KANSAS LOWER REPUBLICAN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit (AU): Perry Lake and Perry Lake Wildlife Area Wetlands

Water Quality Impairment: Eutrophication for Perry Lake; Eutrophication and Dissolved Oxygen for Perry Lake Wildlife Area Wetlands.

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Delaware **Counties**: Jefferson, Jackson, Atchison, Nemaha, Brown

HUC8: **10270103**
HUC10 (HUC12): **01** (01, 02, 03, 04, 05, 06, 07, 08, 09, 10)
02 (01, 02, 03, 04, 05)
03 (01, 02, 03, 04, 05, 06, 07, 08)
04 (01, 02, 03, 04, 05, 06, 07, 08)
05 (01, 02, 03, 04, 05, 06, 07, 08)

Ecoregion: Western Corn Belt Plains, Loess and Glacial Drift Hills (47i)
Central Irregular Plains, Osage Cuestas (40b)

Drainage Area: 1,117 Square Miles

Perry Lake Conservation Pool:
Surface Area = 11,150 acres of multipurpose pool
Watershed/Lake Ratio = 64:1
Maximum Depth = 16 m
Mean Depth = 6.5 m
Storage Volume = 209,513 acre-feel for multipurpose
Estimated Retention Time = 0.72 years
Mean Annual Inflow: 440,595 acre-feet/year (2005-2008)
Mean Discharge: 411,179 acre-feet/year (2005-2008)
Year Constructed: 1969
Design Sedimentation Rate: 930 acre-ft/year
Actual Sedimentation Rate: 1143 acre-feet/year

Perry Lake Wildlife Area Wetlands:
Wildlife Area = 11,704 acres
Wetland Description: There are fourteen wetland areas within the Wildlife area located in the flood pool of Perry Lake, which contain shallow water or saturated soils.

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

Perry Lake Wildlife Area Wetlands Designated Uses: Expected Aquatic Life; Primary Contact Recreation Class B; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply; Irrigation use; and Livestock Watering Use.

303(d) Listings: Perry Lake Eutrophication; 2002, 2004, 2008, and 2010 Kansas Lower Republican River Basin Lakes.

Perry Lake Wildlife Area Wetlands Eutrophication and Dissolved Oxygen Deficiency; 2002, 2004, 2008, and 2010 Kansas Lower Republican River Basin.

Impaired Use: All uses in Perry Lake are impaired to a degree by eutrophication. All uses in the Perry Lake Wildlife Area Wetlands are impaired to a degree by eutrophication. Expected Aquatic Life Support is additionally impaired in the Perry Lake Wildlife Area Wetlands due to dissolved oxygen deficiencies.

Water Quality Criteria: Nutrients – Narratives: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life (K.A.R. 28-16-28e(c)(2)(A)).

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

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation (K.A.R. 28-26-28e(c)(7)(A)).

The concentration of Dissolved Oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. Dissolved Oxygen (DO): 5 mg/L (K.A.R. 28-16-28e(d), Table 1g).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2010-303(d): Excessive nutrients are not being controlled and are thus impairing aquatic life; domestic water supply; and

contributing to objectionable algal blooms that contribute to the eutrophication and impairment of contact recreation within Perry Lake.

Level of Eutrophication for Perry Lake:

Recent Average (1996-2009):	Fully Eutrophic, Trophic State Index = 58.7 Chlorophyll *a* = 17.5 µg/L
Current Condition (2009):	Fully Eutrophic, Trophic State Index = 59.4 Chlorophyll *a* = 18.8 µg/L

Level of Eutrophication for Perry Lake Wildlife Area Wetlands:

Period of Record Average (1997-2000):	Hypereutrophic, Trophic State Index = 65.3 Chlorophyll a = 45.05 µg/L

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* concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic condition is seen with chlorophyll *a* concentrations over 12 µg/l and hypereutrophy occurs at levels over 30 µg/l. 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: 5-59.99
5. Very Eutrophic TSI: 60-63.99
6. Hypereutrophic TSI: ≥64

Lake Monitoring Sites: KDHE Station LM029001 in Perry Lake.

Period of Record: Fourteen surveys conducted by KDHE in calendar years; 1977, 1980, 1982, 1985, 1988, 1991, 1994, 1996, 1997, 1998, 2000, 2003, 2006, and 2009.

United States Army Corps of Engineers (USACE) select sampling points for years ranging from 1996-2009.

Wetland Monitoring Site: KDHE Station LM029041 in the Perry Lake Wildlife Area Wetlands. The Station is located in the Lassiter Marshes Northwest of Valley Fall and serves as a representative sampling site for all of the wetlands. The size is approximately 40 acres and the maximum depth is approximately 1.5 meters. Three surveys conducted by KDHE in calendar years; 1997, 1998, and 2000.

Stream Chemistry Monitoring Sites (Period of Record Used):

Station SC554 on Delaware River (1990-2009)
Station SC603 on Grasshopper Cr (1992-2008)
Station SC604 on Elk Cr (1993-2008)
Station SC686 on Straight Creek (1997-2008)
Station SC684 on Rock Creek (1996-2007)

Flow Record: USGS 06890100 Delaware R near Muscotah (1990-2009)
USGS 06890500 Delaware R at Valley Falls (1950-1967)

Long term flow conditions in the watershed are displayed in Tables 1 and 2.

Table 1. Long Term Flow for the Delaware River at USGS Gages

Stream	Drainage Area (mi^2)	Avg.	10%	25%	50%	75%	90%
Delaware River at Muscotah – Gage 06890100	431	238	364	117	40	13	3.4
Delaware River at Valley Falls – Gage 06890500	922	406	598	205	76	19	5.1

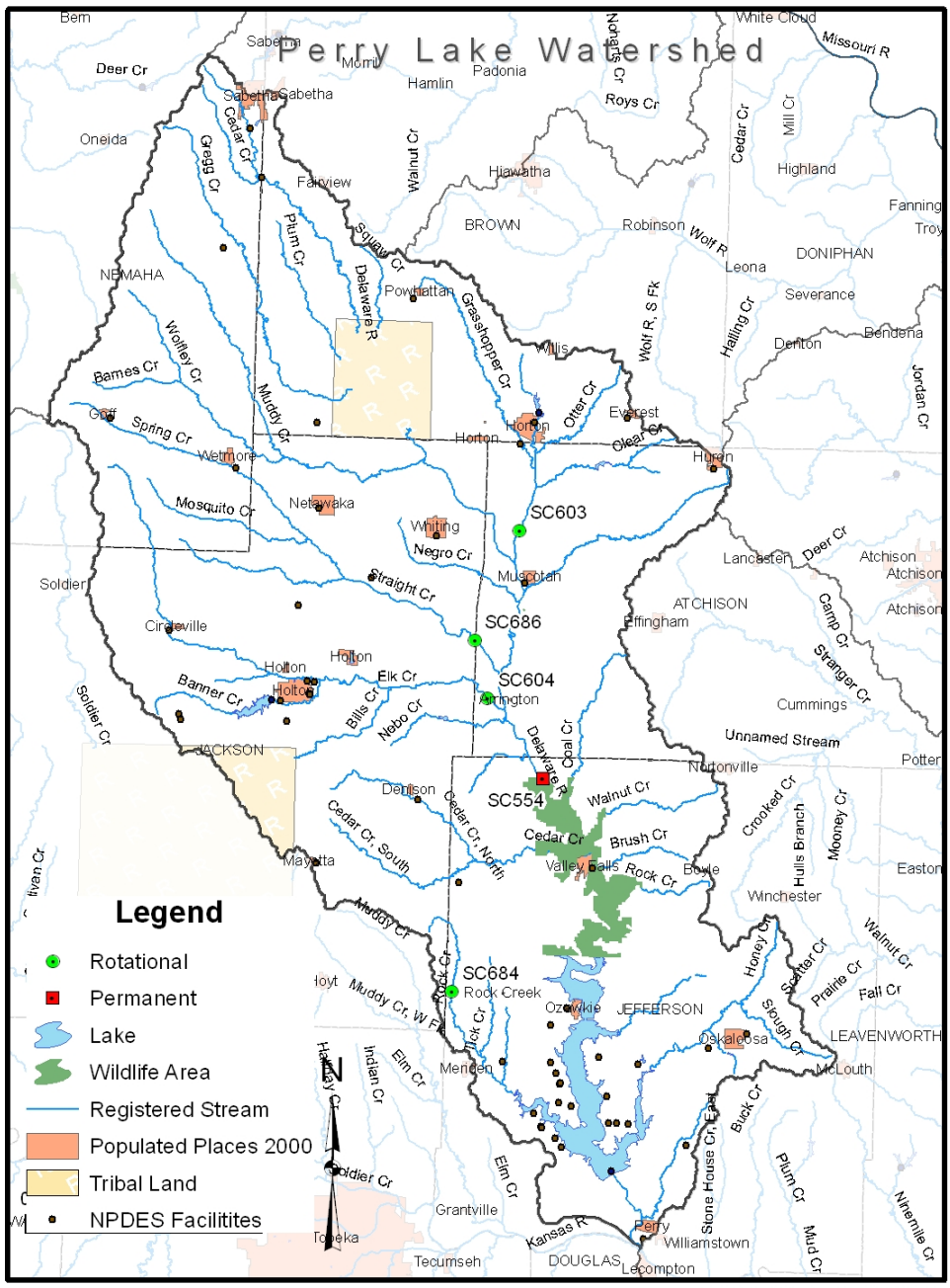
Table 2. Long Term Flow Estimates for streams entering Perry Lake as calculated by USGS using multiple regression techniques (Perry, 2004).

Stream (USGS Site ID)	Drainage Area (mi^2)	Average	10%	25%	50%	75%	90%
Delaware River (1398)	959	448.33	858.85	255.67	70.82	19.2	9.49
Rock Creek (1588)	49.6	39.46	58.88	20.34	5.66	0.84	0.03
Slough Creek (1553)	45.2	42.62	64.94	22.76	6.33	0.97	0.03
Little Slough Creek (1510)	22.0	21.77	32.74	12.29	3.79	0.54	0.01

According to the USGS Lake Hydro data, the mean runoff in the watershed is 6.5 inches/year; the mean precipitation in the watershed is 34.4 inches/year and the mean loss

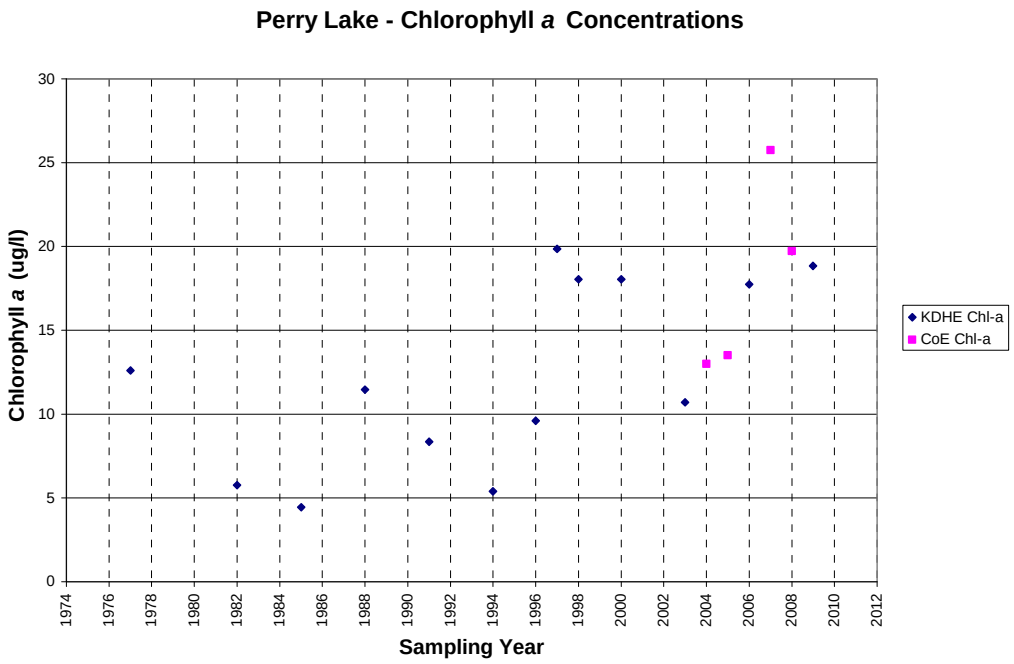
due to evaporation for the Lake is 45.1 inches/year. Based on the USACE daily outflow and inflow data for Perry Lake, the calculated mean annual outflow for the lake is 411,179 acre-feet/year. The average annual inflow for the lake is 440,595 acre-feet/year.

Figure 1. Perry Lake Watershed.



Current Condition: The chlorophyll *a* concentration average over the entire period of record for the KDHE data in Perry Lake is 12.37 µg/l. Annual concentration averages have consistently been greater than 10 µg/l since 1996, as seen in Figure 2. The more recent chlorophyll *a* concentration average for KDHE samples obtained from 1996-2009 is 16.1 µg/l. The United States Army Corps of Engineers (USACE) has sampled the main basin of Perry Lake thirteen times since 2004. The overall Chlorophyll *a* average for all the USACE samples from the main basin is 19.63 ug/l. Since the USACE sampled Perry Lake several times in some years and only once or twice in others the best way to analyze Perry Lake is to establish annual averages for each sampling year. The annual average chlorophyll *a* concentration based on the USACE data in Perry Lake is 18.0 ug/l. Utilizing all available data, the annual average chlorophyll *a* concentration since 1996 in Perry Lake is 17.5 ug/l.

Figure 2. Chlorophyll *a* concentration for the respective years Perry Lake was sampled.



The KDHE average secchi depth in Perry Lake is 1.2 meters, with the lowest reading of 0.6 m in 1996. Since this time, KDHE secchi depth observations have remained relatively stable and have ranged from 1.13 m to 1.57 m. The secchi depth readings obtained by the USACE had an annual average of 0.83 m from 2005-2008. The average turbidity value in Perry Lake for the recent period of record is 7.68 NTU, ranging from 3.1 to 16.5 NTU. The turbidity average has decreased to 5.86 NTU for samples obtained since 1996. The average Total Suspended Solids (TSS) concentration within Perry Lake is 7.95 mg/l for KDHE data and 7.38 mg/l for USACE data over the entire period of record.

The average total nitrogen (TN) and total phosphorus (TP) concentrations over the entire period of record are 0.99 mg/L and 0.059 mg/L respectively for the KDHE sampling data. The USACE data yielded annual averages of 0.93 mg/l of TN and 0.089 mg/l of TP. The recent average TN and TP concentrations for the combined data sets since 1996 is 0.92 mg/l and 0.076 mg/l respectively. The maximum TP concentration of 0.165 mg/L was detected in 1996. Data for calculating TN is not available prior to the 1994 sampling event and a maximum TN detection of 1.45 mg/L occurred in 1999.

Figure 3. Perry Lake average and median Secchi Depth readings.

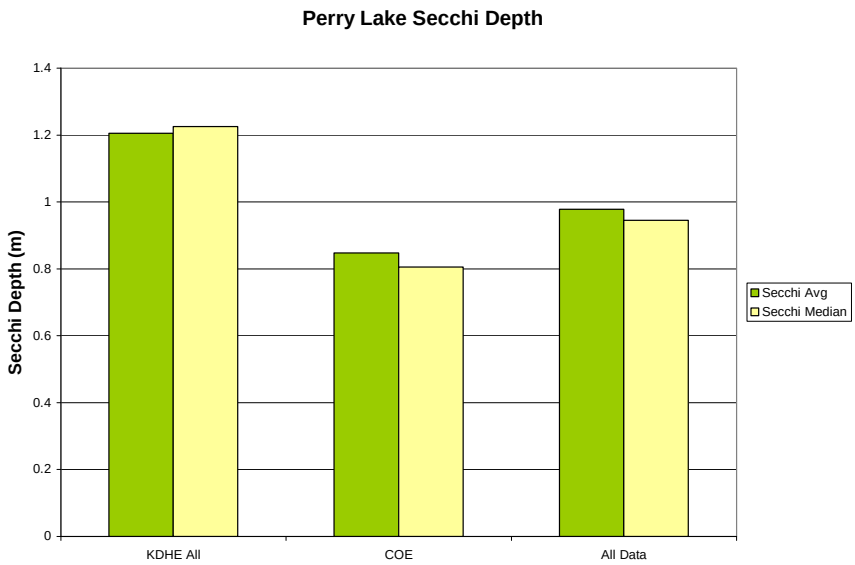


Figure 4. Total Phosphorus Concentrations in Perry for all data.

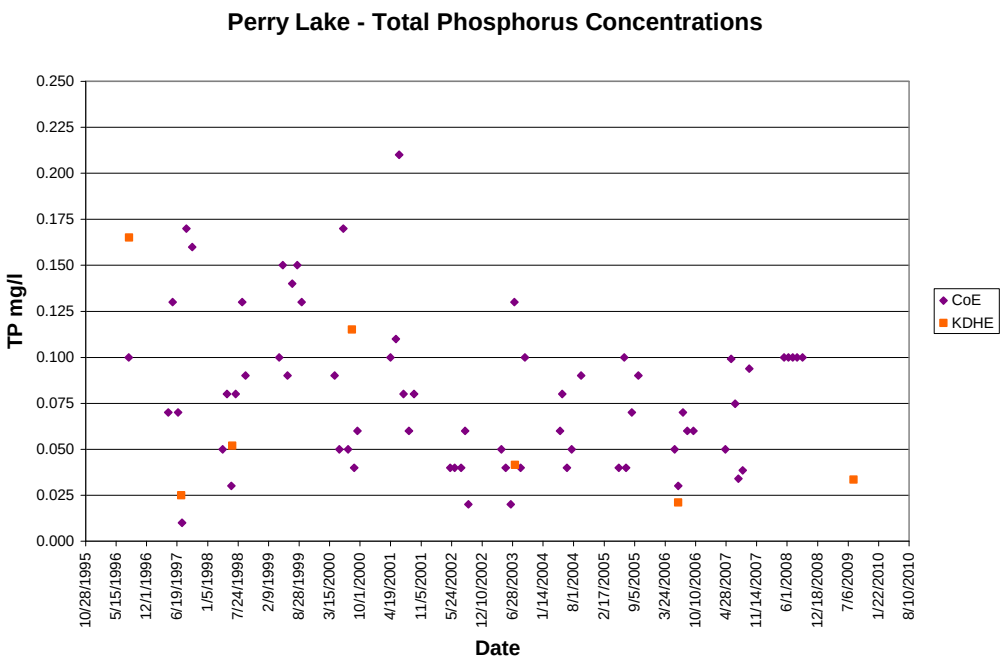


Figure 5. Total Phosphorus annual average concentrations.

