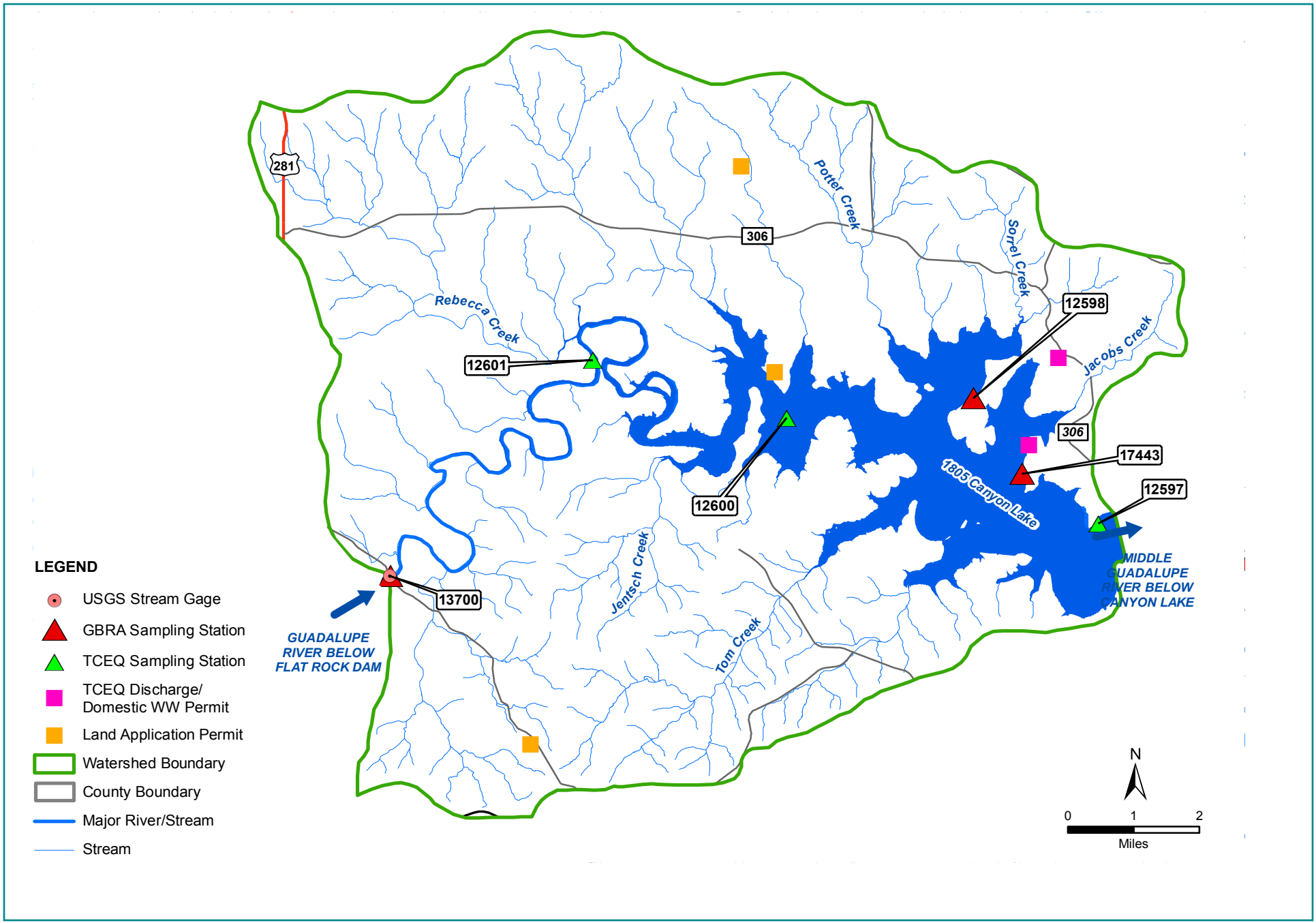
CANYON LAKE


281
306
Potter Creek
Sorrel Creek
Rebecca Creek
Jacobs Creek
12598
12601
306
17443
1805 Canyon Lake
12600
12597
Jentsch Creek
Tom Creek
13700
GUADALUPE RIVER BELOW FLAT ROCK DAM
MIDDLE GUADALUPE RIVER BELOW CANYON LAKE
LEGEND
USGS Stream Gage
GBRA Sampling Station
TCEQ Sampling Station
TCEQ Discharge/ Domestic WW Permit
Land Application Permit
Watershed Boundary
County Boundary
Major River/Stream
Stream
N
0
1
2
Miles

