

Birch Lake Water Quality: 2012

The Birch Lake dam is located at river mile 0.8 on Birch Creek, a tributary of Bird Creek, ~1.8 miles south of Barnsdall in Osage County, Oklahoma. Birch Lake is a multi-purpose project authorized for flood control, water supply and water quality, recreation, and fish and wildlife. It was designed and is regulated for flood protection on Bird Creek operating in conjunction with Skiatook Lake and is a component of the multiple-purpose Verdigris and Arkansas River flood control and navigation system. The impoundment extends west-southwest from the dam following the sinuous channel of Birch Creek. The lake and watershed are within Hydrologic Unit Code 1107010703 (Middle Bird Creek). Construction of the Birch Lake dam began in November 1973 and was completed for full flood control operation in March 1977. The total drainage area above the dam is ~64 square miles (Figure 1). Land use/cover (U.S. Geological Survey, 2014) in the basin is dominated by grassland/pasture (~54.5%) and forested areas (~37%). Based on a 2010 bathymetric survey (Wilson & Company, Inc., 2011), at the conservation pool elevation of 750.5 feet (NGVD 29), lake capacity had diminished by about 8.5% since a 1989 survey. Descriptive characteristics of Birch Lake are included in Table 1.

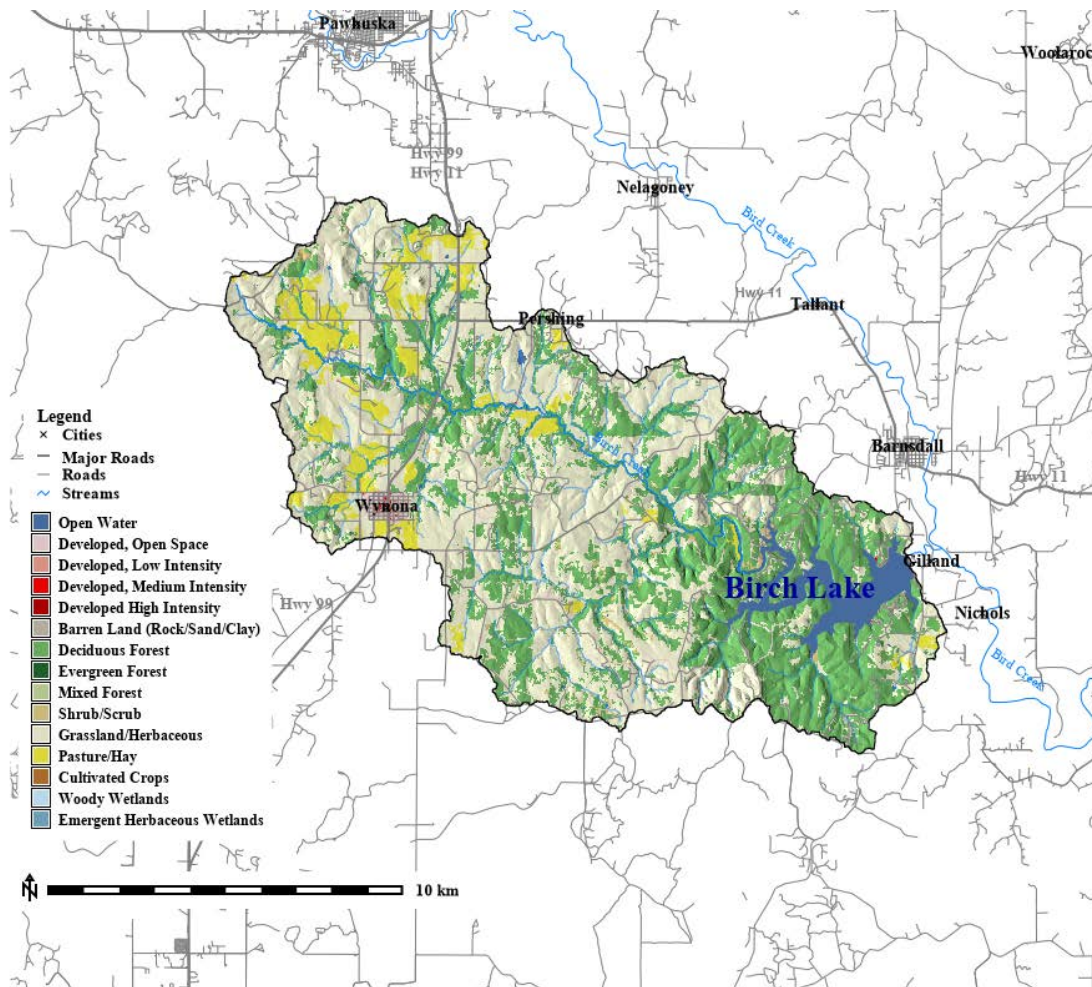


Figure 1. The Birch Lake (Birch Creek) Watershed above the Birch Lake Dam.

Table 1. Descriptive Characteristics of Birch Lake, OK.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	750.5 ft. NGVD	228.75 m
