KANSAS LOWER REPUBLICAN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit (AU): Mission Lake

Water Quality Impairment: Siltation

1. INTRODUCTIONS AND PROBLEM IDENTIFICATION

Subbasin: Delaware
County: Brown

HUC8 (HUC12): 10270103(0201)

Ecoregion: Western Corn Belt, Loess and Glacial Drift Hills (47i)

Drainage Area: Approximately 8.1 square miles

Conservation Pool: Surface Area = 123 acres
Watershed/Lake Ratio = 42:1
Maximum Depth = 4.2 meters
Mean Depth = 1.9 meters
Storage Volume = 1035 acre-feet
Estimated Retention Time = 0.38 years
Year Constructed = 1924

Designated Uses: Primary Contact Recreation (A); Expected Aquatic Life Support; Domestic Water Supply; Food Procurement; Industrial Water.

303(d) Listings: 2008 Kansas Lower Republican River Basin Lakes

Impaired Use: All uses impaired to a degree by Siltation

Water Quality Standard: Suspended Solids – Narrative: Suspended solids added to surface waters by artificial sources shall not interfere with the behavior, reproduction, physical habitat or other factors related to the survival and propagation of aquatic or semi-aquatic or terrestrial wildlife (K.A.R. 28-16-28e(c)(2)(B)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Siltation Impairment: The reservoir storage capacity has been reduced significantly due to the accumulation of sediment over the life of the reservoir. The City of Horton had to abandon all raw water intakes from this lake due to the impairment until storage capacity of the lake was improved. Through a pilot project under the Water Supply Restoration Program administered by the State Conservation Commission (SCC), a major dredging project has been completed in 2010. The dredging project reportedly

removed approximately 1,000,000 yd^3 of sediment. The lake sediment was hydraulically dredged and pumped 4,800 feet upstream of the lake to a Confined Disposal Facility (CDF) settling basin. The dredged sediment remains in the CDF, while return water passes over a stop-log overflow weir at the outlet of the basin and enters an unnamed tributary that flows back into Mission Lake. With the restoration of the storage capacity within the lake, future sediment loadings must be managed to ensure the lake maintains adequate storage capacity.

Monitoring Site: Station LM013601 (rotational site in Mission Lake)

Period of Record Used: Nine Surveys during the years of: 1982, 1989, 1994, 1996, 1997, 1998, 2002, 2006, and 2009.

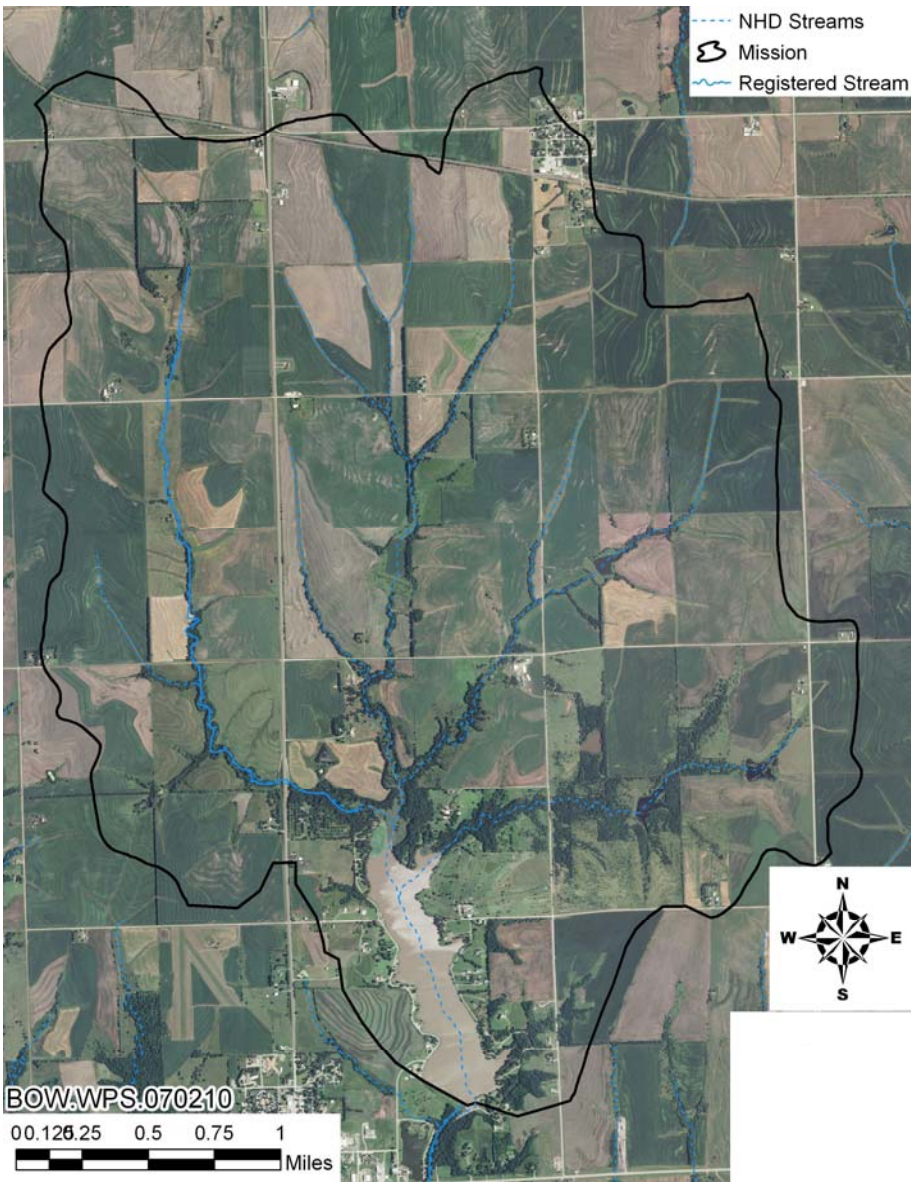

Figure 1. Mission Lake watershed aerial photography map.

Hydrologic Conditions: Mission Creek is the only classified stream that enters Mission Lake. The estimated flow durations, peak discharges, and mean flow for Mission Creek entering the lake are listed in Table 1.

Table 1. Mission Creek Estimated Flow (Q) durations in cfs as calculated using multiple regression techniques (Perry, 2004) and estimated peak discharge (cfs) for indicated peak –discharge frequency.

Inflow	Mean Q	90%	75%	50%	25%	10%	2-year	5-year	10-year
Mission Creek	4.81	0	0	0.07	1.15	5.0	940	1970	2850

According to the USGS Lake Hydro data, the mean runoff in the watershed is 6.20 inches/year; the mean precipitation in the watershed is 32.6 inches/year and the mean loss due to evaporation for the Lake is 44.9 inches/year.

