

Elk City Lake Water Quality: 2008

The Elk City Lake dam is located at river mile 8.7 on the Elk River, a tributary of the Verdigris River, about six miles northwest of the city of Independence in Montgomery County, Kansas within Hydrologic Unit Code 11070104. The conservation pool of Elk City Lake was first filled in June 1967 after embankment closure in March 1966. Authorized purposes of the lake include flood damage reduction, water supply, water quality, recreation, and fish and wildlife. The watershed above the Elk City Lake dam site extends northwest ~47 miles, with headwaters in Butler and Greenwood Counties, KS. The watershed, with land use/cover dominated by pasture/range land, encompasses ~637 square miles (Figure 1). Basin elevations range from about 770 feet below the dam to ~1,675 feet. At the conservation pool elevation of 796 feet (NGVD 29), lake capacity and surface area have progressively diminished due to sedimentation. The most recent bathymetric survey conducted in 2010 indicated an annual conservation pool sedimentation rate of 340 ac-ft/yr since embankment closure reducing the original conservation pool volume by 28.8%. Descriptive characteristics of Elk City Lake are included in Table 1.

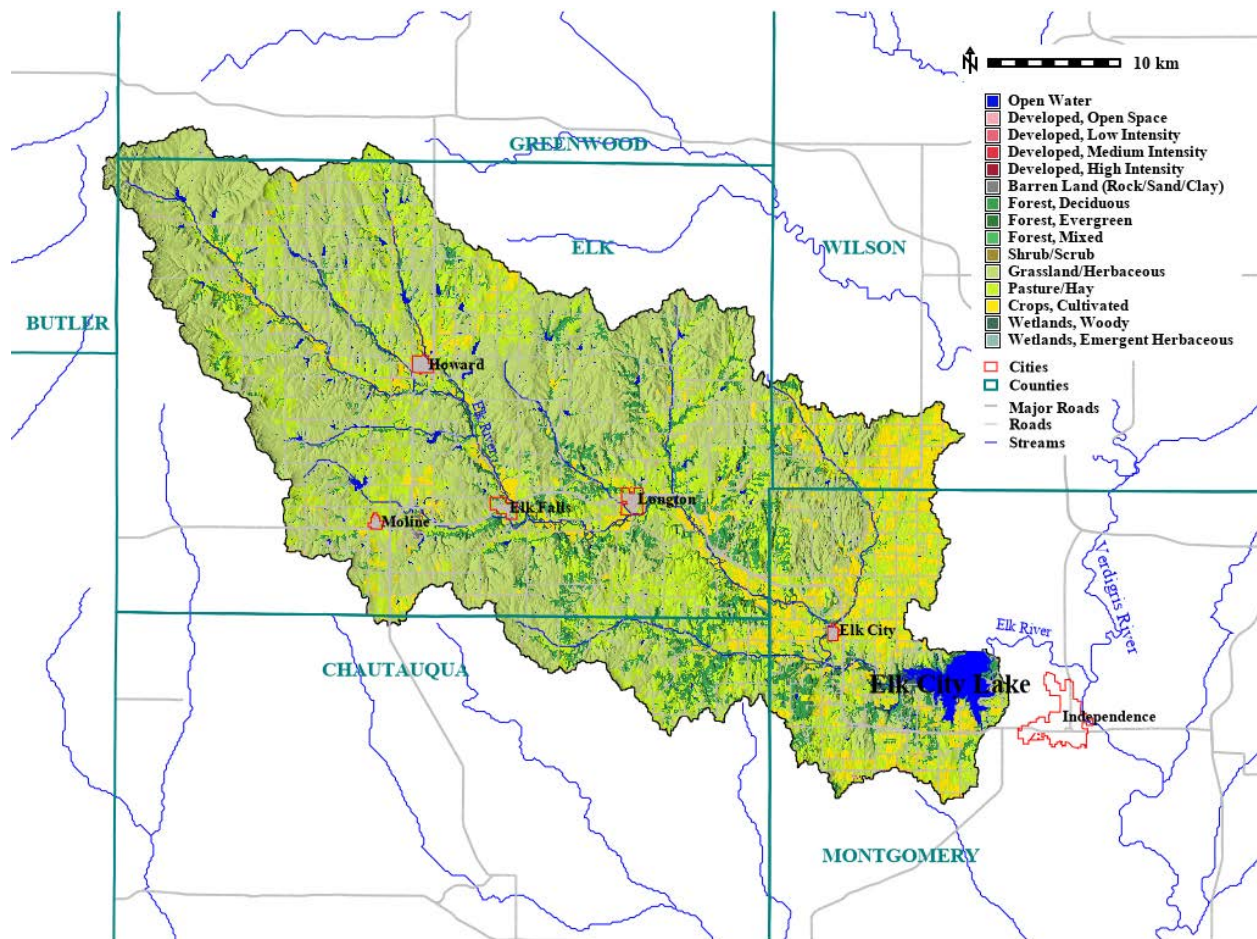


Figure 1. The Elk City Lake, KS Watershed above the Elk City Lake Dam.