Lake Surface Area (Conservation Pool)	1,115 ac	451.22 ha
Lake Volume (Conservation Pool)	17,967 ac-ft	22.162*10 ⁶ m ³
Total Drainage Area (contributing)	63.8 mi ²	165.24 km ²
Mean Depth	16.11 ft.	4.91 m
Maximum Depth (Conservation Pool)	52.5 ft.	16.0 m
Shoreline Length	26.14 mi	42.07 km
Shoreline Development Index	5.64	5.64
Annual Inflow, Average 1938 – 2012 [Water Years]	28,700 ac-ft	35.401*10 ⁶ m ³
Annual Inflow, 2012 [Calendar Year]	13,925 ac-ft	17.176*10 ⁶ m ³
Hydraulic Residence Time, 2012 [Calendar Year]	359.25 d	0.98 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 Birch Lake (U.S. ACE - Tulsa District, 2023), and the 2010 bathymetric survey (Wilson & Company, Inc., 2011).

Designated beneficial uses of the impoundment and watershed of the Birch 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 a 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), Birch Lake is listed as impaired by low dissolved oxygen, affecting Fish and Wildlife Propagation as a Warm Water Aquatic Community, by high algal concentrations affecting Public and Private Water Supply, and mercury affecting fish consumption.

Physical and chemical water quality data were collected monthly by USACE from three in-lake sites and the tailwater at Birch Lake beginning 24 April and ending 25 September 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 BIROKN0027 (over channel near dam), BIROKN0028 (mid-lake), BIROKN0029 (upper lake), and BIROKN0237 (tailwater). 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.

