

Marion Reservoir Water Quality: 2006

The Marion Reservoir dam is located on the Cottonwood River, a tributary of the Neosho River, at river mile 126.7 about 3 miles northwest of the city of Marion in Marion County, Kansas within Hydrologic Unit Code 11070202. The conservation pool of Marion Reservoir was first filled in May 1969 after embankment closure in October 1967. Authorized purposes include flood damage reduction, water supply, water quality, and recreation. The watershed above the Marion dam site extends northwest ~21 miles and encompasses ~207 square miles (Figure 1) with basin elevations ranging from about 1,295 feet below the dam to ~1,594 feet. Land use/cover in the basin is dominated by cultivated cropland (~49%) and grassland (~35%). At the conservation pool elevation of 1,350.5 feet (NGVD 29), lake capacity has diminished by about 5% due to sedimentation. The most recent bathymetric survey conducted in 2008 indicated an annual conservation pool sedimentation rate of 107 ac-ft/yr since embankment closure reducing the original conservation pool volume by greater than 4,000 ac-ft. Descriptive characteristics of Marion Reservoir are included in Table 1.

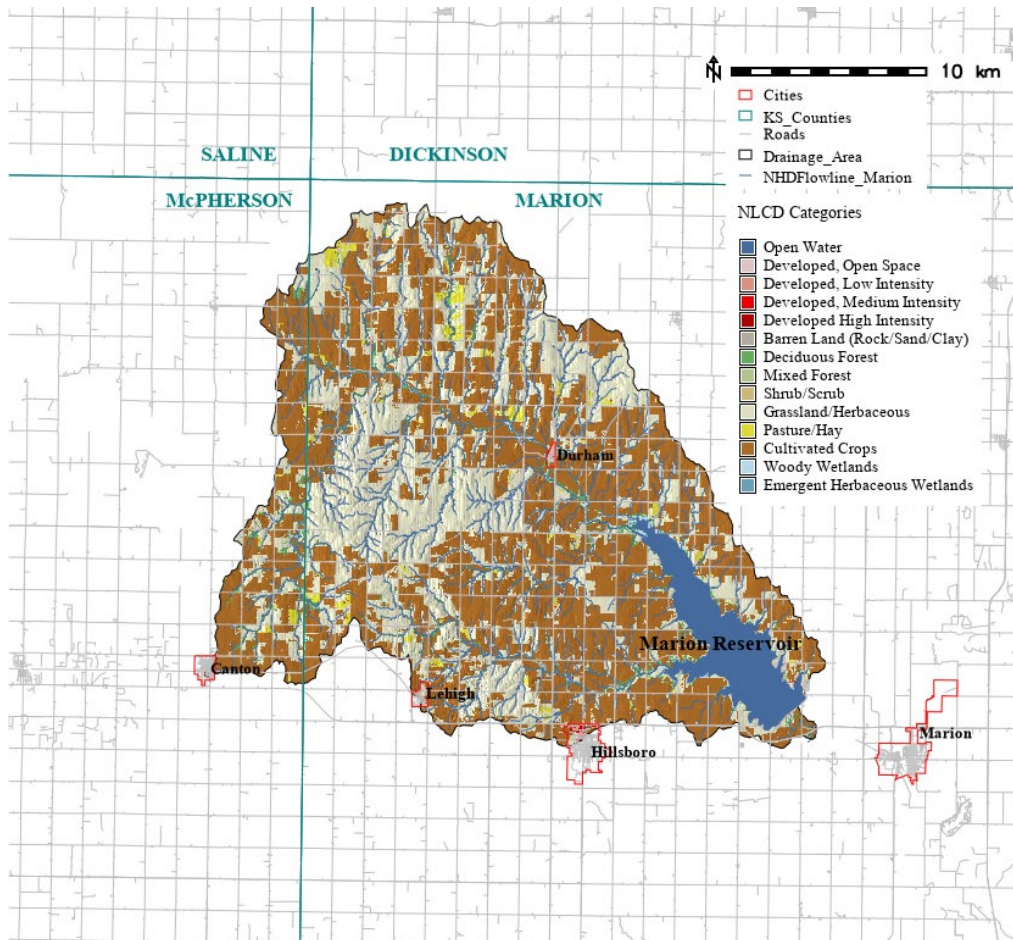


Figure 1. The Marion Reservoir, KS Watershed above the Marion Dam.

