## Hugo Lake Water Quality Summary

The Hugo Lake Dam is located at mile 17.6 on the Kiamichi River, approximately 7 miles east of Hugo in Choctaw County, Oklahoma (OK). The reservoir extends almost 10 miles north-northwest of the dam following the channel of the Kiamichi River. Hugo Lake is a multiple-purpose project for flood control, water supply, water quality, recreation, and fish and wildlife conservation. Hugo Lake is a unit of a multiple-purpose system regulating floods, generating hydropower, and supporting navigation and other beneficial water uses on the Red River and its tributaries. The lake and watershed are within Hydrologic Unit Code 11140115 (Kiamichi). Construction began in September 1968, final storage began in January 1974, and the conservation pool was filled in March 1974. The watershed above the Hugo Lake Dam encompasses 1,709 square miles including the 275 square mile Sardis Lake watershed. The uncontrolled drainage area is 1,434 square miles, extending north through Pushmataha County, into Latimer County, and then east through Le Flore County (OK) edging across the OK State border into Polk County, Arkansas (Figure 1). Elevations range from 2,666 feet in the headwaters to 370 feet near the dam. Land use/cover (Dewitz, 2023) in the watershed is dominated by forest (66.9%) and pasture/grassland (21.2%). A 2015 hydrographic survey (Bowen Engineering & Surveying. Inc., 2015) suggests pool capacity at 404.5 feet NGVD has diminished ~9.1% since impoundment due to sedimentation. Descriptive characteristics of Hugo Lake are included in Table 1.