Table 1. Descriptive Characteristics of Elk City Lake, KS.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	796.0 ft. NGVD	242.62 m
Lake Surface Area (Conservation Pool)	3,515 ac	1,422.47 ha
Lake Volume (Conservation Pool)	37,422 ac-ft	46,159,350 m ³
Total Drainage Area	636 mi ²	1,647 km ²
Mean Depth	10.6 ft.	3.25 m
Maximum Depth (Conservation Pool)	35 ft.	10.6 m
Shoreline Length	28 mi	45.1 km
Shoreline Development Index	5.9	5.9
Annual Inflow, Average 1922 – 2012 [Water Years]	303,000 ac-ft	373,744,995 m ³
Annual Inflow, 2008 [Calendar Year]	809,080 ac-ft	997,985,485 m ³
Hydraulic Residence Time, 2008 [Calendar Year]	30.16 d	0.08 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2012 Annual Water Control Report (U.S. ACE - SWD RCC, 2013), Tulsa District's Water Control page for Elk City Lake (U.S. ACE - Tulsa District, 2023), and the 2010 KBS Bathymetric Survey (Kansas Biological Survey, 2011).

Use designations (KDHE, 2013) for Elk City Lake include expected aquatic life (AL), secondary contact recreation (CR), domestic water supply (DS), food procurement (FP), ground water recharge (GR), industrial water supply (IW), irrigation use (IR), and livestock watering (LW). Based on the 2022 Kansas Integrated Water Quality Assessment (KDHE, 2022), Elk City Lake is listed as impaired by eutrophication affecting aquatic life, and siltation affecting water supply.

Physical and chemical water quality data were collected by USACE approximately monthly from two in-lake sites and the stilling basin at Elk City Lake, KS beginning 29-APR and ending 15-SEP-2008 to define existing limnological conditions, provide a basis for future water quality investigations, and to support operational and environmental missions of the Tulsa District. Sampled sites included ELKKSS0008 (near dam), ELKKSS0010 (mid-lake at mouth of Chetopa Creek), and ELKKSS0050 (stilling basin below the dam). In-lake sites were accessed by boat, and samples were collected from locations over the deepest portion of the stream channel (thalweg). Sampling locations are identified in Figure 2.