Table 1. Descriptive Characteristics of Marion Reservoir, KS.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	1,350.5 ft. NGVD	411.63 m
Lake Surface Area (Conservation Pool)	6,402 ac	2,590.8 ha
Lake Volume (Conservation Pool)	80,659 ac-ft	99,491,411 m ³
Total Drainage Area	207 mi ²	536.13 km ²
Mean Depth	12.6 ft.	3.84 m
Maximum Depth (Conservation Pool)	32.8 ft.	10.0 m
Shoreline Length	41 mi	66.1 km
Shoreline Development Index	3.65	3.65
Annual Inflow, Average 1949 – 2012 [Water Years]	65,200 ac-ft	80,423,000 m ³
Annual Inflow, 2006 [Calendar Year]	20,720 ac-ft	25,557,740 m ³
Hydraulic Residence Time, 2006 [Calendar Year]	1,241 d	3.4 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 Marion Lake (U.S. ACE - Tulsa District, 2023), and the 2008 KBS Bathymetric Survey (Kansas Biological Survey, 2009).

Use designations (KDHE, 2013) for Marion 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), Marion Reservoir is listed as impaired by eutrophication affecting AL.

Physical and chemical water quality data were collected by USACE approximately bi-monthly from a tributary site above the lake, five in-lake sites, and the stilling basin at Marion Reservoir, KS beginning 26-APR and ending 13-SEP-2006 to define existing limnological conditions, provide a basis for future water quality investigations, and to support operational and environmental missions of the Tulsa District. USACE collected water quality data during the growing season at Marion Reservoir for three consecutive years (2004 through 2006) in response to harmful cyanobacterial blooms (CyanoHABs) noted in June 2003, June 2004, and summer months of 2005. The bloom events contributed to water supply taste, odor, and toxin issues for the City of Hillsboro, KS, and prompted recreational advisories. Sampled sites included MARKSS0027 (stilling basin below the dam), MARKSS0028 (in-lake dam site), MARKSS0029 (mid-lake), MARKSS0030 (upper lake north of Durham Cove), MARKSS0059 (mouth of French Creek Cove), MARKSS0068 (~¾ up lake from the dam), and MARKSS0069 (Cottonwood River ~10 miles [16.75 km] upstream of the lake). 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.

