Fall River Lake Water Quality: 2012

The Fall River Lake dam is located on the Fall River, a tributary of the Verdigris River, at river mile 54.2 about 4 miles northwest of the city of Fall River in Greenwood County, Kansas within Hydrologic Unit Code 11070102. The conservation pool of Fall River Lake was first filled in June 1949 after embankment closure in August 1948. Authorized purposes of the lake include flood damage reduction, water quality, fish and wildlife, and supplemental water supply. The watershed above the Fall River dam site extends northwest ~35 miles up to the Flint Hills in Kansas and encompasses ~585 square miles (Figure 1) with basin elevations ranging from about 910 feet below the dam to ~1,667 feet. Land use/cover is dominated by grassland and pasture. At the conservation pool elevation of 948.5 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 158 ac-ft/yr since embankment closure reducing the original conservation pool volume by 31.9%. Descriptive characteristics of Fall River Lake are included in Table 1.

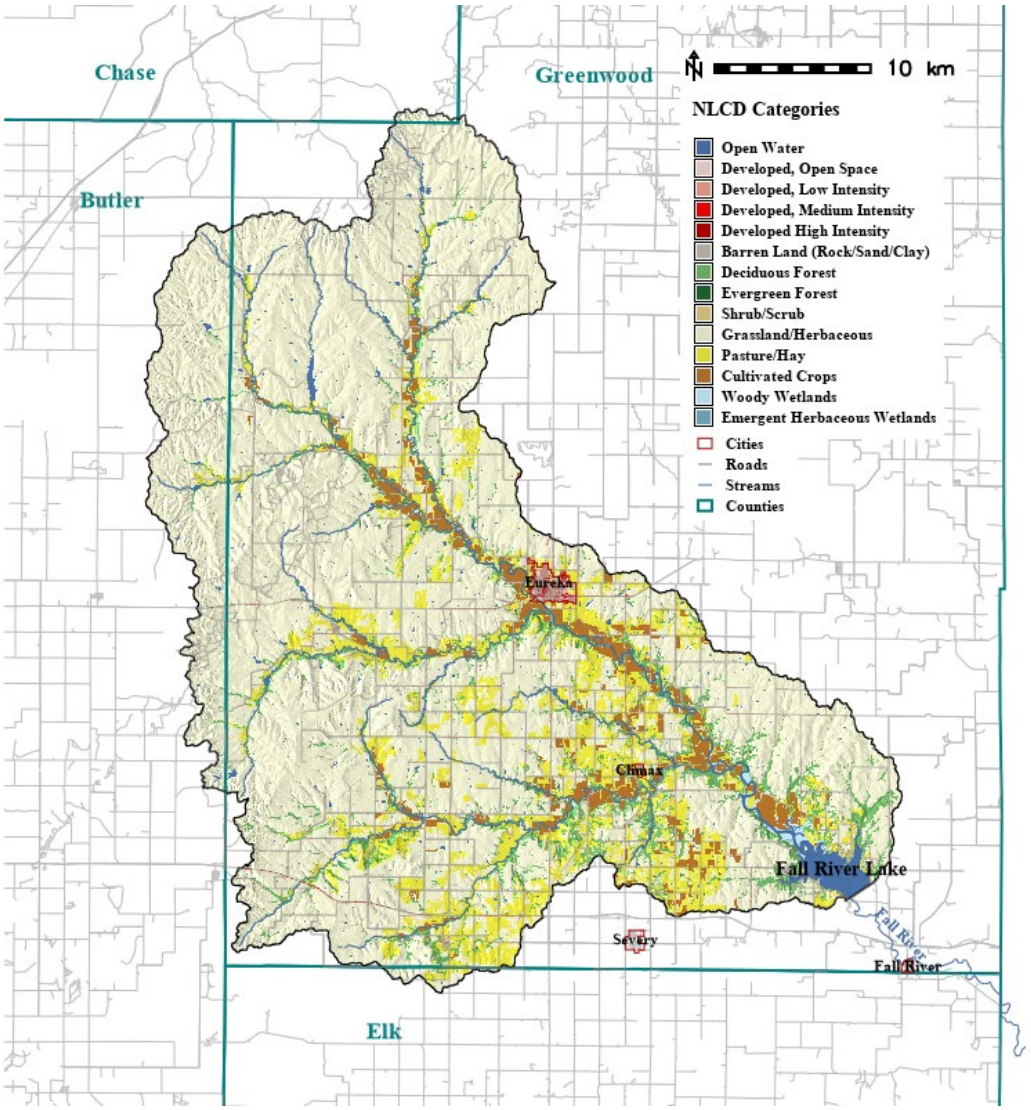

Figure 1. The Fall River Lake, KS Watershed above the Fall River Lake Dam.

