLA)	0 lbs/year
Atmospheric Air Deposition (LA)	6.23 lbs/ year
Other Nonpoint (LA)	106.7 lbs/year
Total Load Allocation (LA)	112.9 lbs/year
Margin of Safety (MOS)	12.5 lbs/year

*LC=WLA + LA + MOS

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE -> **Jetmore City Lake**

Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...		Latitude	37
Drainage Area	km2	83.4	83.4
Precipitation	m/yr	0.51	0.51
Evaporation	m/yr	1.7	1.7
Unit Runoff	m/yr	0.01	0.01
Stream Total P Conc.	ppb	254	65
Stream Ortho P Conc.	ppb	50.8	13
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	0.283	0.283
Max Depth	m	4	4
Mean Depth	m	1.7	1.7
Non-Algal Turbidity	1/m	0.12	1.08
Mean Depth of Mixed Layer	m	1.69	1.69
Mean Depth of Hypolimnion	m	0.62	0.62
Observed Phosphorus	ppb	88.2	35.0
Observed Chl-a	ppb	48.5	10.0
Observed Secchi	meters	0.75	0.75
MODEL PARAMETERS...			
BATHTUB Total P Model Number	(1-8)	4	4
BATHTUB Total P Model Name		CANFIELD	
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	0.027491	0.133333
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	10	10
WATER BALANCE...			
Precipitation Flow	hm3/yr	0.14	0.14
NonPoint Flow	hm3/yr	0.83	0.83
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	0.98	0.98
Evaporation	hm3/yr	0.48	0.48
Outflow	hm3/yr	0.50	0.50

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	3	3
NonPoint Load	kg/yr	212	54
Point Load	kg/yr	0	0
Total Load	kg/yr	215	57
Sedimentation	kg/yr	171	37
Outflow	kg/yr	44	21
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.796	0.640
Mean Phosphorus	ppb	88.2	41.2
Mean Chlorophyll-a	ppb	49.2	10.0
Algal Nuisance Frequency	%	100.0	43.3
Mean Secchi Depth	meters	0.68	0.41
Hypol. Oxygen Depletion A	mg/m2-d	1682.7	759.7
Hypol. Oxygen Depletion V	mg/m3-d	2714.1	1225.3
Organic Nitrogen	ppb	1286.9	466.8
Non Ortho Phosphorus	ppb	86.2	39.3
Chl-a x Secchi	mg/m2	33.4	4.1
Principal Component 1	-	3.30	2.70
Principal Component 2	-	1.14	0.51
	Observed	Pred	Target
Carlson TSI P	68.8	68.8	57.8
Carlson TSI Chl-a	68.7	68.8	53.2
Carlson TSI Secchi	64.1	65.6	72.7
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	0.85
Chlorophyll-a		0.99	1.00
Secchi		1.10	1.81
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		0.00	-0.60
Chlorophyll-a		-0.05	-0.01
Secchi		0.36	2.19

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	0.4811	0.4811
Residence Time	yrs	0.9676	0.9676
Overflow Rate	m/yr	1.8	1.8
Total P Availability Factor		1	1
Ortho P Availability Factor		0	0
Inflow Ortho P/Total P		0.197	0.190
Inflow P Conc	ppb	431.7	114.7
P Reaction Rate - Mods :		8.3	2.2
P Reaction Rate - Model 2		13.8	3.8
P Reaction Rate - Model 3		41.8	11.1
1-Rp Model 1 - Avail P		0.292	0.484
1-Rp Model 2 - Decay Rate		0.235	0.397
1-Rp Model 3 - 2nd Order Fixed		0.143	0.258
1-Rp Model 4 - Canfield & Bachm		0.204	0.360
1-Rp Model 5 - Vollenweider 197		0.504	0.504
1-Rp Model 6 - First Order Deca		0.508	0.508
1-Rp Model 7 - First Order Sett		0.637	0.637
1-Rp Model 8 - 2nd Order Tp Onl		0.292	0.484
1-Rp - Used		0.204	0.360
Reservoir P Conc	ppb	88.2	41.2
Gp		0.328	0.328
Bp	ppb	94.9	33.5
Chla vs. P, Turb, Flush:	2	49.2	10.0
Chla vs. P Linear	4	24.7	11.5
Chla vs. P 1.46	5	56.1	18.5
Chla Used	ppb	49.2	10.0
m1 - Nuisance Freq Calc.		3.8	2.2
z		-4.375	0.169
v		0.000	0.393
w		0.407	0.947
x		0.000	0.433

ORTHO P LOADS...				TOTAL P LOADS...			
				BAF Override (KS)	OrP %		
Precipitation	kg/yr	0	0	0	0%	2.8	2.8
NonPoint	kg/yr	42	11	0	20%	211.8	54.2
Point	kg/yr	0	0	0	0%	0.0	0.0
Total	kg/yr	42	11			214.7	57.0
Total	#/year	93	24			472.3	125.5

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	NonPoint LA lbs/day	MOS (10%) lbs/day
TP	125.5	0.75	3.78	1.30	0.06	1.17	0.13

Maximum Daily Load Calculation
Annual TP Load = 125.5 lbs/yr

Maximum Daily TP Load = [(125.5 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.668) - 0.5*(0.668)^2]}$
= 1.30 lbs/day

Margin of Safety (MOS) for Daily Load
Annual TP MOS = 12.5 lbs/yr

Daily TP MOS = [(12.5 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.668) - 0.5*(0.668)^2]}$
= 0.13 lbs/day

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