Current Condition: The average Total Suspended Solids (TSS) concentration over the period of record is 32.8 mg/L, ranging from 12 mg/L to 46.25 mg/L as seen in Figure 2. The average turbidity value in Mission Lake is 41.3 NTU, ranging from a low of 13.15 NTU in 2006 to a high of 165 NTU in 1996 as seen in Figure 2. The average secchi depth is 0.35 meters, with the lowest reading of 0.1 meters occurring in 1996 and a maximum depth reading of 0.52 meters occurring in 2006 as seen in Figure 3. There is currently an approved Eutrophication TMDL for Mission Lake due to the elevated phosphorus levels within the lake. The average lake depth has steadily declined as sediment has filled the lake, resulting in a storage volume reduction of over 45% since the lake was constructed. There are numerous citations as to the estimated size and storage volume of Mission Lake throughout the years. The estimated surface area and storage volume from 1954, as seen in Table 2, is cited from the Corps of Engineers National Inventory of Dams (no date). The 2004 estimate in particular, is obviously a poor estimate. In 2007, the Kansas Biological Survey (KBS) performed a bathymetric and sedimentation survey of Mission Lake and determined that the lake surface area is 123 acres and the lake volume is 1035 acre-feet. These values are accurate compared to all the previous estimates of the area and volume of the lake. Based on this survey the Kansas Water Office determined the sedimentation rate is 10 acre-feet/year, as further illustrated in Table 3. Figures 4, 5 and 6 are from the 2007 bathymetric survey and illustrate the areas of sediment accumulation and the associated changes in depth throughout the lake from 1923 to 2007.

In 2010, as the dredging project was nearing completion the KBS conducted another Bathymetric Survey. Results from this survey concluded that 459 acre-ft of storage volume was restored, which indicates that 740,520 cubic yards of material was removed through the dredging project. It has been reported that the contractor continued to dredge Mission Lake for an additional few weeks after the KBS survey and the dredging contractor reported that 1,000,000 cubic yards of material was removed with this project.

Table 2. Mission Lake degradation due to sediment accumulation.

Year	Lake Area (Acres)	Average Lake Depth (Feet)	Sediment Volume (Cubic Yards)	Storage Volume (Acre-Feet)
1924	169	11	0	1866
1954	154.8	7.7	1.1 million	1188
2004*	71	6.95	2.2 million	493
2007	123			1035
2010 -Restored	133			1438

* - estimation from citation (BG Consultants and KDHE)

Table 3. Mission Lake Sedimentation Rate.

Year	Lake Area (Acres)	Volume (Acre-Feet)
1924	169	1866
2007	124	1035
Total Years = 83	Total Surface Area Lost = 45 acres	Total Volume Lost = 831 acre-feet
Current Sedimentation Rate = 831 Acre-Feet / 83 years = **10 acre-feet / year**		

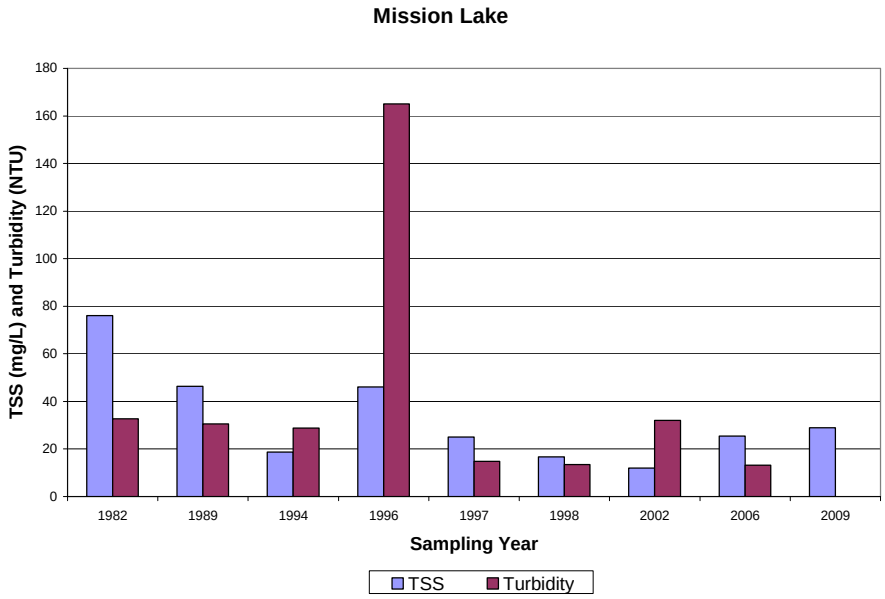

Figure 2. Annual average TSS and Turbidity concentrations within Mission Lake.

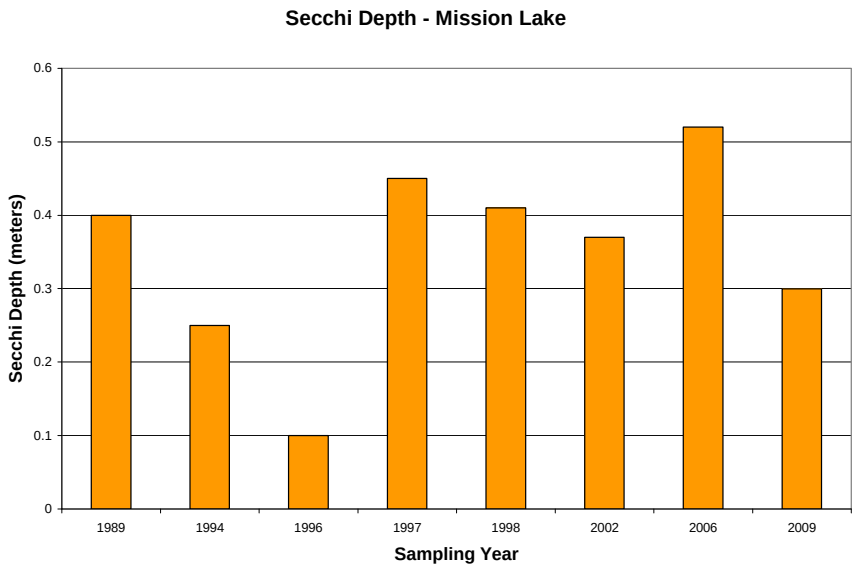

Figure 3. Secchi Disk measurements for the year KDHE sampled Mission Lake.