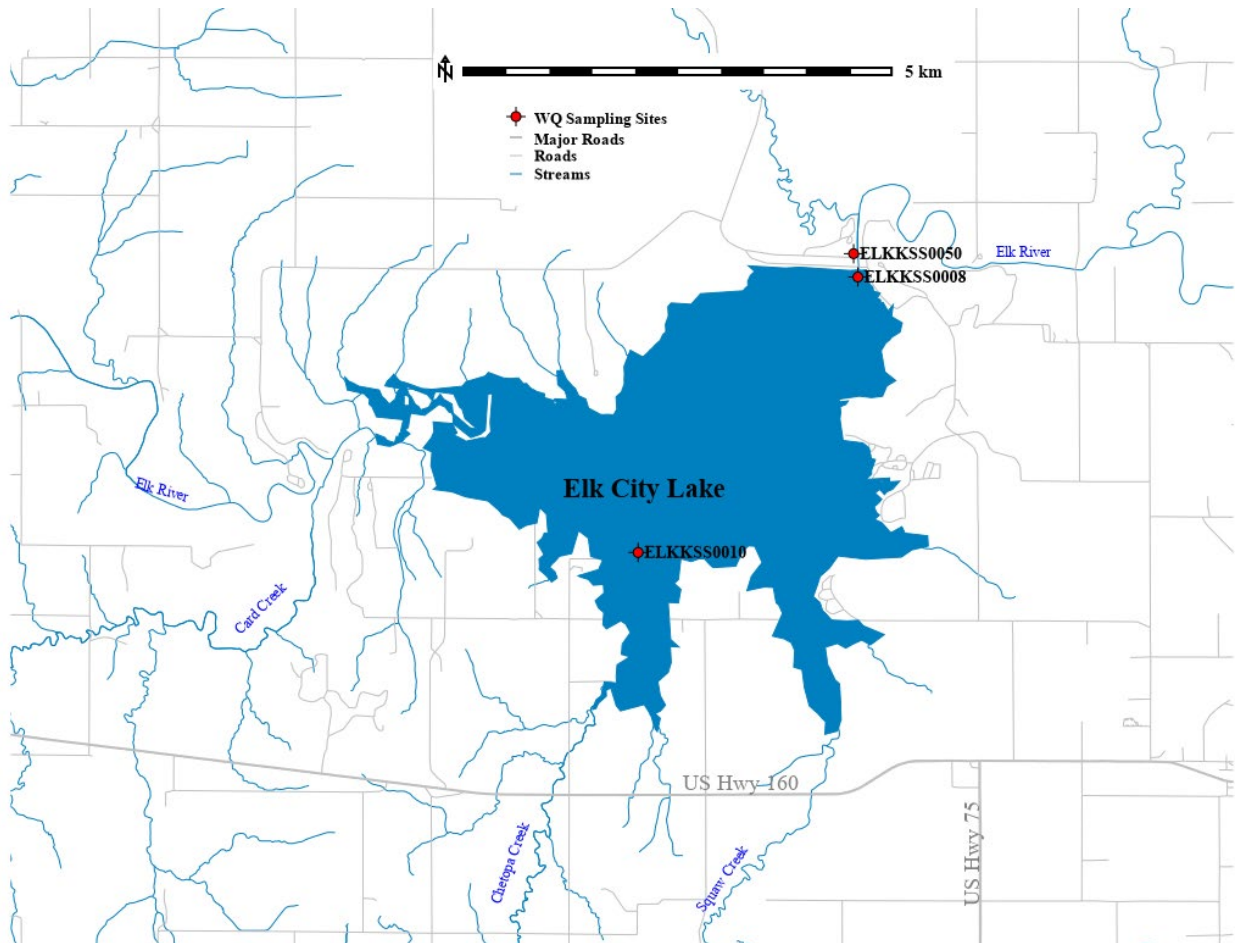


Figure 2. Locations of water quality sampling sites at Elk City Lake, KS, 2008.

Water quality in Elk City Lake, KS, during the period from April to September 2008, was influenced by high inflow events in May, June and July. Calendar year 2008 lake pool elevation, seasonal conservation pool elevation, basin precipitation, and water quality sampling dates are shown in Figure 3.

