Pat Mayse Lake Water Quality: 2013

The Pat Mayse Lake Dam is located at River Mile 4.6 on Sanders Creek, a tributary of the Red River, approximately 1.5 miles southwest of Arthur City, Texas (TX), and 12 miles north of Paris in Lamar County, TX within Hydrologic Unit Code 1114010605. The conservation pool of Pat Mayse Lake was first filled in April 1968 after final storage began in September 1967. Authorized purposes include flood damage reduction, water supply, fish and wildlife, and recreation. The watershed above the Pat Mayse Lake dam site extends southwest of the dam about 26 miles just north of Honey Grove, TX and encompasses ~178 square miles (Figure 1) with basin elevations ranging from about 460 feet below the dam to ~704 feet. Land use/cover in the basin is dominated by grassland/pasture (~39%), forest (~31%), and cultivated cropland (~13%). At the conservation pool elevation of 451.0 feet (NGVD 29), lake capacity, based on the most recent bathymetric survey conducted in 2019 is 107,630 ac-ft. Original conservation pool capacity was estimated to be ~123,000 ac-ft. These estimates suggest an annual conservation pool sedimentation rate of ~300 ac-ft/yr. Descriptive characteristics of Pat Mayse Lake are included in Table 1.

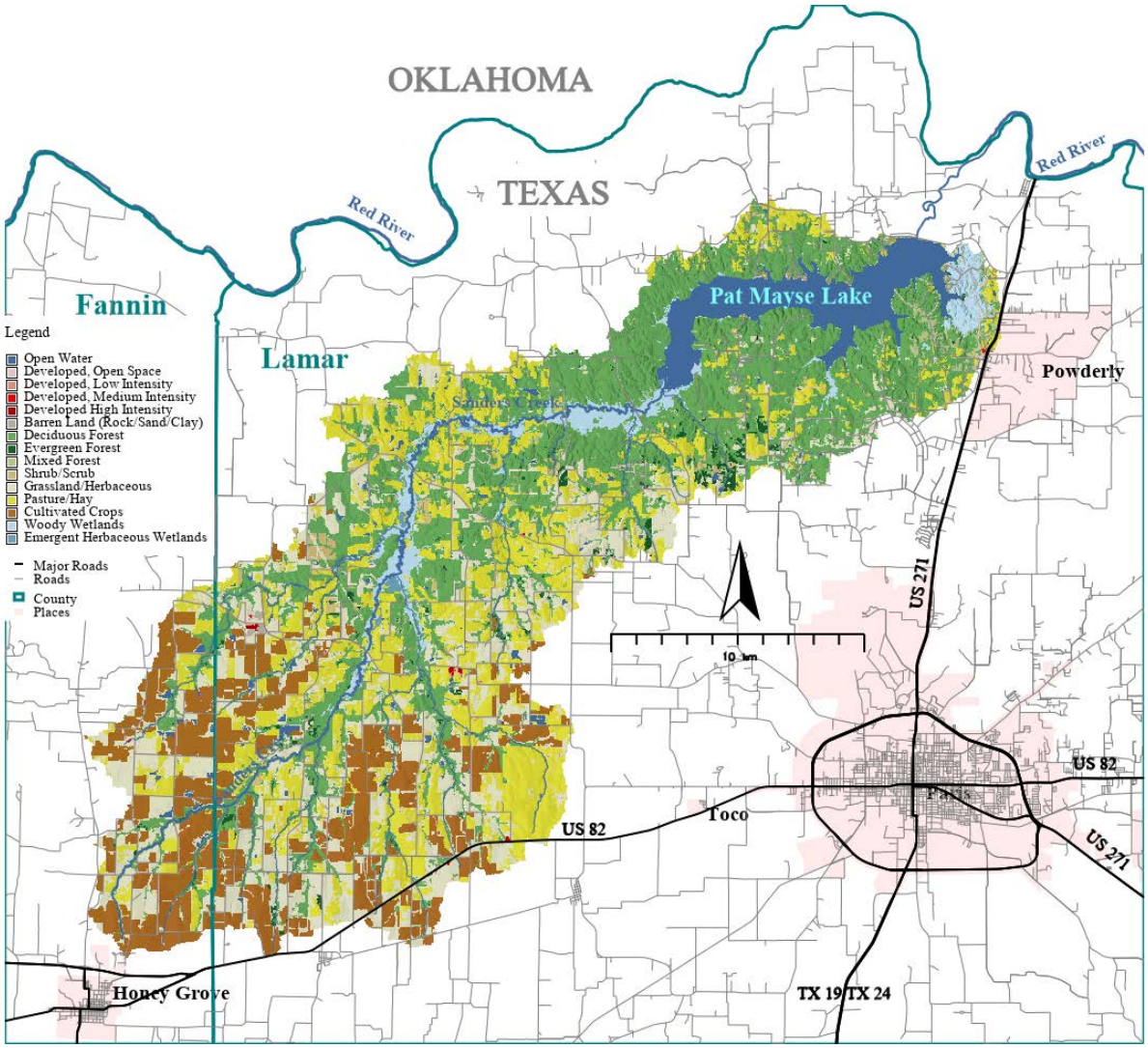

Figure 1. The Pat Mayse Lake, TX Watershed.