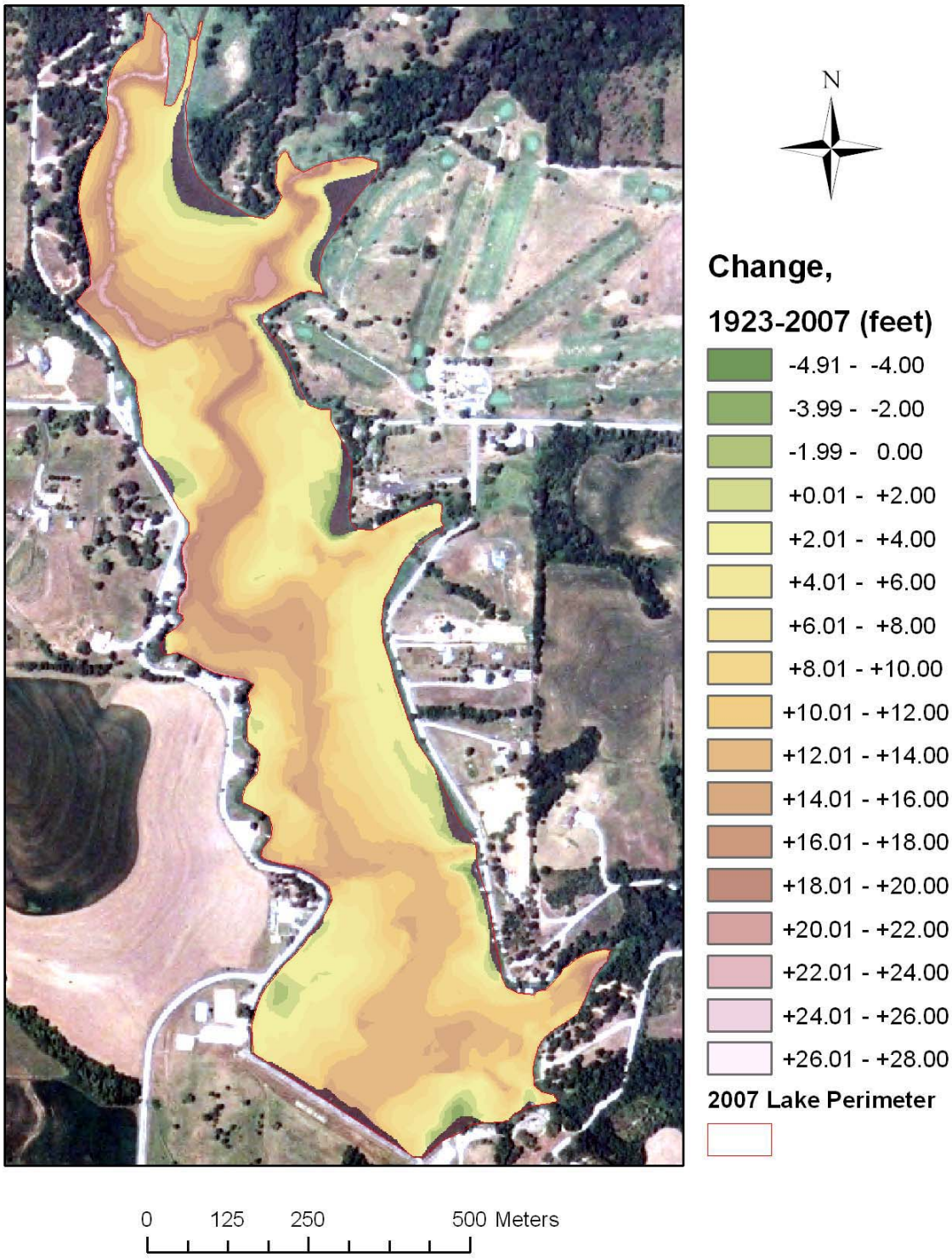

Figure 4. Change in elevation from 1923 – 2007. Siltation and sediment accumulation are associated with positive numbers (Kansas Biological Survey, 2007).

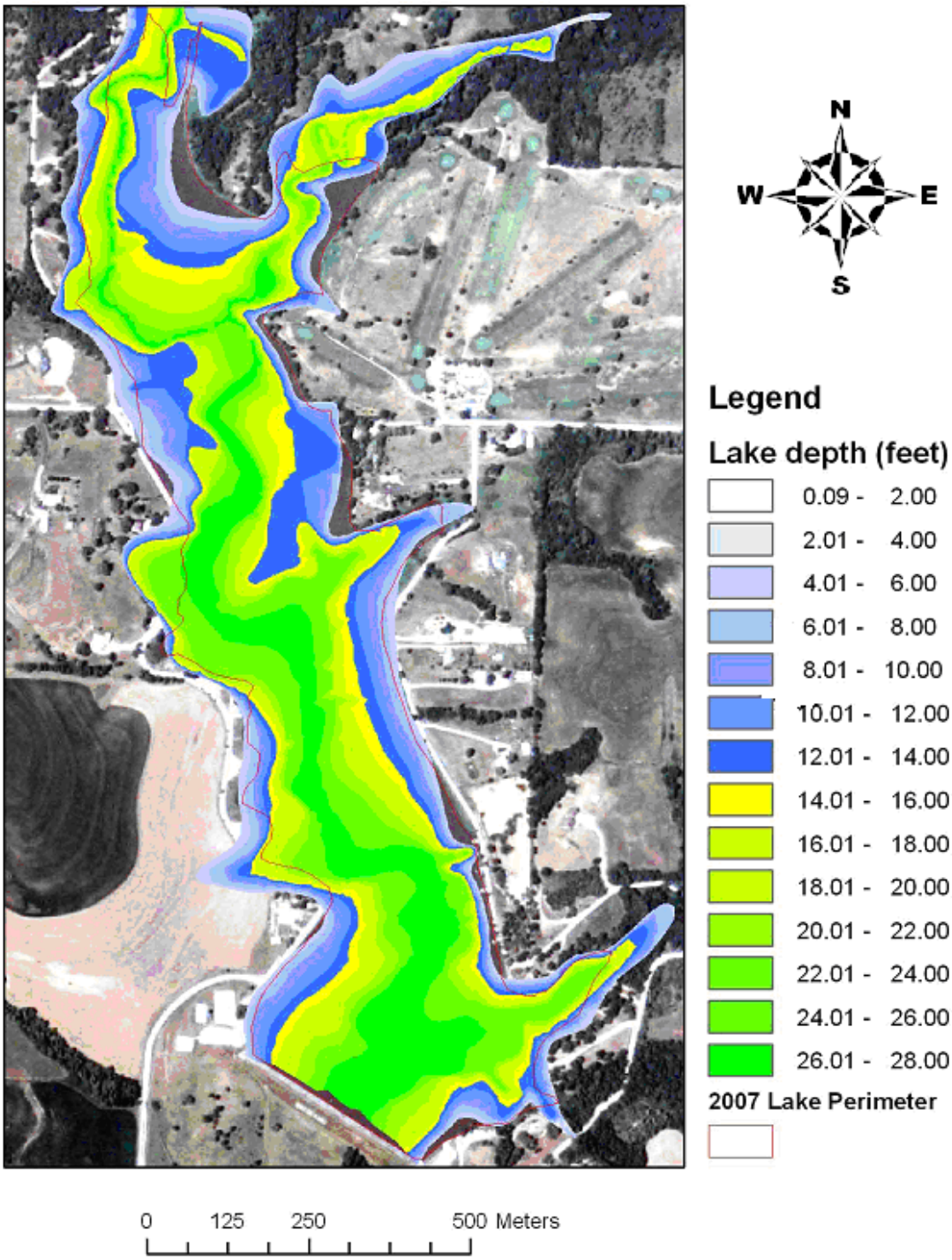

Figure 5. Lake depth of Mission lake based on a digital elevation model created from the 1923 topographic map (Kansas Biological Survey, 2007)