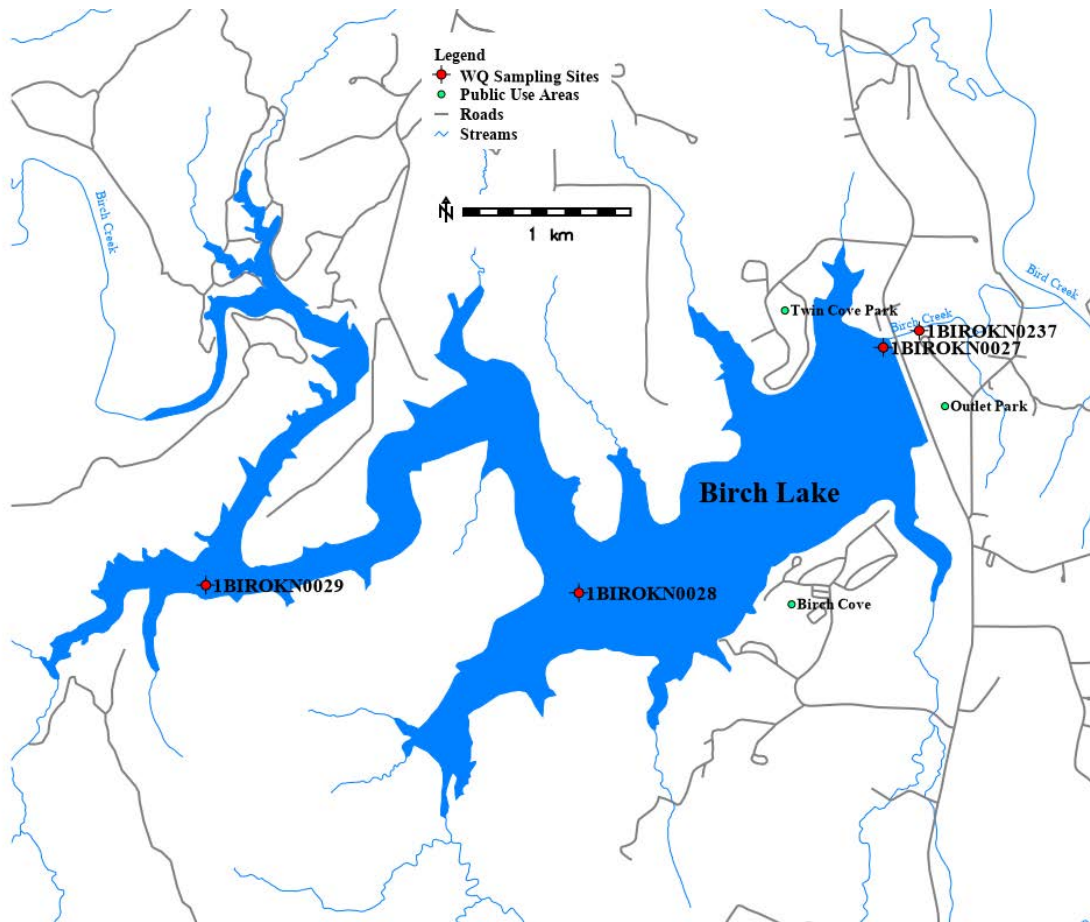


Figure 2. Locations of water quality sampling sites at Birch Lake, OK, 2012.

The Birch Lake pool was near conservation elevation (750.5 feet) for April, May, and June collection events. Basin-wide precipitation was below the long-term normal from May through December 2012. Pool elevation was well below 750.5 feet for July, August, and September sampling efforts. Calendar year 2012 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling events are shown in Figure 3.