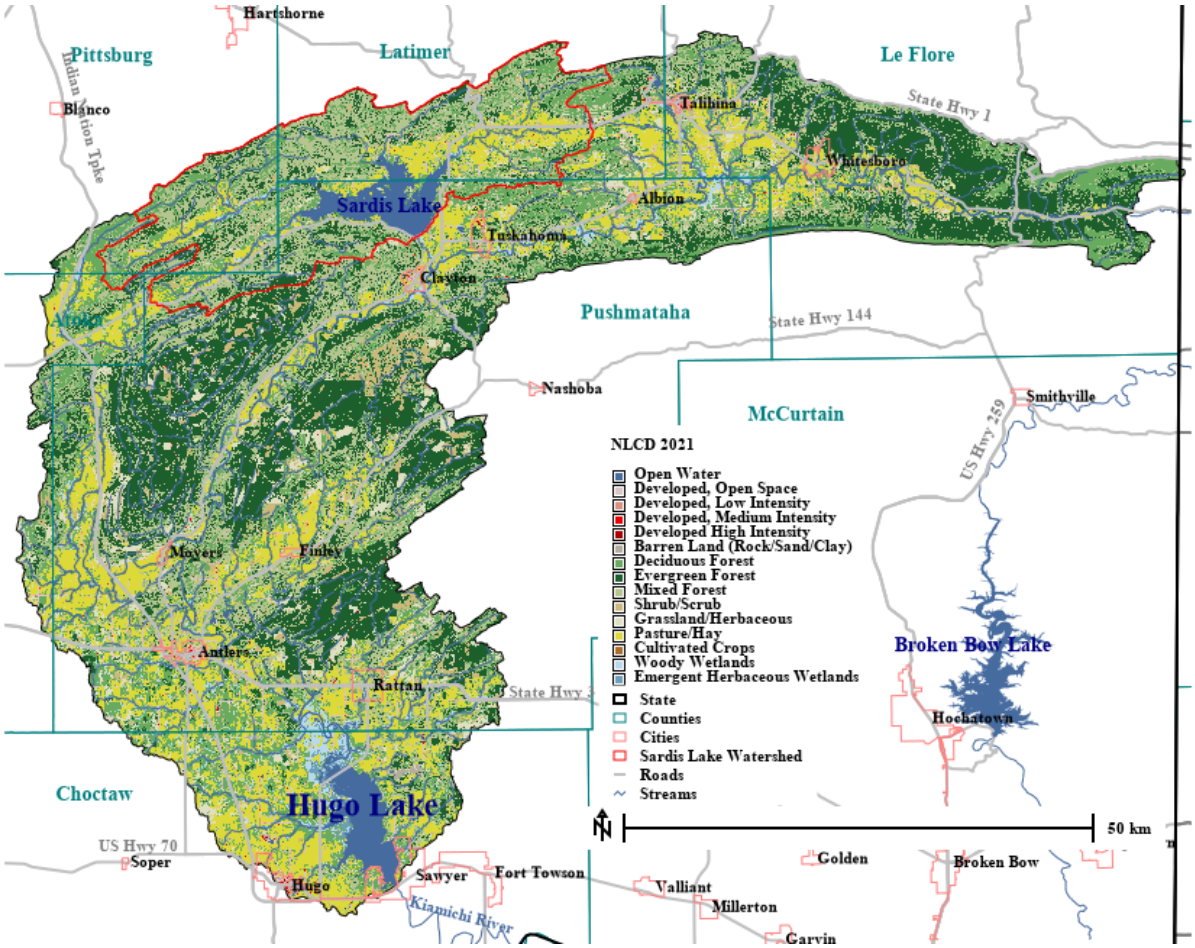


**Figure 1.** **The Hugo Lake (Kiamichi River) Watershed above the Hugo Lake Dam. The Sardis Lake Watershed, contributing to Hugo Lake inflow, is outlined in red.**

**Table 1. Descriptive Characteristics of Hugo Lake, OK.**

| Parameter | English Units | Metric Units |
|---|---|---|
| Lake Elevation (Conservation Pool) | 404.5 ft NGVD | 123.29 m |
| Lake Surface Area (Conservation Pool) | 12,497 ac | 5,057.4 ha |
| Lake Volume (Conservation Pool) | 143,313 ac-ft | $176.774*10^6$ $m^3$ |
| Uncontrolled Drainage Area | 1,434 $mi^2$ | 3,714 $km^2$ |
| Total Drainage Area (including Sardis Lake basin) | 1,709 $mi^2$ | 4,426 $km^2$ |
| Mean Depth | 11.5 ft | 3.51 m |
| Maximum Depth (Conservation Pool) | 47.5 ft | 14.5 m |
| Shoreline Length | 98.6 mi | 158.68 km |
| Shoreline Development Index | 6.3 | 6.3 |
| Annual Inflow, Average 1926 – 2015 [Water Years] | 1,577,000 ac-ft | $1,945.2*10^6$ $m^3$ |
| Annual Inflow, 2015 [Calendar Year] | 3,610,580 ac-ft | $4,453.6*10^6$ $m^3$ |
| Hydraulic Residence Time, 2015 [Calendar Year] | 29.93 d | 0.08 yr |

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2021), the FY 2015 Annual Water Control Report (U.S. ACE - SWD RCC, 2016), Tulsa District's Water Control page for Hugo Lake (U.S. ACE - Tulsa District, 2024), and a bathymetric survey (Bowen Engineering & Surveying. Inc., 2015).

Designated beneficial uses of the of the impoundment created by the Hugo Lake Dam include Public and Private Water Supply, Fish and Wildlife Propagation – Warm Water Aquatic Community, Agriculture, Primary Body Contact Recreation, and Aesthetics (OAC, 2023a). Hugo Lake State Park and the Hugo Wildlife Management Area (WQM Segment 410300) are designated as areas with waters of recreational and/or ecological significance. Based on the biennial Integrated Water Quality Assessment prepared by the Oklahoma Department of Environmental Quality (ODEQ, 2022), Hugo Lake (Waterbody ID: OK410300020020_00) is listed as impaired by turbidity affecting the Warm Water Aquatic Community, and by mercury concentrations affecting Fish Consumption.