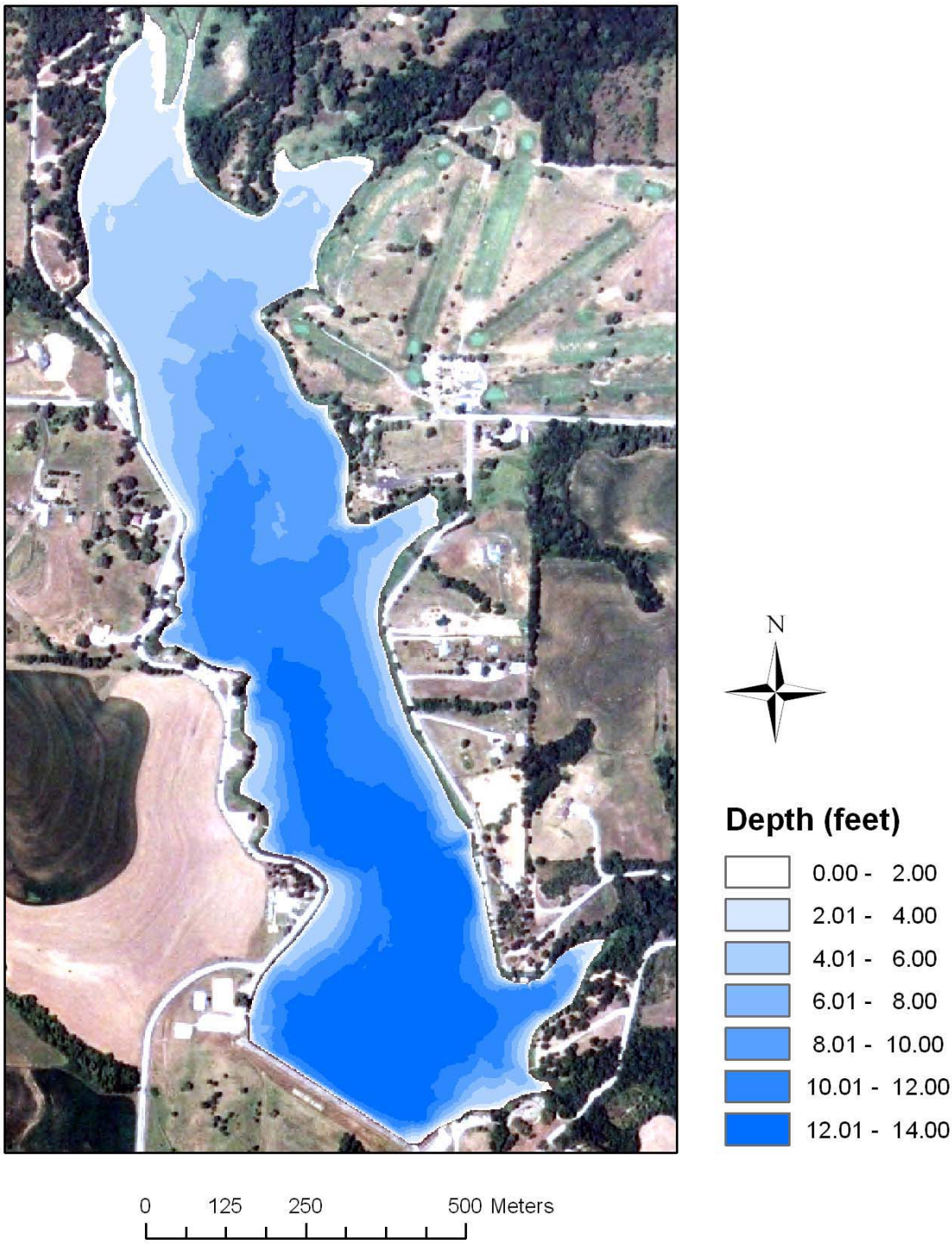

Figure 6. Mission Lake depth map based on bathymetric survey on May 25, 2007.

In 2010, the dredging of 1,000,000 cubic yards of sediment from Mission Lake was reportedly complete. The restored capacity from the removal of 1,000,000 cubic yards of sediment resulted in the restoration of 620 acre-feet of storage as stated by the Kansas Water Office. However, based on the KBS bathymetric survey in 2010 there was 740,520 cubic yards of sediment removed resulting in the restoration of 459 acre-feet of storage. It is anticipated that another bathymetric survey will be conducted in 2012 by the KBS to confirm the results of the dredging project. In addition to restoring capacity within the lake, the dredging of the sediment is anticipated to improve water quality since the sediment is responsible for the siltation impairment and phosphorus is bound to the sediment, which led to the eutrophication impairment of the lake.

There has not been any data collected from the lake since the completion of the dredging project. Mission Lake is a predominantly turbid lake and therefore the goal of this TMDL will be based off nonalgal turbidity (NAT) values within Mission Lake in order to assess turbidity within the lake. The NAT values within Mission Lake have been calculated utilizing the Jones and Hubbart calculation for non-chlorophyll light attenuation (Jones and Hubbart, 2011). The referenced NAT calculation is:

$$\log_{10}(\text{maximum Secchi}) = 0.90 - 0.29(\log_{10}\text{Chla}) - 0.13(\log_{10}\text{Chla})^2$$
$$\text{NAT } (m-1) = [1/\text{Secchi}] - [1/\text{maximum Secchi}]$$

The current average NAT values in Mission Lake are 3.19 m^{-1}. Generally there are low levels of suspended sediment (silt and/or clay) with NAT values less than 40 cm^{-1}. Inorganic turbidity assumes a greater influence on water clarity with NAT values between 40 cm^{-1} and 100 cm^{-1}.