CANYON LAKE

Segment 1805 represents the portion of the Guadalupe impounded in Canyon Lake. This stream segment encompasses the area upstream of Canyon Dam to a point 1.7 miles downstream of Rebecca Creek Road in Comal County. A total of 1432 square miles drain into Canyon Lake. The lake is used for conservation of water, flood control, and recreation. Construction of the dam began in 1958 and ended in 1964, when the first water impoundment began. The normal maximum operating level of the reservoir is 909 feet above mean sea level (msl) with a conservation storage capacity of 382,000 acre-feet, a shoreline of 80 miles and a surface area of 8,240 acres. The stream segment has been divided by the TCEQ into four assessment units: 1805_01 is in the cove around Jacob's Creek Park, 1805_02 is near the center of the lake from the north end of Crane's Mill Park peninsula to the south of Canyon Park, 1805_03 is the upstream portion of the segment, and 1805_04 is between Canyon Dam and Canyon Park.

The total reservoir storage of Canyon Lake is divided into three sections. The dead pool is the portion of water in the reservoir below 775 msl that cannot be drained through the dam by gravity (71 acre-ft). The conservation pool is the dead pool capacity subtracted from the design conservation capacity of the lake (378,781 acre-ft), between 775 msl and 909 msl. The flood pool is the storage capacity at the point when the spillway is crested at 943 msl, to the top of the conservation pool at 909 msl (373,738 acre-ft). Canyon Lake is operated by two governmental entities. The United States Army Corp of Engineers (USACE) owns the 6,830 foot long earthen dam, and controls the release of water in the flood pool above 909 msl. The Guadalupe-Blanco River Authority (GBRA) has the rights to the use and release of water in the conservation pool, when the lake level is between 775 msl to 909 msl. The water in the conservation pool is used for water supply to municipalities, industries, agricultural irrigation, and hydroelectric power generation.

Canyon is a holomytic lake, which means that it experiences uniform water temperatures throughout the entire depth of the lake during the winter months. The lake is also monomictic, which means that it usually only experiences a single thermal stratification event during the early summer. The epilimion water layer is the uppermost layer of a thermally stratified lake near the surface, which becomes significantly warmer and less dense than the hypolimnion water layer at the bottom due to solar radiation. This causes the lake to separate around a transitional thermocline water layer, where the temperature rapidly decreases below the surface layer. Precipitation and freshwater discharges into the lake are particularly influential on the amount of mixing that occurs in the lake. Thermal stratification of the lake is usually less pronounced during periods of high rainfall because the influx of water and subsequent releases from the bottom of the dam cause mixing of the eplimnion and the hypolimion. The hypolimion layer at the bottom of the lake also tends to

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Canyon Lake
Drainage Area: 1432 square miles
Reservoir Surface Area: 8,308 acres
Reservoir Conservation Capacity: 378,781 acre-ft
Tributaries of Canyon Lake: Rebecca Creek, Shultz Creek, Jentsch Creek, Tom Creek, Potter Creek, Sorrel Creek, Jacobs Creek
Aquifer: Trinity, Edwards Plateau
River Segments: 1805
Cities and Communities: Sattler, Startzville, Cranes Mill, Hancock
Counties: Comal
EcoRegion: Edwards Plateau
Climate: Average annual rainfall 37.43 inches, Average annual temperature 19.36°C
Vegetation Cover: Evergreen Forest 64.19%, Deciduous Forest 8.49%, Shrubland 10.98%, Grassland 8.35%, Woody Wetlands .08%, Cultivated Crops 0.08% , Pasture Hay 0.75%
Land Uses: unincorporated suburban sprawl, cattle, goat and sheep production, light industry, and recreational.
Development: Low Intensity 1.3% ; Medium Intensity 0.2%; High Intensity 0.06%; Open Space 3.94%
Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils: Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities: Land Application 1, Domestic 2