Table 1. Descriptive Characteristics of Pat Mayse Lake, TX.

Parameter	English Units	Metric Units
Lake Elevation (Conservation Pool)	451.0 ft. [NGVD29]	137.46 m
Lake Surface Area (Conservation Pool)	*5,500 ac	2,225.8 ha
Lake Volume (Conservation Pool)	*107,630 ac-ft	132,759,650 m^3
Total Drainage Area	177.8 mi^2	460.5 km^2
Mean Depth	*19.6 ft.	6.0 m
Maximum Depth (Conservation Pool)	*50 ft.	15.2 m
Shoreline Length	56.1 mi	145.3 km
Shoreline Development Index	5.25	5.25
Total Annual Inflow, Average 1929– 2013 [Water Years]	111,300 ac-ft	137,286,529 m^3
Total Annual Inflow, 2013 [Calendar Year]	33,352 ac-ft	41,139,168 m^3
Hydraulic Residence Time, 2013 [Calendar Year]	1,148.87 d	2.87 yr

Data derived from the Tulsa District's Pertinent Data Book (U.S. ACE - Tulsa District, 2004), the FY 2013 Annual Water Control Report (U.S. ACE - SWD RCC, 2014), and Tulsa District's Water Control page for Pat Mayse Lake (U.S. ACE - Tulsa District, 2021), *Data derived from 2019 survey (Seaworks Group, LCC, 2019).

Use designations (TCEQ, 2022) for Pat Mayse Lake include primary contact recreational with significant risk of ingestion of water (PCR1), high aquatic life use (H), and domestic [public] water supply (PS). Based on the 2022 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d), (TCEQ, 2022), Pat Mayse Lake is listed as impaired by excessive algal growth in water.

Physical and chemical water quality data were collected approximately monthly from three in-lake sites and Sanders Creek above the lake beginning March 20 and ending September 17, 2013. Sampled sites included PATTXN0007 (near dam), PATTXN0011 (mid-lake over channel), PATTXN0009 (upper lake), and PATTXN0010 (Sanders Creek, above 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.

