

Sardis Lake Water Quality: 2022

The Sardis Lake dam is located in Pushmataha County, Oklahoma (OK) at river mile 2.8 on Jackfork Creek, a tributary of the Kiamichi River, approximately 2.5 miles north of Clayton and five miles northwest of Tuskahoma, OK. The impoundment extends west-northwest of the dam following the Jackfork Creek and North Jackfork Creek channels (~8.5 miles), northwest (~6 miles) up the Anderson Creek channel, and northeast of the dam (~6 miles) following the Buffalo Creek channel. The Anderson Creek and Buffalo Creek arms of the reservoir extend into Latimer County, OK. The lake, within Hydrologic Unit Code 11140105 (Sardis Lake), is a multi-purpose project for flood control, water supply, recreation, and fish and wildlife. Construction began in August 1975 and the conservation pool was filled in October 1984. Sardis Lake is a component of the multiple-purpose Kiamichi River system regulated for the control of floods and other beneficial uses on the Red River and its tributaries. The total drainage area above the dam is ~270 square miles. The full watershed is shown in Figure 1. Topography in the Sardis Lake drainage basin varies from rugged mountainous terrain with narrow, steep sided valleys in the upper elevations, to gently rolling terrain in flood plains at lower elevations. Land use/cover (Dewitz, 2023) in the basin is dominated by forest (~71%), grassland/pasture (~15%), and open water (8%). Based on a recent bathymetric survey (Seaworks Group, LLC, 2019), at the conservation pool elevation of 599 feet (NGVD 29), lake capacity has not diminished appreciably due to sedimentation since impoundment. Descriptive characteristics of Sardis Lake are included in Table 1.

