John Redmond Reservoir Water Quality: 2020

The John Redmond Reservoir dam is located on the Neosho River at river mile 343.7 about three miles northwest of the city of Burlington in Coffey County, Kansas within Hydrologic Unit Code 11070201. The conservation pool of John Redmond Reservoir was first filled in November 1964 after final storage began in September 1964. Authorized purposes include flood damage reduction, water supply, water quality, fish and wildlife, and recreation. The watershed above the John Redmond Reservoir dam site extends northwest ~64 miles to the headwaters of the Neosho River above Council Grove Lake, and WNW ~94 miles to the headwaters of the Cottonwood River above Marion Reservoir and encompasses ~3,033 square miles (Figure 1) with basin elevations ranging from ~995 feet below the dam to ~1,652 feet. The uncontrolled drainage area, below the Marion Reservoir and the Council Grove Lake dams, is ~2,565 square miles. Land use/cover in the basin is dominated by grassland/pasture (~63%) and cultivated cropland (~26%). At the conservation pool elevation of 1,041.0 feet (NGVD 29), lake capacity has diminished by about 38% due to sedimentation. A 2014 bathymetric survey indicated an annual conservation pool sedimentation rate of ~450 ac-ft/yr between 2007 and 2014. In 2016 the Kansas Water Office completed Phase I of a dredging operation removing three million cubic yards of sediment from the reservoir. Descriptive characteristics of John Redmond Reservoir are included in Table 1.

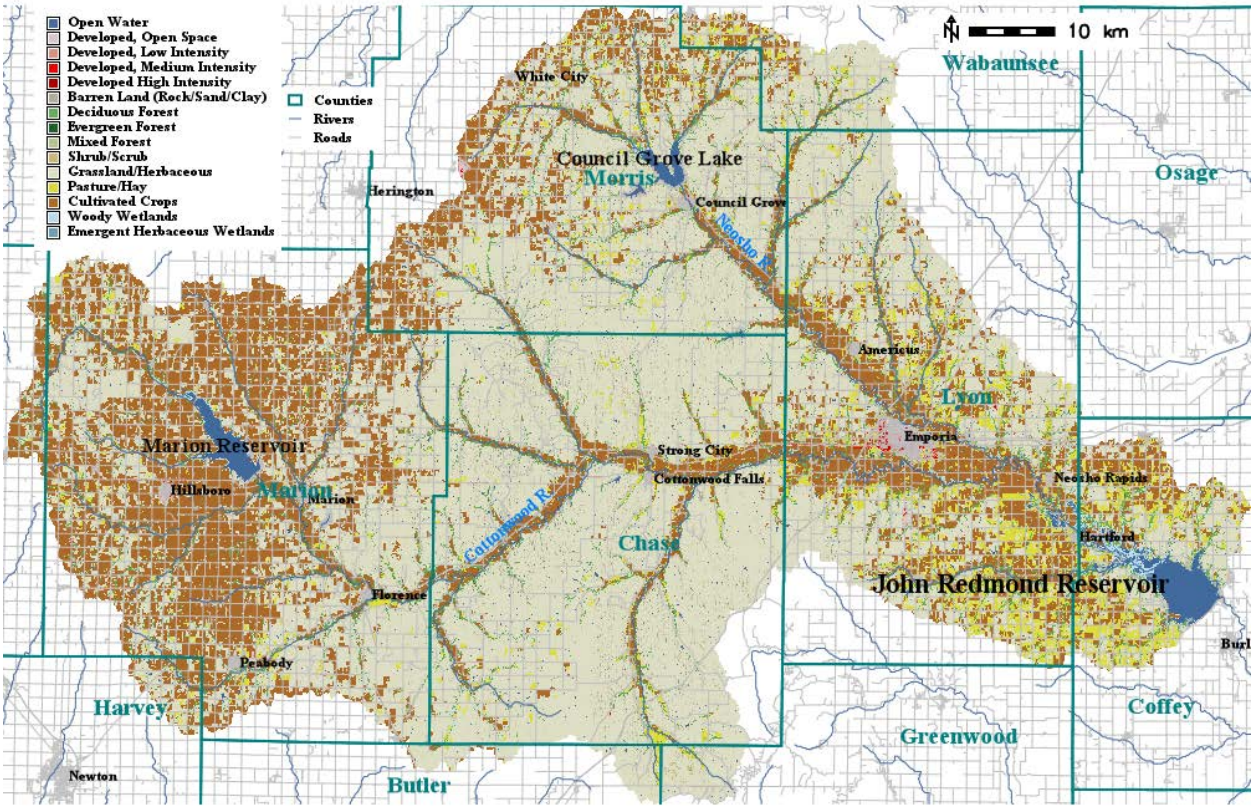

Figure 1. The John Redmond Reservoir, KS Watershed.