Table 1. Descriptive Characteristics of Fall River Lake, KS (2012).

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	948.5 ft. NGVD	274.78 m
Lake Surface Area (Conservation Pool)	2,064 ac	894.36 ha
Lake Volume (Conservation Pool)	20,690 ac-ft	20,389,455 m^3
Total Drainage Area	585 mi^2	1,890.69 km^2
Mean Depth	10.02 ft.	3.05 m
Maximum Depth (Conservation Pool)	25.1 ft.	7.65 m
Shoreline Length	40 mi	64.4 km
Shoreline Development Index	5.9	5.9
Annual Inflow, Average 1922 – 2012 [Water Years]	254,400 ac-ft	313,797,750 m^3
Annual Inflow, 2012 [Calendar Year]	73,376.5 ac-ft	90,508,580 m^3
Hydraulic Residence Time, 2012 [Calendar Year]	106.9 d	0.29 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 Fall River Lake (U.S. ACE - Tulsa District, 2019), and the 2010 KBS Bathymetric Survey (Kansas Biological Survey, 2011).

Use designations (KDHE, 2013) for Fall River Lake include expected aquatic life (AL), primary 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), Fall River Lake is listed as impaired by epilimnetic dissolved oxygen concentrations less than 5.0 mg/l affecting aquatic life, eutrophication affecting aquatic life, and siltation affecting water supply.

Physical and chemical water quality data were collected by USACE approximately monthly from three in-lake sites and the stilling basin at Fall River Lake, KS beginning 18-APR and ending 18-SEP-2012 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 FARKSS0004 (near dam), FARKSS0005 (channel at mouth of Whitehall Bay), FARKSS0006 (channel at mouth of Rock Ridge Cove), and FARKSS0024 (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.