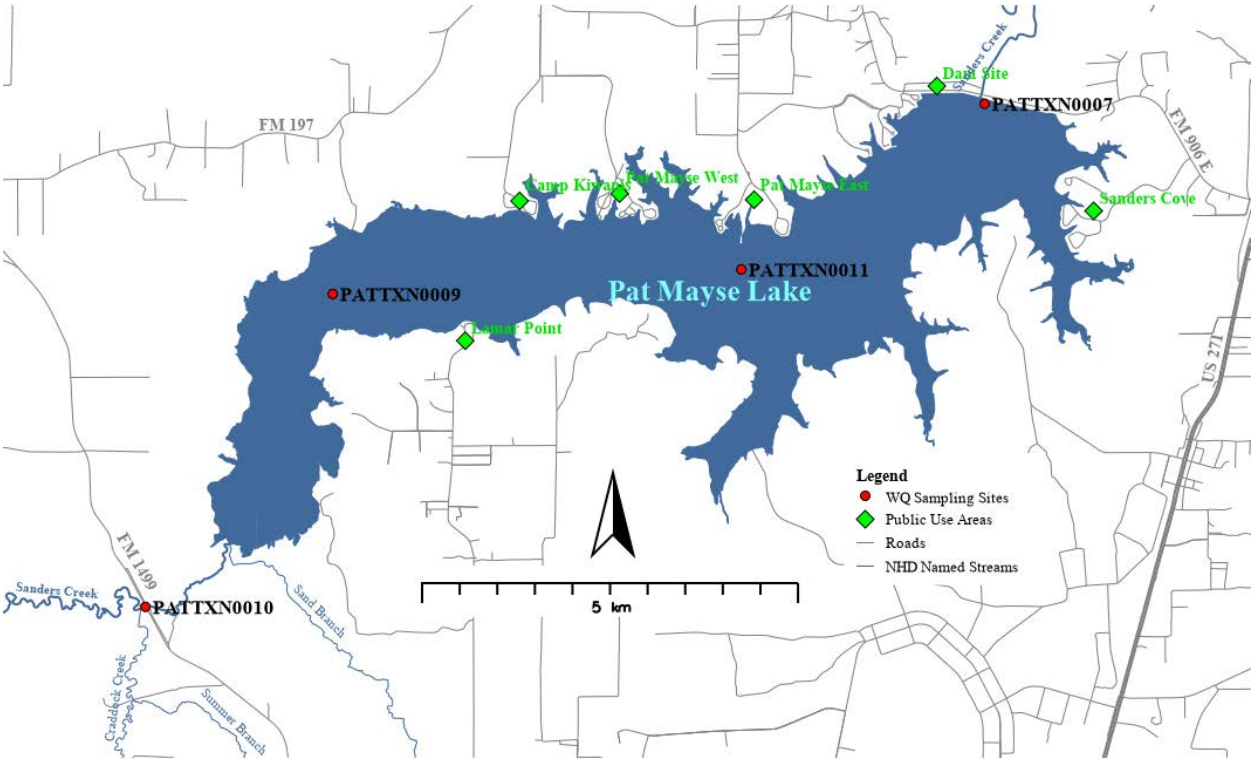

Figure 2. Locations of water quality sampling sites at Pat Mayse Lake, TX, 2013.

The Pat Mayse Lake pool elevation remained well below the conservation pool elevation of 451.0 feet throughout the year precluding releases from the morning glory outlet. Calendar year 2013 lake elevation, conservation pool elevation, basin precipitation, calculated evaporation rate, and water quality sampling dates are shown in Figure 3.

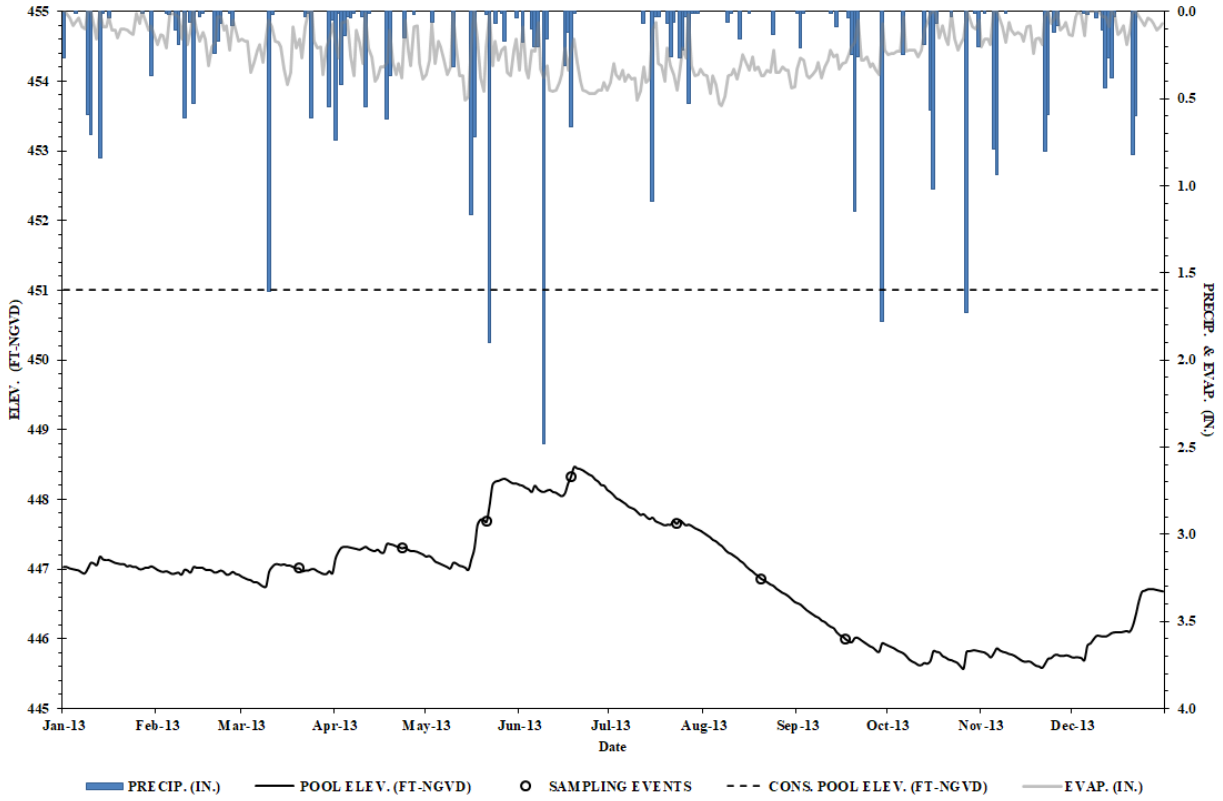

Figure 3. Daily lake elevation (feet, NGVD at 0800 hours), conservation pool elevation (feet), basin precipitation and evaporation (in.), and water quality sampling dates at Pat Mayse Lake, TX, 2013.