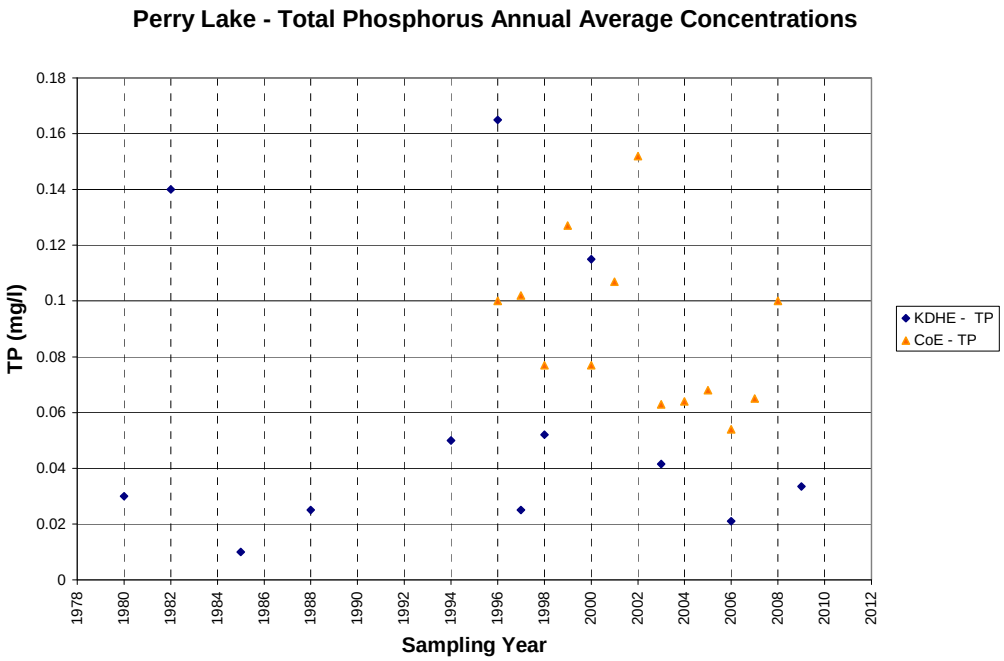


Figure 6. Total Nitrogen Concentrations for all main basin samples.

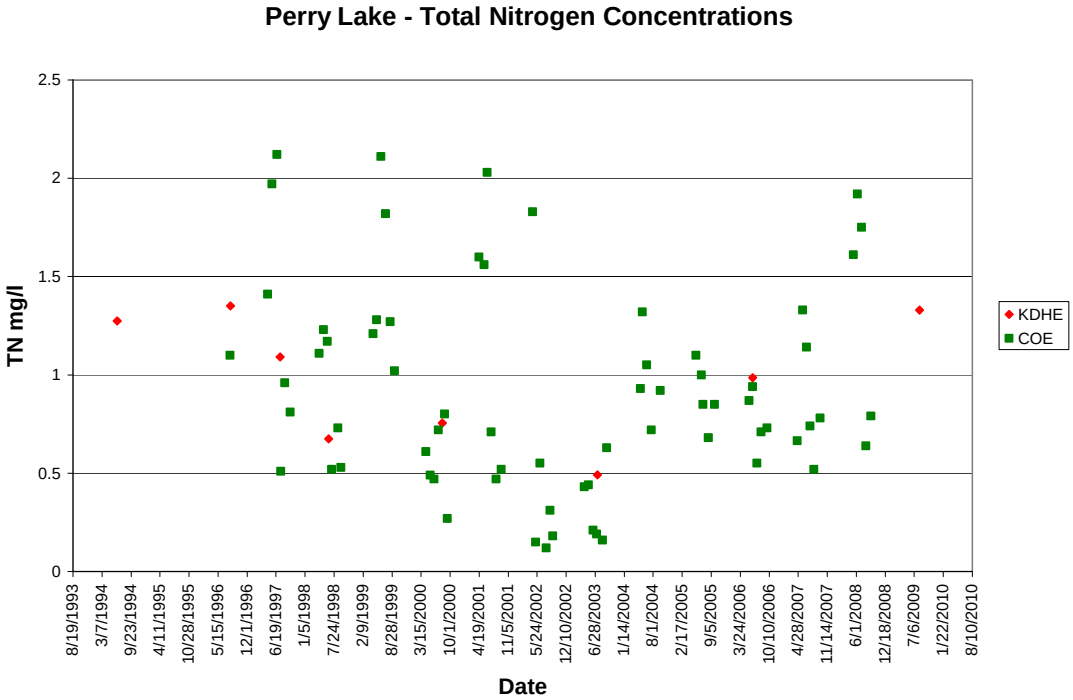


Figure 7. Annual total nitrogen concentration averages for the main basin of Perry Lake..

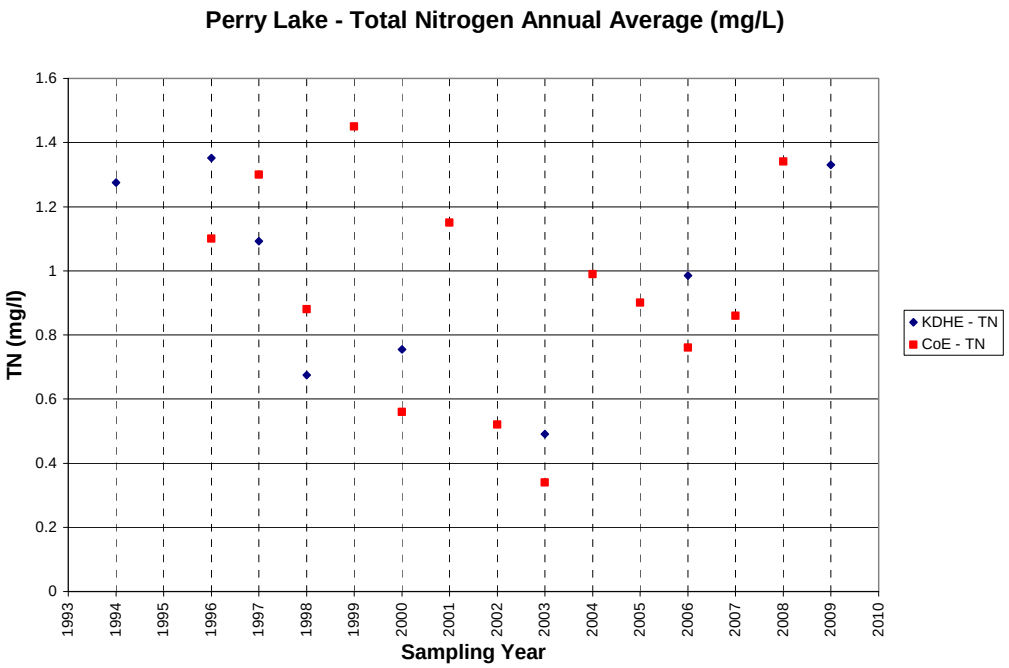
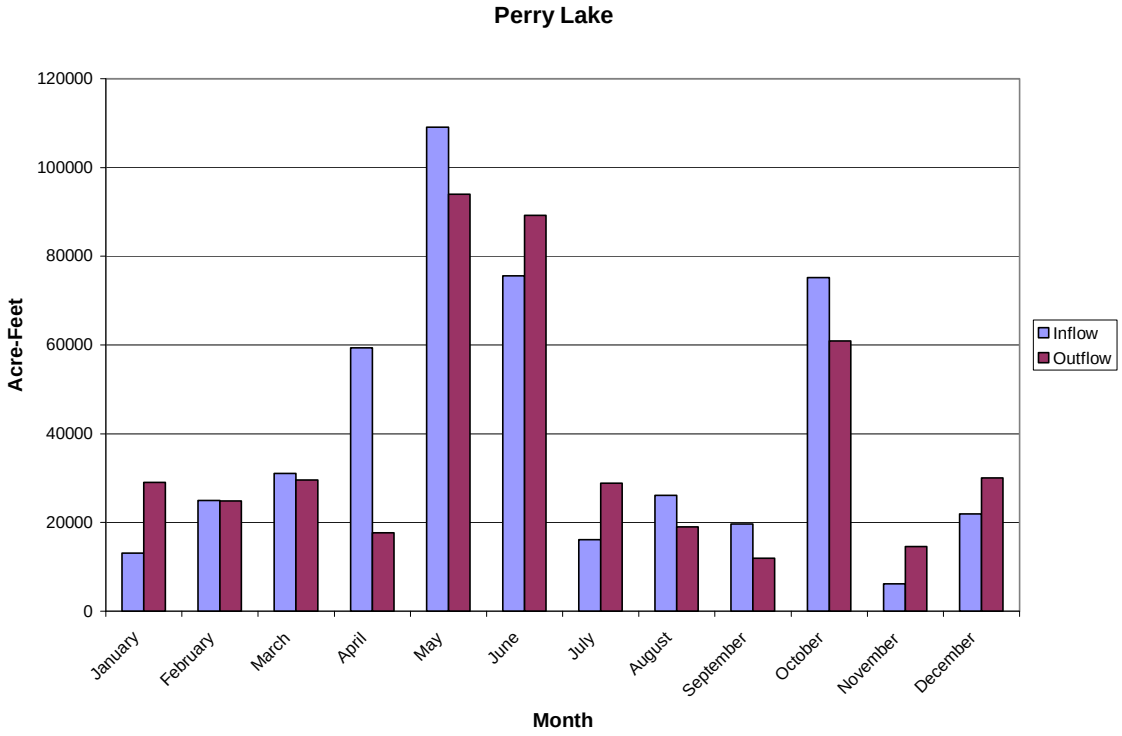


Figure 8. Perry Lake inflow and outflow summary from 2005-2009.



The ratio of total nitrogen and total phosphorus is a common ratio utilized to determine which of these nutrients is likely limiting plant growth in Kansas aquatic ecosystems. Typically, lakes that are nitrogen limited have a water column TN:TP ratio < 8 (mass); lakes that are co-limited by nitrogen and phosphorus have a TN:TP ratio between 9 and 21; and lakes that are P limited have a water column TN:TP ratio > 29 (Dzialowski et. al., 2005). Perry lake has varied between being phosphorus limited in 1997, 2006, and 2009; nitrogen limited in 2002; and co-limited by nitrogen and phosphorus in 1994, 1996, 1997, 1998, 1999, 2000, 2001, 2003, 2004, 2005, 2006, 2007, and 2008. Table 3 details the annual concentration averages within Perry Lake.

Table 3. Concentration averages for the main basin of Perry Lake for KDHE and USACE data for all sampling years.

Sample Year	Source	Chl-a (µg/L)	TN (mg/L)	TP (mg/L)	TN:TP ratio	Secchi Depth (m)	TSS (mg/l)
1977	KDHE	12.6					4
1980	KDHE			0.03			5
1982	KDHE	5.76		0.14			10.75
1985	KDHE	4.45		0.01			8.5
1988	KDHE	11.46		0.025			6.5
1991	KDHE	8.35				1.2	5.5
1994	KDHE	5.4	1.275	0.05	25.5		5
1996	KDHE	9.6	1.352	0.165	8.19	0.6	5
1996	USACE		1.1	0.1	11		
1997	KDHE	19.85	1.092	0.025	43.68	1.25	6
1997	USACE		1.3	0.102	21.22		
1998	KDHE	18.08	0.675	0.052	12.98	1.15	13.5
1998	USACE		0.88	0.077	15.76		
1999	USACE		1.45	0.127	12.23		
2000	KDHE	18.05	0.755	0.115	6.57	1.13	10.5
2000	USACE		0.56	0.077	9.71		
2001	USACE		1.15	0.107	10.51		
2002	USACE		0.52	0.152	6.21		
2003	KDHE	10.7	0.491	0.0415	11.83	1.42	10
2003	USACE		0.34	0.063	6.97		
2004	USACE	13	0.99	0.064	16.57		
2005	USACE	13.52	0.9	0.068	15.58	0.63	7
2006	KDHE	17.75	0.985	0.021	46.90	1.57	11
2006	USACE		0.76	0.054	16.12	1.07	3.8
2007	USACE	25.75	0.86	0.065	14.26	0.87	12
2008	USACE	19.73	1.34	0.1	13.42	0.75	6.7
2009	KDHE	18.85	1.33	0.0335	39.70	1.32	10
KDHE Data Avg		12.37	0.99	0.059	24.42	1.21	7.95
USACE Data Avg.		18.0	0.93	0.089	13.04	0.83	7.38
All Data Average		13.7	0.96	0.075	17.37	1.08	7.82
1996-Present Data Average		17.53	0.92	0.076	17.43	1.12	9.05
1996-Present Data Median		18.05	0.90	0.068	13.42	1.14	10

* USACE TN:TP annual averages from individual ratios for each year averaged.

Table 4 lists the six metrics measuring the roles of light and nutrients in Perry 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 1.0 m^{-1}.

Table 4. Perry Lake limiting factor metrics.

Year	Source	Non-algal Turbidity	Light Availability in the Mixed Layer	Partioning 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**	
1991	KDHE	0.62	2.81	10.02		3.75		8.35
1994	KDHE							5.4
1996	KDHE	1.43	6.4	5.76	0.06	7.5		9.6
1997	KDHE	0.3	1.36	24.81	0.79	3.6		19.85
1998	KDHE	0.42	1.88	20.76	0.35	4.73	9.78	18.08
2000	KDHE	0.43	1.95	20.4	0.36	3.97	7.31	18.05
2003	KDHE	0.44	1.96	15.19	0.255	3.160	6.34	10.7
2005	USACE	1.29	5.82	7.41	0.250	7.14		13.52
2006	KDHE	0.193	0.87	27.87	1.109	2.858	6.73	17.75
2007	USACE	0.78	3.50	21.97	0.41	5.7		25.75
2008	USACE	0.87	3.93	15.57	0.20	6.15		19.73
2009	KDHE	0.288	1.29	24.82	0.561	3.399	7.09	18.85

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 <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 >16. Values <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 <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 <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 conclude that Perry Lake has generally low levels of silt and clay in the water column and inorganic turbidity has a moderate influence on water clarity; there is a moderate to high response by algae to nutrient input; inorganic turbidity is not typically responsible for light extinction in the water column; there is a moderate amount of light available in the mixed zone and self shading of algae does not impede productivity.

Another method for evaluating limiting factors is the TSI deviation metrics. Figure 9 (Multivariate Deviation Graph) summarizes the current trophic conditions at Perry Lake using a multivariate TSI comparison chart for data obtained by KDHE throughout 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, than 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. For the years plotted in Figure 9, Perry Lake generally varies from year to year between phosphorus limitation and turbidity dampening algal growth.

Figure 9. Multivariate TSI comparison chart for Perry Lake.

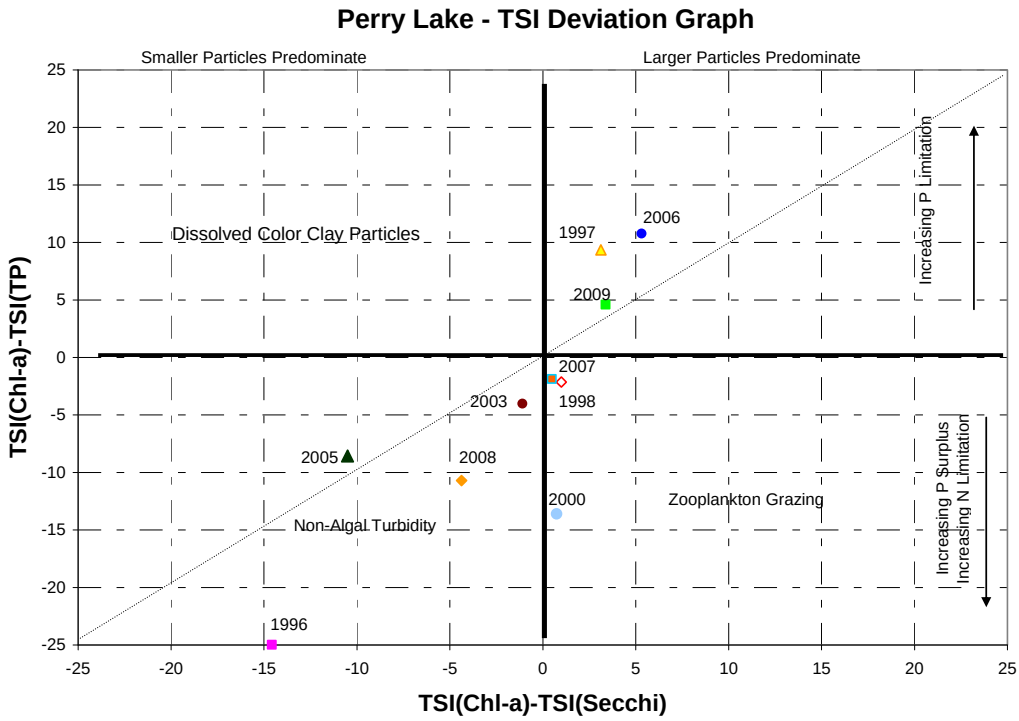
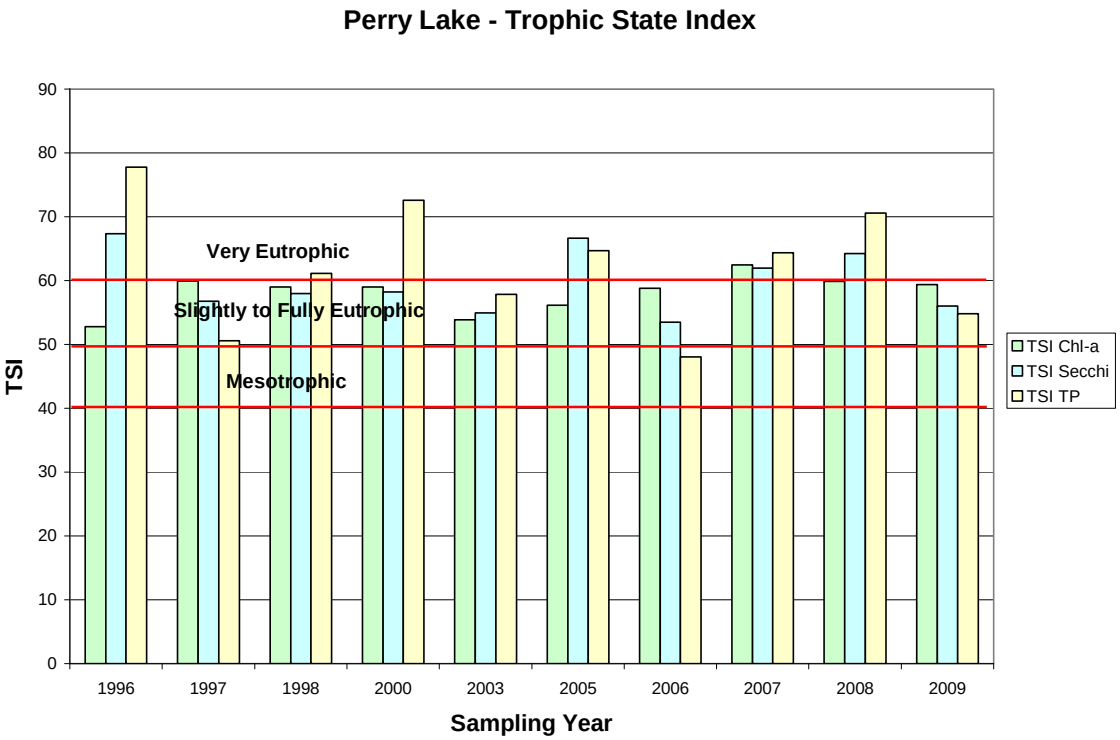


Figure 10. Perry Lake Trophic State Indices.