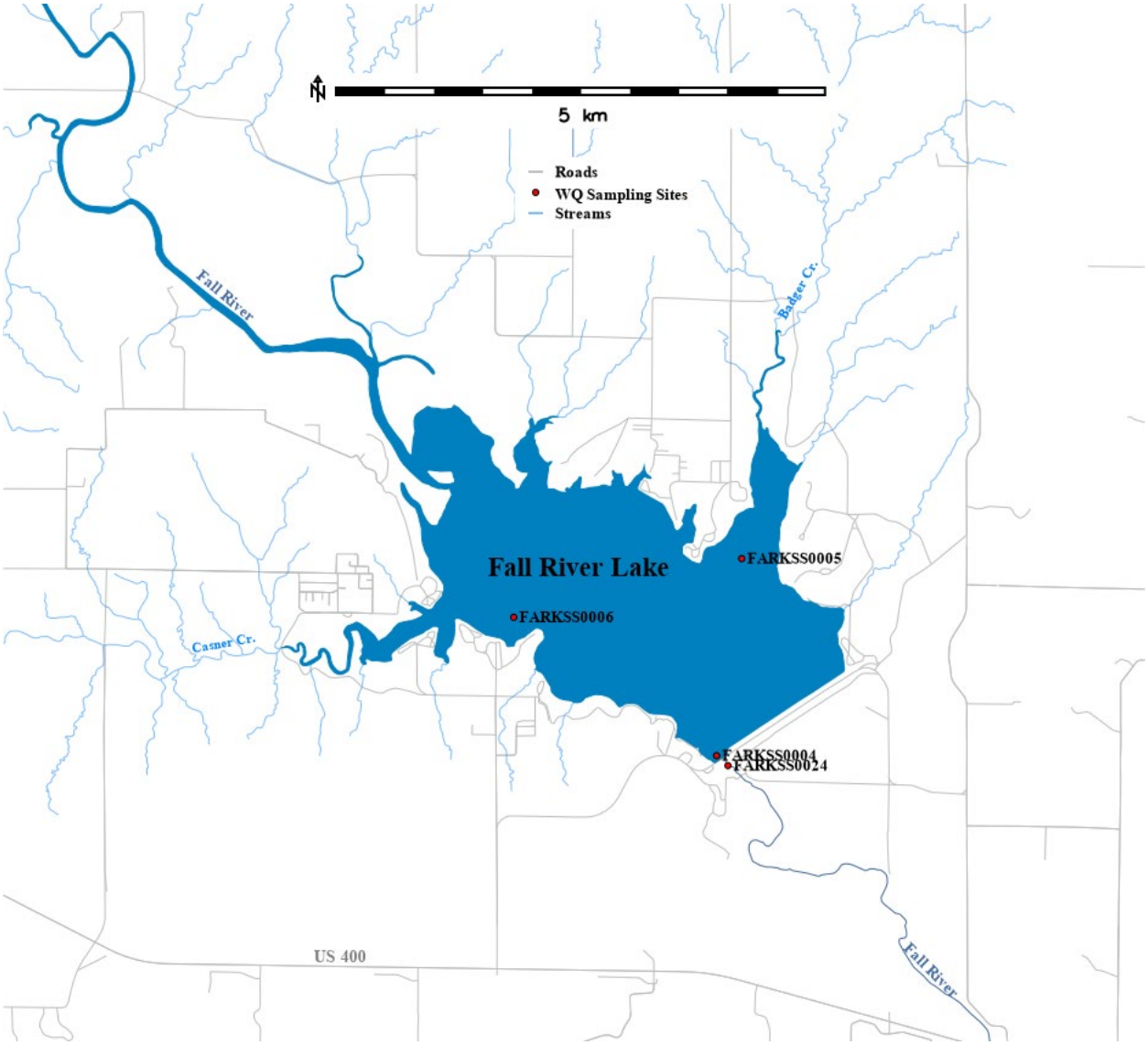

Figure 2. Locations of water quality sampling sites at Fall River Lake, KS, 2012.

Fall River Lake pool elevation was above the conservation pool elevation in April 2012, but a combination of lower than normal precipitation and higher than normal air temperatures led to a diminishing pool elevation drifting below conservation pool elevation in mid-July 2012. Calendar year 2012 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

