

Skiatook Lake Water Quality: 2019

The Skiatook Lake dam is located at river mile 14.3 on Hominy Creek, about five miles west of Skiatook in Osage County, Oklahoma (OK). The impoundment extends 11.5 miles northwest upstream of the dam following Hominy Creek. Skiatook Lake, within Hydrologic Unit Code 1107010702 (Hominy Creek), is a multi-purpose project for flood control, water supply, water quality, recreation, and other beneficial uses, including fish & wildlife. The project was designed and is regulated to provide maximum benefits in conjunction with other reservoirs in the Bird Creek and Verdigris River systems. Construction began in January 1974 and the conservation pool was filled in July 1989. Skiatook Lake is a component of the multi-purpose Verdigris River and Arkansas River Basin flood control and navigation system. The total drainage area above the dam is 354 square miles extending about ~35 miles northwest to the headwaters of Hominy and Little Hominy creeks. The full watershed is shown in Figure 1. Land use/cover (Dewitz, 2021) in the basin is dominated by grassland/pasture (55.3%), forest (33.9%), open water (4.8%), and developed/urban (3.2%). Based on a 2017 bathymetric survey (Bowen Engineering & Survey, Inc, 2017), at the conservation pool elevation of 714.0.0 feet (NGVD 29), lake capacity has not diminished appreciably since impoundment due to sedimentation. Descriptive characteristics of Skiatook Lake are included in Table 1.

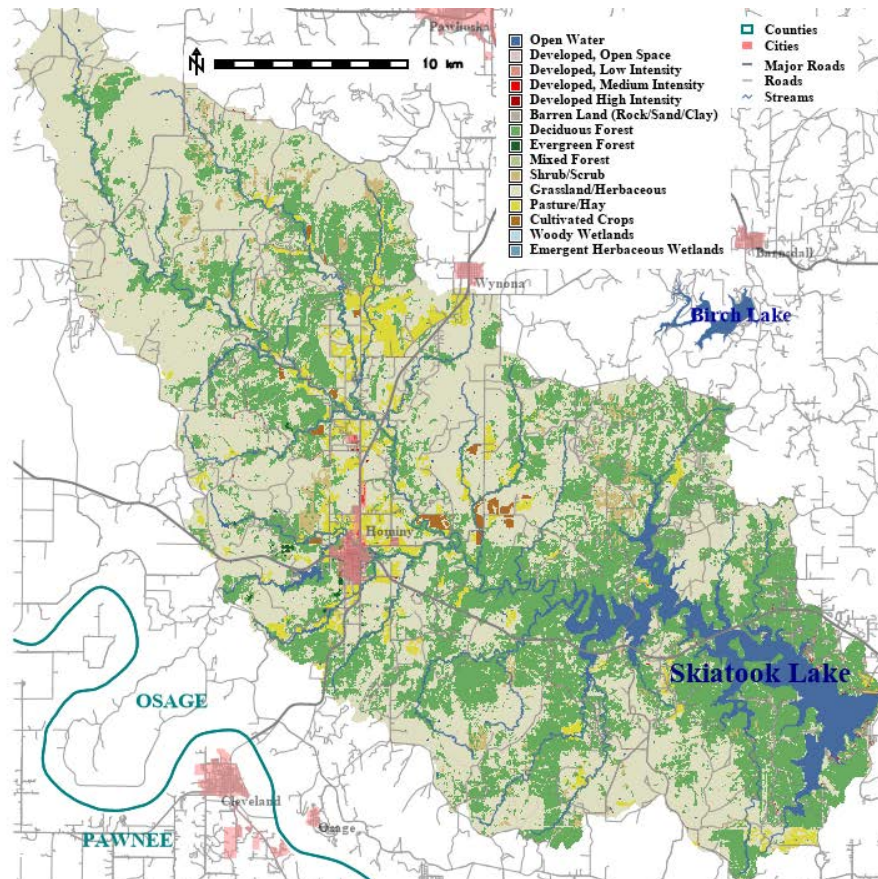


Figure 1. The Skiatook Lake (Hominy Creek) Watershed above the Skiatook Lake Dam.