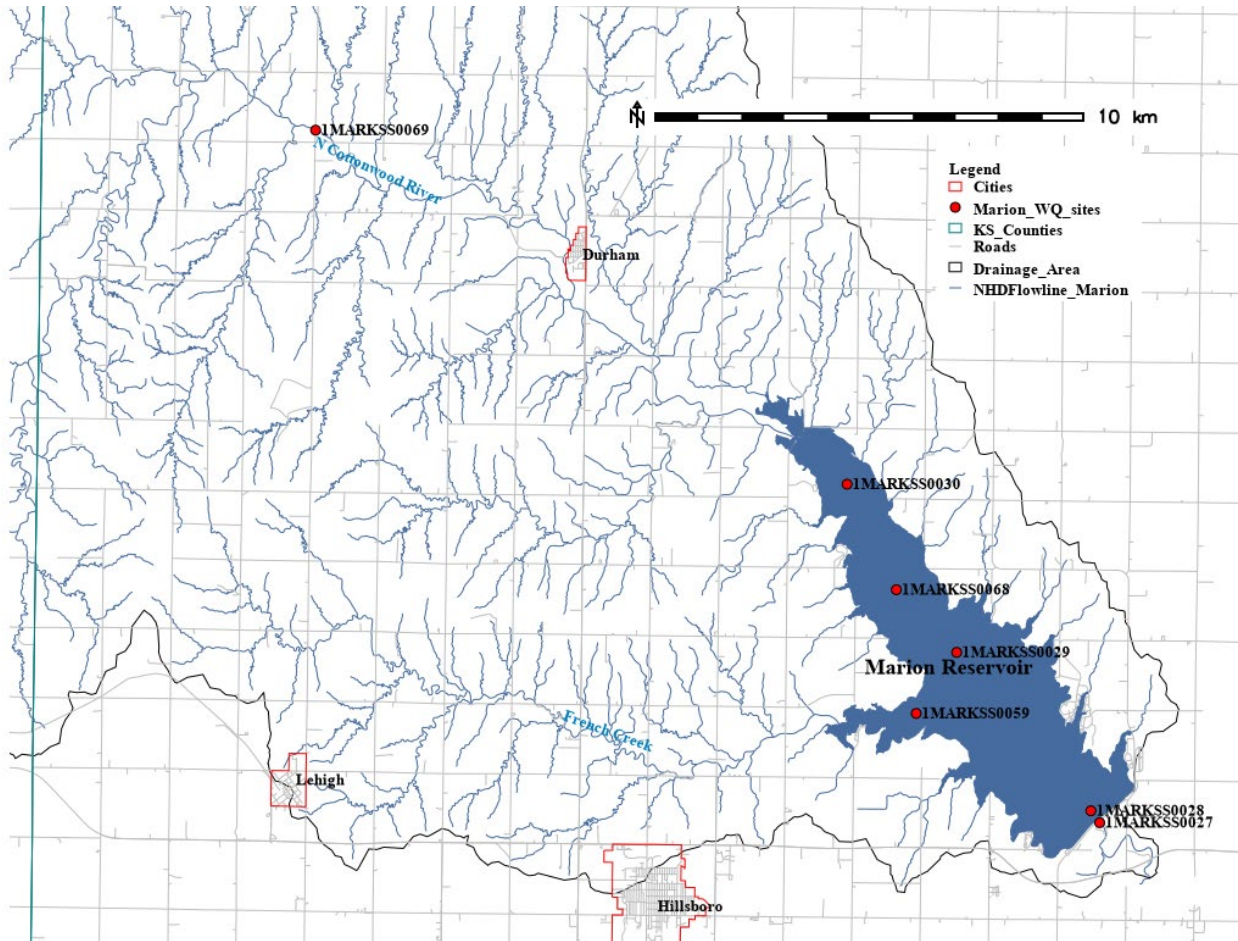


Figure 2. Locations of water quality sampling sites at Marion Reservoir, KS, 2006.

Marion Reservoir pool elevation was below conservation pool elevation throughout calendar year 2006 and decreased from a peak of 1349.79 feet in May through the sampling period. Calendar year 2006 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