The Carlson Trophic State Indices for Chlorophyll *a*, Secchi depth and total phosphorus in Perry Lake (Figure 10) show a generally consistent state of fully eutrophic to very eutrophic conditions for the three parameters within Perry Lake.

The median trophic conditions within Perry Lake compared to other Federal lakes in the state are summarized in Table 5. The trophic indicator values within Perry Lake do not meet any of the statewide benchmarks. The median Secchi depth and nutrient concentrations are slightly better than the median values for Federal Lakes in Kansas. The median chlorophyll *a* concentration for Perry Lake is higher than all of the other benchmarks.

Table 5. Median trophic indicator values of Perry Lake in comparison with other federal lakes and draft nutrient benchmarks in Kansas. Median values based on based on data from KDHE and USACE from 1996-2009. 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	Perry Lake	Federal Lake	Central Great Plains	Statewide Benchmark
Secchi Depth (cm)	114	95	117	129
TN (µg/l)	900	903	695	625
TP (µg/l)	68	76	44	23
Chlorophyll *a* (µg/l)	18.05	12	11	8

The USACE sampled Perry Lake at numerous locations since 1996. Chlorophyll *a* concentrations were analyzed at the main basin (near the dam), middle lake, and upper lake. Table 6 summarizes the concentrations observed at the three sampling sites within the lake for the samples obtained by the USACE. These data indicate the upper portion of the lake takes the brunt of nutrient and sediment loads arriving from the watershed. Conditions improve in the lake as it approaches the main body of water near the dam.

Table 6. USACE of Engineers data summary for samples collected within Perry Lake.

USACE Sampling Point	Chl-a (µg/l) (2004-2008)	TN (mg/L) (1996-2008)	TP (mg/l) (1996-2008)	TN:TP Ratio	Secchi Depth (m) (2004-2008)
Upper Lake	25.3	1.18	0.14	10.61	0.4
Middle Lake	22.4	1.11	0.09	17.17	0.65
Main Basin (near dam)	18	0.93	0.089	13.04	0.83

The USGS conducted a 2-year study on Perry Lake that was initiated in 2001 to determine the extent of sedimentation within Perry Lake. In addition, the study evaluated chemical data and diatoms within the lake bottom sediment and the associated trends among the data. Utilizing the results of a bathymetric survey and bottom-sediment coring the report concluded that Perry Lake has an estimated mean annual sediment

deposition of 3,040 million lbs from 1969 to 2001 with the mean annual outflow estimated at 23 million lbs of sediment. Therefore USGS concluded that the mean annual amount of sediment entering the lake from the watershed at 3,063 million lbs (Juracek, 2003). Based on the results of the chemical analyses of the sediment core samples, USGS estimated the mean annual yields from the Perry Lake watershed for total nitrogen and total phosphorus at 6,850 (lb/mi^2)/yr and 3,020 (lb/mi^2)/yr respectively (Juracek, 2003).

Algal Communities: As seen in Table 7, algal communities in Perry Lake have recently been dominated by blue-green algae, or cyanobacteria. An increasing supply of nutrients, especially phosphorus and possibly nitrogen, will often result in higher growth of blue-green algae because they possess certain adaptations that enable them to out compete true algae (Soil and Water Conservation Society of Metro Halifax, 2007). Several of the cyanobacteria species possess gas vacuoles that allow them to move within the water column vertically. This selective advantage allows for some species to move within the water column to avoid predation and reach optimal primary productivity. Their movement within the water column may influence chlorophyll *a* levels within the lake at various depths during the diel cycle.

Table 7. Algal Communities observed in Perry Lake during KDHE sampling years.

Sampling Date	Total Cell Count cells/mL	Percent Composition				Chl-*a* µg/l
		Green	Blue Green	Diatom	Other	
1991	9,000	69	0	22	9	8.35
1994	1,890	27	0	70	3	5.4
1996	5,607	37	0	53	10	9.6
1997	9,167	36	29	24	11	19.85
1998	13,388	52	0	22	26	18.08
2000	13,010	7	61	32	26	18.05
2003	5,954	17	49	31	3	10.7
2006	44,195	<2	90	9	<1	17.75
2009	18,869	2	86	11	1	18.85

Relationships: Within Perry Lake there are poor relationships between; chlorophyll *a* and Secchi depth; chlorophyll *a* and total nitrogen; and chlorophyll *a* and total phosphorus as seen in Figures 11 and 12. There is a weak relationship between Secchi depth and total nitrogen and there is a significant relationship between Secchi depth and total phosphorus.

Figure 11. Relationship between chlorophyll *a*, TP, and TN within Perry Lake.

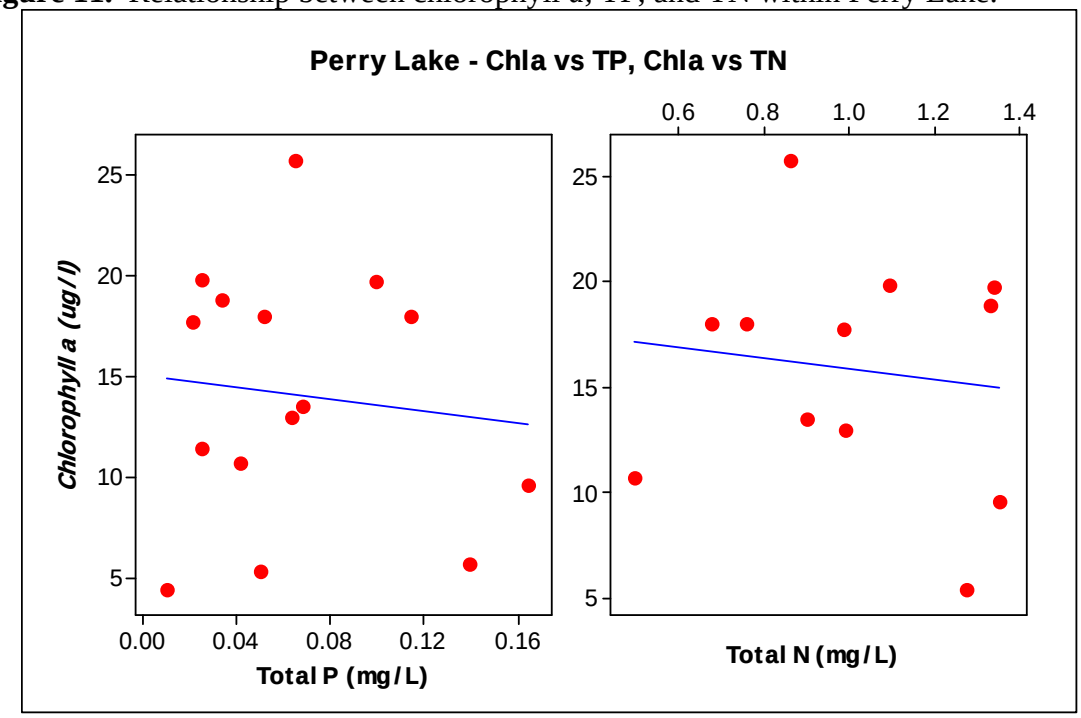
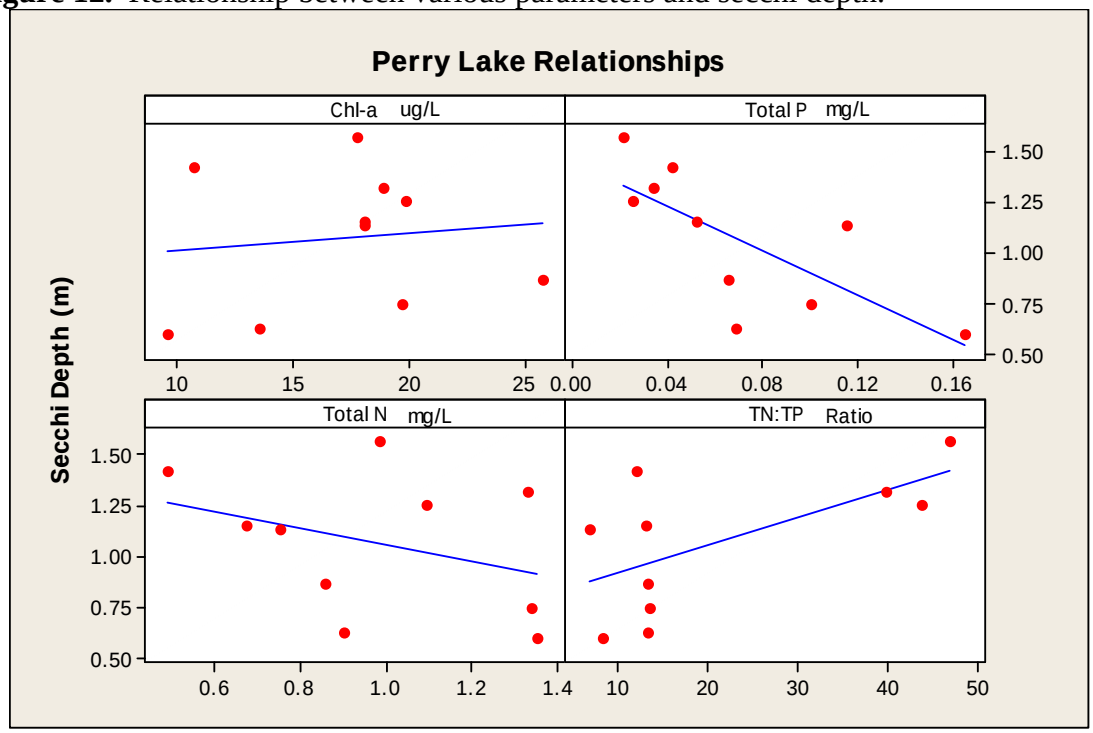


Figure 12. Relationship between various parameters and secchi depth.



Stream Data: There are five KDHE stream monitoring stations within the Delaware watershed, of which three are impaired by total phosphorus. The impaired stations are located on Elk Creek, Grasshopper Creek, and the Delaware River. A summary of the stream data in the watershed is detailed in Table 8 and Figures 13, 14, and 15.

Table 8. KDHE stream station sampling average and median concentrations.

Station	TP Avg (mg/L)	TP Median (mg/L)	TN Avg. (mg/L)	TN Median (mg/L)	TSS Avg. (mg/L)	TSS Median (mg/L)	# of Samples
SC554 – Delaware R.	0.324	0.214	1.33	1.03	208	56	127
SC603 – Grasshopper Cr	0.276	0.21	2.15	2.08	80.58	36	111
SC604 – Elk Cr	0.329	0.245	1.56	0.99	160.6	33.5	34
SC686 – Straight Cr	0.249	0.18	1.11	0.77	108.9	39	28
SC684 – Rock Cr	0.105	0.101	0.752	0.69	28	21	16

Figure 13. TP concentrations for KDHE sampling stations in the Perry Lake watershed (means indicated).

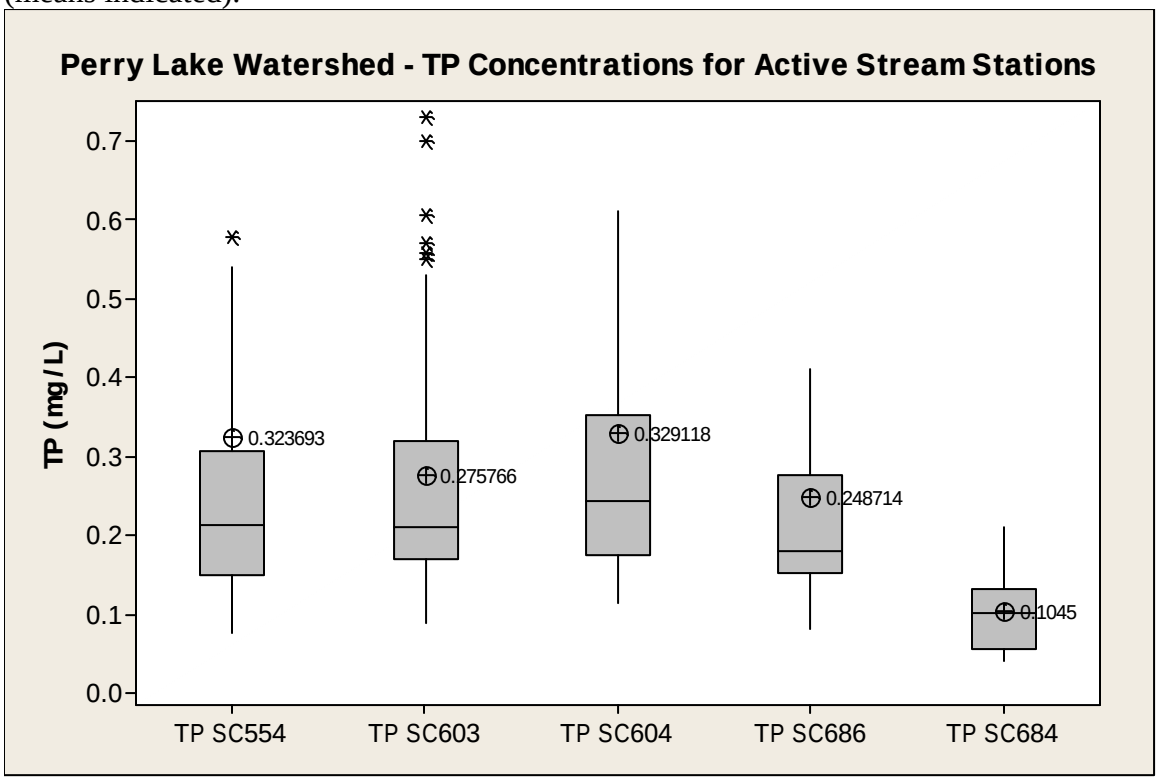


Figure 14. TN concentrations for KDHE sampling stations in the Perry Lake watershed.

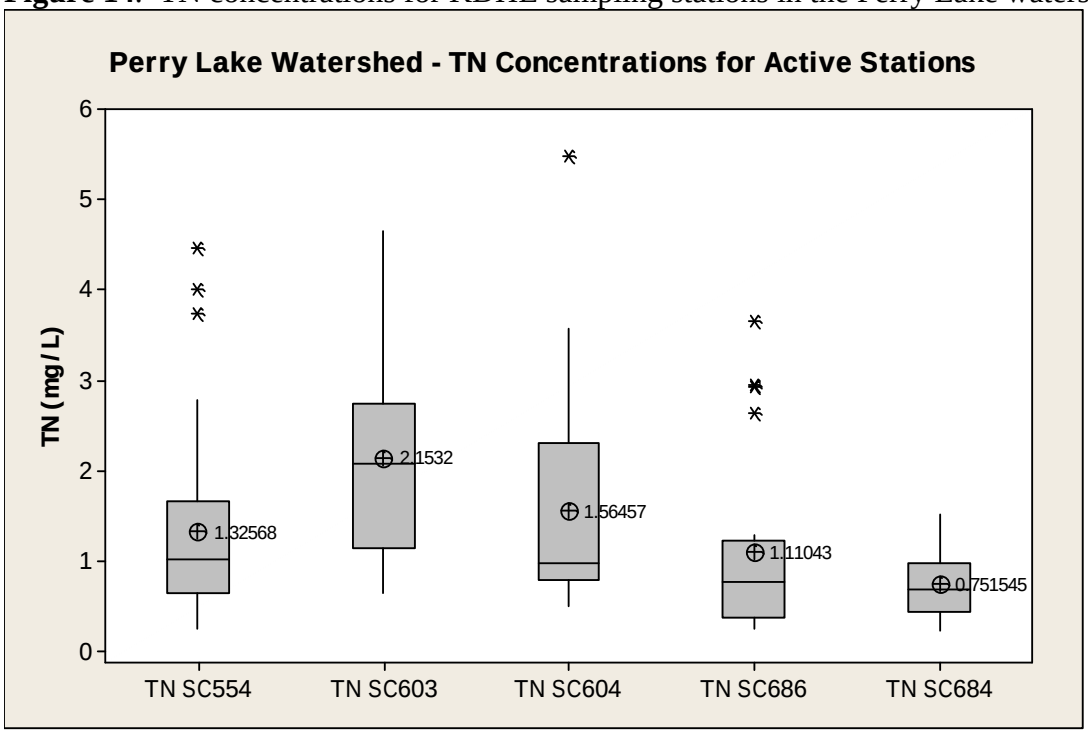


Figure 15. TSS concentrations for KDHE sampling stations in the Perry Lake watershed.