Water temperatures generally increased through the sampling period (ranging from 10.32 to 27.60 ºC) peaking in September. Lake-wide water temperatures, on earliest sampling dates (March and April), displayed nominal variation. The reservoir experienced thermal stratification starting in May and extending into September 2013 with significant temperature variation between surface and depth. The study period median dissolved oxygen concentration was 8.07 mg/l. Hypoxia, dissolved oxygen concentration <2 mg/l, was observed at depth at the dam site (PATTXN0007) May through September, at depth at the mid-lake site (PATTXN0011) June through August, and at the upper lake site (PATTXN0009) in June and July. Lake-wide total organic carbon concentrations were moderately high, peaking in September, with a study period median of 5.5 mg/l.

Specific conductance (median 156 µS/cm) was consistent with regional norms. Total dissolved solids median concentration was 113 mg/l. Median concentrations of calcium, magnesium, sodium, and potassium were 19.5, 2.34, 6.94, and 3.26 mg/l, respectively. Low to moderate chloride and sulfate concentrations (medians 6.92 and 13.40 mg/l, respectively) were observed. Lake-wide concentrations of chloride tended to drift upward through the sampling period, while sulfate concentrations drifted down. Alkalinity levels (median 52.4 mg/l as $CaCO_3$) imply a moderately well-buffered system capable of maintaining pH levels. Hardness levels, median 59.2 mg/l as $CaCO_3$, indicate 'soft' water. Observed pH (6.88 to 8.95) ranged within regional norms. Lowest pH observations were recorded in September at depth (PATTXN0007) with corresponding low (<0.5 mg/l) dissolved oxygen concentrations. Highest pH observations were observed July through September corresponding with relatively high dissolved oxygen (and chlorophyll-*a*) concentrations indicating abundant algal activity.

The lake was moderately turbid through 2013. Maximum recorded Secchi depth was 1.67 meters, and the study period median was 0.85 meters. Lake-wide mean turbidity was 15.4 NTU. Approximately 10% of all turbidity observations exceeded 25 NTU. Total suspended solids concentrations (median 9.0 mg/l) were highest in March and September. The euphotic zone at Pat Mayse Lake was typically between 2 to 4 meters.

Ammonia concentrations tended to increase through the sampling period (median 0.030 mg/l) corresponding with lake stratification. Nitrite plus nitrate concentrations were low (median 0.02 mg/l). Total Kjeldahl nitrogen concentrations (median 0.67 mg/l) were moderately high. Estimated median total nitrogen concentration during the 2013 study was ~0.69 mg/l. Total phosphorus concentrations ranged between <0.04 and 0.888 mg/l (median 0.026 mg/l). No observations of dissolved ortho-phosphate concentration were above the analysis method detection limit of 0.05 mg/l. Surface nitrogen to phosphorus concentration ratios (N:P) in 2013 were elevated (median 50.5), indicating likely phosphorus limitation of algal growth at Pat Mayse Lake. Lake-wide N:P ratios tended to decrease through the sampling period from a high in March of 308, to a low in September of 31.1.

Chlorophyll-*a* concentrations ranged from 6.6 to 46.2 µg/l, with a median concentration of 20.7µg/l. Observations were greater than 12.40 µg/l, the TX Water Quality Standards chlorophyll-*a* criterion, at all in-lake sites in all months except May and June. The trophic status of Pat Mayse Lake in 2013, assessed using Carlson's trophic state index (TSI), indicated a eutrophic lake as measured by Secchi depth (TSI(SD), 62.3) and chlorophyll-*a* concentrations (TSI(CHLa), 60.3). The index developed from total phosphorus concentrations (TSI(TP), 47.4) corresponds with N:P ratio results suggesting low available phosphorus concentrations potentially limiting algal growth (Figure 4).