Table 1. Descriptive Characteristics of John Redmond Reservoir, KS.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	1,041.0 ft. NGVD	317.3 m
Lake Surface Area (Conservation Pool)	9,200 ac	3,723 ha
Lake Volume (Conservation Pool)	67,300 ac-ft	83,013,328 m^3
Total Drainage Area	3,033 mi^2	7,855 km^2
Mean Depth	7.3 ft.	2.2 m
Maximum Depth (Conservation Pool)	15 ft.	4.6 m
Shoreline Length	43.8 mi	70.5 km
Shoreline Development Index	3.26	3.26
Annual Inflow, Average 1922 – 2020 [Water Years]	1,081,760 ac-ft	$1.334*10^9$ m^3
Annual Inflow, 2020 [Calendar Year]	1,007,018 ac-ft	$1.242*10^9$ m^3
Hydraulic Residence Time, 2020 [Calendar Year]	26.7 d	0.07 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, 2021), Tulsa District's Water Control page for John Redmond Reservoir (U.S. ACE - Tulsa District, 2023), and the 2014 bathymetric survey (Kansas Biological Survey, 2014).

Use designations (KDHE, 2013) for John Redmond Reservoir 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), John Redmond Reservoir is listed as impaired by eutrophication and dissolved oxygen concentrations affecting aquatic life, and siltation affecting water supply.

Physical and chemical water quality data were collected by USACE from two in-lake sites, an inflow location, and the stilling basin at John Redmond Reservoir beginning 15-JUN and ending 14-SEP-2020 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 JORKSS0044 over the channel at the dam, JORKSS0045 mid-lake over the channel, JORKSS0046 just above (inflow) the lake at Strawn Ramp, and JORKSS0043 in the 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.