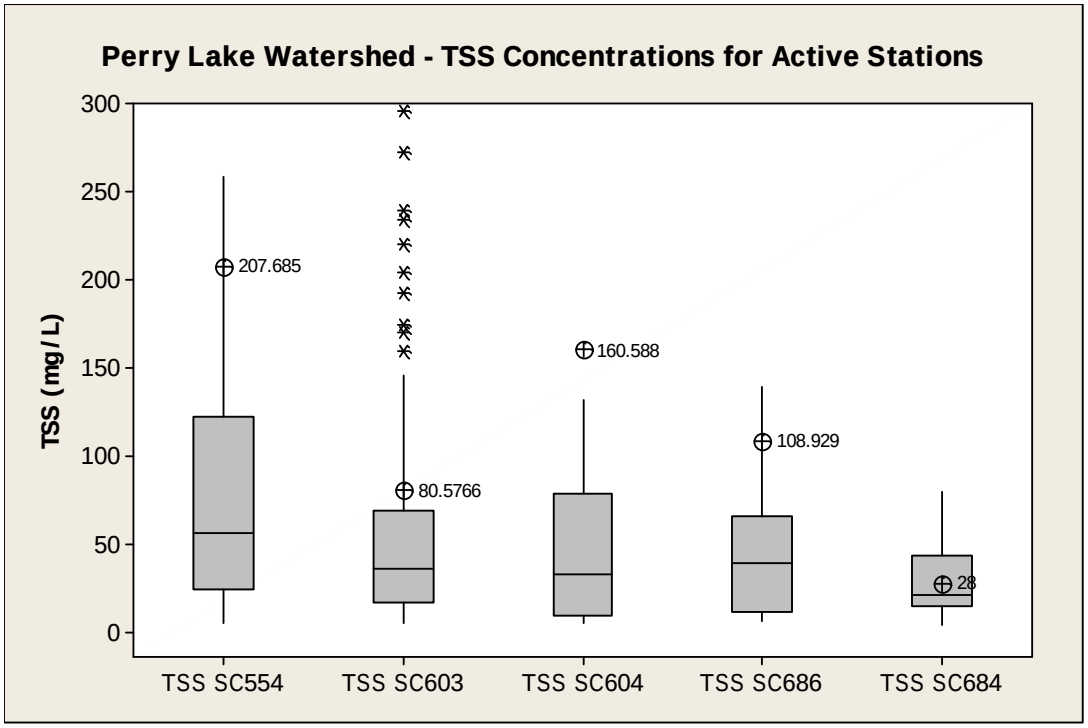


Table 9 details the KDHE stream sampling sites associated with the Probabilistic Stream Monitoring program. Sampling stations for the probabilistic program are chosen randomly throughout the state. The general goal of probabilistic sampling is to assess the condition of Kansas' waters. For probabilistic stream stations in the Perry Lake watershed, the stations were sampled one to five times during the year in which they were sampled. General inferences may be made with the probabilistic data. For example, the upper segments of the Delaware River below Sabetha has elevated TP concentrations, which are then diluted by Muddy Creek and the Muddy Creek tributaries (including Barnes Cr) prior to the confluence with Grasshopper Creek.

Table 9. KDHE probabilistic stream sampling station summary within the Perry Lake watershed.

KDHE Station	Stream / Segment	Year Sampled (# of Samples)	TP Avg. Concentration (mg/L)	TN Avg. Concentration (mg/L)
SP049	DelawareR (23)	2006 (3)	0.308	1.43
SP429	Barnes Cr. (39)	2009 (5)	0.107	1.06
SP125	Mission Cr (40)	2007 (4)	0.214	1.26
SP028	Spring Cr (42)	2010 (1)	0.158	1.57
SP070	Elk Cr (30)	2006 (1)	0.092	0.34
SP434	Elk Cr (29)	2009 (4)	0.209	1.20
SP006	Elk Cr (29)	2006 (4)	0.170	0.70

Table 10 details the current total phosphorus loads under average flow conditions by utilizing a mass balance calculation to estimate loads throughout the watershed. The average TP concentrations utilized for the mass balance calculation composed of samples obtained in 1997, 2004 and 2008 at the four sampling stations that had common sampling dates. The mass balance exercise provides a general estimate of the current loads in the Delaware watershed above KDHE sampling station SC554. The concentration for the upper portion of the upper Delware River watershed was estimated based on a number of factors, to include the KDHE available probabilistic monitoring data and the NPDES discharge data from the City of Sabetha.

Table 10. Estimated mass balance of current daily loads in the Delaware River watershed.

Stream	Est. Avg Flow (cfs)	Common Period Avg. TP Concentration (mg/L)	Current TP Daily Load (lbs/day)	Percent of TP Load at SC554
Grasshopper Cr – SC603	68.5	0.278	103	16 %
Upper Delaware River (above confluence with Grasshopper Cr)	165	0.27*	240	37 %
Little Grasshopper	32.5	0.15*	26	4 %
Negro Cr	17	0.14*	13	2 %
Straight Cr –SC686	73.4	0.252	100	16 %
Elk Cr – SC604	83.6	0.322	145	23 %
Nebo Cr	11.7	0.14*	9	1 %
Catamount Cr	9.82	0.14*	7	1 %
Delaware R at SC554	461.5	0.258	643	100%

* - Estimated concentrations for unmonitored tributaries.

Based on the sedimentation rates established by the Kansas Water Office, Perry Lake is losing storage capacity at a faster rate than designed. In order to ensure Perry Lake maintains the 100 year design capacity, the sedimentation rate must be reduced by 28% from the current estimated sedimentation rate as seen in Table 11.

Table 11. Perry Lake Estimated Sedimentation Rates from KWO Fact Sheet.

Rate	Sedimentation Rate (acre-feet / year)	Estimated tons/year Sediment	Capacity after 100 years (acre-feet)
Design Sedimentation Rate	930	830,470	150,220
Estimated Current Sedimentation Rate	1143	1,020,674	132,380
Future Rate Desired to meet 100 year Design Life for Sediment Storage	824	735,814	150,220
Reduction Necessary to meet 100 year Design Rate	**319 (28%)**	**284,860 (28%)**	

Perry Lake Wildlife Area Wetlands Current Condition:
Many wetlands have reduced dissolved oxygen concentrations during the summer months. Low dissolved oxygen may result from high plant material decomposition, decreased water volume, prolonged hydraulic residence times and local groundwater interaction. It is likely that dissolved oxygen concentrations within the Perry Lake Wildlife Area Wetlands will remain below 5 mg/L during the summer months as this is typical for wetlands. In addition, high chlorophyll *a* concentrations are not uncommon in wetland ecosystems. Chlorophyll *a* concentrations have increased significantly since 1997 as seen in Table 12. Turbidity is low and secchi depth observations remain shallow. Nutrient ratios of N:P are low, indicating nitrogen limitation.

Table 12. Perry WA Wetlands sampling results.

Sampling Year	Chl-a (µg/L)	TP (mg/L)	TN (mg/L)	TN:TP Ratio	DO (mg/L)	Turbidity (NTU)	Secchi Depth (m)
1997	17.95	0.165			2.4	18.5	0.4
1998	24.9	0.668	2.23	3.33	3.3	4.85	0.6
2000	92.3	0.507	1.99	3.93	2.3	14	0.4

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

In order to improve the trophic condition of Perry Lake from its Fully Eutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* average concentrations below 10 ug/l, with the reductions focused on nutrients (available N and P) entering the lake. The chlorophyll *a* endpoint of 10 ug/l is the statewide goal for Federal Lakes and 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 BATHTUB reservoir eutrophication model (see Appendix A), available phosphorus and available nitrogen concentrations entering the lake must be reduced by 63%. With these reductions, the endpoint for Perry Lake will be met. These reductions at the inflows to Perry Lake will result in a 62% reduction of TP, 58% reduction of TN, and a 57% reduction of Chlorophyll *a* within the lake. Achievement of the endpoints 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 Perry Lake utilized in the model input was based on data from 1996-2009 from both the USACE and KDHE for the main basin of the lake and based on the USACE data obtained since 1996 for three of the other segments in the model. Tributary data for the water flowing into the lake was averaged from the available data from KDHE monitoring stations for the Delaware River and Rock Creek. Inflowing concentrations from Slough Creek and Little Slough Creek were estimated based on the Rock Creek data since these streams are not monitored.

Table 13. Perry Lake Current average condition and TMDL based on BATHTUB.

Lake Inflow	Current Avg. Condition	TMDL	Percent Reduction
Available P – Annual Load (lbs/year)	**270,497**	**103,794**	**62%**
Available P – Daily Load (lbs/day)	**2305**	**884**	**62%**
TP – Lake Concentration (ug/L)	**109**	**55**	**50%**
Available N – Annual Load (lbs/year)	**1,382,683**	**584,680**	**58%**
Available N – Daily Load (lbs/day)	**7198**	**3043**	**58%**
TN – Lake Concentration (ug/L)	**940**	**441**	**53%**

The KDHE goal for lakes or wetlands that have a designated use of primary contact recreation but are not active public water supplies is to maintain a summer time chlorophyll *a* average below 12 ug/L. The endpoint for the Perry Lake Wildlife Area Wetlands will be to maintain an average chlorophyll *a* concentration below 12 ug/L during the summer months. In addition, organic matter entering the wetland from external sources or produced internally should not cause additional declines in summer dissolved oxygen beyond levels typically associated with a dystrophic system, and meet the Water Quality Standard of 5 mg/L. At this point, it is presumed the endpoint for the Perry Lake Wildlife Area Wetlands will likely be achieved and all designated uses will be met if the endpoint for Perry Lake is reached. Once the endpoint for Perry Lake is achieved, the endpoint for the Wildlife Area Wetlands will be refined if necessary, based on the results of additional monitoring and further external source assessment. If the Perry Lake Wildlife Area Wetlands endpoints are not achieved when the endpoints for Perry Lake are achieved, the Wildlife Area Wetlands endpoints will revised .

3. SOURCE INVENTORY AND ASSESSEMENT

NPDES: There are 49 NPDES permit facilities within the Perry Lake watershed. Of these facilities, there are 20 that are non-discharging facilities and 29 permitted discharging facilities (see Appendix C). Of the discharging facilities, there are 21 permitted municipal facilities and 8 industrial facilities.

Of the municipal discharging facilities, there are six permits that require nutrient monitoring that may be viable sources and contributors to the impairments associated

with this TMDL. These facilities along with their average discharge flow, average effluent TP concentration and their average effluent TN concentrations are listed in Table 14. The City of Horton discharges to Grasshopper Creek and the effects of their nutrient loading is observed at KDHE stream sampling station SC603. The City of Sabetha discharges to the upper Delaware River. During heavy rainfall events the City of Sabetha often reports lift stations that are being bypassed since these lift stations can not keep up with the volume of stormwater flow. This has led to a number of complaints and significant pollution loading to the upper Delaware River. The City of Holton discharges into Elk and Banner Creek and has two discharge outfalls associated with their facility. The three cell lagoon system has a 120 day detention with a design flow of 0.132 MGD. The second outfall is associated with an extended aeration activated sludge Aero-Mod system, which has a design flow of 0.528 MGD. The nutrient loads associated with the City of Holton are observable with the nutrient concentrations detected at KDHE sampling station SC604. The Jefferson County S.D. #2 facility discharges to Perry Lake via an unnamed tributary, and currently does not monitor their flow exiting their lagoon system. Lakewood Hills Improvement District discharges to Perry Lake via an unnamed tributary. The discharges associated with the Oldham's LLC facility enter Banner Creek and their nutrient contribution is detected at the KDHE sampling station SC604. Although no nutrient monitoring is associated with the City of Valley Falls permit, they are permitted to discharge into the Delaware River from a lagoon system with a design flow of 0.486 MGD with a 120-day detention time.

Table 14. Discharging Facilities with nutrient monitoring within the Perry Lake watershed.

NPDES Facility	Average Discharge MGD	Nutrient Monitoring Frequency	Avg. TP Concentration (mg/L)	Avg. TN Concentration (mg/L)
City of Holton	0.51	Monthly	2.2	7.2
City of Horton	0.20	Twice Monthly	3.3	15.1
City of Sabetha	0.40	Monthly	2.15	5.85
Jefferson County S.D. #2	NA	Quarterly	1.03	3.04
Lakewood Hills Improvement District	0.015	Monthly	4.55	20.0
Oldham's LLC	0.138	Quarterly TP/ Monthly TN	1.5	3.9

The non-overflowing permitted facilities are prohibited from discharging and may contribute a nutrient load under extreme precipitation or flooding events. Such events would not occur at a frequency or for duration sufficient to cause impairment in the watershed.

Population Density: According to the 2000 census data from the U.S. Census Bureau, the population of the entire watershed is approximately 28,722 people, and therefore the population density for the watershed is approximately 24.8 people/square mile. There are numerous municipalities within the watershed with the four largest cities consisting of the Cities of Holton, Horton, Sabetha, and Valley Falls. These four cities account for 32% of the population within the watershed. All four cities had a stable to slightly declining population in 2010 as seen in Table 15. The wastewater treatment plants associated with these same four cities are the largest NPDES discharging facilities within the watershed. The existing wastewater facilities appear to be able to handle the optimistic population growth projections through the year 2030 for the cities of Holton, Horton, Sabetha, and Valley Falls.

Table 15. US Census and KWO

City	2000 U.S. Census Populations	2010 U.S. Census Populations	2030 Population Projection (KWO)
Holton	3353	3329	4414
Horton	1967	1776	2135
Sabetha	2589	2571	2814
Valley Falls	1254	1192	1506

Livestock Waste Management Systems: There are eighty-five certified or permitted confined animal feeding operations (CAFOs) within the Perry Lake watershed (see Appendix D). All of these livestock facilities have waste management systems designed to minimize runoff entering their operation and detain runoff emanating from their facilities. These facilities are designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with streamflow that is less than 1-5% of the time. Though the total potential number of animals is approximately 50,618 head in the watershed, the actual number of animals at the feedlot operations is typically less than the allowable permitted number.

According to the Kansas Agricultural Statistics the estimated number of all cattle and cows for counties that are included within this watershed as of January 1, 2010 are: 28,000 for Atchison, 27,000 for Brown, 46,000 for Jackson, 68,000 for Nemaha and 33,000 for Jefferson County. The animal waste from both confined and unconfined feeding sites is considered a possible major source of nutrient loading into Perry Lake. Of particular concern are lands near the riparian areas that are subject to livestock grazing or watering and fertilizer applications. Landuse within the riparian areas are detailed in Table 16b.

On-Site Waste Systems: Households outside of the municipalities that operate a wastewater treatment facility are presumably utilizing on-site septic systems. Significant nutrient loading may occur if a system fails and it is located near a stream. However,

since this watershed is so large and there are so many municipalities it is likely that nutrient loading associated with on-site septic systems is likely to be a minor source to the watershed and Perry Lake.

Landuse: Landuse within the Perry Lake watershed is dominated by grassland and cropland. The landuse percentages summarized from the 2001 NLCD for the entire HUC8 are listed in Table 16a and the percentage of the landuses for the five HUC10 watersheds are listed in Table 17. The Straight Creek and Elk Creek subwatersheds have a high percentage of grassland, whereas the Grasshopper Creek subwatershed is dominated by cropland. The HUC10 next to Perry Lake has the highest percentage of forested land in the watershed.

Table 16a. General Land Use acres in the Perry Lake Watershed.

Land Use	Acres	Percent of HUC8
Grassland	399,432	54.0%
Cropland	180,847	24.5%
Forest	94,919	12.9%
Open Water	18,459	2.5%
Roads	30,432	4.1%
Developed	7,256	1.0%
Wetlands	7,355	1.0%

Figure 16. Perry Lake Landuse map (2001 NLCD).

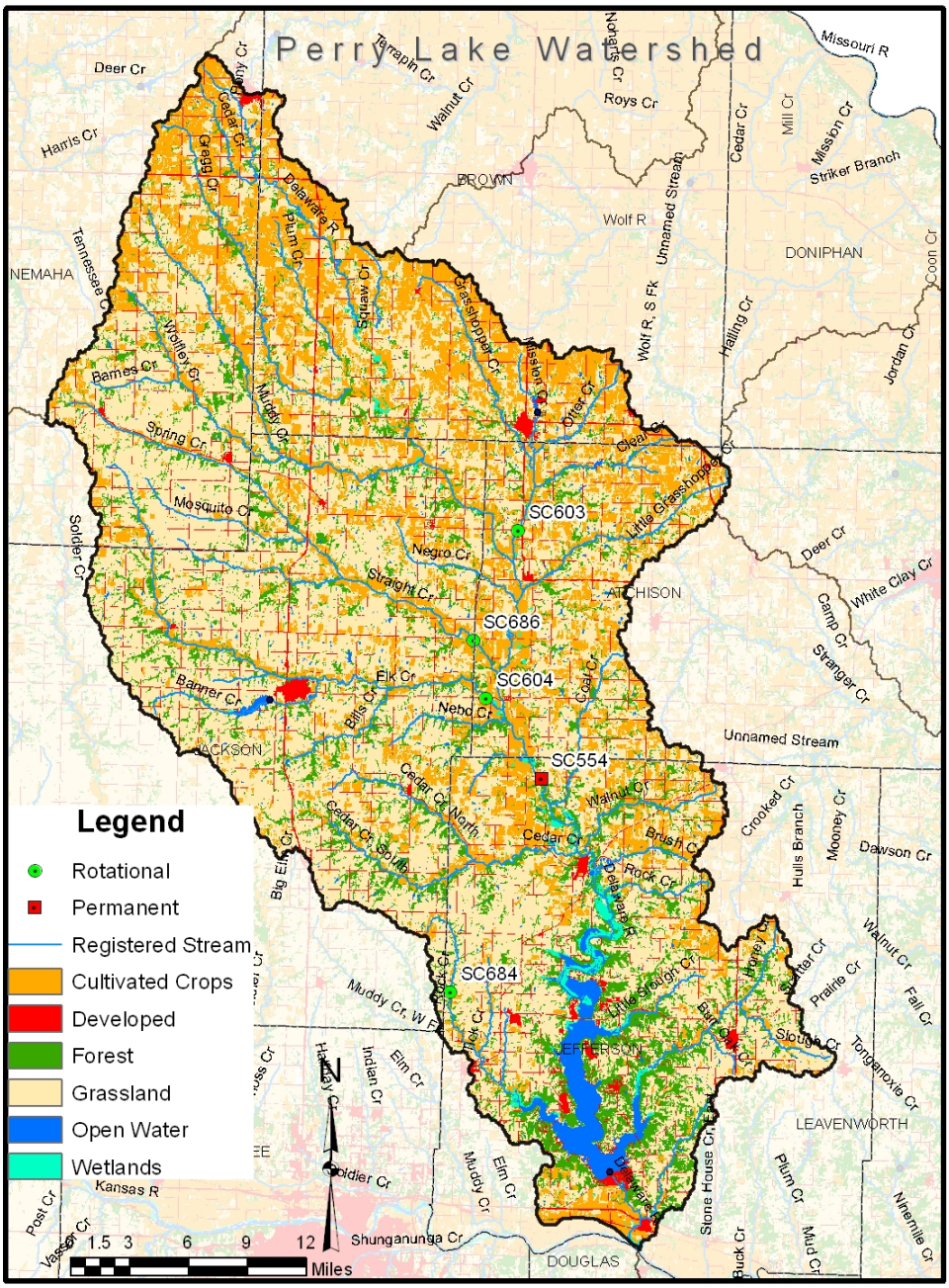


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Table 16b. Land Use acres in the 100 foot riparian buffer by HUC 12.