Desired Endpoint: The ultimate endpoint of this TMDL is to achieve Kansas Water Quality Standards to fully support the designated uses of Mission Lake. With the completion of the dredging project the lake should not exceed an average NAT value of 1 m^{-1} in order to fully restore all designated uses within the lake. The BATHTUB model was utilized to evaluate NAT. Based on the BATHTUB reservoir model (see Appendix B), the sediment entering the lake must be reduced by 80% to achieve an NAT value of less than 1 m^{-1}. These reductions will be applied to the current sedimentation rate and translated to annual tons of TSS, rather than applying these reductions strictly to the TSS stream concentrations entering the lake to account for the lack of knowledge associated with the stream data. Therefore, the sedimentation rate for Mission Lake should not exceed 2 acre-feet per year to ensure the restored capacity of Mission Lake is protected and fully restore all designated uses within the lake. It is expected that Mission Lake will have a higher sedimentation rate in the next twenty-five years than the following years since lakes lose sediment trapping efficiency as they age. Therefore, this TMDL is based and managed on an annual average load that will also be translated to a daily average load.

The current sedimentation rate of 10 acre-feet/year is equal to 16,133 cubic yards of sediment/year, which translates to 8,874 tons/year of TSS. The TMDL sedimentation rate of 2 acre-feet/year will result in 3,227 cubic yards of sediment/year, translating to a

TMDL of 1,775 tons/year of TSS. The necessary sedimentation reduction for Mission Lake is 80% from the current sedimentation rate. Achievement of this endpoint will preserve the restored storage capacity for more than 75 years and achieve Kansas Water Quality Standards to fully support the designated uses of Mission Lake.

Since this TMDL will be managed on an annual average load, seasonal variation in the endpoint is not established by this TMDL. This endpoint can be reached as a result of sediment loading reductions from various sources in the watershed resulting from the implementation of corrective actions and Best Management Practices.

3.0 SOURCE INVENTORY AND ASSESSMENT

Land Use: The predominant land cover in the watershed around Mission Lake is dominated by cropland and grassland. The land cover for the watershed is detailed in Table 4 and Figure 7. Land cover within the 100 foot riparian buffer is detailed in Table 5.

Table 4. Land use in the Mission Lake watershed.

Land Cover	Acres	Percent
Cropland	2965	53.98%
Grassland	1649	30.03%
Developed	461	8.39%
Forest	216	3.94%
Open Water	169	3.07%
Wetlands	32	0.59%

Table 5. Land Use acres in the 100 foot riparian buffer in HUC12: 102701030201.

Grassland	Cropland	Forest	Open Water	Developed	Wetlands	Total Riparian Acres
64.72	30.25	57.82	4.67	2.67	17.12	192.15

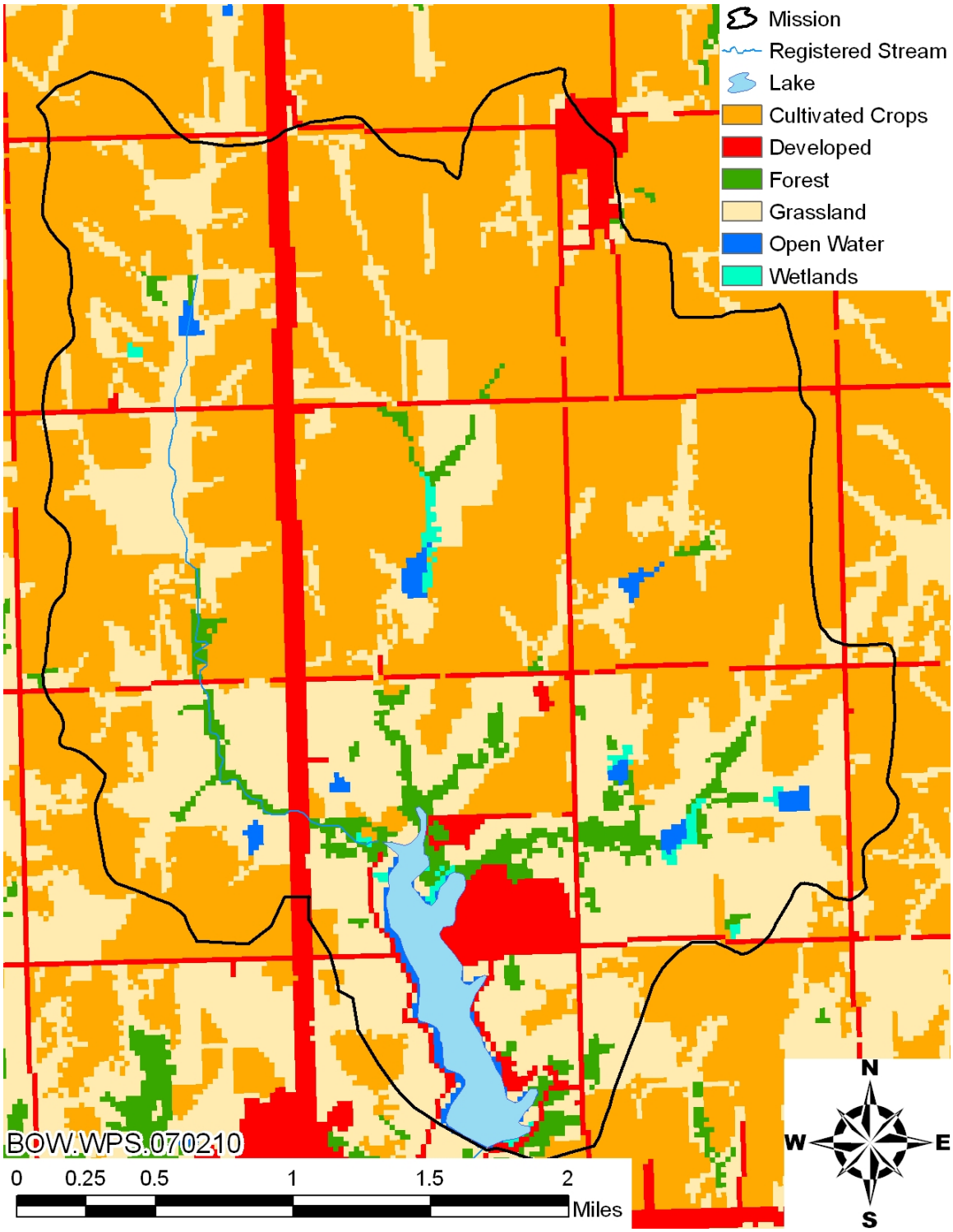

Figure 7. Mission Lake watershed land use and land cover map (2001 NLCD).

Livestock Waste Management: There is no certified or permitted confined animal feedlot operations located within the Mission Lake watershed. It is possible that there are smaller animal feeding operations that are not registered, particularly during the seasonal

feeding months in the winter. Winter feeding operations that denude vegetation in riparian corridors may contribute to the sedimentation of Mission Lake. According to the Kansas Agricultural Statistics, as of January 1, 2010 the estimated number of all cattle and cows for Brown County is 27,000.