experience seasonal anoxic conditions as inflows of organic matter are deposited near the dam and broken down by bacteria. Biological organisms deplete the dissolved oxygen from the bottom layer of the lake and then use the oxygen from any available nitrate or sulfate molecules in the water. This process can sometimes cause a "rotton egg" smell to occur in the discharges downstream of the dam as the sulfate molecules are reduced and hydrogen sulfide molecules are formed.

Two permitted wastewater discharges occur in Canyon Lake. Both wastewater treatment facilities (WWTFs) discharge directly into a cove on the north side of the lake around Jacob's Creek Park, in assessment unit 1805_01. The GBRA operates the Canyon Park Estates Wastewater Treatment Facility (CPE WWTF), which is permitted to discharge up to 0.26 million gallons per day (MGD). The CPE WWTF discharges a very high quality effluent, with an average daily biochemical oxygen demand (BOD) of 5 milligrams per liter (mg/L), total suspended solids (TSS) of 5 mg/L, ammonia nitrogen (NH3-N) of 2 mg/L and total phosphorus (TP) of 1 mg/L and 126 MPN/100 mL of E. coli. The second WWTF on the lake is owned and operated by the U.S. Department of the Air Force and is permitted to discharge 0.0125 MGD of treated wastewater. The effluent for this WWTF has an average daily BOD of 10 mg/L, a TSS of 15 mg/L and an E. coli concentration of 126 MPN/100 mL. The remaining developments around the lake are served by septic tanks permitted by Comal County. The USACOE has an ordinance that prohibits placement of septic systems, plumbing and electricity below 948 msl and requires Corp approval of other construction around the lake.

In 2005, the Texas Parks and Wildlife Department collected and analyzed a composite sample from 3 largemouth bass for mercury. The initial results from this sample indicated that the 0.7 milligrams per kilogram (mg/kg) concentration of mercury in this sample exceeded the human health screening criteria of 0.525 mg/kg. This finding prompted the Department of State Health Services (DSHS) to perform additional fish tissue monitoring for mercury. In November of 2005, the DSHS collected 30 fish samples from Canyon Lake spread across three different locations near the dam (AU 1805_04), in the middle portion of the lake (AU 1805_02) and in the upper portion of the lake (AU 1805_03).

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Largemouth bass, striped bass, blue catfish, flathead catfish, longnose gar and white bass were collected during the study. All fish samples collected during the study contained detectable levels of total mercury. The mean concentrations for longnose gar (0.772 mg/kg) and striped bass (1.149 mg/kg) were determined to exceed the chronic ingestion minimal risk level if more than two 8 ounce portions of these fish were consumed per month by adults or two 4 ounce portions were consumed by children under the age of 12. As a result of this study, all four assessment units of Canyon Lake were recognized as impaired for fish consumption due to mercury in edible fish tissue. Fish can absorb methylmercury from water or feeding more quickly than it passes through their bodies. This process can lead to bioaccumulation of toxic methylmercury in the tissues of the fish and often occurs more frequently in larger predatory fish. To date, no direct sources of mercury into Canyon Lake have been discovered. Atmospheric deposition from airborne emissions produced by coal power plants and industrial uses remains the most likely source.