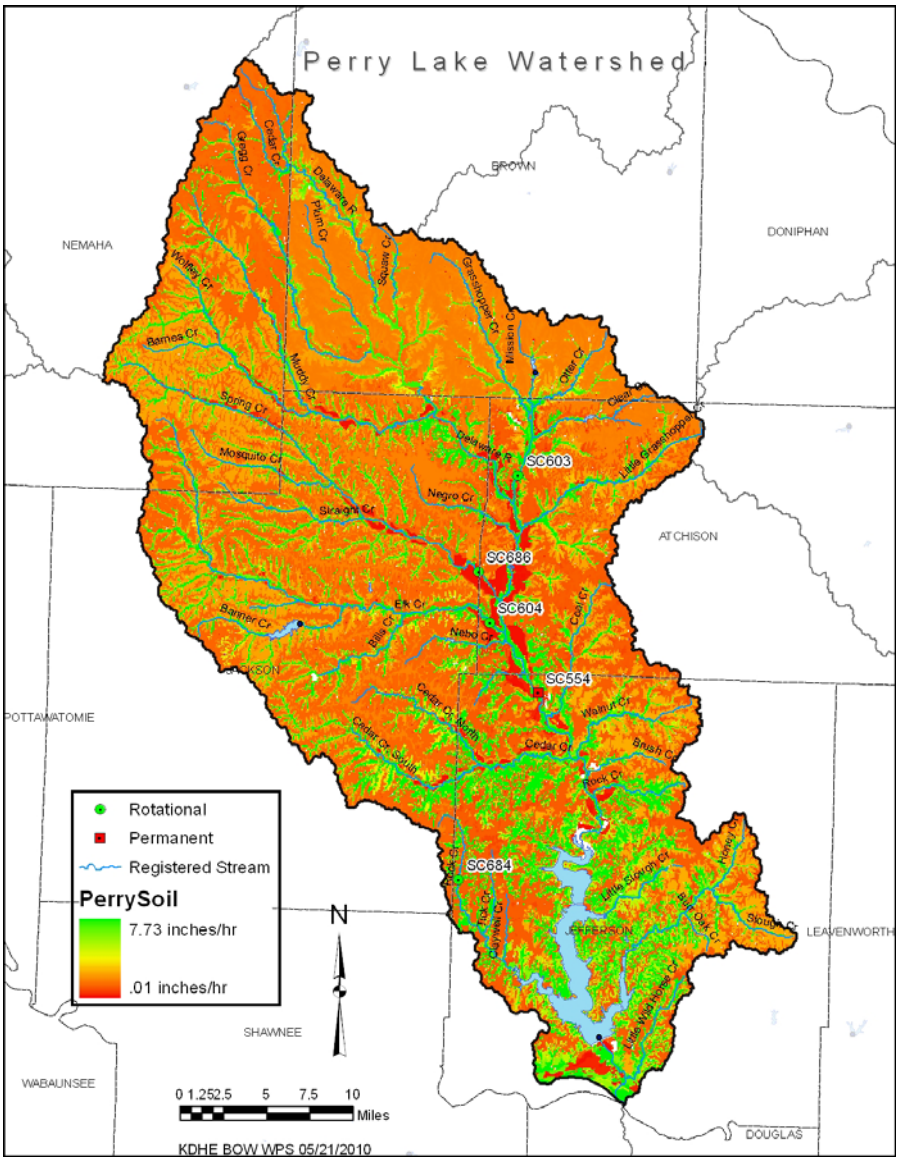
HUC12	Grassland	Cropland	Forest	Open Water	Developed	Wetlands	Total Riparian Acres
102701030101	120.98	42.26	98.30	8.01	0.22	18.46	300.24
102701030102	154.79	218.62	290.89	1.33	8.23	134.33	836.43
102701030103	76.50	49.82	78.73	0.00	1.11	1.11	212.39
102701030104	85.85	117.65	150.34	0.00	1.33	2.45	364.51
102701030105	136.11	355.17	404.76	1.11	2.45	11.34	938.07
102701030106	0.00	0.00	0.00	0.00	0.00	0.00	0.00
102701030107	121.43	210.61	363.84	0.00	1.33	0.89	711.00
102701030108	156.79	271.77	316.92	0.00	1.78	0.00	765.71
102701030109	35.36	98.97	175.47	8.23	1.11	35.14	362.28
102701030110	10.01	88.74	59.38	52.71	1.56	172.13	390.97
102701030201	64.72	30.25	57.82	4.67	2.67	17.12	192.15
102701030202	113.64	239.74	212.61	0.00	4.00	27.80	612.92
102701030203	210.83	237.96	358.50	13.12	7.34	92.07	945.41
102701030204	114.09	168.13	322.03	0.22	2.22	4.89	625.60
102701030205	113.87	74.73	201.49	35.14	1.56	48.70	485.27
102701030301	233.07	316.03	536.87	1.11	5.78	1.56	1,124.44
102701030302	109.20	60.94	235.30	2.00	1.11	0.22	419.44
102701030303	19.79	95.19	179.70	17.79	1.56	88.74	410.10
102701030304	166.13	231.96	459.69	0.00	4.89	13.34	909.82
102701030305	100.97	34.69	210.83	96.52	4.67	4.67	464.81
102701030306	42.26	56.93	194.15	0.00	1.33	0.00	301.79
102701030307	62.94	117.87	245.53	2.45	2.22	44.70	480.15
102701030308	12.90	48.48	36.25	56.27	0.22	72.72	229.74
102701030401	46.93	50.71	171.91	0.67	0.00	4.00	284.00
102701030402	144.56	41.37	222.17	14.90	0.67	0.89	436.34
102701030403	55.82	116.09	261.98	0.00	1.11	0.00	441.46
102701030404	91.63	98.08	235.52	0.00	0.00	0.00	447.91
102701030405	31.58	72.95	127.21	0.00	1.11	52.49	288.67
102701030406	0.00	0.00	0.00	0.00	0.00	0.00	0.00
102701030407	48.04	55.15	277.33	0.00	1.11	2.89	392.97
102701030408	59.82	68.72	169.47	139.67	0.00	113.42	559.10
102701030501	30.02	16.68	175.69	1.78	1.33	0.00	229.29
102701030502	39.36	17.57	195.49	0.00	0.89	6.45	265.32
102701030503	1.56	0.00	31.80	142.78	1.33	73.61	252.86
102701030504	0.00	0.00	0.00	0.00	0.00	0.00	0.00
102701030505	45.37	16.01	155.90	5.12	1.56	25.58	257.09
102701030506	282.44	114.76	444.35	10.01	12.01	17.12	903.37
102701030507	233.74	105.19	496.17	18.01	2.67	3.11	882.02
102701030508	0.00	0.00	0.00	0.44	0.22	0.00	1.78

Table 17. Percentage of landuse for specified HUC10 subwatersheds (2001 NLCD).

HUC 10	HUC Name	Grassland	Cropland	Forest	Open Water	Roads	Developed	Wetlands
1027010301	Muddy Cr – Delaware R	49.1%	35.7%	9.3%	0.6%	3.7%	0.9%	0.7%
1027010302	Grasshopper – Delaware R	42.4%	42.6%	7.7%	1.1%	4.6%	1.0%	0.6%
1027010303	Elk Cr – Delaware R	66.6%	15.8%	11.2%	1.1%	3.8%	1.1%	0.4%
1027010304	Coal Cr – Delaware R	56.9%	23.3%	14.0%	1.0%	3.5%	0.5%	0.8%
1027010305	Perry Lake – Delaware R	50.3%	10.7%	21.2%	8.5%	5.3%	1.5%	2.5%

Contributing Runoff: The watershed of Perry Lake has a mean soil permeability value of 0.47 inches/hour, ranging from 0.01 to 7.73 inches/hour according to the NRCS STATSGO database. About 77% of the watershed has a permeability value less than 0.57 inches/hour, which contributes to runoff during extremely low rainfall intensity 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 with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced. As seen in Figure 17, the majority of the nonpoint source nutrient runoff will be contributed to the central and northern portions of the watershed.

Figure 17. Perry Lake contributing runoff map.



Water Diversions: There are a total 413 unique points of diversion within the five counties encompassing the watershed. The leading use of water in Atchison, Jackson, and Nemaha Counties is for municipal use; whereas irrigation is the leading use in Brown and Jefferson Counties. Jackson County has the fewest points of diversions and Jefferson County has the greatest number of diversions. Surface Water is the primary source of water in Jackson and Atchison Counties, whereas groundwater is the dominant source in Jefferson, Brown, and Nemaha Counties. While many of these points of diversion may be outside the watershed, significant use of the Delaware River for public water supply occurs, particularly Valley Falls and numerous Rural Water Districts in the vicinity of Perry Lake. Additionally, the State of Kansas owns the conservation storage of Perry Lake for municipal and industrial water supply in northeast Kansas and along the lower Kansas River.

Table 18. WIMAS Authorized quantity summary for counties within the Perry Lake watershed.

County	Points of Diversion	Total Acre-Feet Authorized
Atchison	60	8,045.1
Brown	89	7,210.3
Jackson	32	3,699.8
Jefferson	158	11,288.4
Nemaha	74	4,345.7

Background: Phosphorus is naturally found in rocks, soil and organic material and is essential for the growth of aquatic and terrestrial vegetation, to include agricultural crops. The natural erosion of soil contributes to the amount of background phosphorus within the watershed that becomes available as nutrients to the ecosystem. However, erosion that may be facilitated by human activities and practices may cause excess runoff and streambank erosion, which contributes to high levels of suspended phosphorus-bound streambed sediment during runoff events. Land use changes such as the removal of riparian forests and wetlands, streambank erosion, urbanization, and agricultural activities, to include manure application to cropland, may significantly affect the levels of total phosphorus in aquatic systems. The typical levels of phosphorus within some streams have been significantly increased due to human activities and land use changes and practices within Kansas, and therefore it is difficult to determine what the actual background phosphorus concentrations within the watershed are expected to be. The atmospheric deposition of nutrients may also contribute to the nutrient load within the watershed.

Background nitrogen loading may be associated with natural biogeochemical transformations. The nitrogen contributions may be associated with soils, wildlife, streamside vegetation or streambed sediment. These background nitrogen levels should result in minimal loading to the watershed.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Perry Lake is primarily co-limited by phosphorus and nitrogen, with some years being limited by only phosphorous. Chlorophyll *a* concentrations within the main basin of the lake are greater than 10 µg/l during all conditions, and therefore both phosphorus and nitrogen allocations will be made under this TMDL.

BATHTUB is an empirical receiving water quality model that was developed by the U.S. USACE 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 for the eutrophication assessment of Perry Lake. Perry Lake was segmented into six sections for the BATHTUB model as seen in Figure 18a, which included the upper lake (riverine area), upper middle pool (transitional area), lower middle pool (transitional area), the Rock Creek Arm, the Slough Creek arm and the main basin (near dam). Atmospheric total nitrogen was obtained from the Clean Air Status and Trends Network (CASTNET), which is available at www.epa.gov/castnet/. The CASTNET station from the Konza Prairie (KS) was utilized to estimate the atmospheric TN concentration for the model. Total phosphorus atmospheric loading was estimated using the 1983 study of Rast and Lee. Water quality data from the main basin segment was averaged using the 1996-2009 data from KDHE and the USACE. Data associated with the upper lake, Rock Creek arm, and the Slough Creek arm was collected by the USACE as seen in Table 6. Model input data for the lake inflow from the Delaware River and Rock Creek was estimated using averages from the KDHE stream chemistry monitoring stations SC554 and SC684 respectively. Tributary inflow data for the Little Slough Creek and Slough Creek were estimated based on the data from Rock Creek.

The BATHTUB model was calibrated for the area-weighted mean per EPA's guidance. The model results (see Appendix A) estimate that the lake currently retains 58.6% of the TP and 21.8% of the TN load annually. Based on the modeling results, a 63% reduction of TP and TN concentrations within the inflows of the lake is necessary to meet the TMDL endpoint. If reductions were only applied to TP, a 90% reduction in TP would be necessary to meet the TMDL endpoint as seen in Figure 18b.

Additional monitoring over time will be needed to ascertain the dissolved oxygen characteristics of the Perry Lake Wildlife Area Wetlands and ascertain any level of impairment. Allocations assigned to Perry Lake will encompass the entire watershed, therefore allocations for the Perry Lake Wildlife Area Wetlands are encompassed in the established allocations under this TMDL.

Point Sources: Wasteload Allocations are established for the discharging wastewater treatment facilities permitted within the watershed. There are twenty-four NPDES facilities that have been assigned a wasteload allocation. Of these, the largest wasteload allocations are associated with the cities of Holton, Horton, Sabetha, and Valley Falls. The six discharging facilities that currently monitor nutrients have been assigned a wasteload allocation based on the lesser of their average discharge concentration or 1.5

mg/L TP and 8 mg/L TN at their respective design flow. The facilities that do not monitor nutrients utilize lagoon systems, and have been assigned a discharge concentration of 2.0 mg/l of TP and 8.0 mg/l of TN, which are concentrations typically observed in the effluent of lagoon systems in Kansas. The wasteload allocations for Perry Lake are 42.49 lbs/day of TP and 175.34 lbs/day of TN. The WLA for the facilities that currently monitor for nutrients are listed in Table 19.

Figure 18a. Perry Lake BATHTUB Segmentation.

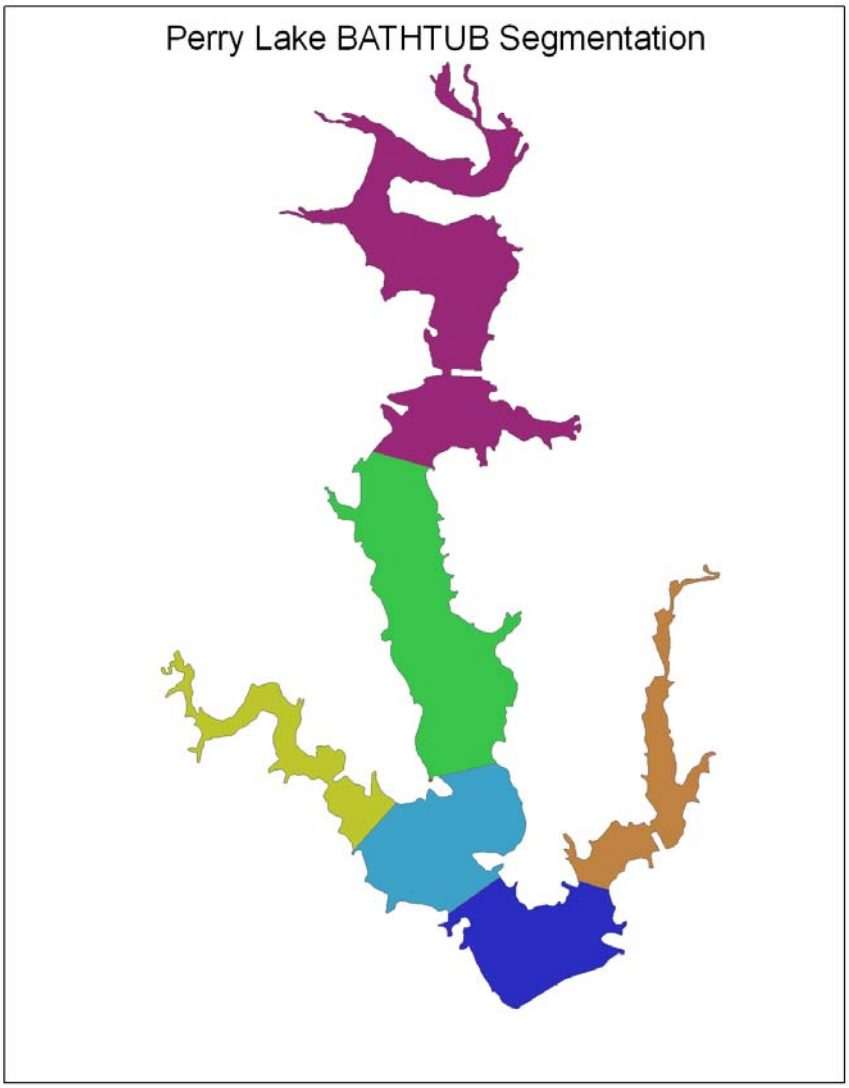


Figure 18b. Perry Lake Load Reductions for TP only and TP and TN indicating necessary reduction to meet the endpoint based on BATHTUB.

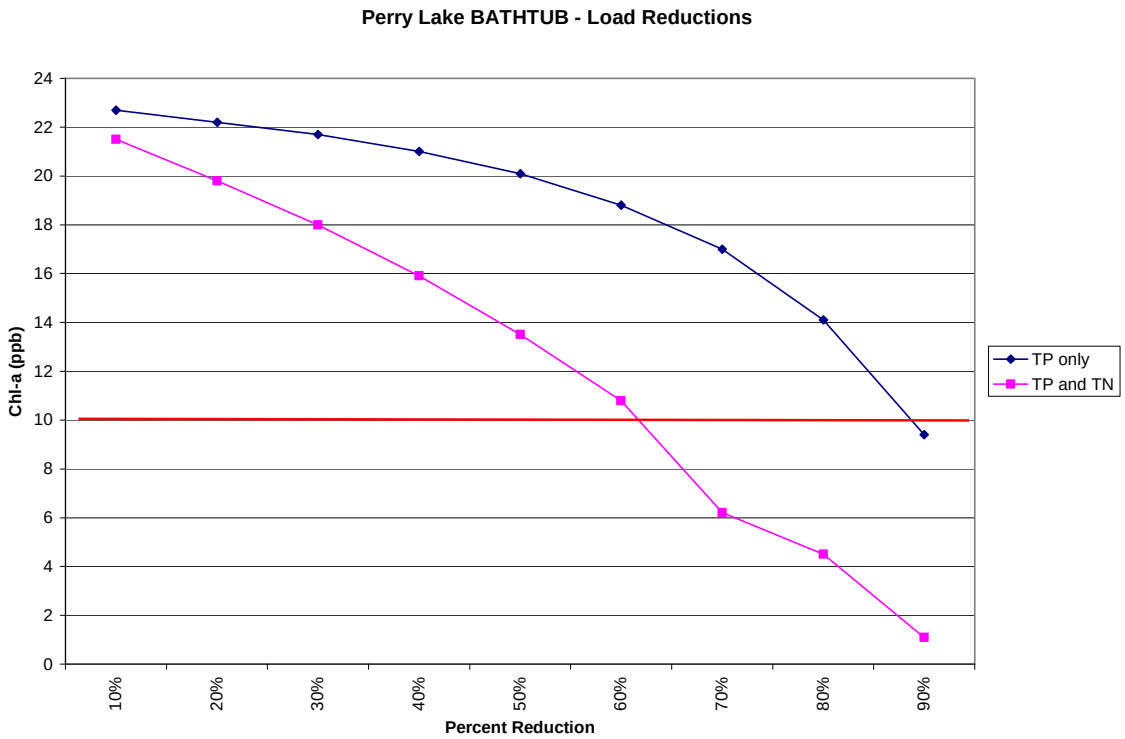


Table 19. NPDES facilities that monitor for nutrients within the Perry Lake watershed. Limits based on current average or 1.5 mg/L TP and 8.0 mg/L TN, whichever is lower.