NPDES: There is one active NPDES facility located within the watershed, which is issued to the Mission Lake Sediment Removal Project. The permit (I-KS24-P001) is effective from September 10, 2009 to August 31, 2014. The facility is a 56 acre Confined Disposal Facility sediment settling basin, where settled dredge return water flows to Mission Lake via Mission Creek via an unnamed tributary.

On-site Waste Systems: There are very few households within the watershed, of which are all likely on septic systems. Failing septic systems may account for minor nutrient contributions to the lake, particularly systems located in close proximity to the lake shore. Failing septic systems are not likely to contribute to the siltation impairment of Mission Lake.

Contributing Runoff: The watershed of Mission Lake has a mean soil permeability value of 0.34 inches/hour, ranging from 0.01 to 1.23 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”/ hr, 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 potentially may 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. For the Mission Lake watershed, approximately 83% of the watershed will produce runoff with rainfall events that produce 0.57 inches/hour of rain. The entire watershed has a low soil permeability value and will produce runoff with rainfall events that produce 1.23 inches/hour of rain. Runoff generated from cropland and grassland are major sources to the siltation impairment within Mission Lake.

Background Levels: Since Mission Lake is a relatively small lake, the resuspension of sediment (from wind and bottom feeding fish) is likely contributing to higher turbidity values within the lake. The turbid conditions that are the result of the wind suspending sediment within the lake contribute to the siltation impairment within the lake.

4.0 ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

To address the siltation impairment in Mission Lake, allocations for this TMDL will be made for TSS within the watershed based on the sedimentation rate of the lake.

BATHTUB is an empirical receiving water quality model that was developed by the U.S. Corps of Engineers (Walker, 1996), and has been widely used in the nation to address

many TMDLs relating to issues associated with morphometrically complex lakes and reservoirs (Wang et al., 2005). The BATHTUB model was utilized to assess Mission Lake and was calibrated based on stream and lake data collected in 2001. The model results indicate an 80% reduction of the stream input concentrations is necessary to achieve the endpoint of this TMDL, an NAT value of less than 1 m^{-1}.
Allocations for Mission Lake will ensure the lake maintains a storage volume greater than the pre-dredge condition for more than 75 years. The TMDL is based on an average sedimentation rate of 2 acre-feet/year, which translates into an average loading of 3,227 cubic yards of sediment per year. The resulting Load Capacity is 1,775 tons/year of TSS, which calculates to 16.63 tons/day of TSS (see Appendix A for conversion calculation and Appendix B for Daily Load Calculation). A more detailed source assessment within this watershed must be made in order to further refine potential sediment sources within the watershed, though the general inventory of sources within the watershed does provide some guidance as to areas of load reduction.

Point Sources: The NPDES permitted facility associated with the Mission Lake Sediment Removal Project expires in 2014, at which time it will not be renewed. The Wasteload Allocation (WLA) is set at 0 lbs/day from this facility since it no longer discharges now that the dredging project is completed.

Nonpoint Sources: Siltation loading comes exclusively from nonpoint sources. Given the runoff characteristics of the watershed, overland runoff can easily carry sediment into the lake. The Load Allocation is 14.97 tons/day of sediment in Mission Lake as illustrated in Table 6.

Table 6. Mission Lake Sediment TMDL.

Waterbody	Load Allocation (tons/day of TSS)	Wasteload Allocation (tons/day of TSS)	Margin of Safety (tons/day TSS)	TMDL (tons/day of TSS)
Mission Lake	14.97	0	1.66	16.63

Note – See Appendix B for Daily Load Calculation

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of wide varying annual TSS loads in the Mission Lake watershed. The margin of safety is explicitly set at 10% of the total allocations for TSS, 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, and is 1.66 tons/day of TSS

State Water Plan Implementation Priority: Since Mission Lake is the first State investment in dredged storage restoration and since siltation and eutrophication problems imperil its uses as a water supply resource, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Delaware Subbasin (HUC8: 10270103) with a priority ranking of 3 (Highest Priority for restoration work).

Priority HUC12 and Stream Segments: The drainage of this lake is within a single HUC12 and the priority stream segment is Mission Creek (40).

5.0 IMPLEMENTATION

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

1. Implement soil sampling to recommend appropriate fertilizer applications on cultivated croplands.
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.
8. Utilize state-supported Delaware WRAPS process to coordinate load reduction of nutrients and sediment to the lake.

Implementation Program Guidance:

NPDES-KDHE

a. Ensure any future NPDES permits in the watershed do not discharge excessive nutrients or TSS to streams above Mission Lake.

Watershed Management Program – KDHE

a. Support new and ongoing Section 319 implementation and demonstration activities conducted under the Delaware WRAPS projects focused on Mission Lake, including demonstration projects and outreach efforts dealing with nutrient management.
b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management in the vicinity of streams.
d. Support Delaware Watershed Restoration and Protection Strategy (WRAPS) efforts for protecting Mission Lake.

e. Incorporate the provisions of this TMDL into Delaware WRAPS documents relating to Mission Lake.

Water Resource Cost Share and Nonpoint Pollution Control Programs – SCC

a. Apply or maintain 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- SCC

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

Buffer Initiative Program – SCC

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

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
c. Provide technical assistance on livestock waste management systems and nutrient management planning.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold nutrients.
f. Support outreach efforts by Delaware WRAPS projects and continue to educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Time Frame for Implementation: Pollutant reduction strategies and pollutant source assessment should be initiated within the Mission Lake watershed in 2011 through the 9-element watershed plan of the WRAPS. Pollutant reduction practices and implementation activities within the priority area should be initiated by 2012 and continue through 2020.

Targeted Participants: The primary participants for implementation will be agricultural and livestock operations immediately adjacent to Mission Creek and the drainage waterways leading to Mission Lake. Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2011. Implementation activities should target those areas with the greatest potential to impact sediment deposition within the Mission Lake watershed and should be targeted to:

1. Unbuffered cropland adjacent to the stream.
2. Sites where drainage runs through or adjacent to livestock areas.
3. Sites where livestock have full access to the stream and it is their primary water supply.
4. Conservation compliance on highly erodible areas.
5. Acreage of poor rangeland or overstocked pasture.
6. Poor riparian area and denuded riparian vegetation along the stream.
7. Fields with manure applications.

Milestone for 2015: In accordance with the Kansas TMDL development schedule, the year 2015 marks the next cycle of 303(d) activities in the Kansas Lower Republican Basin to review information from Mission Lake to assess implementation measures. If siltation problems continue, adjustments to source assessment, allocation, and implementation activities may occur.

Delivery Agents: The primary delivery agents for program participation will be KDHE, the State Conservation Commission, the Kansas State University Extension Service and the Delaware WRAPS team. Implementation decisions and scheduling will be guided by planning documents prepared through Delaware WRAPS.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. 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.