Table 1. Descriptive Characteristics of Skiatook Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	714.0 ft. NGVD	217.63 m
Lake Surface Area (Conservation Pool)	10,190 ac	4,124 ha
Lake Volume (Conservation Pool)	321,407 ac-ft	396.55*10 ⁶ m ³
Total Drainage Area (contributing)	354 mi ²	916.9 km ²
Mean Depth	31.5 ft.	9.6 m
Maximum Depth (Conservation Pool)	88 ft.	26.8 m
Shoreline Length	182 mi	292.9 km
Shoreline Development Index	12.7	12.7
Annual Inflow, Average 1936 – 2019 [Water Years]	163,420 ac-ft	201.56*10 ⁶ m ³
Annual Inflow, 2019 [Calendar Year]	468,773 ac-ft	578.22*10 ⁶ m ³
Hydraulic Residence Time, 2019 [Calendar Year]	268.6 d	0.74 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2019 Annual Water Control Report (USACE - SWD - Reservoir Control Center, 2020), Tulsa District's Water Control page for Skiatook Lake (U.S. ACE - Tulsa District, 2024), and the 2017 bathymetric survey (Bowen Engineering & Survey, Inc, 2017).

Designated beneficial uses of the impoundment created by the Skiatook Lake Dam include Public and Private Water Supply, Fish and Wildlife Propagation as a Warm Water Aquatic Community, Agriculture, Primary Body Contact Recreation, and Aesthetics; and Hominy Creek upstream from and including Skiatook Lake is designated Sensitive Public and Private Water Supply (OAC, 2023). Based on the 2022 Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ 2022), Skiatook Lake is listed as impaired by mercury concentrations affecting Fish and Shellfish Consumption.

Physical and chemical water quality data were collected monthly by USACE from four in-lake sites and the tailwater beginning 2 April and ending 3 September 2019 to define existing limnological conditions, provide a basis for future water quality investigations, and to support operational and environmental missions of the Tulsa District. Water quality samples were not collected in June 2019 due to high water levels. Sampled sites included SKIOKN0218 (channel at the dam), SKIOKN0219 (near Osage Park Recreation Area), SKIOKN0220 (mouth of Bull Creek Arm), SKIOKN0221 (near Hominy Landing in Hominy Creek Arm), and SKIOKN0217 (downstream of the stilling basin). Sites SKIOKN0218, SKIOKN0219, SKIOKN0220, and SKIOKN0221 were accessed by boat from locations over the deepest portion of the stream channel (thalweg). Sampling locations are identified in Figure 2.