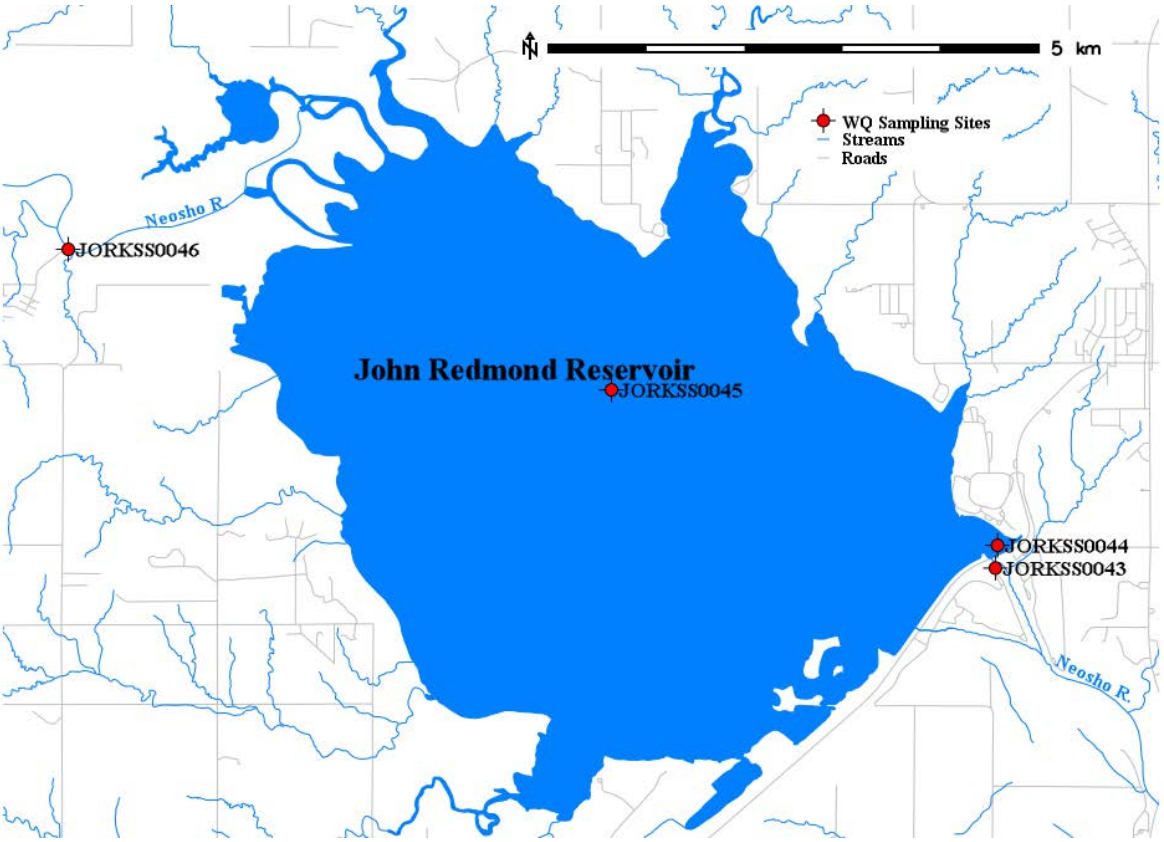

Figure 2. Locations of water quality sampling sites at John Redmond Reservoir, KS, 2020.

The John Redmond Reservoir pool elevation was at or above the conservation pool elevation through the first half of calendar year 2020 due to frequent rainfall-runoff events, and near conservation pool elevation for each sampling effort. Calendar year 2020 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

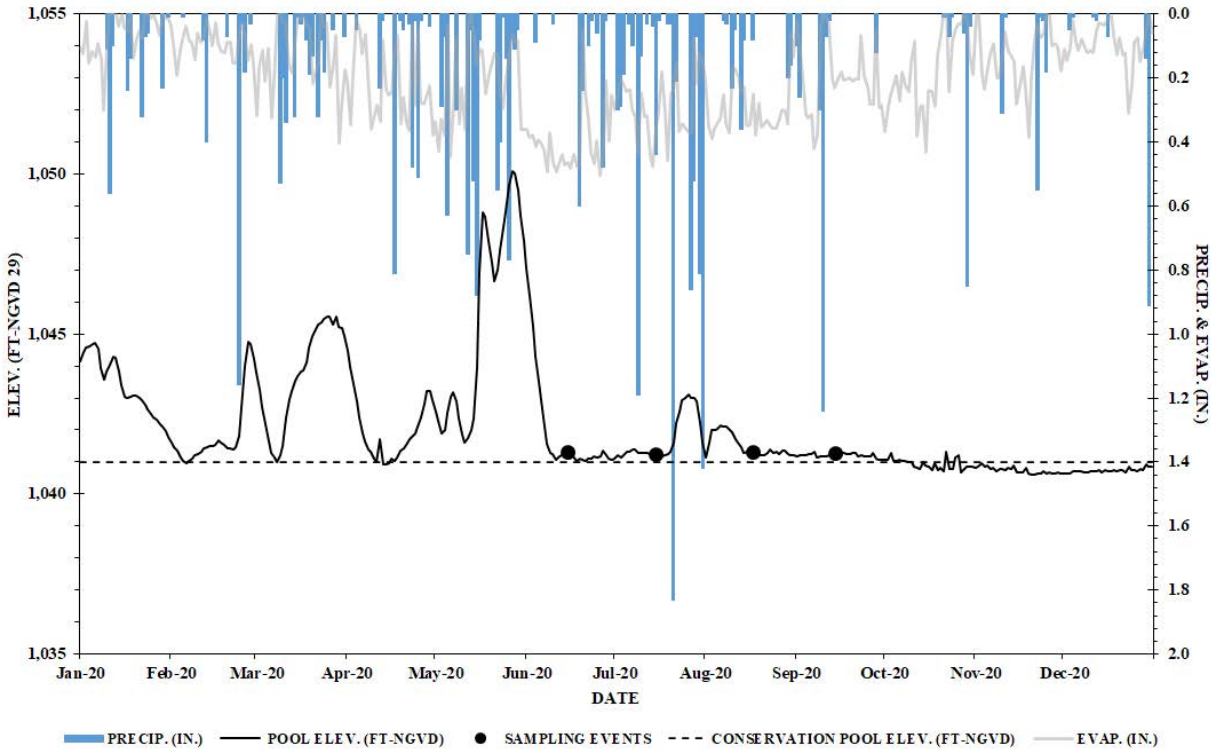

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), seasonal conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at John Redmond Reservoir, KS, 2020.