NPDES Facility	Design Flow MGD	TP (mg/L)	TP WLA (lbs/day)	TN (mg/L)	TN WLA (lbs/day)
City of Holton	0.66	1.5	8.27	7.2	39.70
City of Horton	0.248	1.5	3.11	8.0	16.57
City of Sabetha	0.75	1.5	9.40	5.85	36.65
Jefferson County S.D. #2	0.02538	1.03	0.22	3.04	0.64
Lakewood Hills Improvement District	0.04	1.5	0.50	8.0	2.67
Oldham's LLC	0.279	1.5	3.50	3.9	9.09

All other NPDES facilities and the confined animal feeding operations within the watershed have been assigned a Wasteload Allocation of zero since these facilities should not discharge to receiving streams within the watershed and should not add to the impairment within Perry Lake, except potentially under extreme wet conditions. Ongoing inspections and monitoring of these facilities should be made to ensure that a 25-year, 24-hour precipitation event does not result in significant pollutant loadings.

Within the BATHTUB model, the WLA for the facilities located above the KDHE monitoring stations are included within the total load inflowing from the tributaries since the discharge from these facilities is accounted for through the concentrations observed at these stations. For those facilities that discharge above the monitoring stations their WLA has been subtracted out of the BATHTUB output to differentiate between the inflowing load allocation and wasteload allocation. The facilities that discharge below the monitoring stations have been added into the BATHTUB model separately to the appropriate segment of the lake. Table 20 identifies the facilities that discharge to segments that are not monitored within the watershed. The receiving lake segment is associated with the BATHTUB model setup.

Table 20. Discharging Facilities located below KDHE monitoring Stations.

Facility	Design Flow (MGD)	TP WLA (lbs/day)	TN WLA (lbs/day)	Receiving Lake Segment
Denison, City of	0.04	0.67	2.67	Upper
Mayetta, City of	0.05	0.84	3.34	Upper
Oskaloosa, City of	0.14	2.34	9.36	Slough Cr
Lakewood Hills Improvement District	0.04	0.5	2.67	Upper
Jefferson Co. S.D. #7	0.0197	0.33	1.32	Upper
Jefferson Co. S.D.#2	0.02538	0.22	0.64	Upper
Jefferson County S.D. #6	0.037	0.62	2.47	Upper
Valley Falls, City of	0.486	8.12	32.48	Upper
Total below KDHE Sampling Stations	**0.838**	**13.63**	**54.96**	

Nonpoint Sources: Nonpoint sources are the main contributor for the nutrient input and impairment in Perry Lake. Background levels may be attributed to nutrient recycling and leaf litter. The assessment suggest that runoff transporting nutrient loads associated with animal wastes and cultivated crops where fertilizer has been applied, to include pasture and hay, contribute to the eutrophic condition of the lake. Nutrient load allocations for Perry Lake were calculated using the BATHTUB model (see Appendix). A summary of the Perry Lake TMDL and the respective allocations are listed in Table 21.

Table 21. Perry Lake TMDL.

Description	Allocations (lbs/year)	Allocations (lbs/day)*
Available Phosphorus Atmospheric Load Allocation	4048	34
Available Phosphorus Nonpoint Source Load Allocation	76,254	650
Available Phosphorus Wasteload Allocation	13,113	112
Available Phosphorus Margin of Safety	10,379	88
Available Phosphorus TMDL	103,794	884
Available Nitrogen Atmospheric Deposition	102,628	534
Available Nitrogen Nonpoint Source Load Allocation	366,335	1907
Available Nitrogen Wasteload Allocation	57,249	298
Available Nitrogen Margin of Safety	58,467	304
Available Nitrogen TMDL	584,679	3043

* - See Appendix B for daily load calculations.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual available phosphorus and nitrogen loads along with the chlorophyll *a* endpoint. Therefore, the margin of safety is explicitly set at 10% of the total allocations for the available phosphorus and nitrogen, which compensates for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety for available phosphorus and nitrogen is 88 lbs/day and 304 lbs/day respectively, as indicated in Table 21.

State Water Plan Implementation Priority: Since Perry Lake is a federal reservoir in a large watershed and is a very important multi purpose resource for the region, this TMDL will be a High Priority for implementation.

Priority HUC 12s: The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was utilized to identify priority HUC12s within the watershed. STEPL is a simple watershed model that provides both agricultural and urban annual average sediment and nutrient simulations as well as implementation evaluation of best management practices. Preliminary STEPL results for phosphorus and nitrogen are illustrated in Figures 19 and 20. Based on the results initial priorities should focus on the top three HUC 12 subwatersheds in Table 22.

Unified Watershed Assessment Priority Ranking: The Perry Lake watershed lies with the Delaware Subbasin (HUC8: 10270103) with a priority ranking of 3 (Highest Priority for Restoration Work).

Table 22. Priority HUC 12 subwatersheds as identified through STEPL.

HUC12	Acres	TP Load (lbs/year)	TP Acre (lbs/acre/year)	TN Load (lbs/year)	TN Acre (lbs/acre/year)	Preliminary Implementation Priority Ranking
102701030308	9087.4	34725.5	3.82	128114.2	14.10	1
102701030203	32030.5	121124.6	3.78	448289.7	14.00	2
102701030205	11750.8	38978.3	3.32	149341.4	12.71	3
102701030204	30366.3	94661.9	3.12	371608.7	12.24	4
102701030201	6318.1	19321.4	3.06	76410.2	12.09	5
102701030202	21889.6	63935.4	2.92	255725.2	11.68	6
102701030101	6928.2	19888.3	2.87	78959.7	11.40	7
102701030402	18261.6	51916.3	2.84	210141.9	11.51	8
102701030104	11572.2	32895.4	2.84	129772.4	11.21	9
102701030110	18600.5	52785.3	2.84	211808.6	11.39	10
102701030501	4952.9	13148.2	2.65	54050.9	10.91	11
102701030103	6121.8	15881.3	2.59	66871.0	10.92	12
102701030408	19620.7	48212.6	2.46	203410.3	10.37	13
102701030105	29091.2	71159.1	2.45	297360.9	10.22	14
102701030102	25154.5	60481.9	2.40	253391.6	10.07	15
102701030303	27011.2	64917.1	2.40	284991.4	10.55	16
102701030407	18564.7	44040.4	2.37	186336.7	10.04	17
102701030401	8897.9	20739.4	2.33	87871.0	9.88	18
102701030109	15079.7	34904.9	2.31	152327.5	10.10	19
102701030307	15601.0	34573.1	2.22	159179.5	10.20	20
102701030404	15263.8	33570.0	2.20	150630.6	9.87	21
102701030406	4899.6	10270.6	2.10	49219.3	10.05	22
102701030106	11078.7	22894.2	2.07	108541.3	9.80	23
102701030107	22782.2	45756.4	2.01	205446.0	9.02	24
102701030405	10832.2	18828.7	1.74	93246.9	8.61	25
102701030502	7578.7	12330.8	1.63	60448.6	7.98	26
102701030505	14243.0	22449.2	1.58	104952.7	7.37	27
102701030108	28212.4	44366.6	1.57	229353.0	8.13	28
102701030403	27399.4	42966.7	1.57	224493.9	8.19	29
102701030306	15536.8	24170.6	1.56	127309.0	8.19	30
102701030302	16492.4	25268.2	1.53	136619.0	8.28	31
102701030304	41991.8	63058.1	1.50	336429.8	8.01	32

102701030301	36886.8	54251.6	1.47	301430.5	8.17	33
102701030506	24880.2	35499.7	1.43	190865.6	7.67	34
102701030305	14655.5	18381.7	1.25	112443.6	7.67	35
102701030507	35820.5	42342.6	1.18	233536.7	6.52	36
102701030503	9722.4	11205.5	1.15	56577.3	5.82	37
102701030504	16635.8	17333.1	1.04	109246.2	6.57	38
102701030508	9301.9	6979.8	0.75	42802.6	4.60	39

Figure 19. STEPL results for TP loading in the Perry Lake watershed.

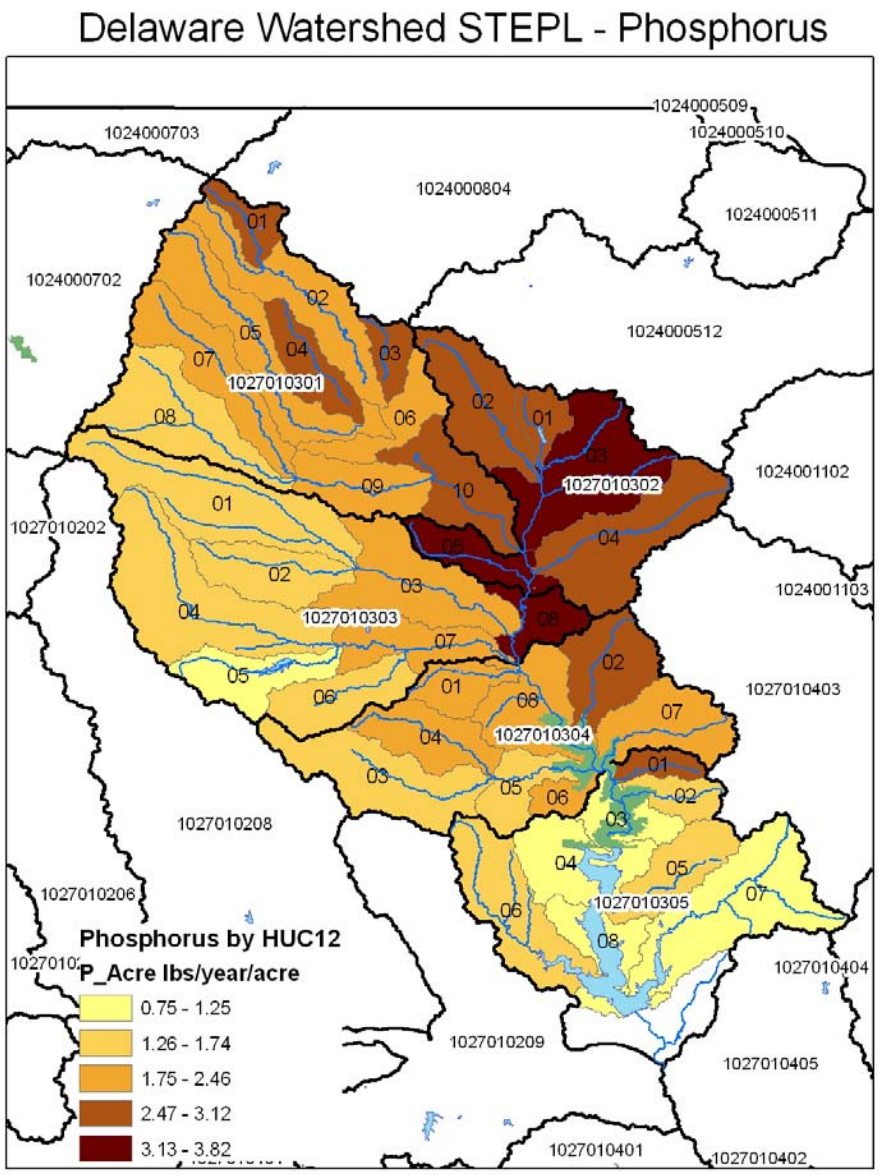
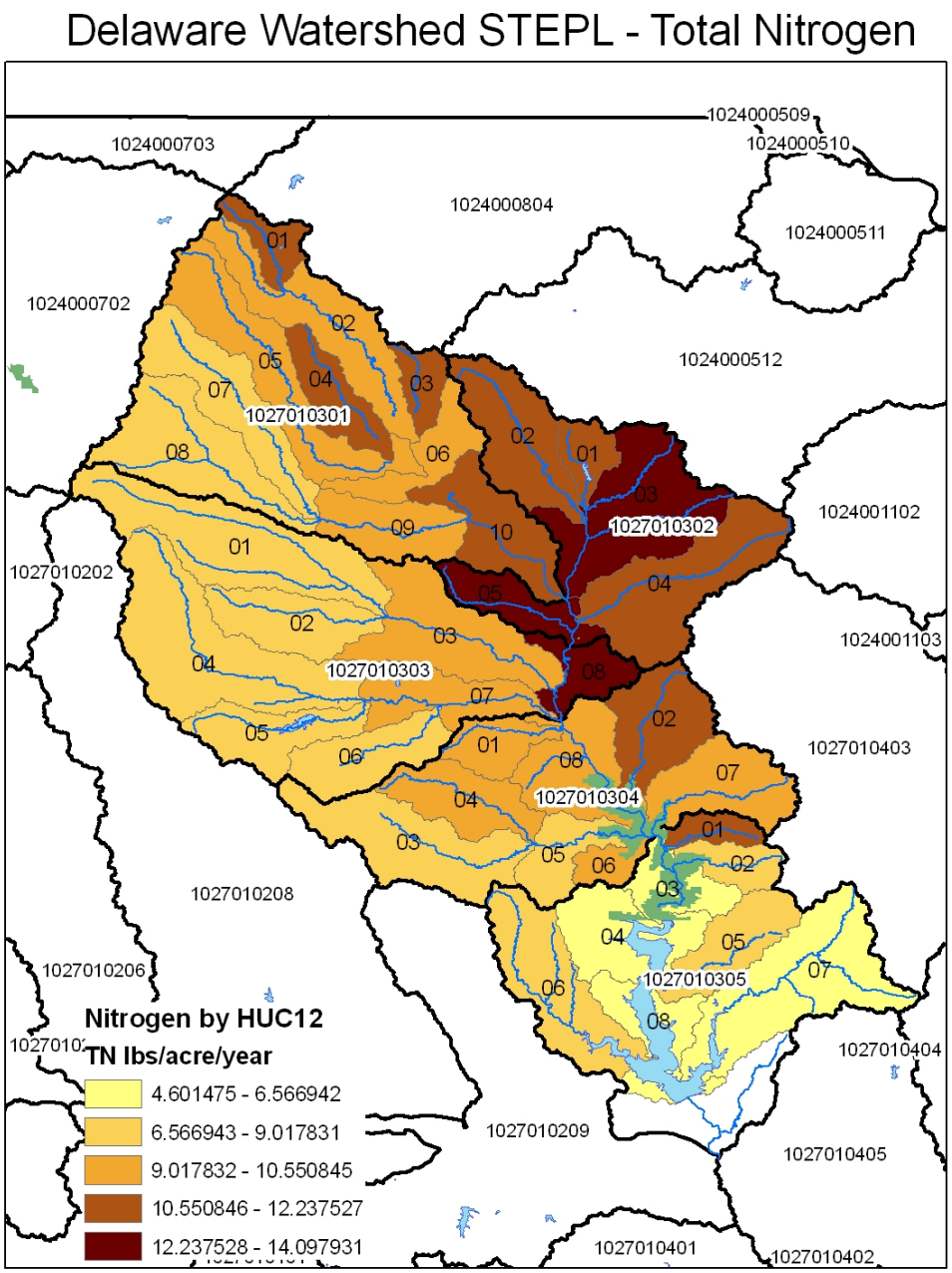


Figure 20. STEPL results for TN Loading in the Perry Lake Watershed.



5. IMPLEMENTATION

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

1. Implement soil sampling to recommend appropriate fertilizer applications on cultivated croplands to ensure excess nutrients are not being applied.
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. Install pasture management practices, including proper stock density to reduce soil erosion and storm runoff.
9. Renew state and federal permits and inspect permitted facilities for permit compliance.
10. Utilize state-supported Delaware WRAPS process to coordinate load reduction of nutrients to the lake.

Implementation Program Guidance:

NPDES-KDHE

a. Evaluate nutrient loading from all permitted dischargers in the watershed and establish applicable permit limits.
b. Work with dischargers to reduce individual loadings.
c. Work with the larger municipalities to ensure statewide nutrient reduction goals are met.
d. Inspect permitted livestock facilities to ensure compliance.
e. New Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
f. New Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
g. Manure management plans will be implemented, to include proper land application rates and practices that will prevent runoff of applied manure.

Watershed Management Program – KDHE

a. Support new and ongoing Section 319 implementation and demonstration activities conducted under the Delaware WRAPS

projects focused on Perry 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 Watershed Restoration and Protection Strategy (WRAPS) efforts for Perry Lake.
e. Incorporate the provisions of this TMDL into WRAPS documents relating to Perry Lake.
f. Provide nutrient reduction as a secondary benefit of ongoing WRAPS efforts to abate livestock loading of bacteria across the Delaware and Grasshopper watersheds.

Water Resource Cost Share and Nonpoint Pollution Control Programs – SCC

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- SCC

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 – 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 priority HUC12 subwatersheds in 2011 through the 9-element watershed plan of the WRAPS. Pollutant reduction practices and implementation activities within the priority HUC12 subwatersheds should be initiated by 2011 and continue through 2020.

Targeted Participants: The primary participants for implementation will be agricultural and livestock operations immediately adjacent to the streams within the priority subwatersheds. Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2011. The Delaware WRAPS will direct implementation activities that should target those areas with the greatest potential to influence nutrient concentrations within the Perry 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 TMDL development schedule for the State of Kansas, the year 2015 marks the next cycle of 303(d) activities in the Kansas Lower Republican Basin to review data from Perry Lake to assess improved conditions. Should the impairment 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 teams. 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.