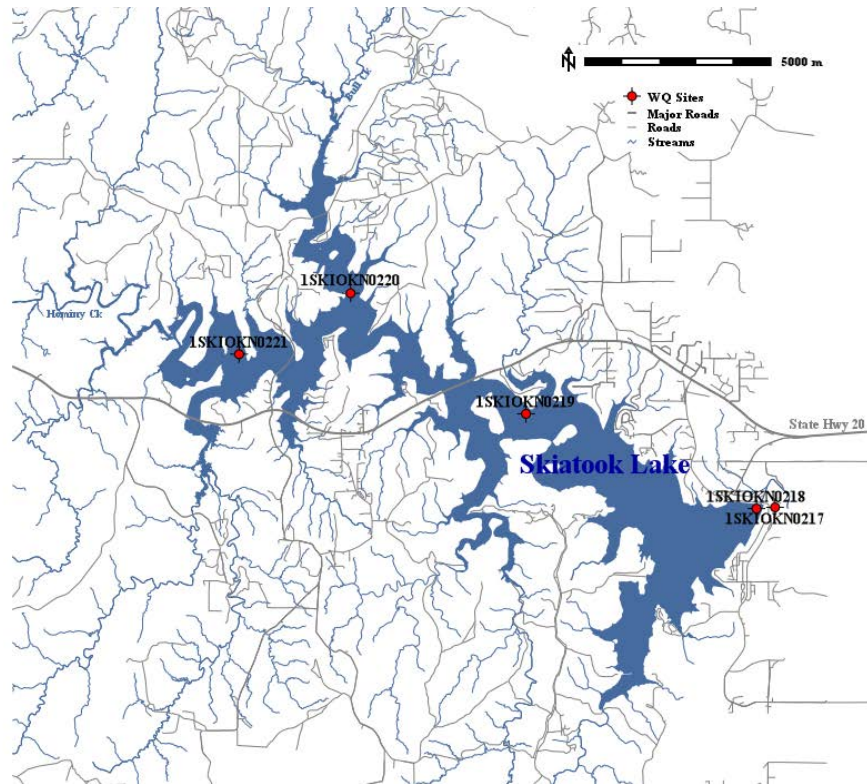


Figure 2. Locations of water quality sampling sites at Skiatook Lake, OK, 2019.

The Skiatook Lake pool was below the conservation pool elevation only in April. Basin precipitation in May brought the pool level to 731 feet near the end of the month. The August and September pool was near conservation elevation. Calendar year 2019 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3.

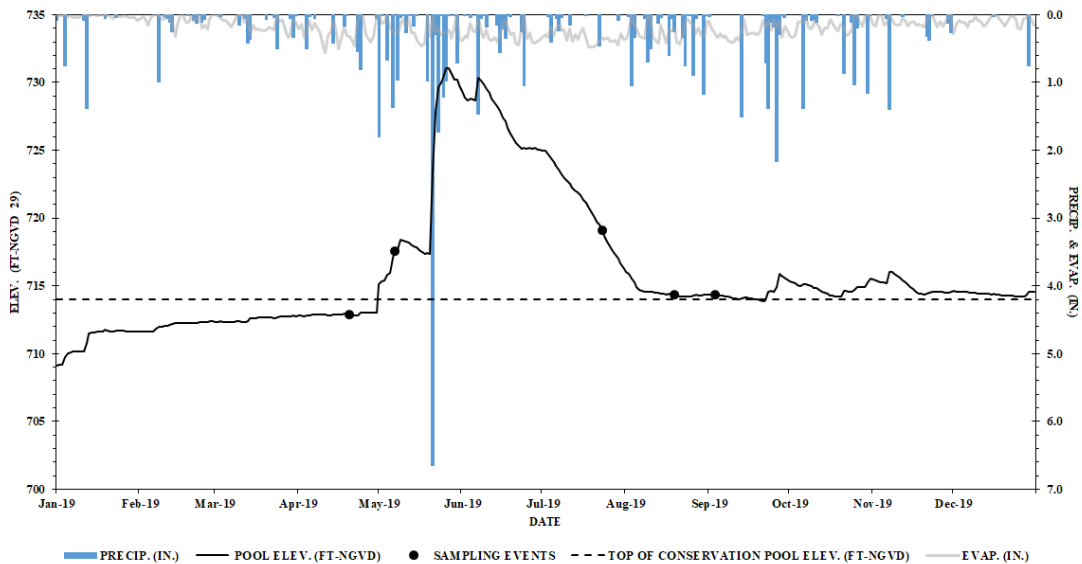


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Skiatook Lake, OK, 2019.