Physical and chemical water quality data were collected from three in-lake sites and one site on the Kiamichi River above the lake on just two dates in April and May 2015. Further sampling planned through September 2015 was aborted due to flood conditions. In-lake sites were accessed by boat and samples were collected from locations over the deepest portion of the stream channel (thalweg). Sites sampled in 2015 included HUGOKS0026 (channel near dam), HUGOKS0027 (mouth of Salt Creek Cove), HUGOKS0028 (timber clearing limit, mid-lake), and HUGOKS0095 (riverine, Rattan Landing, State Highway 3). Prior water quality sampling efforts, in years 1979, 1993, and 2000, collected data from sites listed above, and also from HUGOKS0096 (upper lake at State Highway 93) and HUGOKS0097 (tailwater). Sampling locations are identified in Figure 2.

As shown in Figure 3 below, significant rainfall May through July 2015 (>25 inches) propelled the Hugo Lake level well above the conservation pool elevation until September 2015. Climate normals (NCEI-NOAA, 2024) generated from 1991-2020 data at Antlers, OK (USC00340256) within the Hugo watershed, indicate average annual precipitation of 47.9 inches with an average annual temperature of 61.7 °F. Spring (March through May) is normally the wettest season averaging 14.7 inches of precipitation. Total basin precipitation recorded for calendar year 2015 was 82.14 inches. Hugo Lake hydraulic residence time, driven by rainfall, runoff, basin size, and lake volume, averages about 33 days.