3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. 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.

5. 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.

6. 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.

7. 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.

8. 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.

9. The *Kansas Water Plan* and the Kansas Lower Republican 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 watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection through the WRAPS program. This watershed and its TMDL are a High Priority consideration for funding.

Effectiveness: Sediment control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. In addition, the proper implementation and maintenance of comprehensive livestock waste management plans has proven effective at reducing nutrient and sediment loads associated with livestock facilities. 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 to collect samples every 3 years from Mission Lake in order to assess the trophic state, with the next round of sampling to be conducted in 2012. In order to evaluate the sediment loading in Mission Lake the Kansas Water Office will be consulted to assist in the monitoring of sedimentation rates. In 2012, a bathymetric survey will be done to establish a baseline for the completed project. In 2019, a bathymetric survey will be conducted to determine changes since 2010. The improved status of Mission Lake will be evaluated in 2020. If the impairment status continues, the desired endpoints under this TMDL will be further evaluated.

7. FEEDBACK

Public Notice: An active internet website was established at http://www.kdheks.gov/tmdl/index.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Kansas Lower Republican Basin.

Public Hearing: A Public Hearing on the Kansas Lower Republican TMDLs was held on August 30, 2011 in Holton to receive comments on this TMDL.

Basin Advisory Committee: The Kansas Lower Republican Basin Advisory Committee met to discuss the TMDLs in the basin on September 30, 2010 in Lawrence, March 17, 2011 in Manhattan, June 16, 2011 in Lawrence, and September 29, 2011 in Topeka.

Watershed Restoration and Protection Strategy Group: This TMDL has been reviewed in August 2011 by the Delaware Subbasin WRAPS group.

Milestone Evaluation: In 2015, evaluation will be made as to the degree of implementation which has occurred within the watershed. In 2019, a bathymetric survey will determine if less than 22,589 yd^3 of sediment has deposited in the lake. 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 delisting cycle for this basin in 2020 with consultation from local stakeholders and WRAPS teams. Additionally, Horton should have plans in place to use the lake for a water supply.

Consideration for 303(d) Delisting: Mission Lake will be evaluated for delisting under section 303(d), based on the 2019 bathymetric survey. Therefore, the decision for delisting will come about in the preparation of the 2020-303(d) list. Should modifications be made to the applicable endpoint 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, 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 2011-2020.

Revised January 6, 2012

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Appendix A
Related Calculation and Conversion

TMDL = Sedimentation Rate of 2.0 acre-ft/year = 3,227 cubic yards of sediment/year

3,227 cubic yards of sediment is converted to tons/year for TMDL expression.

Tons of material/Year = (Material in cubic yards * bulk density of material (lbs/yd^3))/ 2000 lbs

Where material bulk density weight = 40 lbs/cubic foot
1 lbs/ft3 = 27 lbs/yd^3
40 lbs/ft3 = 1100 lbs/yd^3
1 acre-ft = 1613.33 yd^3

TMDL in Tons of Sediment per Year:

1,775 tons/year = (3,227 yd^3 * 1100 lbs/yd^3) / 2000 lbs

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

The TMDL has estimated annual average TSS loads 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

MOS= Margin of Safety

Parameter	LTA	CV	$e^{[Z\sigma - 0.5\sigma^2]}$	MDL	LA	WLA	MOS (10%)
TSS	1775 tons/yr	0.67	3.42	16.63 tons/day	14.97 tons/day	0 tons/day	1.66 tons/day

Maximum Daily Load Calculation

Annual TSS Load = 1,775 tons/yr

Maximum Daily TSS Load =[(1,775 tons/yr)/(365days/yr)]*$e^{[2.326*(0.609)-0.5*(0.609)^2]}$
= 16.63 tons/day

Margin of Safety (MOS) for Daily Load

Annual TSS MOS = 177.5 tons/yr

Daily TSS MOS = [(177.5 tons/yr)/(365 days/yr)]*$e^{[2.326*(0.609)-0.5*(0.609)^2]}$
= 1.66 tons/day

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

Appendix C – BATHTUB RESULTS Current Condition.

Mission Lake
File: C:\TFFiles\Bathtub\Mission\MissionKDHE2011Dredge.btb
Description:

water year 2001
no outflow
no storage info
N-limiting
rainfall and evap = Brown

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.25	0.0
Evaporation (m)	1.33	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	2	2ND ORDER, DECAY
Nitrogen Balance	2	2ND ORDER, DECAY
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	3	VS. TOTAL P
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	2	ALL MODELS EXCEPT 2
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	whole lake	0	1	0.53	4.06	1.8	4	0	0	0	5.1	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	284.94	0.03	1795	0.06	15.5	0.09	0.35	0.14	787.3	0.03	152.85	0.06	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	MLT1-baseflow	1	1	0	0.07	0	0	0	142.26	0.31	733.34	0.17	65.58	0.36	288.54	0.27
2	MLT1-runoff16	1	1	0	1.22	0	0	0	875.27	0	1958.99	0	510.71	0	846.59	0
3	MLT2-baseflow	1	1	0	0.06	0	0	0	296.73	0.13	1760	0.08	90.06	0.26	789.22	0.21
4	MLT3-baseflow	1	1	0	0.06	0	0	0	157.29	0.26	3498.29	0.16	79.06	0.25	2858.17	0.23
5	MLT2-3runoff53	1	1	0	2	0	0	0	862	0	1917.26	0	505.59	0	835.06	0
6	MLT4-baseflow	1	1	0	0.04	0	0	0	110.35	0.26	681.34	0.15	26.62	0.42	116.18	0.39
7	MLT4-runoff98	1	1	0	0.63	0	0	0	833.64	0	1992.81	0	477.46	0	889.65	0
8	Country Club 119	1	1	0	0.01	0	0	0	1056.6	0	2376.99	0	555.18	0	690.62	0
9	Spillway 120	1	1	0	0.09	0	0	0	473	0	1565.81	0	283.33	0	997.23	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	0.780	0.45
Total Nitrogen	0.500	0.55
Chl-a Model	0.700	0.26
Secchi Model	1.400	0.10
Organic N Model	0.900	0.12
TP-OP Model	1.100	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