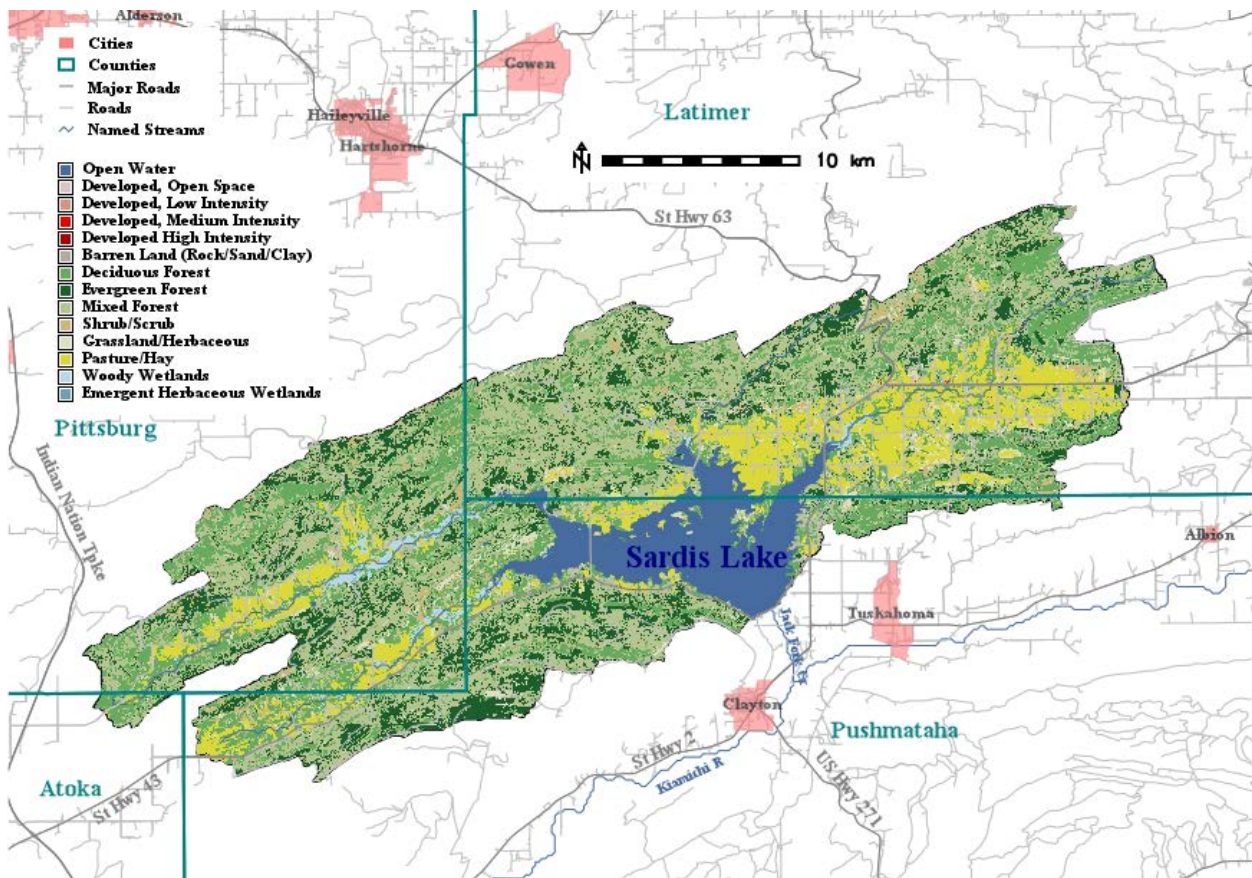


Figure 1. The Sardis Lake (Jackfork Creek) Watershed above the Sardis Lake Dam.

Table 1. Descriptive Characteristics of Sardis Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	599.0 ft. NGVD	182.58 m
Lake Surface Area (Conservation Pool)	13,610 ac	5,508 ha
Lake Volume (Conservation Pool)	274,189 ac-ft	338.21*10 ⁶ m ³
Total Drainage Area (contributing)	270 mi ²	699.3 km ²
Mean Depth	20.1 ft.	6.12 m
Maximum Depth (Conservation Pool)	62 ft.	19.0 m
Shoreline Length	99.7 mi	160.5 km
Shoreline Development Index	6.1	6.1
Annual Inflow, Average 1926 – 2022 [Water Years]	253,710 ac-ft	312.95*10 ⁶ m ³
Annual Inflow, 2022 [Calendar Year]	170,212 ac-ft	209.95*10 ⁶ m ³
Hydraulic Residence Time, 2022 [Calendar Year]	562.6 d	1.54 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2022 Annual Water Control Report (U.S. ACE - SWD RCC, 2023), Tulsa District's Water Control page for Sardis Lake (U.S. ACE - Tulsa District, 2023), and the 2019 bathymetric survey (Seaworks Group, LLC, 2019).

Designated beneficial uses of the impoundment created by the Sardis Lake Dam include Public and Private Water Supply, Fish and Wildlife Propagation as a Warm Water Aquatic Community, Agriculture, Primary Body Contact Recreation, Aesthetics, and the lake and watershed are designated as 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), Sardis Lake is listed as impaired by turbidity and pH affecting Fish and Wildlife Propagation as a Warm Water Aquatic Community, and 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 19 April and ending 20 September 2022 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 SAROKS0132 (channel at the dam), SAROKS0133 (west of Potato Hills boat ramp), SAROKS0135 (near The Narrows [N Jackfork Creek] and Sardis Cove Public Use Areas), SAROKS0136 (Anderson Creek Arm at N4290 Road bridge), and SAROKS0137 (tailwater below dam). Sites SAROKS0132, SAROKS0133, SAROKS0135, and SAROKS0136 were accessed by boat from locations over the deepest portion of the stream channel (thalweg). Vertical profiles of water temperature, dissolved oxygen, pH, and conductivity were not recorded in April. Sampling locations are identified in Figure 2.