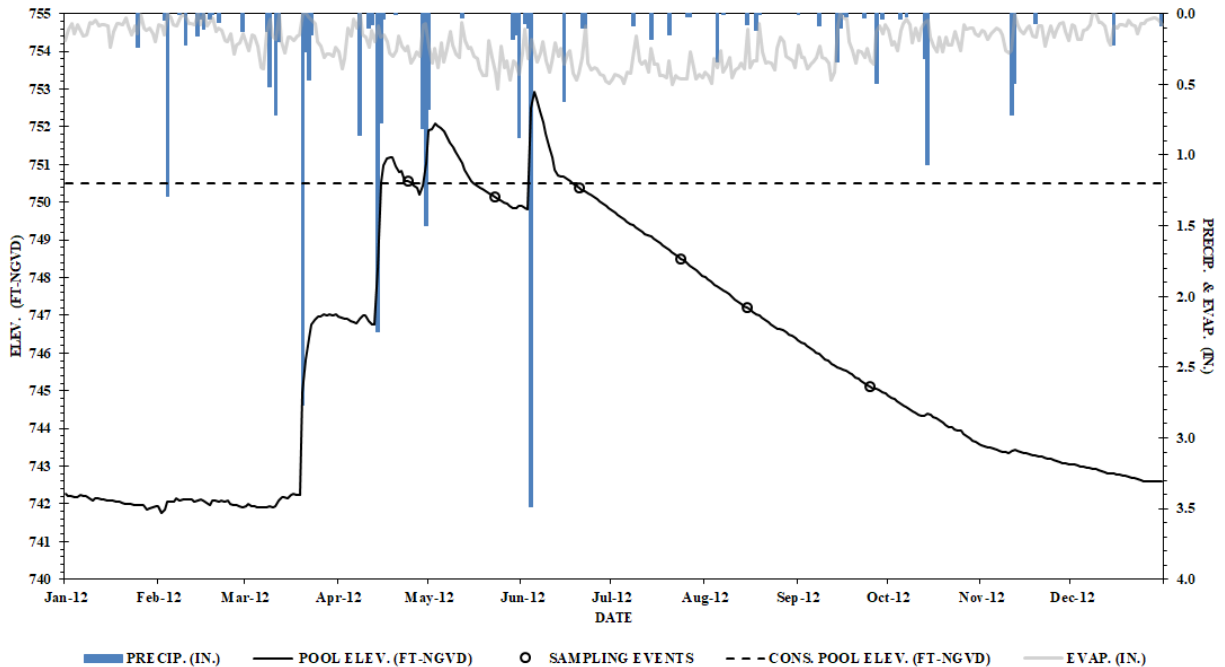


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling events at Birch Lake, OK, 2012.

Water temperatures varied seasonally (ranging from 16.99 to 29.39 °C). Highest recorded water temperatures occurred in July with all three in-lake sites recording temperatures greater than 28.0 °C. Water temperatures varied nominally from surface to bottom in April and September, while vertical profiles from May through August revealed significant variation. Thermal stratification was observed at site BIROKN0027 beginning in May and continuing through August 2012. The study period lakewide median dissolved oxygen concentration (DO) was 6.16 mg/l. DO ranged from 0.08 to 8.62 mg/l and concentrations of 2 mg/l or less were recorded on all sampling dates. DO at the dam site (BIROKN0027) revealed hypoxia (concentrations less than 2 mg/l) from May through August at depths 8-meters below the surface. Hypoxia was noted at the mid-lake site (BIROKN0028) May through August at depths 6-meters below the surface, and the upper lake site (BIROKN0029) May through July 3- to 5-meters below the surface. The highest observed DO was recorded in April at BIROKN0027, corresponding with coolest water temperatures. Lakewide total organic carbon concentrations were high with a study period median of 6.55 mg/l. The highest site median total organic carbon concentration (7.3 mg/l) was observed at the upper lake site (BIROKN0029).

Specific conductance (median 193.0 $\mu\text{S}/\text{cm}$) was moderate, consistent with regional geology. Total dissolved solids median concentration was 128.5 mg/l. Low chloride and sulfate concentrations (medians 19.85 and 10.6 mg/l, respectively) were observed. Alkalinity levels (median 47.5 mg/l as CaCO_3) were low, although the system appears capable of maintaining pH levels. Hardness levels, median 62.7 mg/l as CaCO_3 , indicated 'soft' water. Observed pH (6.78 to 8.53) ranged within regional norms. Highest pH was recorded near the surface at site BIROKN0027 in July, and lowest pH (<7.0) was recorded at depth, June through August, at all in-lake sites.

Secchi depth (SD) at Birch Lake during the study period ranged from 0.28 to 1.20 meters with a median value of 0.66 meters. Median site SD observations were highest at BIROKN0027 and diminished moving up-lake. Highest SD observations at all three in-lake sites occurred in July. Median turbidity was 31.15 NTUs, and 63% of all observations were greater than or equal to 25 NTUs. Median surface total suspended solids concentrations (7.0 mg/l) decreased from the upper lake site (BIROKN0029, 12.5 mg/l) down to the dam site (BIROKN0027, 5.0 mg/l). The euphotic zone at Birch Lake ranged from 1.8 to 4.7 meters with highest estimates occurring in July.