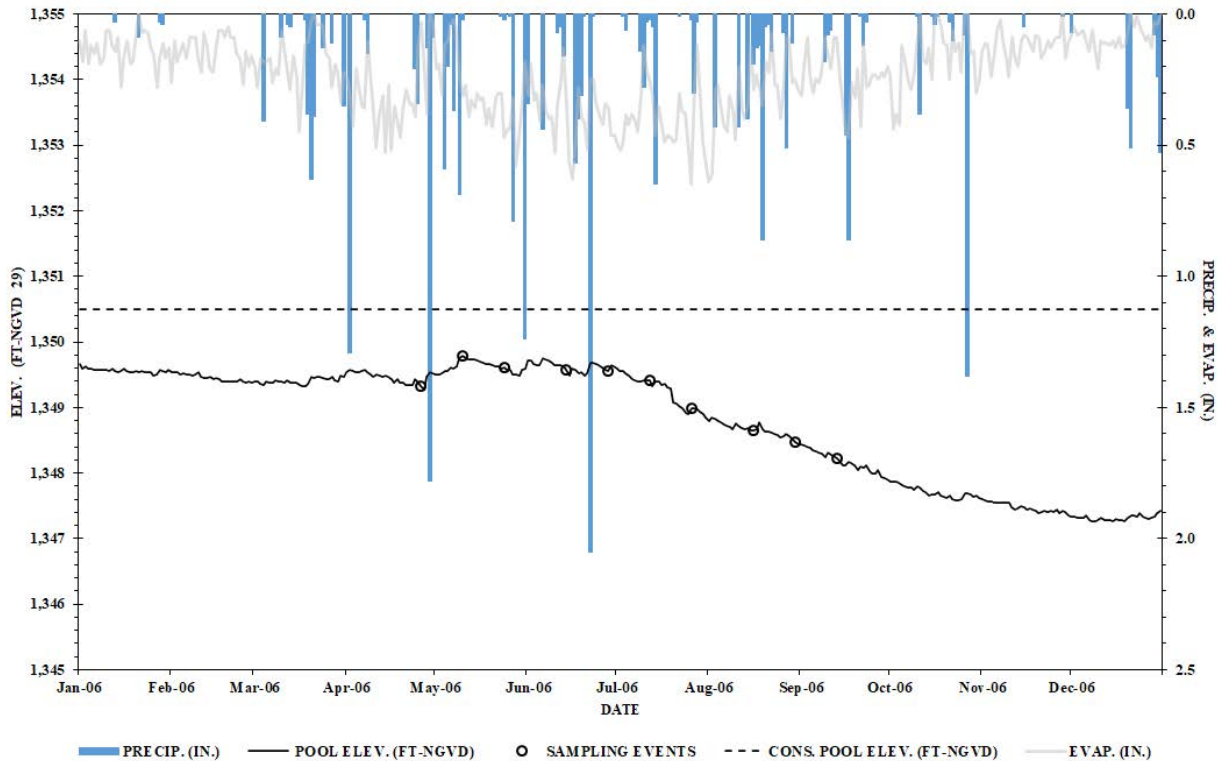


Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), basin precipitation and evaporation (in.), and water quality sampling dates at Marion Reservoir, KS, 2006.

Water temperatures varied seasonally (ranging from 11.96 to 26.78 °C) peaking in July, but lake-wide water temperatures, on individual sampling dates, displayed nominal variation. The reservoir experienced weak thermal stratification in June 2006 with anoxic conditions at depth. The study period median dissolved oxygen concentration was 8.14 mg/l. Super-saturation of dissolved oxygen (11.82 mg/l, 141.9%) was observed at the dam site in June corresponding with a high chlorophyll-*a* (86.8 µg/l) concentration. Lake-wide total organic carbon concentrations were moderately high with a study period median of 5.5 mg/l.

Specific conductance (median 579 µS/cm) was moderately elevated, consistent with regional norms. Moderate chloride concentrations were observed (median 12 mg/l). Alkalinity levels (median 100.0 mg/l as CaCO₃ [2004 and 2005]) imply a reasonably well-buffered system capable of maintaining pH levels. Hardness levels (2004 and 2005) were exclusively higher than 150 mg/l as CaCO₃, indicating 'hard' water. Observed pH (7.80 to 8.90) ranged within regional norms.

The lake was moderately turbid in 2006, due to suspended organic and inorganic particles. Maximum recorded Secchi depth was 1.20 meters, and the study period median was 0.39 meters. Total suspended solids concentrations (median 18.0 mg/l) were influenced by sediment-laden inflows during runoff events, and re-suspension of bottom sediment through wind and wave action. The euphotic zone at Marion Reservoir was typically ~1 meter.

Ammonia concentrations were typically low (median 0.08 mg/l), and nitrite plus nitrate concentrations were low (median 0.01 mg/l). Total Kjeldahl nitrogen concentrations (median 0.98 mg/l) were moderately high. Estimated median total nitrogen concentration during the 2006 study was ~1.0 mg/l. Total phosphorus concentrations ranged between 0.03 and 0.40

mg/l (median 0.15 mg/l) with elevated observations occurring throughout the summer months. Observations of dissolved ortho-phosphate, median 0.06 mg/l, were elevated (>0.10 mg/l) at depth at the dam site in June, and throughout the lake in late July and early August. Nitrogen to phosphorus ratios (N:P) in 2006 were <10 (median 7.0), indicating a tendency toward limited nitrogen availability.

Chlorophyll-a concentrations ranged from 1.8 to 96.1 µg/l through the study period, with a median concentration of 23.2 µg/l, indicating a highly productive system. The trophic status of Marion Reservoir from 2004 through 2006, assessed using Carlson's trophic state index (TSI), indicates a eutrophic lake as measured by each of the indices including Secchi depth (TSI(SD)), total phosphorus concentrations (TSI(TP)), and chlorophyll-a concentrations (TSI(CHLa)) (Figure 4).