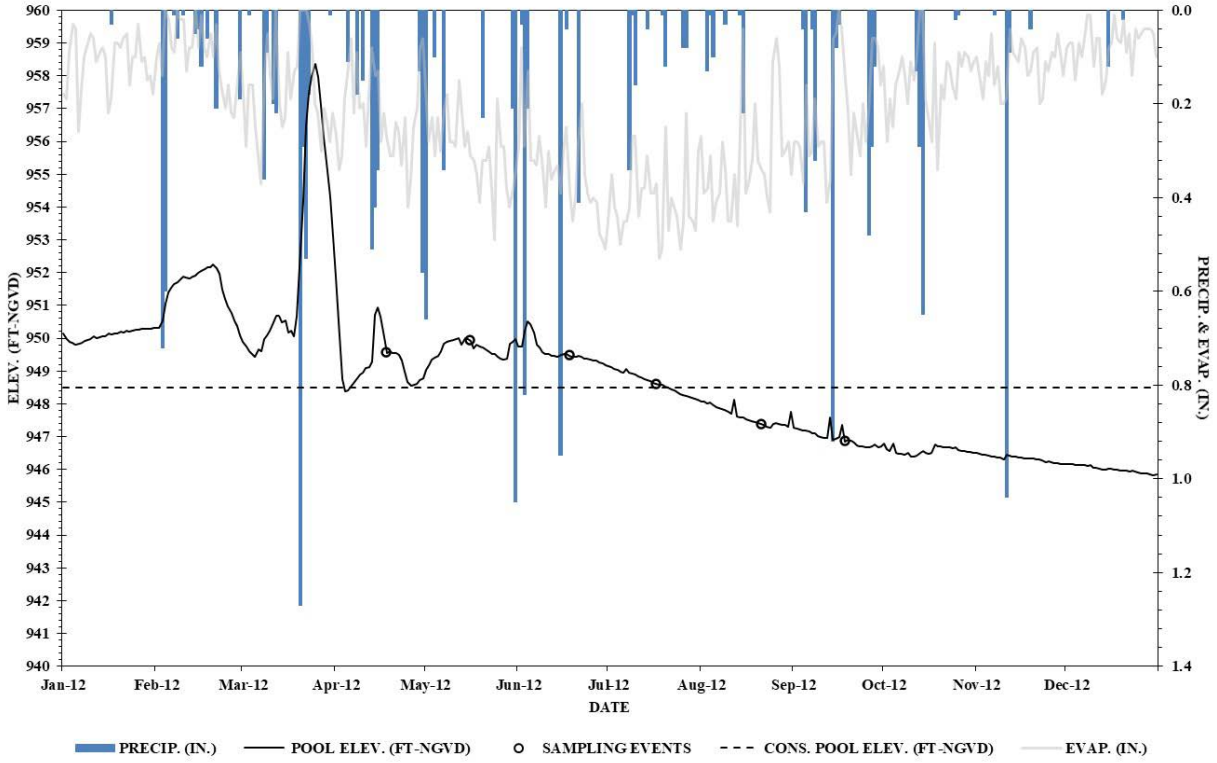

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), basin precipitation and evaporation (in.), and water quality sampling dates at Fall River Lake, KS, 2012.

Water temperatures varied seasonally (ranging from 16.9 to 27.2 ºC) peaking in July, but lake-wide water temperatures, on individual sampling dates, displayed nominal variation. The generally shallow reservoir did not experience observable thermal stratification through the 2012 study period. A single observation of dissolved oxygen concentration below 3.0 mg/l was noted at the dam site at depth in July. The study period median dissolved oxygen concentration was 7.62 mg/l. Lake-wide total organic carbon concentrations were moderately high with a study period median of 4.50 mg/l.

Specific conductance (median 379.5 µS/cm) and total dissolved solids concentration (median 245.5 mg/l) were moderately elevated, consistent with regional norms. An elevated total dissolved solids concentration was observed in August corresponding with an apparent aquatic invertebrate emergence. Moderate observed concentrations of chloride and sulfate indicate other components (minerals, cations) contributing to dissolved solids. Alkalinity levels (median 160.0 mg/l as $CaCO_3$) imply a well-buffered system capable of maintaining pH levels. Hardness levels were exclusively higher than 150 mg/l as $CaCO_3$, indicating 'hard' water. Observed pH (7.72 to 8.83) ranged within regional norms.

The lake was fairly turbid through the 2012 study primarily due to suspended inorganic particles. Maximum recorded Secchi depth was 0.67 meters, and the study period median was 0.35 meters. The majority (87%) of recorded turbidity measurements were greater than 25 NTUs. Total suspended solids concentrations (median 17.0 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 Fall River Lake was typically ≤1 meter.

Ammonia concentrations were typically low (median 0.20 mg/l), and nitrite plus nitrate concentrations were moderate to low (median 0.10 mg/l). Total Kjeldahl nitrogen concentrations (median 0.42 mg/l) were moderate with one elevated observation in April. Estimated total nitrogen concentration through the study period was 0.52 mg/l. Total phosphorus concentrations ranged between 0.037 and 2.47 mg/l (median 0.061 mg/l) with highest observations occurring in August corresponding with the aquatic invertebrate emergence. No observations of dissolved ortho-phosphate were greater than the analytical detection limit of 0.05 mg/l. Nitrogen to phosphorus (N:P) ratios varied through the study period, with a lake-wide study period median of 8.3, indicating a tendency toward limited nitrogen availability.

Chlorophyll-*a* concentrations ranged from 5.4 to 22.8 µg/l through the study period, with a median concentration of 8.7 µg/l, indicating a moderately productive system. A temporal decrease in dissolved silica concentration from April through August suggests a significant diatom component of total phytoplankton. The trophic status of Fall River Lake during the 2012 study period, assessed by Carlson's trophic state index (TSI) based on chlorophyll-*a* concentrations, with an index value of 51.5, indicates a moderately eutrophic lake (Figure 4).