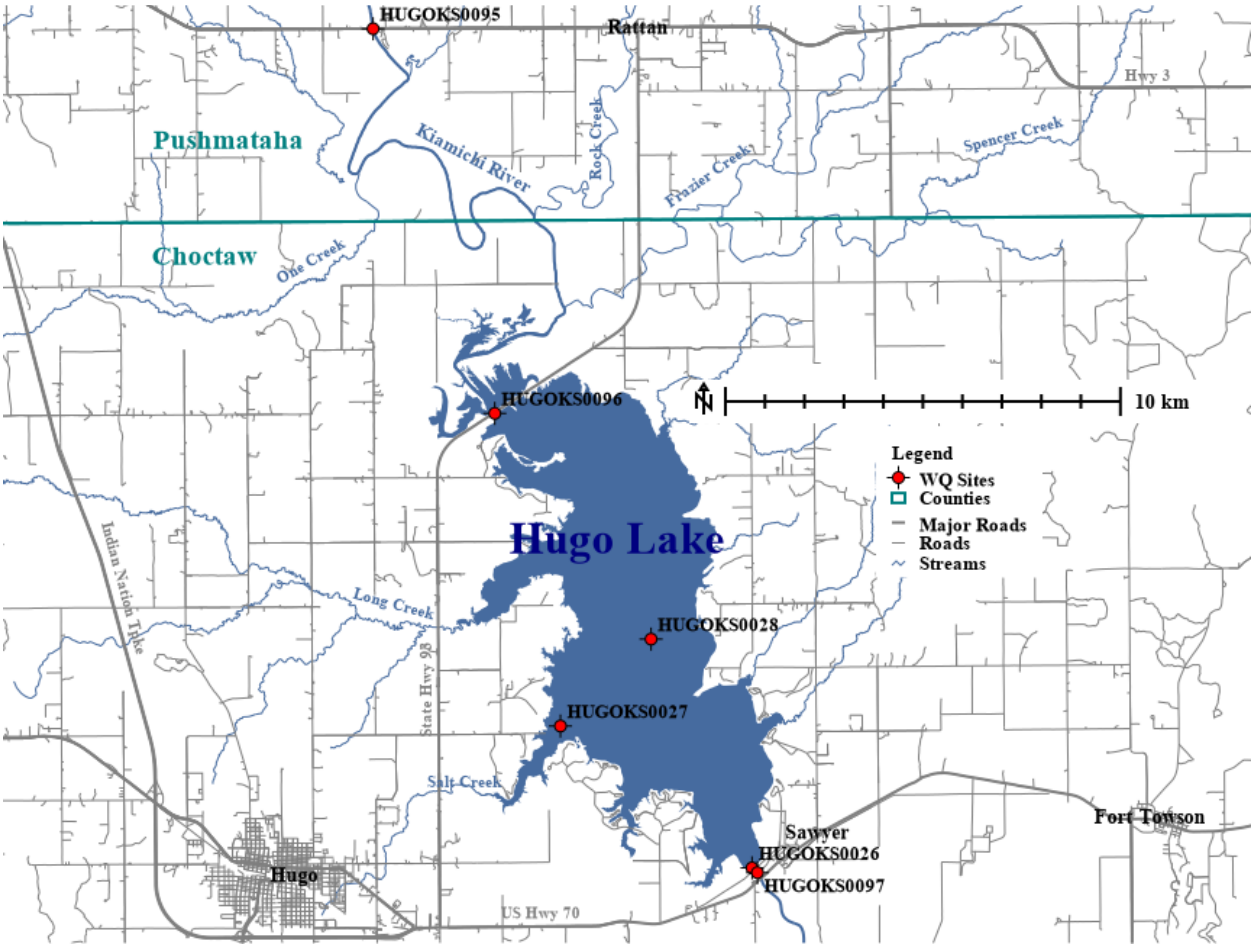


**Figure 2. Locations of water quality sampling sites at Hugo Lake, OK.**

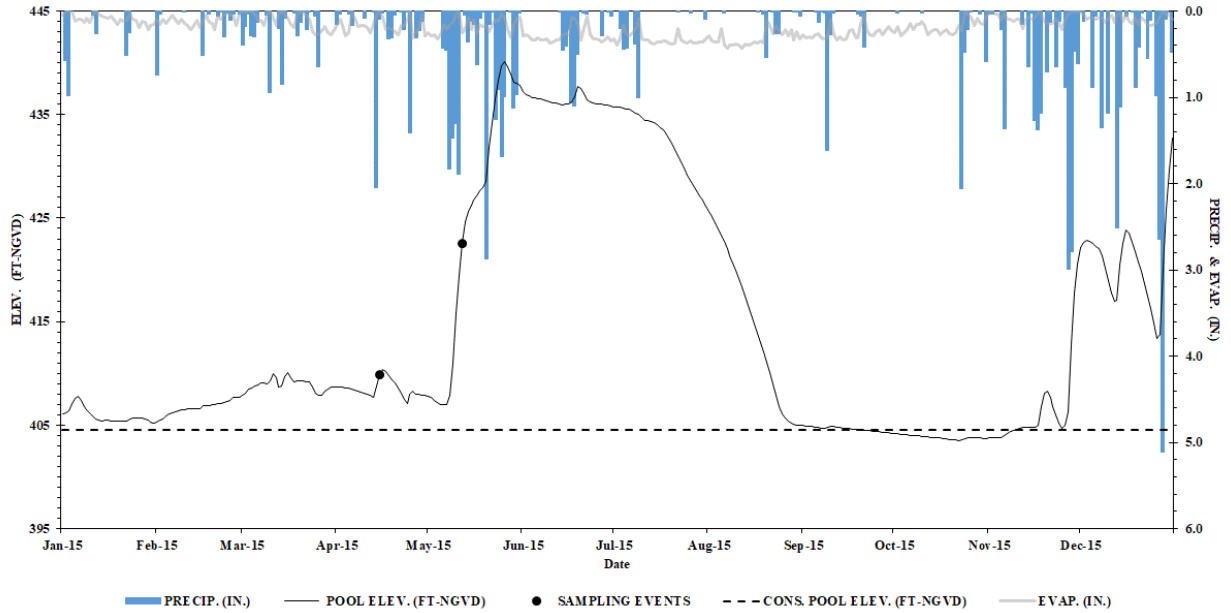


**Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Hugo Lake, OK, 2015.**

The 1979 water quality study (U.S. ACE - Tulsa District, OSDH, 1979) collected data in August 1979, five years after the initial filling of the conservation pool. Results indicated elevated total organic carbon concentrations, dissolved oxygen depletion in the hypolimnion, total phosphorus concentrations conducive to algal blooms, likely nitrogen limitation of algal growth, minimal sediment loading, and reportable concentrations of PCB and mercury.