The Texas Parks and Wildlife Department has been monitoring for invasive Zebra Mussels (Dreissena Polymorpha) since they were first discovered in Texas in April 2009. Zebra Mussels were accidently introduced into the U.S. Great Lakes from the Balkans in 1986. The high proclivity and unique ability of this species to hitch rides on recreational watercraft have allowed them to quickly make their way down the Mississippi River drainage to the waterways of the southern U.S. Adult mussels are less than 1.5 inches long and have a long smooth shell with a zebra striped pattern on the surface. These mussels form large clusters which can cause significant economic and environmental damage by attaching to all sorts of natural and artificial surfaces such as submerged pipes, recreational boats, and even the shells of native freshwater mussels. On June 8th of 2017, employees of the Crane's Mill Marina discovered a boat parked in a slip with Zebra Mussels attached to the hull. A TPWD fisheries biologist and Game Warden investigated the boat and verified the presence of Zebra Mussels. The TPWD conducted additional plankton monitoring at multiple sites throughout the lake and found microscopic zebra mussel larvae at multiple stations. The identification of both adults and larval mussels confirmed that Canyon Lake has an established reproducing population. The TPWD has designated Canyon Lake as fully infested, along with 12 other lakes in Texas. Canyon is the southernmost lake in the United States with a breeding population of Zebra Mussels, but many other water bodies in the area are now in significant danger of infestation because the microscopic larvae and adults can be easily transported on boats and trailers without being seen. Proper decontamination protocols for boats and trailers that are transported between freshwater reservoirs are being strictly enforced in order to prevent the spread of these organisms. The TPWD requires all boats and onboard receptacles to be completely drained of water and dried before entering or leaving a body of freshwater. The TPWD and the GBRA have partnered to actively monitor the reservoirs downstream of Canyon Lake with deployed recruitment traps, as well as microscopic and DNA analysis of plankton samples collected in the spring and fall of each year, in order to document any further spread of these organisms.

The TCEQ has divided Canyon Lake into four assessment units. All four assessment units have at least one monitoring station where data is collected at a routine frequency by either the TCEQ or the GBRA. The main body of the lake is divided into three assessment units that are all monitored for conventional and bacteria parameters at the surface and for field measurements such as temperature, pH, dissolved oxygen and specific conductance throughout the water column. A fourth assessment unit is monitored at the surface of the coves on the north sides of the lake. All five active monitoring stations were analyzed for trends in water quality and compared against TCEQ water quality screening criteria. The EPA has mandated that states incorporate numerical nutrient criteria into their water quality standards in order to evaluate nutrient impacts from discharge permits. The TCEQ had previously developed preliminary numerical screening levels for total phosphorus, nitrate nitrogen, and chlorophyll a concentrations. In 2010, the TCEQ developed numerical nutrient indicator criteria for many of the reservoirs in Texas. The numerical criterion that the TCEQ has developed for evaluation of Canyon Lake is a chlorophyll-a concentration of 27.60 µg/L.

The body of Canyon Lake between the dam and Canyon Park peninsula is defined by assessment unit 1805_04. This AU is represented by a single monitoring station 12597, which is monitored by the TCEQ on a quarterly basis. This station is located by the dam close to the north side of the lake. The deepest monitoring depth recorded at this station was 42.6

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meters, but the historical average depth is 29.3 meters. All conventional and bacteria parameters are collected at a surface depth of 0.3 meters, but depth profiles for temperature, dissolved oxygen, pH and specific conductance are regularly performed by the TCEQ at this station. A depth profile at this station consists of a measurement at 0.3 meters from the surface, another measurement at 1.0 meters from the surface, additional measurements at 3.0 meters increments, and a final measurement at 0.3 meters above the bottom. The average temperature at the bottom of the lake is 15.3°C, compared to 19.1°C at the surface. The average dissolved oxygen readings ranged from 8.7 mg/L at the surface to 4.4 mg/L at the bottom. Dissolved oxygen values of 0 mg/L have been recorded near the bottom of the lake during periods of thermal stratification. Mean total dissolved solid (TDS) concentrations ranged from 255 mg/L at the surface to 272 mg/L at the bottom. The average pH ranged from 8.2 standard units at the surface 7.7 at the bottom of the lake. The average concentrations of all water quality parameters collected at 0.3 meters from the surface were within the TCEQ screening criteria. The only water quality parameter that showed

a significant change over time at this station was chloride, which is significantly increasing (Figure 1). The increasing level of chlorides is mostly likely due to the influence of several years of drought that began 2008. During this time period, fresh water inflows were reduced and salts became more concentrated in the water column. The average chloride concentration of 16.8 mg/L remains well below the state screening criteria of 50.0 mg/L.