Water temperatures varied seasonally (ranging from 8.16 to 29.00 °C) peaking in July. Water temperature observations >28.5 °C were recorded at SKIOKN0219, SKIOKN0220, and SKIOKN0221 to at least 4-meters depth in July, and to 2-meters depth in August. All water temperature observations <10 °C occurred in April 2019 at SKIOKN0218 (surface to 19-meters depth), and at SKIOKN0219 (7- to 12-meters depth). Thermal stratification was noted in July 2019 at both SKIOKN0218 and SKIOKN0219 continuing through September, and also at SKIOKN0220 and SKIOKN0221 in July weakening by September. The study period lakewide median dissolved oxygen concentration (DO) was 6.41 mg/l. Median DO was moderately higher at the Bull Creek site (SKIOKN0220, 7.17 mg/l) and lowest at SKIOKN0221 (5.85 mg/l). Observed in-lake DO ranged from 0.00 to 12.58 mg/l. Lowest DO concentrations (<2 mg/l) were observed at all in-lake sites in July (SKIOKN0218, 8- to 24-meters depth; SKIOKN0219, 6- to 15-meters depth; SKIOKN0220, 7- to 9-meters depth; and SKIOKN0221, 9- to 11-meters depth). Hypoxia was noted at SKIOKN0218, SKIOKN0219, and SKIOKN0220 at depth in August, and SKIOKN0218 and SKIOKN0219 in September. Highest DO concentrations (>12 mg/l) were observed at SKIOKN0218 in April from the surface to 19-meters depth, and at SKIOKN0219 (surface to 1-meter depth). Total organic carbon concentrations were moderately high with a lakewide study period median of 6.07 mg/l. Observed site median total organic carbon concentrations were highest at SKIOKN0220 (6.38 mg/l) and SKIOKN0221 (7.38 mg/l).

Specific conductance, ranging from 161.0 to 260.0 $\mu\text{S}/\text{cm}$ (lakewide median 192.0 $\mu\text{S}/\text{cm}$), was moderate, consistent with regional geology. Total dissolved solids median concentration was 138.0 mg/l with site medians ranging from 134.0 (SKIOKN0218) to 169.0 (SKIOKN0220) mg/l. Lakewide chloride and sulfate concentrations (medians 17.5 and 8.2 mg/l, respectively) were moderate to low. Alkalinity levels (lakewide median 61.3 mg/l as CaCO_3) imply a weakly buffered system demonstrated by seasonal variation of pH levels. Hardness levels, lakewide median 67.5 mg/l as CaCO_3 , indicate 'soft' water. Observed in-lake pH ranged from 2.52 to 8.26 (lakewide median 7.45). Highest pH (>8.15) was recorded from the surface to 2-meters depth at SKIOKN0221 in September. Lowest pH (<6.0) was recorded in July at SKIOKN0218 and SKIOKN0219 (18- to 24-, and 11- to 15-meters depth, respectively), and SKIOKN0218 (17- and 18-meters depth) in September.

Median lakewide Secchi depth was 1.21 meters. Through the sampling period, median Secchi depth was lowest at upper lake sites (SKIOKN0220, 0.91 m and SKIOKN0221, 0.52 m) and highest at the dam site (SKIOKN0218, 2.10 m). Lakewide median turbidity was 12.4 NTUs, and 18% of all in-lake observations were greater than or equal to 25 NTUs. Median site turbidity was lower at the dam site (SKIOKN0218, 9.5 NTUs) relative to upper lake sites (SKIOKN0220, 20.6 NTUs and SKIOKN0221, 45.9 NTUs). Median lakewide total suspended solids concentration was 4.4 mg/l, with median SKIOKN0221 concentration (10.0 mg/l) higher than the SKIOKN0218 median (2.3 mg/l). The euphotic zone at Skiatook Lake site SKIOKN0218 ranged from 6.5 to 8.3 meters with greatest depths occurring in May. An approximation of euphotic zone depth at upper lake sites, based on Secchi depth, ranged from 1.5 (SKIOKN0221) to 2.7 (SKIOKN0220) meters.

Lakewide ammonia concentrations (median 0.04 mg/l) and nitrite plus nitrate concentrations (median 0.02 mg/l) were low. Highest site median ammonia concentrations were found in bottom samples at SKIOKN0219 (0.33 mg/l), and highest site median nitrite plus nitrate concentration was found at SKIOKN0221 (0.09 mg/l). Total Kjeldahl nitrogen concentrations (lakewide median 0.39 mg/l) were highest at SKIOKN0221 (median 0.49 mg/l) and lowest at SKIOKN0218 (median 0.32 mg/l). Estimated lakewide median surface total nitrogen concentration during the 2019 study was 0.39 mg/l ranging from a site median of 0.33 mg/l at SKIOKN0218 to 0.52 mg/l at SKIOKN0220. Total phosphorus concentrations lakewide ranged

between 0.03 and 0.16 mg/l (median 0.08 mg/l). Detectable concentrations of dissolved ortho-phosphate, lakewide median 0.02 mg/l, were present in 16.6% of samples collected. Nitrogen to phosphorus ratios (N:P) in 2019 were <10 (median 6.9) indicating a tendency toward limited nitrogen availability and the potential for phytoplankton dominance by cyanophytes.