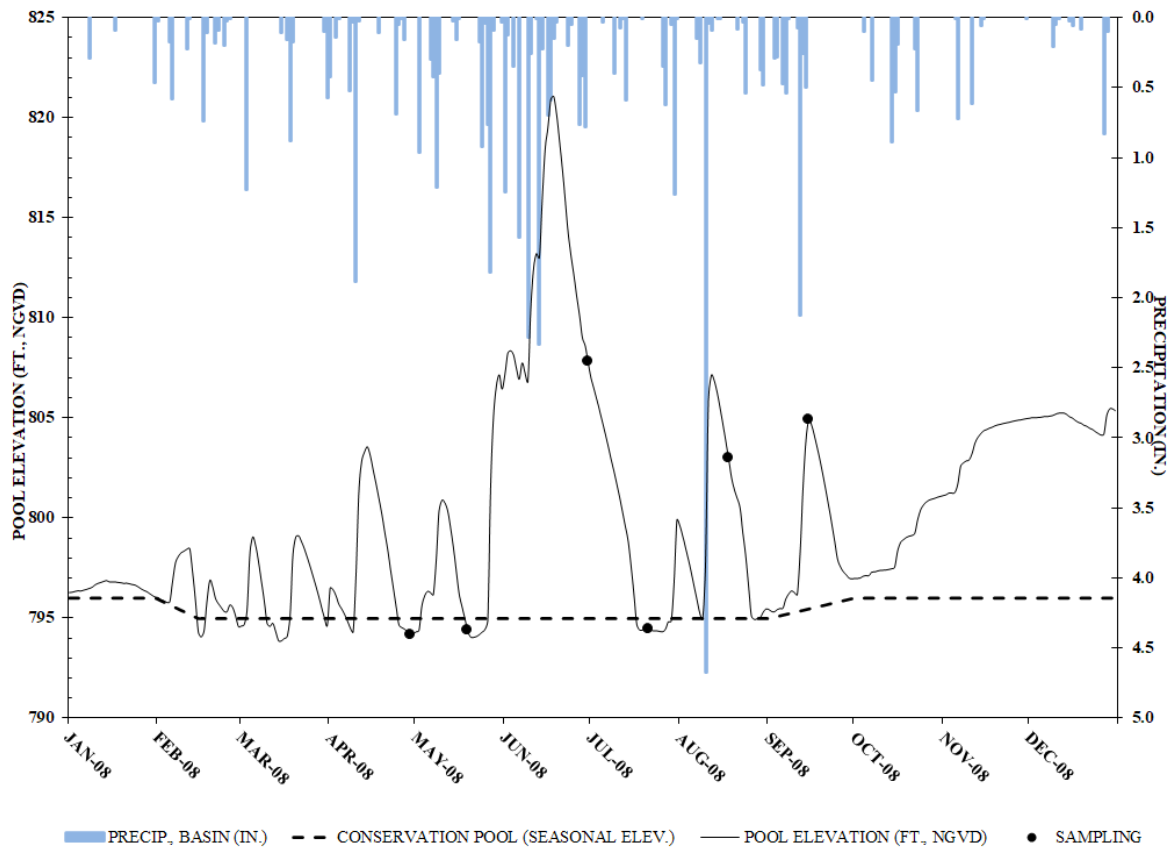


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), seasonal conservation pool elevation plan (feet), basin precipitation (in.), and water quality sampling dates at Elk City Lake, KS, 2008.

Water temperatures varied seasonally (ranging from 15.03 to 29.41 °C) peaking in July, but lake-wide water temperatures, on individual sampling dates, displayed nominal variation. The generally shallow reservoir did experience observable temporary thermal stratification in July and August 2008 after high June inflows. Observations of dissolved oxygen concentrations less than or equal to 2.0 mg/l were noted at depth at the dam site in July and August. The study period median dissolved oxygen concentration was 6.55 mg/l. Lake-wide total organic carbon concentrations were moderately high with a study period median of 5.83 mg/l.

Specific conductance (median 258 $\mu\text{S}/\text{cm}$) was moderately elevated, consistent with regional norms. Median observed chloride concentration was 4.5 mg/l. Alkalinity levels (median 105.0 mg/l as CaCO_3) imply a well-buffered system capable of maintaining pH levels. Hardness levels (median 124.0 mg/l as CaCO_3) indicated 'moderately hard' water. Observed pH (7.20 to 7.99) ranged within regional norms.

The lake was consistently turbid through the 2008 study, primarily due to suspended inorganic particles. Maximum recorded Secchi depth was 0.30 meters, and the study period median was 0.23 meters. All recorded turbidity measurements were greater than 25 NTUs (median 55.8 NTU). Total suspended solids concentrations (median 25.0 mg/l) were influenced by sediment-laden inflows during runoff events, re-suspension of bottom sediment through wind and wave action, and shoreline erosion. The euphotic zone at Elk City Lake was typically <1 meter.

Ammonia concentrations were typically low (median 0.01 mg/l), and nitrite plus nitrate concentrations were moderate (median 0.40 mg/l). Total Kjeldahl nitrogen concentrations (median 0.57 mg/l) were moderately elevated, due in part to significant and frequent inflow events carrying organic material into the lake. Estimated total nitrogen concentration through the study period was 0.95 mg/l. Total phosphorus concentrations ranged between 0.04 and 0.69 mg/l (median 0.057 mg/l) with highest observations occurring in July after a significant inflow event. Just one dissolved ortho-phosphate (median 0.023 mg/l) observation was below the analytical detection limit of 0.007 mg/l, and sampling date medians increased through the sampling period. Nitrogen to phosphorus (N:P) ratios varied through the study period, with a lake-wide study period median of 15.2, indicating a tendency toward limited phosphorus availability.

Chlorophyll-a concentrations ranged from 2.2 to 18.6 µg/l through the study period, with a median concentration of 6.9 µg/l, indicating a moderately productive system. The trophic status of Elk City Lake during the 2008 study period, assessed by Carlson's trophic state index (TSI) based on chlorophyll-a concentrations (TSI (CHLa)) results in an index value of 49.5, indicating a mesotrophic lake (Figure 4). TSI (CHLa) reflects algal productivity moderated by high levels of inorganic turbidity (SD) limiting the depth of the euphotic zone, and suspended sediment-bound growth nutrients (TP).