Water temperatures varied seasonally (ranging from 18.51 to 28.48 ºC) peaking in July. Lake-wide water temperatures, on individual sampling dates, displayed nominal variation. The generally shallow reservoir did not experience observable thermal stratification in 2020. The study period in-lake median dissolved oxygen concentration was 7.05 mg/l. Observed in-lake dissolved oxygen concentrations ranged from 5.21 to 9.21 mg/l. Lowest dissolved oxygen concentrations were observed at the in-flow site (JORKSS0046, 4.06 mg/l) in July. In-lake total organic carbon concentrations were high with a study period median of 8.97 mg/l.

Specific conductance (in-lake median 476 µS/cm) was moderately elevated, consistent with regional norms. Total dissolved solids median concentration was 284.5 mg/l. Moderate chloride and sulfate concentrations (medians 8.26 and 36.85 mg/l, respectively) were observed indicating other components (minerals, cations) are contributing to dissolved solids. Alkalinity levels (median 184.0 mg/l as $CaCO_3$) imply a well-buffered system capable of maintaining pH levels. Hardness levels, median 210 mg/l as $CaCO_3$, indicate 'hard' water. Observed in-lake pH (7.91 to 8.71) ranged within regional norms. Highest pH was recorded at the mid-lake site (JORKSS0045) in June and lowest pH was recorded in September, also at the mid-lake site.

The lake was turbid through 2020. Maximum recorded Secchi depth was 0.32 meters, and the study period median was 0.22 meters. In-lake mean turbidity was 57.9 NTU. All turbidity observations (in-flow, in-lake, and stilling basin) were greater than 30 NTU. In-lake total suspended solids concentrations (median 32.5 mg/l) varied little between surface and bottom observations. The euphotic zone at John Redmond Reservoir was typically <0.75 meter.

Ammonia concentrations were moderate (median 0.08 mg/l), and nitrite plus nitrate concentrations were moderate to high (median 0.34 mg/l). Total Kjeldahl nitrogen concentrations (median 0.72 mg/l) were moderately high. Estimated in-lake median total nitrogen concentration during the 2020 study was 0.97 mg/l. Total phosphorus concentrations ranged between 0.28 and 0.34 mg/l (median 0.32 mg/l). Observations of dissolved ortho-phosphate, median 0.16 mg/l, were moderately elevated throughout the lake. Nitrogen to phosphorus ratios (N:P) in 2020 were <10 (median 3.2), indicating a tendency toward limited nitrogen availability and the potential for phytoplankton dominance by cyanophytes.

Chlorophyll-*a* concentrations (in-lake) ranged from 5.7 to 56.4 µg/l, with a median concentration of 16.55 µg/l. Highest concentrations were observed in June 2020 at the two in-lake sites. Figure 4, below, summarizes relative abundance and biovolume of divisions of phytoplankton observed at John Redmond Reservoir. Cyanophyte (blue-greens) abundance tended to increase through the sampled period while biovolume was consistently dominated by Bacillariophytes (diatoms).