Chlorophyll-a concentrations (in-lake) ranged from 2.4 to 18.3 µg/l, with a median concentration of 5.9 µg/l. Median chlorophyll-a concentrations were higher at upper lake sites (SKIOKN0220, 11.7 µg/l and SKIOKN0221, 9.7 µg/l). Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton sampled at Skiatook Lake sites. Bacillariophyte (diatoms), Cryptophyte (flagellated unicellular algae), and Cyanophyte (blue green 'algae' that are photosynthetic bacteria) abundance seasonally dominate the sampled period, varying by lake site. Relative biovolume graphics show similar representation of Bacillariophytes, Cryptophytes, Cyanophytes, and others varying by site and season.

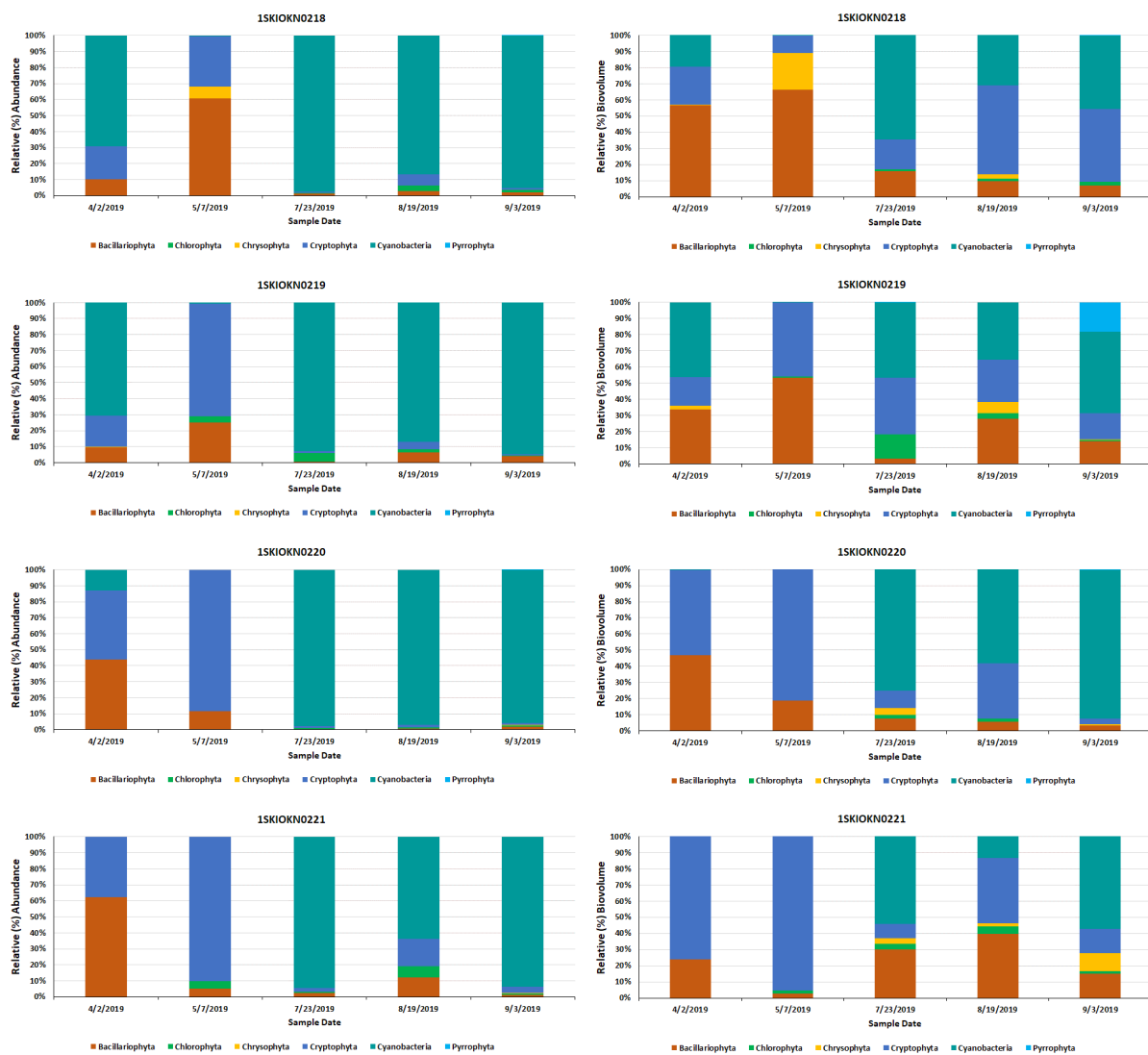


Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at SKIOKN0218, SKIOKN0219, SKIOKN0220, and SKIOKN0221 April through September 2019.