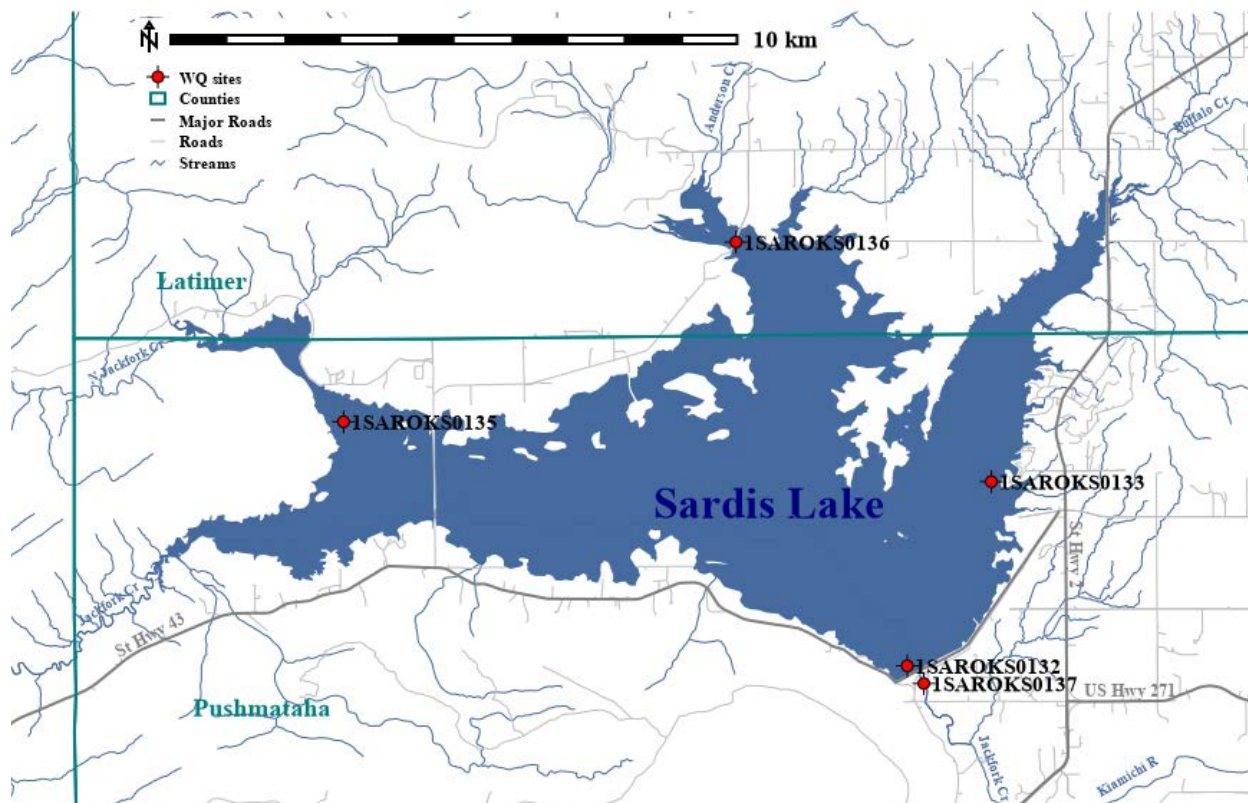


Figure 2. Locations of water quality sampling sites at Sardis Lake, OK, 2022.

The Sardis Lake pool was near the conservation pool elevation April through June, and then dropped steadily into September. Calendar year 2022 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3.

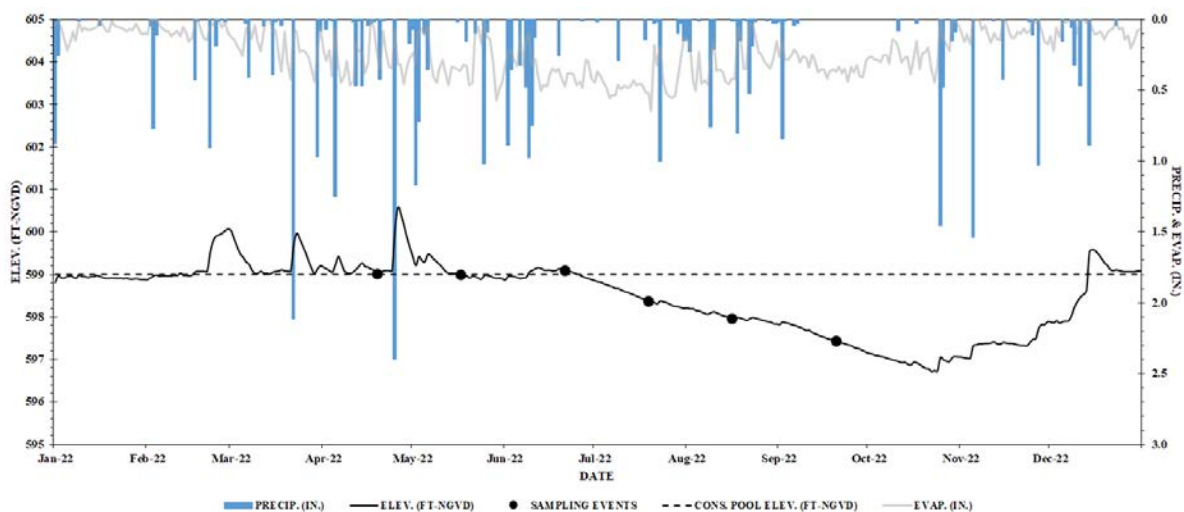


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Sardis Lake, OK, 2022.