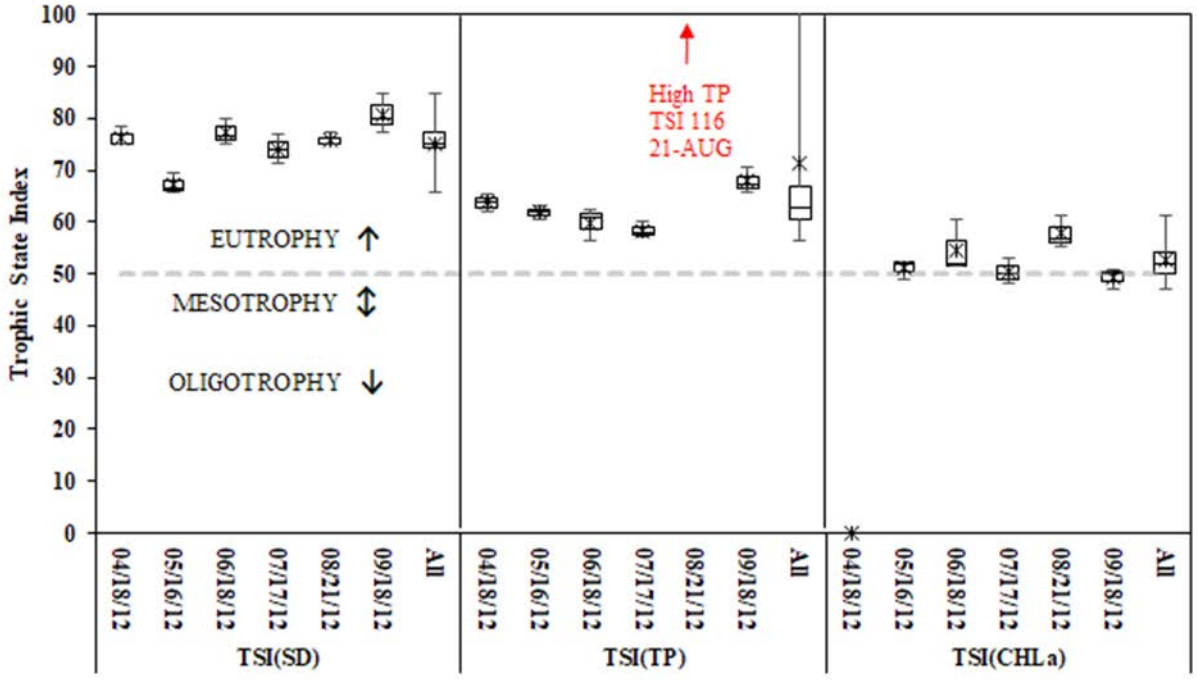

Figure 4. Distributions of Carlson's Trophic Sate Index (TSI), by sampling date and for the lake as a whole, based on observations of Secchi Depth [TSI(SD)], surface total phosphorus concentrations [TSI(TP)], and chlorophyll-*a* concentrations [TSI(CHLa)] at Fall River Lake, KS, 18-APR through 18-SEP-2012.

Iron (median 0.580 mg/l) and manganese (median 0.088 mg/l) concentrations were moderately high, although no iron concentration observations exceeded the recommended criterion (1.0 mg/l) for protection of freshwater aquatic life. Seventy-five percent of observed manganese concentrations exceeded the recommended criterion (0.05 mg/l) for human health and consumption of water and organisms. No observations of priority pollutant metal (arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury) concentrations from water samples collected at Fall River Lake in 2012 exceeded current acute or chronic criteria for the

protection of aquatic life, agriculture, or public health, although all 2012 samples collected revealed detectable concentrations of arsenic, chromium, nickel, and zinc.

Water samples were collected each sampling trip in the stilling basin below the Fall River Lake dam at site FARKSS0024. Generally, mean and median parameter results are directly comparable to in-lake data collected near the dam (FARKSS0004).

USACE conducted a water quality study of Fall River Lake, KS in 1998 and noted reduced water clarity likely limiting lake productivity. Also noted were relatively high total phosphorus concentrations, and trace metals arsenic and mercury occasionally exceeded U.S. EPA criteria for the protection of human health and aquatic life. A comparison of parameter medians between the 1998 and 2012 study periods, both field and laboratory, revealed highly similar results. Notable differences include higher median dissolved oxygen concentration in 2012; slightly lower chloride and sulfate median concentrations in 2012; lower median ammonia, total Kjeldahl nitrogen, and total phosphorus concentrations in 2012; and higher median chlorophyll-*a* concentration in 2012.