Figure 5 summarizes zooplankton densities observed in 2019 (note the log scale density axis) at SKIOKN0218, SKIOKN0219, SKIOKN0220, and SKIOKN0221. Cladocerans, Copepods, and Rotifers were generally well represented across the sampled period, while notable Bivalve densities (exclusively *Dreissena*, or zebra mussel, veligers) were found in May at SKIOKN0219 and SKIOKN0220, and August at SKIOKN0219.

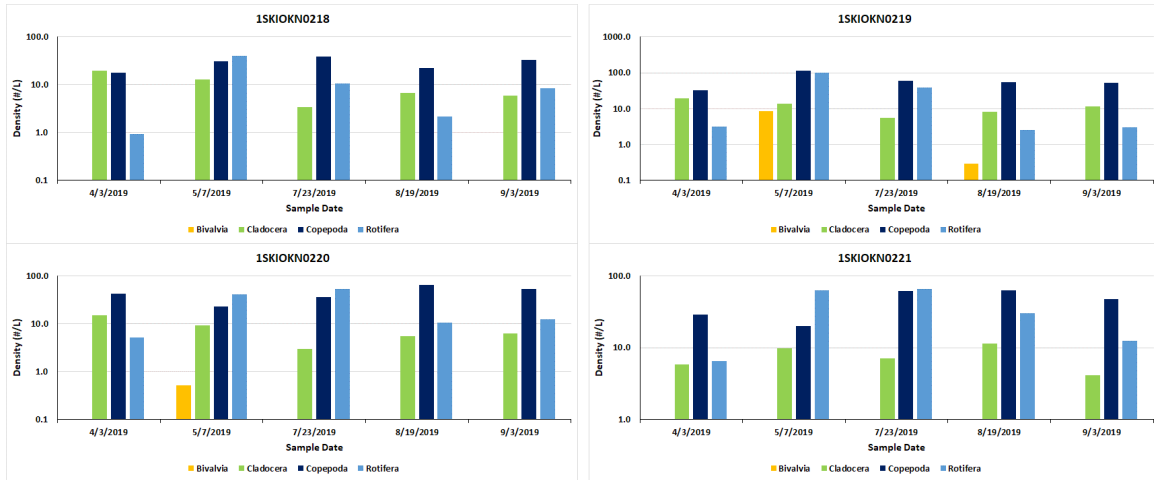


Figure 5. Zooplankton density at SKIOKN0218, SKIOKN0219, SKIOKN0220, and SKIOKN0221 April through September 2019.

Trophic status of Skiatook Lake was assessed using all three metrics of Carlson's trophic state index (TSI) at each in-lake site and the lake as a whole. Median lakewide indexes based on Secchi depth (TSI(SD), 57.3) and surface total phosphorus concentrations (TSI(TP), 61.2) indicate eutrophy, although Secchi depth was influenced by inorganic suspended matter. The median lakewide index developed from chlorophyll-a concentrations (TSI(CHLa)), 48.0.0, indicates a waterbody approaching eutrophy, especially moving up lake (Figure 6).