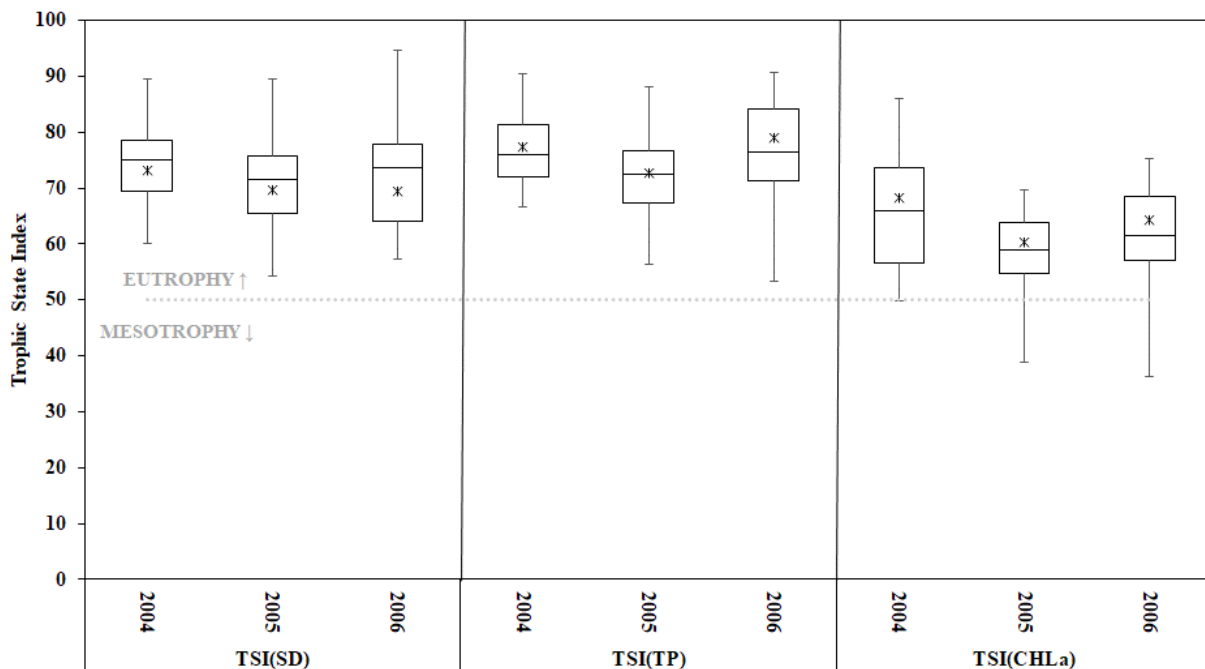


Figure 4. Distributions of Carlson's Trophic State Index (TSI), by year, based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-a concentrations (TSI(CHLa)) at Marion Reservoir, KS.

Total iron (median 0.895 mg/l) and manganese (median 0.151 mg/l) concentrations were high. Surface (0.5 m depth) total iron concentration observations in the main body increased from May through mid-August. Surface iron concentration observations at the upper lake site (MARKSS0030) were exclusively greater than 1.0 mg/l. Similarly, surface observations of total manganese increased from May through mid-August in the main body of the lake and observations at the upper lake site were exclusively greater than 0.10 mg/l. Priority pollutant metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury) were not assessed in the 2006 study, but 2004 samples revealed detectable concentrations of arsenic, and mercury.

Water samples were collected each sampling trip in the stilling basin below the Marion Reservoir dam at site MARKSS0027. Generally, mean and median parameter results are comparable to in-lake data collected near the dam (MARKSS0028).

USACE conducted a water quality study of Marion Reservoir, KS in 1997 and noted low surface dissolved oxygen concentrations near Durham Cove, reduced water clarity limiting lake productivity, high nutrient concentrations, elevated mercury concentrations, and a potential shift to a greater abundance of cyanophytes.