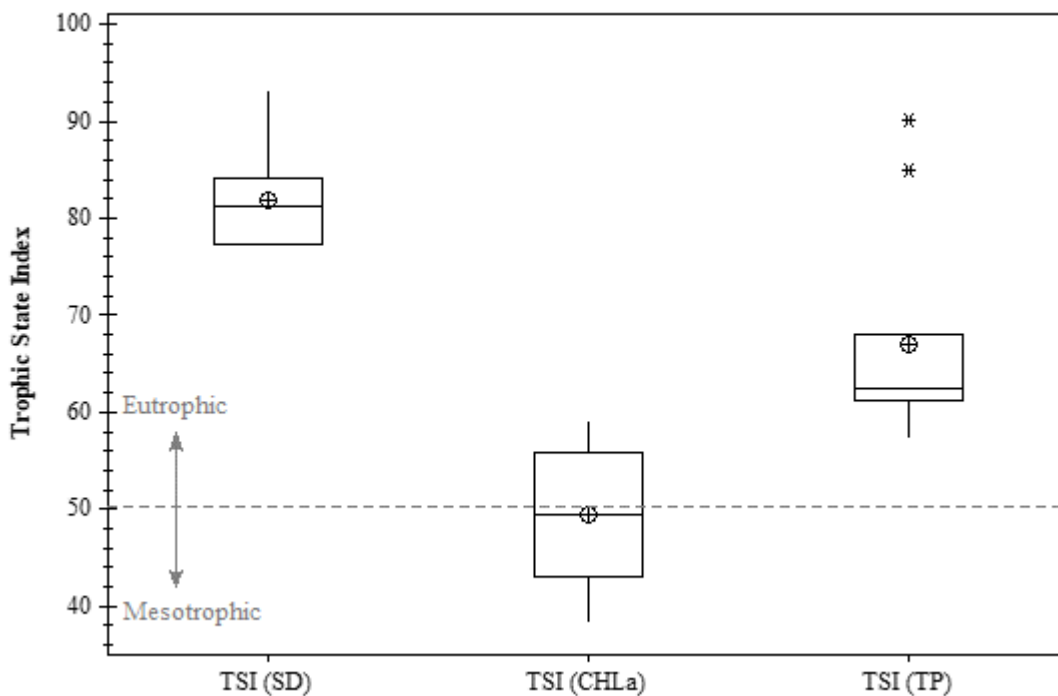


Figure 4. Distributions of Carlson's Trophic State Index (TSI) based on observations of Secchi depth (SD), chlorophyll-a concentrations (CHLa), and surface total phosphorus concentrations (TP) at Elk City Lake, 29 April through 15 September 2008.

Iron (median 0.361 mg/l) and manganese (median 0.177 mg/l) concentrations were moderately high. Two (of 16) iron concentration observations exceeded the recommended criterion (1.0 mg/l) for protection of freshwater aquatic life. Observed manganese concentrations exceeded

the recommended criterion (0.05 mg/l) for human health and consumption of water and organisms in 15 of 16 observations. Observations of priority pollutant metal (arsenic, cadmium, chromium) concentrations from water samples collected at Elk City Lake in 2008 did not exceed current acute or chronic criteria for the protection of aquatic life, agriculture, or public health. Thirteen of sixteen observations of total mercury concentration were above the analysis method detection limit of 0.01 µg/l. One mercury observation of 1.0 µg/l, a surface sample from the dam site (ELKKSS0008) on 21-JUL-2008, exceeded the State of Kansas aquatic life chronic numeric criteria (KDHE, 2004) for mercury (0.77 µg/l).

Water samples were collected each sampling trip from the stilling basin below the Elk City Lake dam at site ELKKSS0050. Generally, mean and median parameter results were directly comparable to in-lake data collected from the lake bottom near the dam (ELKKSS0008).

USACE contracted a water quality study of Elk City Lake, KS in 1980 and noted mercury concentrations occasionally exceeded U.S. EPA water quality criteria (1976). A 1992 USACE-Tulsa District study encountered brief weak thermal stratification but concluded the lake remained well mixed through the summer with only minor variation in dissolved oxygen concentrations from surface to bottom. Surface total phosphorus concentrations indicated hyper-eutrophy while chlorophyll-a concentrations indicated mesotrophy. Mercury was present in water samples and identified as a concern due to the potential for human consumption of concentrated quantities in fish tissues.