Water temperatures varied seasonally (ranging from 19.88 to 31.39 °C) peaking in August. August surface water temperatures recorded at SAROKS0135 and SAROKS0136 were >31 °C. Water temperature observations <20 °C were recorded May 2022 at SAROKS0132 at depth (16- to 17-meters). Persistent lakewide thermal stratification was not noted, although vertical profiles at SAROKS0135 and SAROKS0136 indicated thermocline development at about 4-meters depth in May continuing through August. A weak thermocline began developing at SAROKS0132 in June also continuing through August (about 6-meters depth). The study period lakewide median dissolved oxygen concentration (DO) was 6.33 mg/l. Median DO was moderately lower at SAROKS0135 and SAROKS0136 (5.73 and 5.06 mg/l, respectively) than at SAROKS0132 and SAROKS0133 (6.35 and 6.65 mg/l, respectively). Observed in-lake DO ranged from 0.51 to 8.43 mg/l. DO concentrations ≤2 mg/l were observed at SAROKS0135 at depth in May and July, at SAROKS0136 in June and August, and at SAROKS0132 in July (beginning at 2-meters depth) and August (beginning at 11-meters depth). Highest DO concentrations (>8 mg/l) were observed at SAROKS0133 in May (surface to 4-meters depth), and June (surface to 1-meter depth). Lakewide total organic carbon concentrations were moderate with a study period median of 4.57 mg/l. Observed site median total organic carbon concentration was highest at SAROKS0135 (5.16 mg/l).

Specific conductance (lake wide median 54.0 µS/cm) was low, consistent with regional geology ranging from 40.0 to 72.0 µS/cm. Total dissolved solids median concentration was 86.0 mg/l with in-lake site medians ranging from 72.7 (SAROKS0136) to 106.5 (SAROKS0135) mg/l. Lakewide chloride and sulfate concentrations (medians 2.71 and 5.49 mg/l, respectively) were low. Alkalinity levels (median 13.5 mg/l as CaCO₃) suggest a system with limited buffering capacity to maintain pH levels. Hardness levels, lakewide median 14.8 mg/l as CaCO₃, indicate 'soft' water. Low hardness waters have a reduced ability to complex and reduce toxicity of metal contaminants. Observed in-lake pH (5.68 to 8.03) tended toward acidity with a median of 6.45. Highest pH was recorded from the surface to 2-meters depth at SAROKS0133 in August. Recorded pH <6 was noted at SAROKS0132 from the surface to 16-meters depth in July, and from 10-meters depth and below in August 2022.

Median lakewide Secchi depth was 0.47 meters. Through the sampling period, median Secchi depth was lowest at SAROKS0135 (0.33 m) and highest at SAROKS0132 (0.51 m). Lakewide median turbidity was 52.6 NTUs, and all (100%) in-lake observations were greater than or equal to 25 NTUs. Median lakewide total suspended solids concentration was 7.5 mg/l, with the highest site median concentration at SAROKS0135 (18.5 mg/l). Lakewide, total suspended solids concentrations were higher in bottom samples (median 15.0 mg/l) relative to surface samples (median 6.0 mg/l). The euphotic zone at Sardis Lake site SAROKS0132 ranged from 1.6 to 3.1 meters with greatest depths in June and July.

Lakewide ammonia concentrations (median 0.02 mg/l) and nitrite plus nitrate concentrations (median 0.06 mg/l) were low. Total Kjeldahl nitrogen concentrations (lakewide median 0.43 mg/l) were comparable in all lake areas. Estimated lakewide median surface total nitrogen concentration during the 2022 study was 0.43 mg/l. Total phosphorus concentrations lakewide ranged between 0.01 and 0.08 mg/l (median 0.02 mg/l). Detectable concentrations of dissolved ortho-phosphate, lakewide median 0.02 mg/l, were present in 19% of samples collected. Nitrogen to phosphorus ratios (N:P) in 2022 were near 20 (median 17.7) indicating a tendency toward phosphorus limitation of potential phytoplankton growth.