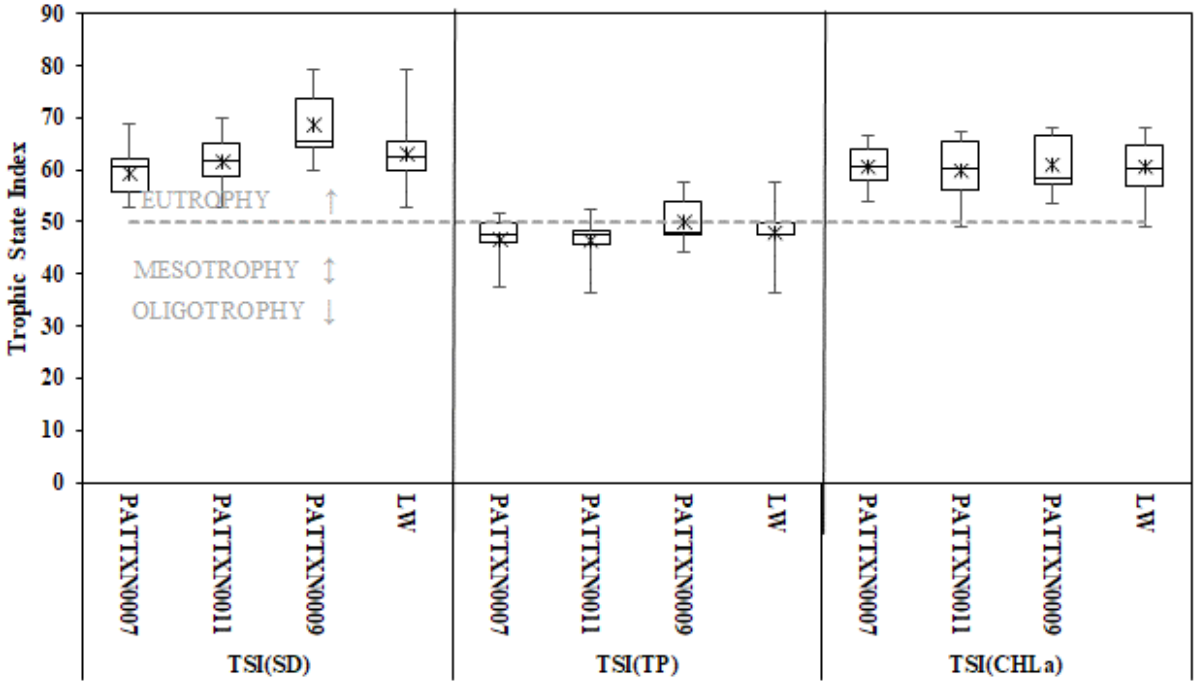

Figure 4. Distributions of Carlson's Trophic Sate Index (TSI), by sampling site and lake-wide (LW), based on observations of Secchi Depth (TSI(SD)), surface total phosphorus concentrations (TSI(TP)), and chlorophyll-*a* concentrations (TSI(CHLa)) at Pat Mayse Lake, TX, 12-MAR through 10-SEP-2013.

Total iron (median 0.248 mg/l) and manganese (median 0.079 mg/l) concentrations were elevated at depth July through September. Water samples from Pat Mayse Lake were analyzed for total concentrations of priority pollutant metals. Analysis results from Pat Mayes lake were compared to State of Texas toxicant inorganics numerical criteria. Of the priority pollutant metal concentrations monitored in 2013, three arsenic observations exceeded current Human Health (Water and Fish) criteria (10 µg/l). No other inorganics criteria exceedances were noted.

Water samples were collected from Sanders Creek at FM 1499 (about 1.25 stream miles above the lake) March through September 2013 (site PATTXN0010). Higher concentrations of total suspended solids, ammonia, total Kjeldahl nitrogen, total phosphorus, total organic carbon were observed at PATTXN0010 compared to the upper lake site, PATTXN0009, and the lake as a whole.

USACE conducted a water quality study of Pat Mayse Lake, TX in 1999. Thermal stratification and anoxia within the hypolimnion was noted beginning in June 1999 at all three in-lake sites. Lake waters were only moderately turbid (Secchi depth and turbidity medians of 1.12 meters and 5.9 NTUs, respectively). Median June through August dissolved oxygen concentration was 5.41 mg/l. Median ammonia and total Kjeldahl nitrogen concentrations were comparable to 2013 observations with concentrations of 0.05 and 0.60 mg/l, respectively. Total phosphorus 1999 median concentration was 0.05 mg/l. Comparing combined data from the three in-lake stations only (PATTXN0007, PATTXN0011, and PATTXN0009) indicates generally similar water quality conditions between 1999 and 2013 with notable differences in water clarity (2013 more turbid than 1999) and chorophyll-*a* concentrations (2013 concentrations greater than 1999).