BATHTUB, Predicted Current Condition

Mission Lake
File: **C:\TFFiles\Bathtub\Mission\MissionKDHE2011Dredge.btb**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1 whole lake**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	207.2	0.19	94.8%	284.9	0.03	97.6%
TOTAL N MG/M3	1301.5	0.15	65.9%	1795.0	0.06	81.9%
C.NUTRIENT MG/M3	87.1	0.14	86.7%	123.5	0.05	94.0%
CHL-A MG/M3	6.7	0.27	33.0%	15.5	0.09	74.2%
SECCHI M	0.4	0.18	11.4%	0.3	0.14	6.9%
ORGANIC N MG/M3	624.3	0.13	70.5%	787.3	0.03	84.0%
TP-ORTHO-P MG/M3	141.6	0.15	94.9%	152.9	0.06	95.7%
ANTILOG PC-1	581.4	0.24	74.5%	1363.9	0.09	90.5%
ANTILOG PC-2	2.4	0.22	3.0%	3.6	0.11	13.1%
(N - 150) / P	5.6	0.25	5.0%	5.8	0.07	5.6%
INORGANIC N / P	10.3	0.77	14.4%	7.6	0.14	8.6%
TURBIDITY 1/M	5.1		99.2%	5.1		99.2%
ZMIX * TURBIDITY	20.4		99.2%	20.4		99.2%
ZMIX / SECCHI	9.2	0.17	87.2%	11.4	0.14	93.3%
CHL-A * SECCHI	2.9	0.32	3.8%	5.4	0.17	18.6%
CHL-A / TOTAL P	0.0	0.32	0.2%	0.1	0.09	2.2%
FREQ(CHL-a>10) %	16.9	0.66	33.0%	65.4	0.08	74.2%
FREQ(CHL-a>20) %	1.9	1.11	33.0%	23.5	0.19	74.2%
FREQ(CHL-a>30) %	0.3	1.40	33.0%	8.5	0.27	74.2%
FREQ(CHL-a>40) %	0.1	1.61	33.0%	3.3	0.33	74.2%
FREQ(CHL-a>50) %	0.0	1.78	33.0%	1.4	0.38	74.2%
FREQ(CHL-a>60) %	0.0	1.92	33.0%	0.6	0.43	74.2%
CARLSON TSI-P	81.1	0.03	94.8%	85.7	0.00	97.6%
CARLSON TSI-CHLA	49.3	0.05	33.0%	57.5	0.02	74.2%
CARLSON TSI-SEC	72.1	0.03	88.6%	75.1	0.03	93.1%

Current Condition NAT = 2.23

Mission Lake BATHTUB, TMDL with 80% Reductions

Mission Lake
File: C:\TFFiles\Bathtub\Mission\MissionKDHE2011Dredge_80%Red.btb
Description:

water year 2001
no outflow
no storage info
N-limiting
rainfall and evap = Brown

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.25	0.0
Evaporation (m)	1.33	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	2	2ND ORDER, DECAY
Nitrogen Balance	2	2ND ORDER, DECAY
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	3	VS. TOTAL P
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	2	ALL MODELS EXCEPT 2
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	whole lake	0	1	0.53	4.06	1.0	4	0	0	0	5.1	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	284.94	0.03	1795	0.06	15.5	0.09	0.35	0.14	787.3	0.03	152.85	0.06	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	MLT1-baseflow	1	1	0	0.07	0	0	0	28.45	0.31	146.67	0.17	13.12	0.36	57.71	0.27
2	MLT1-runoff16	1	1	0	1.22	0	0	0	175.05	0	391.8	0	102.14	0	169.32	0
3	MLT2-baseflow	1	1	0	0.06	0	0	0	59.35	0.13	352	0.08	18.01	0.26	157.84	0.21
4	MLT3-baseflow	1	1	0	0.06	0	0	0	31.46	0.26	699.66	0.16	15.81	0.25	571.63	0.23
5	MLT2-3runoff53	1	1	0	2	0	0	0	172.4	0	383.45	0	101.12	0	167.01	0
6	MLT4-baseflow	1	1	0	0.04	0	0	0	22.07	0.26	136.27	0.15	5.32	0.42	23.24	0.39
7	MLT4-runoff98	1	1	0	0.63	0	0	0	166.73	0	398.56	0	95.49	0	177.93	0
8	Country Club 119	1	1	0	0.01	0	0	0	211.32	0	475.4	0	111.04	0	138.12	0
9	Spillway 120	1	1	0	0.09	0	0	0	94.6	0	313.16	0	56.67	0	199.45	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	0.780	0.45
Total Nitrogen	0.500	0.55
Chl-a Model	0.700	0.26
Secchi Model	1.400	0.10
Organic N Model	0.900	0.12
TP-OP Model	1.100	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Os (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Mission Lake BATHTUB, TMDL with 80% Reductions

Mission Lake
File: C:\TFFiles\Bathtub\Mission\MissionKDHE2011Dredge_80%Re

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 1 whole lake

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	78.8	0.15	71.0%	284.9	0.03	97.6%
TOTAL N MG/M3	431.9	0.13	9.4%	1795.0	0.06	81.9%
C.NUTRIENT MG/M3	22.5	0.19	28.2%	123.5	0.05	94.0%
CHL-A MG/M3	2.1	0.33	2.6%	15.5	0.09	74.2%
SECCHI M	0.9	0.15	40.6%	0.3	0.14	6.9%
ORGANIC N MG/M3	530.0	0.12	58.7%	787.3	0.03	84.0%
TP-ORTHO-P MG/M3	132.6	0.15	94.1%	152.9	0.06	95.7%
ANTILOG PC-1	92.5	0.29	22.9%	1363.9	0.09	90.5%
ANTILOG PC-2	2.3	0.23	2.4%	3.6	0.11	13.1%
(N - 150) / P	3.6	0.25	1.1%	5.8	0.07	5.6%
INORGANIC N / P	1.0		0.0%	7.6	0.14	8.6%
TURBIDITY 1/M	5.1		99.2%	5.1		99.2%
ZMIX * TURBIDITY	20.4		99.2%	20.4		99.2%
ZMIX / SECCHI	4.4	0.15	45.0%	11.4	0.14	93.3%
CHL-A * SECCHI	1.9	0.36	0.9%	5.4	0.17	18.6%
CHL-A / TOTAL P	0.0	0.36	0.1%	0.1	0.09	2.2%
FREQ(CHL-a>10) %	0.2	1.72	2.6%	65.4	0.08	74.2%
FREQ(CHL-a>20) %	0.0	2.34	2.6%	23.5	0.19	74.2%
FREQ(CHL-a>30) %	0.0	2.72	2.6%	8.5	0.27	74.2%
FREQ(CHL-a>40) %	0.0	3.00	2.6%	3.3	0.33	74.2%
FREQ(CHL-a>50) %	0.0	3.22	2.6%	1.4	0.38	74.2%
FREQ(CHL-a>60) %	0.0	3.41	2.6%	0.6	0.43	74.2%
CARLSON TSI-P	67.1	0.03	71.0%	85.7	0.00	97.6%
CARLSON TSI-CHLA	37.9	0.08	2.6%	57.5	0.02	74.2%
CARLSON TSI-SEC	61.5	0.04	59.4%	75.1	0.03	93.1%

TMDL NAT = 0.95