Lakewide ammonia concentrations were low. Just 2 of 24 in-lake samples reported concentrations at the detection limit of 0.2 mg/l. Nitrite plus nitrate (median 0.11 mg/l) concentrations were moderate to high. Total Kjeldahl nitrogen concentrations (median 0.55 mg/l) were moderately high. Estimated lakewide median surface total nitrogen concentration during the 2012 study was 0.65 mg/l. Total phosphorus concentrations ranged between <0.02 and 0.083 mg/l (median 0.03 mg/l). Observations of dissolved ortho-phosphate, median 0.05 mg/l, were low throughout the lake. By sampling date, the lowest lakewide nitrogen to phosphorus ratio (N:P) was observed in July (15.8) while the highest occurred in May (70.1). By sampling site, the highest mean N:P ratios were observed at the dam site (BIROKN0027, 42.4) and lowest at the upper lake site (BIROKN0029, 23.0). Lakewide median N:P ratio was 27.0 indicating likely phosphorus limitation for algal growth at Birch Lake.

Chlorophyll-a concentrations (CHLa) ranged from 5.6 to 27.9 µg/l, with a lakewide median concentration of 10.3 µg/l. Highest median site concentration occurred at the upper lake site (BIROKN0029, 14.7 µg/l). Figure 4, below, shows sampling date distributions of in-lake CHLa observations. Medians on sampling dates increased through the period until September. Also included in Figure 4, for comparison, is the Oklahoma Water Quality Standard CHLa criterion for Sensitive Public and Private Water Supply waterbodies (red dashed line, 10 µg/l, (OAC, 2023)).

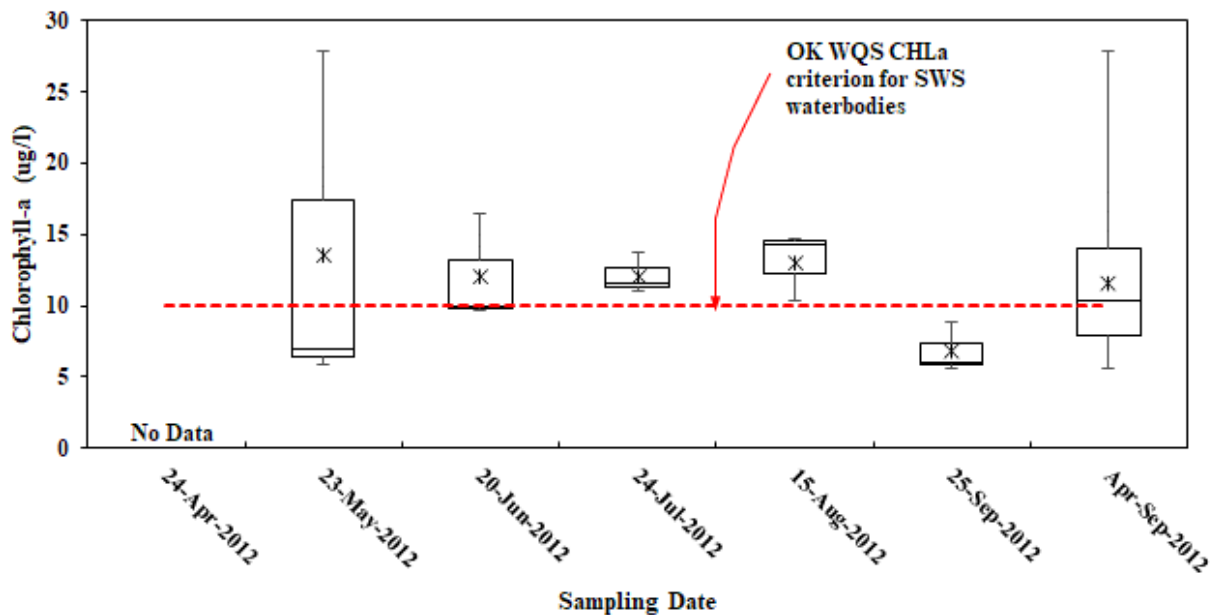


Figure 4. Chlorophyll-a concentration distributions by sampling date, and combined dates, at Birch Lake, OK, May through September 2012. In the box-and-whiskers, 'x' represents mean and the horizontal bar within each box represents median concentration.