Chlorophyll-a concentrations (in-lake) ranged from 3.9 to 16.2 µg/l, with a median concentration of 8.2 µg/l. Median site chlorophyll-a concentrations were highest at SAROKS0133 (9.2 µg/l) and SAROKS0135 (9.6 µg/l). Figure 4, below, summarizes relative abundance and biovolume

of divisions of phytoplankton sampled at select Sardis Lake sites. Cyanophyte (blue green 'algae' that are photosynthetic bacteria) abundance dominated the latter half of the sampled period (July to September), while biovolume shows a varying seasonal representation of an array of phytoplankton divisions influenced by site-specific water quality. Figure 5 summarizes zooplankton densities observed in 2022 (note the log scale density axis) at SAROKS0132, SAROKS0136, and SAROKS0135. Cladocerans, Copepods, and Rotifers were generally well represented across the sampling period.

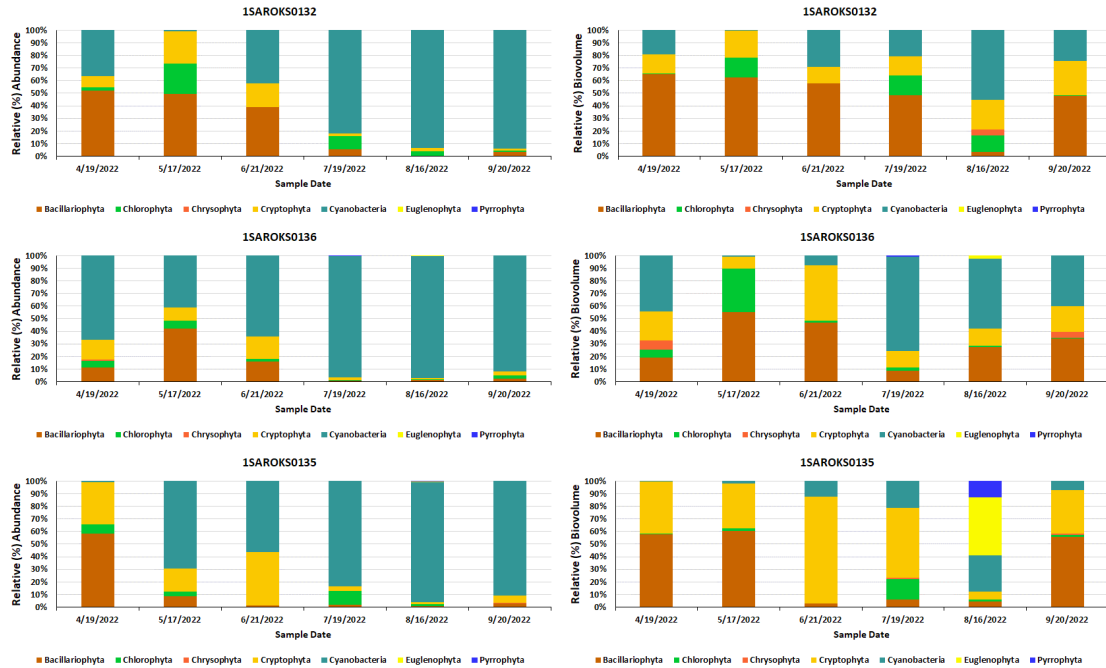


Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at SAROKS0132, SAROKS0136, and SAROKS0135 April through September 2022.

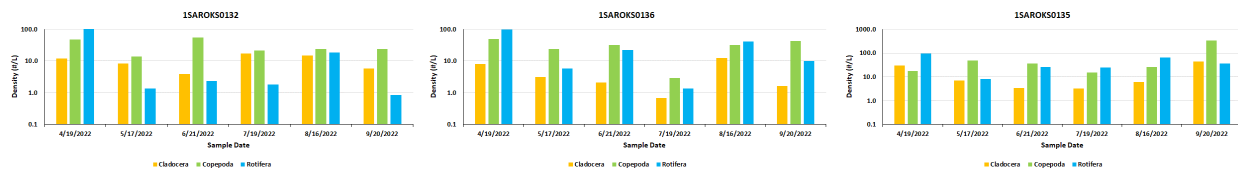


Figure 5. Zooplankton density at SAROKS0132, SAROKS0136, and SAROKS0135 April through September 2022.