10. K.S.A. 32-807 authorized 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 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: 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 to collect samples every 3 years from Perry Lake in order to assess the trophic state, with the next round of sampling to be conducted in 2012. Monitoring will also continue at the KDHE stream monitoring stations within the watershed to assess the nutrient load contributions from the respective monitoring stations. The Kansas City Corps of Engineers Office will continue to collect samples in Perry Lake on a monthly basis between April and October. Additionally, tracking the nutrient loads from point sources should be done to determine their contributions to the watershed and lake. Monitoring should resume at the Perry Lake Wildlife Area Wetlands in order to assess whether water quality conditions improve. Monitoring within the wetlands will be coordinated so sampling is completed in association with the collection of samples from Perry Lake every 3 years starting in 2012. The improved status of Perry Lake and the Wildlife Area Wetlands 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 of 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 WRAPS group.

Milestone Evaluation: In 2015, evaluation will be made as to the degree of implementation which has occurred within the watershed. Subsequent decisions will be

made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2015 with consultation from local stakeholders and WRAPS teams.

Consideration for 303(d) Delisting: Perry Lake will be evaluated for delisting under section 303(d), based on the monitoring data over 2011-2019. Therefore, the decision for delisting will come about in the preparation of the 2020-303(d) list. Should modifications be made to the applicable water quality criteria during the implementation period consideration for delisting, desired endpoints of this TMDL and implementation activities 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 2012-2020.

Revision January 12, 2012

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Appendix A. BATHTUB Model Summary

Case Data for Current Condition

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.1	0.2
Evaporation (m)	0.7	0.3
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	1	2ND ORDER, AVAIL P
Nitrogen Balance	1	2ND ORDER, AVAIL N
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	1	USE FOR MODEL 1 ONLY
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	Upper Pool	5	1	15.04	4	12.6	3.9	0.12	0	0	1.87	0.2	0	0	0	0	0	0
2	Rock Cr Arm	6	1	3.73	6	6.85	5.2	0.12	0	0	0.87	0.2	0	0	0	0	0	0
3	Near Dam	0	1	5.88	8	4.33	6.1	0.12	0	0	0.46	0.2	0	0	0	0	0	0
4	Little Slough Branch	3	1	4.12	5	7.55	4.6	0	0	0	0.59	0	0	0	0	0	0	0
5	Upper Mid Pool	6	1	11.69	5	6.75	4.6	0	0	0	0.9	0	0	0	0	0	0	0
6	Lower Mid Pool	3	1	6.8	7	4.14	5.7	0	0	0	0.6	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	140	0.3	1180	0.3	25.3	0.4	0.4	0.1	710	0.3	90	0.3	0	0	0	0
2	0	0	90	0.5	990	0.6	22.4	0.3	0.7	0.2	700	0.6	60	0.5	0	0	0	0
3	0	0	76	0.6	920	0.3	17.5	0.5	1.12	0.3	556	0.3	56	0.6	0	0	0	0
4	0	0	100	0	1340	0	23.37	0	0.85	0	660	0	30	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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	0.4	0	0.37	0	1.35	0	1	0	1	0	1	0	1	0	1	0
2	1	0	0.4	0	0.360494	0	1.6	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1.4	0	0.360494	0	1.06	0	1	0	1	0	1	0	1	0	1	0
4	1	0	0.35	0	0.360494	0	1.7	0	1	0	1	0	1	0	1	0	1	0
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
6	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	Delaware River	1	1	2484	400	0.1	0	0	324	1.2	1330	0.8	90	0.4	610	0.8
2	Little Slough Cr	1	1	57	19.47	0.1	0	0	105	0.5	752	0.5	20	0.9	285	0.5
3	Rock Cr	2	1	128.5	39.5	0.1	0	0	105	0.5	752	0.5	20	0.9	285	0.5
4	Slough Cr	4	1	117	42.62	0.1	0	0	105	0.5	752	0.5	20	0.9	285	0.5
5	Upper Pool Point Source	1	3	0	0.79	0	0	0	2000	0	8000	0	200	0	800	0
6	Middle Point Source	2	3	0	0.17	0	0	0	1630	0	6969	0	163	0	697	0
7	Slough Cr Point Source	4	3	0	0.19	0	0	0	2000	0	8000	0	200	0	800	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	0.400	0.45
Total Nitrogen	0.350	0.55
Chl-a Model	1.220	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	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

Current Condition, Perry Lake

Segment: 7 **Area-Wtd Mean**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	108.9	0.44	81.9%	114.7	0.32	83.4%
TOTAL N MG/M3	939.6	0.52	46.0%	1125.1	0.28	57.2%
C.NUTRIENT MG/M3	56.1	0.47	71.4%	65.5	0.30	77.6%
CHL-A MG/M3	23.0	0.41	87.7%	23.1	0.34	87.8%
SECCHI M	0.7	0.19	27.2%	0.7	0.17	25.2%
ORGANIC N MG/M3	762.4	0.31	82.4%	670.1	0.30	75.1%
TP-ORTHO-P MG/M3	62.4	0.31	78.0%	70.6	0.35	81.6%
ANTILOG PC-1	819.5	0.66	82.2%	914.4	0.22	84.3%
ANTILOG PC-2	8.4	0.18	69.4%	7.6	0.17	62.2%
(N - 150) / P	7.5	0.71	11.3%	8.8	0.28	16.8%
INORGANIC N / P	3.5	2.52	1.6%	11.3	1.16	16.5%
TURBIDITY 1/M	1.1	0.11	74.3%	1.1	0.11	74.3%
ZMIX * TURBIDITY	4.8	0.12	70.4%	4.8	0.12	70.4%
ZMIX / SECCHI	7.5	0.19	78.0%	7.9	0.11	81.0%
CHL-A * SECCHI	15.2	0.26	71.5%	14.2	0.23	67.9%
CHL-A / TOTAL P	0.2	0.49	58.6%	0.2	0.30	53.5%
FREQ(CHL-a>10) %	84.0	0.19	87.7%	84.0	0.10	87.8%
FREQ(CHL-a>20) %	46.0	0.56	87.7%	46.4	0.31	87.8%
FREQ(CHL-a>30) %	23.0	0.86	87.7%	23.3	0.51	87.8%
FREQ(CHL-a>40) %	11.7	1.10	87.7%	11.8	0.69	87.8%
FREQ(CHL-a>50) %	6.2	1.30	87.7%	6.2	0.84	87.8%
FREQ(CHL-a>60) %	3.4	1.46	87.7%	3.4	0.97	87.8%
CARLSON TSI-P	71.4	0.08	81.9%	72.1	0.04	83.4%
CARLSON TSI-CHLA	61.3	0.07	87.7%	61.3	0.04	87.8%
CARLSON TSI-SEC	66.4	0.04	72.8%	67.6	0.02	74.8%

Current Condition, Perry Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Delaware River	2484.0	400.0	1.60E+03	0.10	0.16
2	1	1	Little Slough Cr	57.0	19.5	3.79E+00	0.10	0.34
3	1	2	Rock Cr	128.5	39.5	1.56E+01	0.10	0.31
4	1	4	Slough Cr	117.0	42.6	1.82E+01	0.10	0.36
5	3	1	Upper Pool Point Source		0.8	0.00E+00	0.00	
6	3	2	Middle Point Source		0.2	0.00E+00	0.00	
7	3	4	Slough Cr Point Source		0.2	0.00E+00	0.00	
PRECIPITATION				47.3	52.0	1.08E+02	0.20	1.10
TRIBUTARY INFLOW				2786.5	501.6	1.64E+03	0.08	0.18
POINT-SOURCE INFLOW					1.2	0.00E+00	0.00	
***TOTAL INFLOW				2833.8	554.7	1.75E+03	0.08	0.20
ADVECTIVE OUTFLOW				2833.8	521.6	1.84E+03	0.08	0.18
***TOTAL OUTFLOW				2833.8	521.6	1.84E+03	0.08	0.18
***EVAPORATION					33.1	9.85E+01	0.30	

Overall Mass Balance Based Upon Component: Predicted AVAILABLE P — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Delaware River	112248.0	91.5%	6.38E+09	99.8%	0.71	280.6	45.2
2	1	1	Little Slough Cr	1426.2	1.2%	1.05E+06	0.0%	0.72	73.3	25.0
3	1	2	Rock Cr	2893.4	2.4%	4.31E+06	0.1%	0.72	73.3	22.5
4	1	4	Slough Cr	3121.9	2.5%	5.02E+06	0.1%	0.72	73.3	26.7
5	3	1	Upper Pool Point Source	826.3	0.7%	0.00E+00		0.00	1046.0	
6	3	2	Middle Point Source	144.9	0.1%	0.00E+00		0.00	852.5	
7	3	4	Slough Cr Point Source	198.7	0.2%	0.00E+00		0.00	1046.0	
PRECIPITATION				1836.1	1.5%	8.43E+05	0.0%	0.50	35.3	38.8
TRIBUTARY INFLOW				119689.5	97.5%	6.40E+09	100.0%	0.67	238.6	43.0
POINT-SOURCE INFLOW				1170.0	1.0%	0.00E+00		0.00	1017.4	
***TOTAL INFLOW				122695.5	100.0%	6.40E+09	100.0%	0.65	221.2	43.3
ADVECTIVE OUTFLOW				50815.4	41.4%	4.88E+08		0.43	97.4	17.9
***TOTAL OUTFLOW				50815.4	41.4%	4.88E+08		0.43	97.4	17.9
***RETENTION				71880.1	58.6%	3.71E+09		0.85		

Overflow Rate (m/yr)	11.0	Nutrient Resid. Time (yrs)	0.2275
Hydraulic Resid. Time (yrs)	0.4912	Turnover Ratio	4.4
Reservoir Conc (mg/m3)	109	Retention Coef.	0.586

Overall Mass Balance Based Upon Component: Predicted AVAILABLE N — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Delaware River	506640.0	80.8%	1.67E+11	99.4%	0.81	1266.6	204.0
2	1	1	Little Slough Cr	13022.1	2.1%	4.41E+07	0.0%	0.51	668.8	228.5
3	1	2	Rock Cr	26418.8	4.2%	1.81E+08	0.1%	0.51	668.8	205.6
4	1	4	Slough Cr	28505.5	4.5%	2.11E+08	0.1%	0.51	668.8	243.6
5	3	1	Upper Pool Point Source	4228.1	0.7%	0.00E+00		0.00	5352.0	
6	3	2	Middle Point Source	792.6	0.1%	0.00E+00		0.00	4662.3	
7	3	4	Slough Cr Point Source	1016.9	0.2%	0.00E+00		0.00	5352.0	
PRECIPITATION				46551.1	7.4%	5.42E+08	0.3%	0.50	895.5	985.0
TRIBUTARY INFLOW				574586.5	91.6%	1.67E+11	99.7%	0.71	1145.5	206.2
POINT-SOURCE INFLOW				6037.6	1.0%	0.00E+00		0.00	5250.0	
***TOTAL INFLOW				627175.2	100.0%	1.68E+11	100.0%	0.65	1130.6	221.3
ADVECTIVE OUTFLOW				490817.2	78.3%	7.22E+10		0.55	940.9	173.2
***TOTAL OUTFLOW				490817.2	78.3%	7.22E+10		0.55	940.9	173.2
***RETENTION				136358.0	21.7%	2.38E+10		1.13		

Overflow Rate (m/yr)	11.0	Nutrient Resid. Time (yrs)	0.3839
Hydraulic Resid. Time (yrs)	0.4912	Turnover Ratio	2.6
Reservoir Conc (mg/m3)	940	Retention Coef.	0.217

Perry Lake, TMDL BATHTUB

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.1	0.2
Evaporation (m)	0.7	0.3
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	1	2ND ORDER, AVAIL P
Nitrogen Balance	1	2ND ORDER, AVAIL N
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	1	USE FOR MODEL 1 ONLY
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

						Length Mixed Depth (m)			Hypol Depth		Internal Loads (mg/m2-day)							
		Outflow		Area	Depth						Non-Algal Turb (m^{-1})		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	Upper Pool	5	1	15.04	4	12.6	3.9	0.12	0	0	1.87	0.2	0	0	0	0	0	0
2	Rock Cr Arm	6	1	3.73	6	6.85	5.2	0.12	0	0	0.87	0.2	0	0	0	0	0	0
3	Near Dam	0	1	6.88	8	4.33	6.1	0.12	0	0	0.46	0.2	0	0	0	0	0	0
4	Little Slough Branch	3	1	4.12	5	7.55	4.6	0	0	0	0.69	0	0	0	0	0	0	0
5	Upper Mid Pool	6	1	11.69	5	6.75	4.6	0	0	0	0.9	0	0	0	0	0	0	0
6	Lower Mid Pool	3	1	6.8	7	4.14	5.7	0	0	0	0.6	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	140	0.3	1180	0.3	25.3	0.4	0.4	0.1	710	0.3	90	0.3	0	0	0	0
2	0	0	90	0.5	990	0.6	22.4	0.3	0.7	0.2	700	0.6	60	0.5	0	0	0	0
3	0	0	76	0.6	920	0.3	17.5	0.5	1.12	0.3	556	0.3	56	0.6	0	0	0	0
4	0	0	100	0	1340	0	23.37	0	0.85	0	660	0	30	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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	0.4	0	0.37	0	1.35	0	1	0	1	0	1	0	1	0	1	0
2	1	0	0.4	0	0.360494	0	1.6	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1.4	0	0.360494	0	1.06	0	1	0	1	0	1	0	1	0	1	0
4	1	0	0.35	0	0.360494	0	1.7	0	1	0	1	0	1	0	1	0	1	0
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
6	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	Mean	CV
1	Delaware River	1	1	2484	400	0.1	0	0	120	1.2	492	0.8	33	0.4	226	0.8
2	Little Slough Cr	1	1	57	19.47	0.1	0	0	39	0.5	278	0.5	7.4	0.9	105	0.5
3	Rock Cr	2	1	126.5	39.5	0.1	0	0	39	0.5	278	0.5	7.4	0.9	105	0.5
4	Slough Cr	4	1	117	42.62	0.1	0	0	39	0.5	278	0.5	7.4	0.9	105	0.5
5	Upper Pool Point Source	1	3	0	0.79	0	0	0	2000	0	8000	0	200	0	800	0
6	Middle Point Source	2	3	0	0.17	0	0	0	1630	0	6969	0	163	0	697	0
7	Slough Cr Point Source	4	3	0	0.19	0	0	0	2000	0	8000	0	200	0	800	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	0.400	0.45
Total Nitrogen	0.350	0.55
Chl-a Model	1.220	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	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

Perry Lake, TMDL BATHTUB

Segment:	7	Area-Wtd Mean				
	Predicted Values--->			Observed Values--->		
Variable	Mean	CV	Rank	Mean	CV	Rank
TOTAL P MG/M3	55.0	0.46	56.1%	114.7	0.32	83.4%
TOTAL N MG/M3	440.6	0.50	10.0%	1125.1	0.28	57.2%
C.NUTRIENT MG/M3	22.1	0.64	27.5%	65.5	0.30	77.6%
CHL-A MG/M3	9.9	0.70	52.5%	23.1	0.34	87.8%
SECCHI M	0.9	0.19	39.8%	0.7	0.17	25.2%
ORGANIC N MG/M3	463.2	0.36	48.2%	670.1	0.30	75.1%
TP-ORTHO-P MG/M3	39.1	0.35	61.0%	70.6	0.35	81.6%
ANTILOG PC-1	221.9	0.96	47.0%	914.4	0.22	84.3%
ANTILOG PC-2	6.3	0.31	48.2%	7.6	0.17	62.2%
(N - 150) / P	5.4	0.84	4.5%	8.8	0.28	16.8%
INORGANIC N / P	0.7	4.62	0.0%	11.3	1.16	16.5%
TURBIDITY 1/M	1.1	0.11	74.3%	1.1	0.11	74.3%
ZMIX * TURBIDITY	4.8	0.12	70.4%	4.8	0.12	70.4%
ZMIX / SECCHI	6.0	0.19	64.8%	7.9	0.11	81.0%
CHL-A * SECCHI	8.7	0.52	41.2%	14.2	0.23	67.9%
CHL-A / TOTAL P	0.2	0.74	47.4%	0.2	0.30	53.5%
FREQ(CHL-a>10) %	36.8	1.15	52.5%	84.0	0.10	87.8%
FREQ(CHL-a>20) %	7.5	2.14	52.5%	46.4	0.31	87.8%
FREQ(CHL-a>30) %	1.8	2.79	52.5%	23.3	0.51	87.8%
FREQ(CHL-a>40) %	0.5	3.26	52.5%	11.8	0.69	87.8%
FREQ(CHL-a>50) %	0.2	3.63	52.5%	6.2	0.84	87.8%
FREQ(CHL-a>60) %	0.1	3.94	52.5%	3.4	0.97	87.8%
CARLSON TSI-P	61.7	0.10	56.1%	72.1	0.04	83.4%
CARLSON TSI-CHLA	53.0	0.13	52.5%	61.3	0.04	87.8%
CARLSON TSI-SEC	62.9	0.04	60.2%	67.6	0.02	74.8%

Perry Lake, TMDL BATHTUB

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Delaware River	2484.0	400.0	1.60E+03	0.10	0.16
2	1	1	Little Slough Cr	57.0	19.5	3.79E+00	0.10	0.34
3	1	2	Rock Cr	128.5	39.5	1.56E+01	0.10	0.31
4	1	4	Slough Cr	117.0	42.6	1.82E+01	0.10	0.36
5	3	1	Upper Pool Point Source		0.8	0.00E+00	0.00	
6	3	2	Middle Point Source		0.2	0.00E+00	0.00	
7	3	4	Slough Cr Point Source		0.2	0.00E+00	0.00	
PRECIPITATION				47.3	52.0	1.08E+02	0.20	1.10
TRIBUTARY INFLOW				2786.5	501.6	1.64E+03	0.08	0.18
POINT-SOURCE INFLOW					1.2	0.00E+00	0.00	
***TOTAL INFLOW				2833.8	554.7	1.75E+03	0.08	0.20
ADVECTIVE OUTFLOW				2833.8	521.6	1.84E+03	0.08	0.18
***TOTAL OUTFLOW				2833.8	521.6	1.84E+03	0.08	0.18
***EVAPORATION					33.1	9.85E+01	0.30	