Trophic status of Birch Lake was assessed using all three metrics of Carlson's trophic state index (TSI) at each in-lake site. Shown in Figure 5, lakewide (LW) median TSI (SD) of 66.0 indicates eutrophy. The LW median based on total phosphorus [TSI (TP)] is lower, 52.0, but indicates enhanced lake productivity. TSI (TP) corresponds closely with TSI (CHLa), with a LW median value of 53.4.

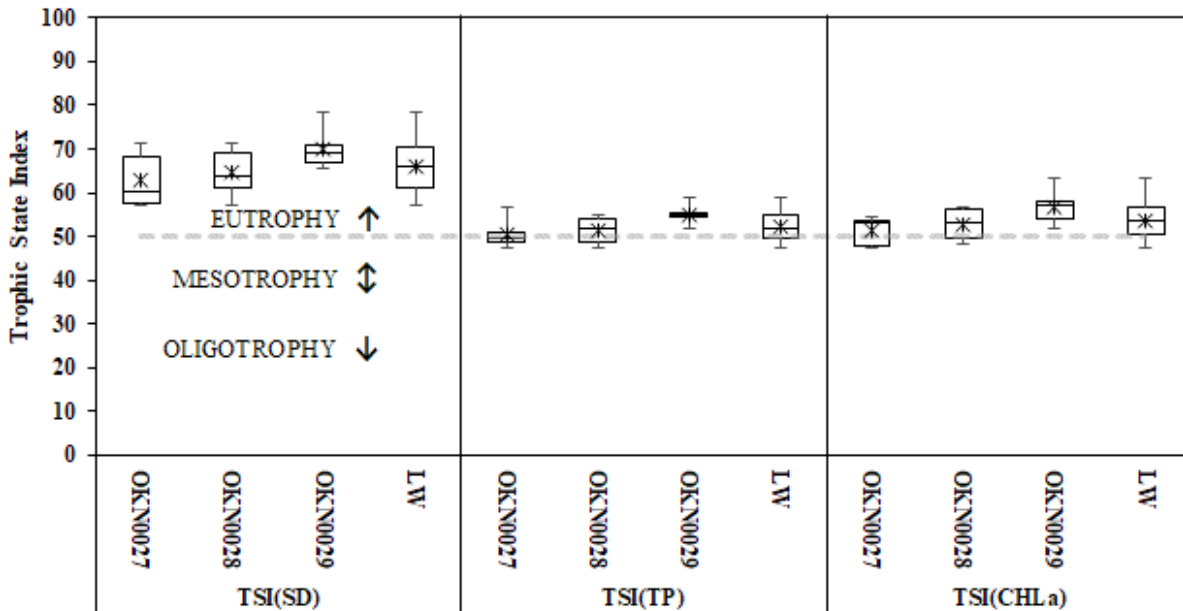


Figure 5. Distributions of Carlson's Trophic State Index (TSI), by sampling site and lakewide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-a concentrations (TSI(CHLa)) at Birch Lake, OK, April through September 2012.

Total iron (median 0.544 mg/l) and manganese (median 0.100 mg/l) concentrations were high. Reportable concentrations of arsenic were found in 91% of samples collected, with a median concentration of 0.0015 mg/l. Reportable concentrations of chromium, copper, and nickel were noted in all samples. Detectable lead, zinc, and mercury concentrations were found in 33, 87, and 37%, respectively, of samples collected.

Samples were collected from the tailwater below the Birch Lake dam each sampling trip (April through September 2012) from site BIROKN0237. Median parameter results are directly comparable to in-lake data collected near the dam (BIROKN0027).

USACE previously conducted water quality sampling at Birch Lake, OK in 1999. Thermal stratification and anoxia within the hypolimnion were noted. With observation frequency focused on mid-summer months, median in-lake dissolved oxygen concentration was less than 4.0 mg/l. Relatively high concentrations of iron and manganese were reported. Reported concentrations of cadmium and lead exceeded criteria for raw drinking water supply sources.