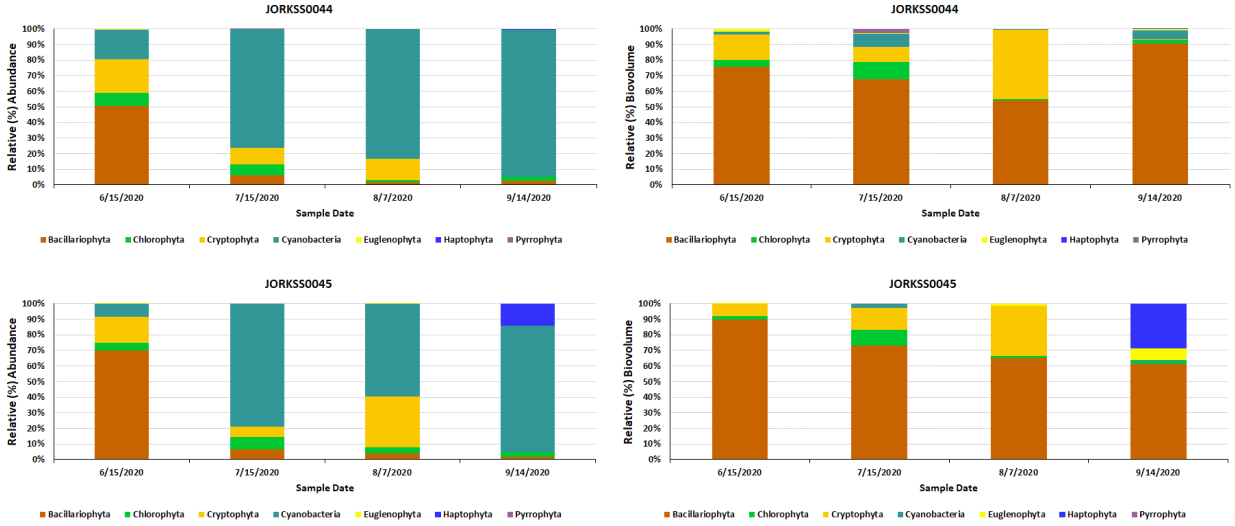

Figure 4. Phytoplankton relative abundance (left) and relative biovolume (right) at JORKSS0044 (top) and JORKSS0045 (bottom) June through September 2020.

The trophic status of John Redmond Reservoir in 2020, assessed using Carlson's trophic state index (TSI), indicated a hyper-eutrophic lake as measured by Secchi depth (TSI(SD)) and total phosphorus concentrations (TSI(TP)). The index developed from chlorophyll-*a* concentrations (TSI(CHLa)) indicated a more moderate level of eutrophy (Figure 5).

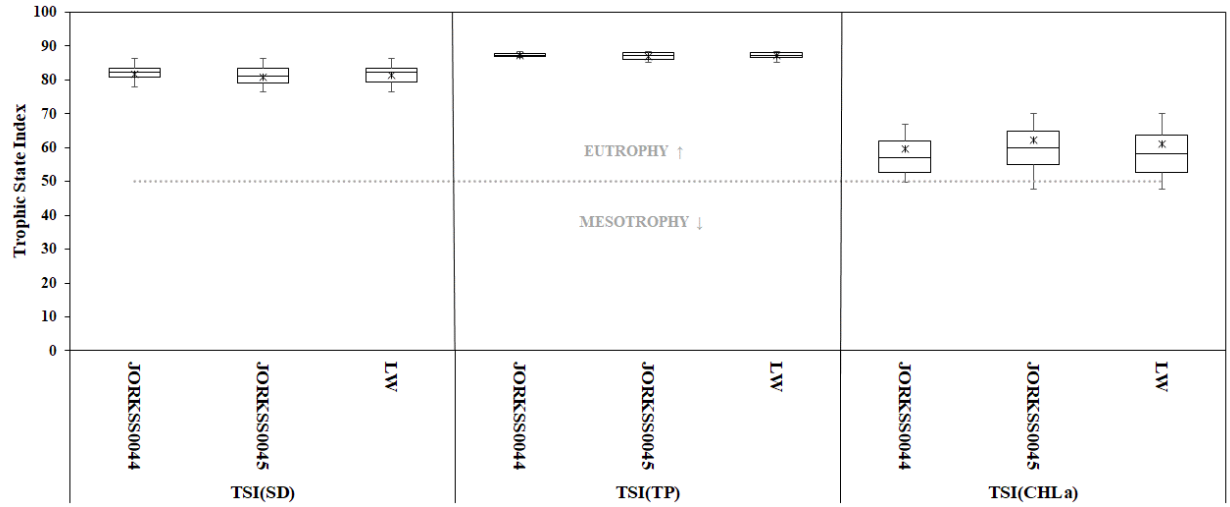

Figure 5. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lake-wide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at John Redmond Reservoir, KS, 15-JUN through 14-SEP-2020.

Total iron (median 0.62 mg/l) and manganese (median 0.13 mg/l) concentrations were relatively high. Reportable concentrations of arsenic were found in all in-lake samples collected with a median concentration of 0.0053 mg/l. Reportable concentrations of chromium, copper, lead, and zinc were noted in all in-lake samples. Detectable nickel concentrations were found in 83% of in-lake samples collected. Detectable concentrations of mercury were noted in ~17% of samples collected.

Water samples collected just above the lake at site JORKSS0046 revealed higher alkalinity, chloride, hardness, sulfate, total dissolved solids, total suspended solids, and chlorophyll-*a* concentrations. Mean and median parameter results from water samples collected in the stilling basin below the John Redmond Reservoir dam at site JORKSS0043 paralleled data collected in-lake. A significantly higher total suspended solids concentration was noted in the stilling basin (median 41.5 mg/l).

USACE conducted a water quality study of John Redmond Reservoir, KS in 1997 and indicated concerns with respect to high nutrient concentrations, the potential for cyanophyte blooms, and reduced water clarity. The 1997 report also recommended continued awareness of elevated trace metal concentrations including iron, lead, and mercury.