Trophic status of Sardis 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. The median lakewide index based on Secchi depth (TSI(SD)), 70.9 reflects the generally turbid conditions encountered, although turbidity at Sardis Lake was primarily the result of suspended inorganic particles rather than algae. Median indexes based on surface total phosphorus (TSI(TP)) and chlorophyll-a concentrations (TSI(CHLa)) were comparable (48.1 and 51.2, respectively), and indicate low level eutrophy at Sardis Lake (Figure 6).

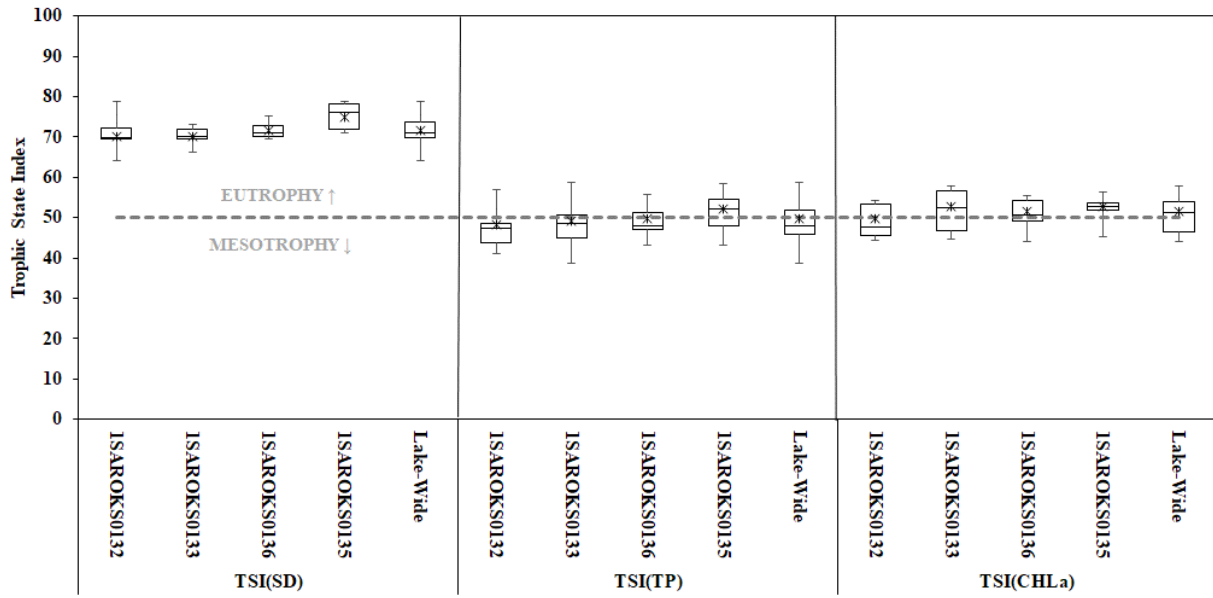


Figure 6. Distributions of Carlson's Trophic State Index (TSI), by sampling site and lakewide, based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-a concentrations (TSI(CHL a)) at Sardis Lake, OK, April through September 2022.

Total iron (median 0.91 mg/l) and manganese (median 0.03 mg/l) concentrations were high and moderate, respectively. Reportable low concentrations of arsenic were found in all in-lake samples collected, with a median concentration of 0.0008 mg/l. Reportable concentrations of chromium, copper, lead, nickel, and zinc were noted in all in-lake samples. Detectable mercury concentrations were noted in 6% of samples collected. Results of water quality parameters from the tailwater (SAROKS0137) were comparable to bottom samples collected at SAROKS0132.

USACE previously conducted water quality sampling at Sardis Lake, OK in 1993 and 2011. Hydraulic residence time was 1.04 years in 1993 and 1.3 years in 2011. Prior efforts noted ephemeral thermal stratification, hypoxia at depth in summer months, and similar low alkalinity, pH, and hardness. Iron and manganese concentrations were at least seasonally high. The 1993 effort noted detectable mercury concentrations in both surface and bottom samples. The 2011 study noted a detectable concentration of lead in just one of twenty-six samples.