Overall Mass Balance Based Upon Component: AVAILABLE P — **Predicted Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Delaware River	41316.0	87.8%	8.70E+08	99.7%	0.71	103.3	16.6
2	1	1	Little Slough Cr	528.6	1.1%	1.44E+05	0.0%	0.72	27.2	9.3
3	1	2	Rock Cr	1072.5	2.3%	5.92E+05	0.1%	0.72	27.2	8.3
4	1	4	Slough Cr	1157.2	2.5%	6.89E+05	0.1%	0.72	27.2	9.9
5	3	1	Upper Pool Point Source	826.3	1.8%	0.00E+00		0.00	1046.0	
6	3	2	Middle Point Source	144.9	0.3%	0.00E+00		0.00	852.5	
7	3	4	Slough Cr Point Source	198.7	0.4%	0.00E+00		0.00	1046.0	
PRECIPITATION				1836.1	3.9%	8.43E+05	0.1%	0.50	35.3	38.8
TRIBUTARY INFLOW				44074.4	93.6%	8.71E+08	99.9%	0.67	87.9	15.8
POINT-SOURCE INFLOW				1170.0	2.5%	0.00E+00		0.00	1017.4	
***TOTAL INFLOW				47080.4	100.0%	8.72E+08	100.0%	0.63	84.9	16.6
ADVECTIVE OUTFLOW				27605.5	58.6%	1.60E+08		0.46	52.9	9.7
***TOTAL OUTFLOW				27605.5	58.6%	1.60E+08		0.46	52.9	9.7
***RETENTION				19474.9	41.4%	3.22E+08		0.92		

Overflow Rate (m/yr)	11.0	Nutrient Resid. Time (yrs)	0.2993
Hydraulic Resid. Time (yrs)	0.4912	Turnover Ratio	3.3
Reservoir Conc (mg/m3)	55	Retention Coef.	0.414

Overall Mass Balance Based Upon Component: AVAILABLE N — **Predicted Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Delaware River	187528.0	70.7%	2.29E+10	97.4%	0.81	468.8	75.5
2	1	1	Little Slough Cr	4808.5	1.8%	6.01E+06	0.0%	0.51	247.0	84.4
3	1	2	Rock Cr	9755.3	3.7%	2.47E+07	0.1%	0.51	247.0	75.9
4	1	4	Slough Cr	10525.9	4.0%	2.88E+07	0.1%	0.51	247.0	90.0
5	3	1	Upper Pool Point Source	4228.1	1.6%	0.00E+00		0.00	5352.0	
6	3	2	Middle Point Source	792.6	0.3%	0.00E+00		0.00	4662.3	
7	3	4	Slough Cr Point Source	1016.9	0.4%	0.00E+00		0.00	5352.0	
PRECIPITATION				46551.1	17.6%	5.42E+08	2.3%	0.50	895.5	985.0
TRIBUTARY INFLOW				212617.7	80.2%	2.29E+10	97.7%	0.71	423.9	76.3
POINT-SOURCE INFLOW				6037.6	2.3%	0.00E+00		0.00	5250.0	
***TOTAL INFLOW				265206.3	100.0%	2.35E+10	100.0%	0.58	478.1	93.6
ADVECTIVE OUTFLOW				234782.6	88.5%	1.51E+10		0.52	450.1	82.9
***TOTAL OUTFLOW				234782.6	88.5%	1.51E+10		0.52	450.1	82.9
***RETENTION				30423.7	11.5%	1.16E+09		1.12		

Overflow Rate (m/yr)	11.0	Nutrient Resid. Time (yrs)	0.4256
Hydraulic Resid. Time (yrs)	0.4912	Turnover Ratio	2.3
Reservoir Conc (mg/m3)	441	Retention Coef.	0.115

Daily Load Calculations for BATHTUB
Appendix B – Conversion to Daily Loads as Regulated by EPA Region VII

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

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

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

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

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

CV = Coefficient of variation = Standard Deviation / Mean

Z = 2.326 for 99th percentile probability basis

LTA= Long Term Average
MOS= Margin of Safety

Parameter	LTA	CV	$e^{[Z\sigma - 0.5\sigma^2]}$	MDL	Atmospheric	LA	WLA	MOS (10%)
Available P	103,794 lbs/yr	0.6	3.11	884 lbs/day	34 lbs/day	650 lbs/day	112 lbs/day	88 lbs/day
Available N	584,679 lbs/yr	0.3	1.90	3043 lbs/day	534 lbs/day	1907 lbs/day	298 lbs/day	304 lbs/day

Maximum Daily Load Calculation

Annual Available P Load = 103,794 lbs/yr

Maximum Daily P Load =[(103,794lbs/yr)/(365days/yr)]*$e^{[2.326*(0.555)-0.5*(0.555)^2]}$
= 884 lbs/day

Annual Available N Load = 584,679 lbs/yr

Maximum Daily N Load = [(584,679 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.294)-0.5*(0.294)^2]}$
= 3043 lbs/day

Margin of Safety (MOS) for Daily Load

Annual P MOS = 10,379 lbs/yr

Daily P MOS = [(10379 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.555)-0.5*(0.555)^2]}$
= 88 lbs/day

Annual N MOS = 58,467 lbs/yr

Daily N MOS = [(58,467 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.294)-0.5*(0.294)^2]}$
= 304 lbs/day

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

Appendix C.

NPDES Municipal Discharging Facilities in Perry Lake watershed.

Kansas Permit No.	Federal Permit No.	Facility	Type	Receiving Stream	Design Flow (MGD)	Permit Expires
M-KS11-OO01	KS0094463	Denison, City of	3-cell Lagoon	Delaware R via N. Cedar Cr	0.04	6/30/2015
M-KS18-OO01	KS0027171	Everest, City of	2-cell Lagoon	Grasshopper Cr via Mission Cr via Otter Cr via Unnamed Trib	0.03275	12/31/2015
M-KS21-OO01	KS0047449	Goff, City of	2-cell Lagoon	Spring Cr via Unnamed Trib	0.01677	6/30/2015
M-KS23-OO02	KS0094528	USD #335 WTF	3-Cell Lagoon	Straight Cr via Unnamed Trib	0.016	6/30/2015
M-KS23-OO03	KS0097951	Holton, City of	Activated Sludge/UV	Elk Cr & Banner Cr	0.66	3/31/2015
M-KS24-OO01	KS0047465	Horton, City of	Trickling Filter/UV	Delaware R via Grasshopper Cr	0.248	6/30/2015
M-KS26-OO01	KS0047473	Huron, City of	2-Cell Lagoon	Delaware R via Little Grasshoper Cr via Unnamed Trib	0.013	9/30/2011
M-KS40-OO01	KS0026182	Mayetta, City of	3-Cell Lagoon	South Cedar Cr via Unnamed Trib	0.05	9/30/2015
M-KS48-OO01	KS0085707	Muscotah, City of	3-Cell Lagoon	Delaware R	0.0248	9/30/2011
M-KS49-OO01	KS0081591	Netawaka, City of	3-Cell Lagoon	Delaware R via Straight Cr via Unnamed Trib	0.015	3/31/2015
M-KS54-OO01	KS0046442	Oskaloosa, City of	3-Cell Lagoon	Big Slough Cr	0.14	3/31/2016
M-KS56-OO03	KS0095061	Lakewood Hills Improvement Dist.	Activated Sludge/ UV	Lake Perry via unnamed Trib	0.04	10/31/2011
M-KS56-OO04	KS0093807	Jefferson County Co S.D. #7	2-Cell Lagoon	Lake Perry via Unnamed Trib	0.0197	9/30/2011
M-KS56-OO05	KS0097748	Jefferson County S.D. #2	3-Cell Lagoon	Lake Perry via unnamed Trib	0.02538	12/31/2015
M-KS56-OO06	KS0093173	Jefferson County Sewer District #6	3-Cell Lagoon	Lake Perry	0.037	3/31/2016
M-KS60-OO01	KS0081540	Powhattan, City of	3-Cell Lagoon	Delaware River via Unnamed Trib	0.012	3/31/2011
M-KS65-OO02	KS0096245	Sabetha, City of	Activated Sludge/ UV	Delaware River	0.75	9/30/2015
M-KS73-OO01	KS0022543	Valley Falls, City of	4-Cell Lagoon	Delaware River into Lake Perry	0.486	9/30/2011
M-KS78-OO02	KS0099431	Wetmore, City of	3-Cell Lagoon	Spring Cr via Unnamed Trib	0.0588	12/31/2011
M-KS81-OO01	KS0083372	Whiting, City of	3-Cell Lagoon	Kansas River via Delaware River via Unnamed Trib	0.023	3/31/2015

M-KS95-OO01	KS0092304	KDOT – Brown Co. Rest Area	2-Cell Lagoon	Delaware River via Cedar Creek	0.0015	3/31/2011
I-KS08-PO01	KS0097632	Smith Quarry #106	Pit de-watering and stormwater runoff	Banner Cr via Unnamed Trib	NA	05/31/2015
I-KS11-POOo2	KS0088951	Dix Quarry #50	Stormwater runoff	Cedar Cr via Unnamed Trib	NA	11/30/2011
I-KS23-PO01	KS0003271	Oldham's LLC	Lagoon	Banner Cr	0.279	05/31/2015
I-KS23-POO02	KS0093700	Adams Quarry #94	Pit de-watering stormwater runoff	Banner Cr via Unnamed Trib	NA	11/30/2010
I-KS23-PO03	KS0096695	Public Wholesale Water Supply Dist. #5	Lagoon	Banner Cr	0.06	09/30/2015
I-KS23-PR-01	KSG110138	Meier's Ready Mix	Concreted basin	Banner Cr via Unnamed Trib	NA	09/30/2012
I-KS24-CO01	KS0092185	Horton Municipal Power Plant	Seasonal Cooling Water	Grasshopper Cr via Lake Municipal Reservoir	NA	12/31/2012
I-KS49-PO01	KS0096059	Jackson Cnty RWD No. 3 WTP	Lagoon	Straight Cr via Unnamed Trib	.0012	09/30/2015

Individual Wasteload Allocations for NPDES Facilities

Kansas Permit No.	**Federal Permit No.**	**Facility**	**Design Flow (MGD)**	**TP WLA (lbs/day)**	**TN WLA (lbs/day)**
M-KS11-OO01	KS0094463	Denison, City of	0.04	0.67	2.67
M-KS18-OO01	KS0027171	Everest, City of	0.03275	0.55	2.19
M-KS21-OO01	KS0047449	Goff, City of	0.01677	0.28	1.12
M-KS23-OO02	KS0094528	USD #335 WTF	0.016	0.27	1.07
M-KS23-OO03	KS0097951	Holton, City of	0.66	8.27	39.70
M-KS24-OO01	KS0047465	Horton, City of	0.248	3.11	16.57
M-KS26-OO01	KS0047473	Huron, City of	0.013	0.22	0.87
M-KS40-OO01	KS0026182	Mayetta, City of	0.05	0.84	3.34
M-KS48-OO01	KS0085707	Muscotah, City of	0.0248	0.41	1.66
M-KS49-OO01	KS0081591	Netawaka, City of	0.015	0.25	1.00
M-KS54-OO01	KS0046442	Oskaloosa, City of	0.14	2.34	9.36

M-KS56-OO03	KS0095061	Lakewood Hills Improvement Dist.	0.04	0.5	2.67
M-KS56-OO04	KS0093807	Jefferson County Co S.D. #7	0.0197	0.33	1.32
M-KS56-OO05	KS0097748	Jefferson County S.D. #2	0.02538	0.22	0.64
M-KS56-OO06	KS0093173	Jefferson County Sewer District #6	0.037	0.62	2.47
M-KS60-OO01	KS0081540	Powhattan, City of	0.012	0.20	0.80
M-KS65-OO02	KS0096245	Sabetha, City of	0.75	9.4	36.65
M-KS73-OO01	KS0022543	Valley Falls, City of	0.486	8.12	32.48
M-KS78-OO02	KS0099431	Wetmore, City of	0.0588	0.98	3.93
M-KS81-OO01	KS0083372	Whiting, City of	0.023	0.38	1.54
M-KS95-OO01	KS0092304	KDOT – Brown Co. Rest Area	0.0015	0.03	0.10
I-KS08-PO01	KS0097632	Smith Quarry #106	NA	0	0
I-KS11-POOo2	KS0088951	Dix Quarry #50	NA	0	0
I-KS23-PO01	KS0003271	Oldham's LLC	0.279	3.5	9.09
I-KS23-POO02	KS0093700	Adams Quarry #94	NA	0	0
I-KS23-PO03	KS0096695	Public Wholesale Water Supply Dist. #18	0.06	1.00	4.01
I-KS23-PR-01	KSG110138	Meier's Ready Mix	NA	0	0
I-KS24-CO01	KS0092185	Horton Municipal Power Plant	NA	0	0
I-KS49-PO01	KS0096059	Jackson Cnty RWD No. 3 WTP	.0012	0.02	0.08

Appendix D. Confined Animal Feeding Operations in Perry Lake Watershed.

PER_PERMIT	FAC_COUNTY	ANI_TOTAL_	PERMIT_ANI	PERMIT_A_1
A-KSAT-B001	Atchison	80	Beef	0-299
A-KSBR-M002	Brown	70	Dairy	0-299
A-KSBR-MA05	Brown	50	Dairy	0-299
A-MOBR-S012	Brown	800	Swine	Swine0-299
A-KSBR-BA08	Brown	110	Beef	0-299
A-KSBR-BA01	Brown	250	Beef	0-299
A-KSBR-BA02	Brown	400	Beef	300-999
A-KSBR-BA06	Brown	150	Beef	0-299
A-KSJA-B004	Jackson	1330	Beef,Swine	300-999,Swine0-299
A-KSJA-MA22	Jackson	50	Dairy	0-299
A-KSJA-S020	Jackson	1800	Swine,Kennel	Swine300-999,Kennel0-999999
A-KSJA-B002	Jackson	909.4	Beef,Swine,Horses,Sheep	300-999,Swine0-299,0-299,0-299
A-KSJA-M009	Jackson	66	Dairy	0-299
A-KSJA-MA09	Jackson	80	Dairy	0-299
A-KSJA-MA08	Jackson	60	Dairy	0-299
A-KSJA-M003	Jackson	86	Dairy	0-299
A-KSJA-M011	Jackson	390	Dairy,Beef	300-999,0-299
A-KSJA-S011	Jackson	515	Swine,Beef	Swine0-299,0-299
A-KSJA-MA10	Jackson	50	Dairy	0-299
A-KSJA-MA03	Jackson	35	Dairy	0-299
A-KSJF-MA16	Jefferson	45	Dairy	0-299
A-KSJF-M011	Jefferson	602	Dairy	300-999
A-KSJF-MA05	Jefferson	90	Dairy	0-299
A-KSJF-M001	Jefferson	37	Dairy,Horses	0-299,0-299
A-KSJF-SA01	Jefferson	200	Swine	Swine0-299
A-KSJF-MA07	Jefferson	50	Dairy	0-299
A-KSJF-B003	Jefferson	305	Beef	0-299
A-KSNM-M004	Nemaha	150	Dairy	0-299
A-KSNM-C001	Nemaha	1450	Beef	1000-9999
A-KSNM-BA01	Nemaha	400	Beef	300-999
A-KSNM-S015	Nemaha	2760	Swine	Swine300-999
A-KSNM-S008	Nemaha	510	Swine,Beef,Dairy	Swine0-299,0-299,0-299
A-KSNM-S014	Nemaha	1296	Swine	Swine300-999
A-KSNM-S003	Nemaha	810	Swine	Swine0-299
A-KSJA-BA08	Jackson	400	Beef	0-299
A-KSAT-C001	Atchison	4999	Beef	1000-9999
A-KSJF-MA11	Jefferson	70	Dairy	0-299
A-KSJA-LA02	Jackson	800	Sheep	0-299
A-KSJA-S017	Jackson	215	Swine,Beef	Swine0-299,0-299
A-KSJA-S018	Jackson	980	Swine,Beef	Swine300-999,0-299
A-KSJA-S019	Jackson	724	Swine,Beef	Swine0-299,0-299
A-KSJF-B002	Jefferson	165	Beef	0-299
A-KSJF-SA04	Jefferson	790	Swine	Swine0-299
A-KSNM-S021	Nemaha	335	Swine,Beef	Swine0-299,0-299
A-KSAT-S012	Atchison	600	Swine	Swine0-299
A-KSJA-B003	Jackson	40	Beef	0-299
A-KSJA-M013	Jackson	215	Dairy	0-299
A-KSNM-S022	Nemaha	772	Swine,Beef	Swine0-299,0-299
N-KSNM-5666	Nemaha	150	Beef	0-299
A-KSBR-BA04	Brown	600	Beef	300-999
A-KSBR-BA05	Brown	100	Beef	0-299
A-KSBR-BA10	Brown	300	Beef	300-999
A-KSJF-BA03	Jefferson	270	Beef	0-299
A-KSJF-BA01	Jefferson	260	Beef	0-299
A-KSJA-BA05	Jackson	300	Beef	300-999
A-KSJA-BA07	Jackson	590	Beef	0-299
A-KSNM-BA05	Nemaha	340	Beef	300-999
A-KSJF-BA05	Jefferson	150	Beef	0-299
A-KSBR-BA03	Brown	300	Beef	300-999
A-KSAT-S013	Atchison	880	Swine,Beef	Swine0-299,0-299
A-KSBR-B002	Brown	350	Beef	300-999
A-KSBR-S025	Brown	900	Swine	Swine0-299
A-KSNM-M011	Nemaha	230	Dairy	0-299
A-KSNM-B003	Nemaha	900	Beef	300-999
A-KSNM-S023	Nemaha	1420	Swine,Beef	Swine300-999,0-299
A-KSJA-SA02	Jackson	291	Beef,Swine	0-299,Swine0-299
A-KSBR-M006	Brown	362	Dairy	300-999
A-KSNM-BA04	Nemaha	300	Beef	300-999
A-KSNM-S024	Nemaha	1760	Swine,Beef	Swine300-999,0-299
A-KSJF-BA06	Jefferson	160	Beef	0-299
A-KSJA-M016	Jackson	115	Dairy	0-299
839	Jefferson	0	Beef	0-299
A-KSJA-BA09	Jackson	500	Beef	0-299
A-KSJA-BA06	Jackson	150	Beef	0-299
A-KSJF-BA04	Jefferson	300	Beef	0-299
A-KSBR-BA09	Brown	292	Beef,Horses	0-299,0-299
A-KSNM-BA06	Nemaha	80	Beef	0-299
A-KSNM-S026	Nemaha	1200	Swine	Swine300-999
A-KSJF-BA07	Jefferson	900	Beef	300-999
A-KSNM-S031	Nemaha	1200	Swine	Swine300-999
A-KSNM-S032	Nemaha	2400	Swine	Swine300-999
A-KSNM-BA07	Nemaha	560	Beef	300-999
A-KSNM-S035	Nemaha	2400	Swine	Swine300-999
A-KSJA-M017	Jackson	18	Dairy	0-299
1062	Brown	2499	Swine	Swine300-999