The 1993 study (U.S. ACE-Tulsa District, 1996), analyzing data collected April through September 1993, found Hugo Lake vulnerable to pH shifts and metal toxicity due to low alkalinity and hardness levels. Median alkalinity and hardness levels were 20 and 40 mg/l as $CaCO_3$, respectively. Thermal stratification at lentic sampling sites was ephemeral, but dissolved oxygen depletion at depth was noted in the upper and mid-lake lake sites July into August. Median conductivity and total dissolved solids concentrations were low, 69 µS/cm and 76 mg/l, respectively. Sulfate and chloride medians were <1 and 4.5 mg/l, respectively. Secchi depth and turbidity medians were 0.3 m and 19.5 NTU, respectively. Elevated ammonia concentrations were noted at upper lake sampling sites HUGOKS0095 and HUGOKS0096, and at HUGOKS0026, HUGOKS0027, and HUGOKS0028 at depth. Total phosphorus concentrations (median 0.075 mg/l) were found at levels indicating eutrophy. Total iron and manganese median concentrations were relatively high (0.47 and 0.075 mg/l, respectively). Five surface samples had detectable mercury levels.

A calendar year 2000 water quality study (U.S. ACE-Tulsa District, 2002) found evident temporary thermal stratification at all in-lake sites with associated lower pH and dissolved oxygen concentrations at depth. Median alkalinity and hardness concentrations were low, 20 and 24 mg/l as $CaCO_3$, respectively. Conductivity, chloride, and sulfate concentrations were low. Median lakewide Secchi depth was 0.45 m and median turbidity was 24.7 NTU. Total phosphorus concentrations ranged from 0.04 to 0.79 mg/l (median 0.13 mg/l) with highest concentrations noted at the upper lake site, HUGOKS0096. Ammonia concentrations were generally low, median nitrite plus nitrate concentration was 0.15 mg/l, and organic nitrogen concentrations were moderately elevated (median 0.53 mg/l). The calculated surface total nitrogen to phosphorus ratio (N:P, 4.2) suggested nitrogen limitation of algal growth. Chlorophyll-a concentrations ranged from 0.7 to 107.8 µg/l with peaks observed in May, late August, and September. The lake was characterized as eutrophic. Sample analysis for presence of trace metals noted reportable concentrations of arsenic, chromium, copper, and lead in less than 10% of samples collected. Zinc and mercury were detected in 75 and 48% of the samples collected. Reportable cadmium concentrations were found in 62 of 63 samples. Total iron and manganese were found at high concentrations, especially in bottom samples.

During the brief 2015 data collection effort, median in-lake turbidity was 52.7 NTU and median Secchi depth was 0.30 m. Calculated euphotic zone depth was about 1.5 m. Observations of pH ranged from 6.79 to 8.19 standard units. Alkalinity and hardness concentrations were low, 16.3, and 19.0 mg/l as $CaCO_3$, respectively. Median conductivity was 67 µS/cm, and chloride and sulfate concentrations were low (3.11 and 5.41 mg/l, respectively). Ammonia concentrations ranged from 0.06 to 0.13 mg/l, and nitrite plus nitrate concentrations ranged from 0.04 to 0.10 mg/l. Total Kjeldahl nitrogen concentrations ranged from 0.44 to 1.07 mg/l, and surface total nitrogen concentration was 0.63 mg/l. Total phosphorus concentrations ranged from 0.01 to 0.05 mg/l. The April/May nitrogen to phosphorus (N:P) ratio was 22.9 suggesting phosphorus limitation of algal growth. Median total iron and manganese concentrations were 0.68 and 0.07 mg/l, respectively. Reportable concentrations of arsenic, chromium, copper, lead, and nickel were found in all samples. Three of 14 in-lake samples had reportable mercury concentrations above the laboratory detection limit of 0.01 µg/l.