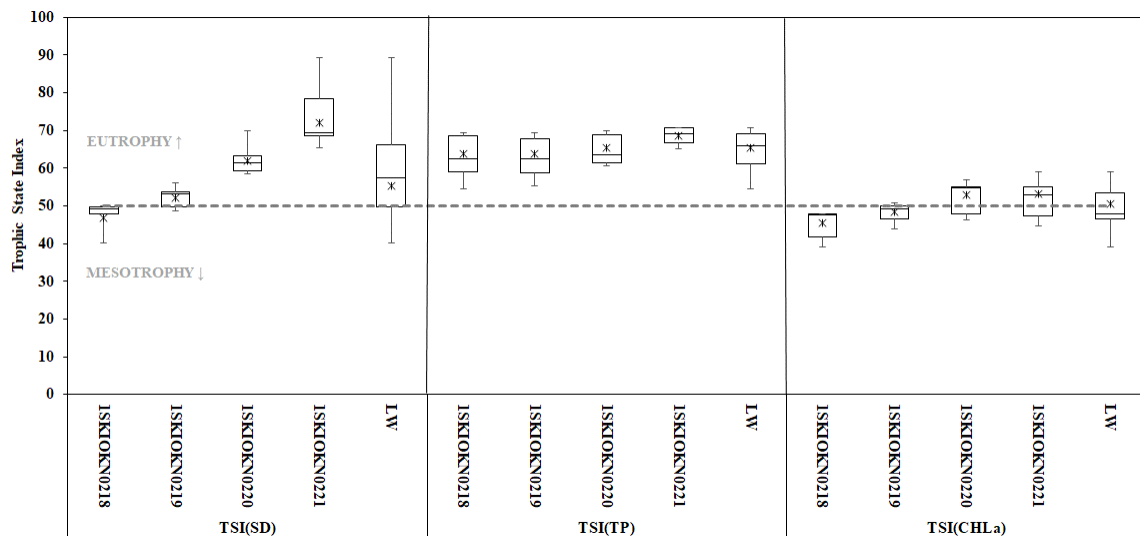


Figure 6. Distributions of Carlson's Trophic State Index (TSI), by sampling site and lakewide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-a concentrations (TSI(CHLa)) at Skiatook Lake, OK, April through September 2019.

Total iron (median 0.20 mg/l) and manganese (median 0.04 mg/l) concentrations were moderate. Maximum total iron concentrations observed were 0.82 mg/l in surface samples and 3.42 mg/l in bottom samples. Reportable concentrations of arsenic were found in all in-lake samples collected, with a median concentration of 0.0013 mg/l. Reportable concentrations of copper, nickel, and zinc were noted in all in-lake samples. Reportable concentrations of chromium and lead were present in 87 and 63%, respectively, of all samples collected. Detectable mercury concentrations were noted in 23% of samples collected. Statistical summaries of water quality parameters from the tailwater (SKIOKN0217) were comparable to data collected at depth at SKIOKN0218 with notably higher median ammonia, nitrite plus nitrate, and total phosphorus concentrations (0.11, 0.10, and 0.10 mg/l, respectively).

USACE previously conducted water quality sampling at Skiatook Lake, OK in 1994, and 2003-2004. Thermal stratification and hypolimnetic hypoxia regularly occur in summer months. Alkalinity is consistently low and median hardness was lower in 2019. Chloride and sulfate concentrations were lower in 2019. Nutrients were present in concentrations supporting a productive system. Water clarity is lower in the upper lake improving moving downstream toward the dam. Trophic classification using chlorophyll-a suggests a moderately eutrophic system with higher productivity in the upper lake. Iron and manganese concentrations are seasonally high. Arsenic is routinely present at low levels. Detectable mercury concentrations occur at similar frequencies each sampled period, often during late summer months.