The middle of the lake is defined by assessment unit 1805_02. This AU stretches through the middle of the lake body from the south end of the Canyon Park peninsula to the north end of the Crane's Mill Park peninsula. This AU is represented by monitoring station 12600, which is located in the middle of the lake south of Potter's Creek Park. This maximum depth recorded at this station was 70.0 meters with an average sampling depth of 19.2 meters. The average temperature at this station ranged from 22.6°C at the surface to 18.2°C at the bottom. The average total dissolved solids ranged from 259 mg/L at the surface to 270 mg/L at the bottom. The average dissolved oxygen ranged from 8.6 mg/L at the surface to 5.1 mg/L at the bottom. Dissolved oxygen concentrations of 0 mg/L were measured at the bottom of the lake. The average pH ranged from 8.2 at the surface to 7.8 at the bottom. The only significant trend in this portion of the lake was an increase in chloride concentrations over time (Figure 2). Water quality conditions at this station were very similar to station 12597 near the dam.

The most upstream portion of the lake body is defined by assessment unit 1805_03. This portion of the lake shares many similar properties to the more riverine portions of the Guadalupe River, including shallower depths, narrower banks, and a more sinuous flow path. The only monitoring station in this AU is station 12601, which is located near the headwaters of Canyon Lake upstream of Crane's Mill Park. This station is monitored quarterly by the TCEQ. The maximum depth recorded at this station was 13.8 meters with an average depth at the sampling point of 7.5 meters. Depth profiles for this station were collected in one meter increments in order to better identify thermal differentials. The average temperature at this station ranged from 22.8°C at the surface to 21.4°C at the bottom. The average total dissolved solids ranged from 269 mg/L at the surface to 282 mg/L at the bottom. The average dissolved oxygen ranged from 8.4 mg/L at the surface to 6.5 mg/L at the bottom. Dissolved oxygen concentrations of 0.2 mg/L were measured at the bottom of the lake. The average pH ranged from 8.2 at the surface to 8.0 at the bottom. Much like the rest of Canyon Lake, the only significant water quality trend that could be identified at this station was an increase in chloride levels over time (Figure 3).

The final assessment unit of Canyon Lake is 1805_01, which covers the two coves on the north side of the lake between Jacob's Creek park peninsula and Canyon Park peninsula and between Canyon Park peninsula and the southeast end of Potter's Creek peninsula. This AU is uniquely representative of recreational use because it is the location of a major public boat launch for the north side of the lake near Farm to Market Road 306. This cove also contains at least three major private boat launches in Canyon Park, Jacob's Creek Park and Joint Base San Antonio. Monitoring for this AU is conducted by the GBRA at two shoreline stations located near recreational boat launches. Both of these stations are usually less than 1.5 meters deep and measurements are collected at 0.3 meters from the surface. Station 12598 is located at the private boat launch for Canyon Park Marina on the west side of the Canyon Park peninsula. This station is monitored monthly and has a mean temperature of 22.7°C, TDS of 259 mg/L, dissolved oxygen concentration of 9.3 mg/L and a pH of 8.2. Canyon Park Marina is one of the locations being monitored for Zebra Mussels and in November of 2017 adult mussels colonized a recruitment sampler that had previously been deployed by the GBRA. The other station on this AU is 17443 located at the Jacob's Creek Park private boat ramp on the west side of the Jacob's Creek peninsula. This location is also located in the same cove as the only two permitted wastewater discharges to the lake. This station is monitored on a quarterly basis by the GBRA and mean field measurements at this station are very similar to station 12598 with an average temperature of 22.1 °C, TDS of 259 mg/L, dissolved oxygen of 9.5 mg/L and a pH of 8.2. Although this AU is listed as impaired in the 2014 TCEQ Texas Integrated Report for mercury in edible fish tissue, none of the fish samples that led to this listing were collected in either of the coves that comprise this AU. The AU does have a concern for ammonia nitrogen because 28 of the 66 data points that were assessed in the 2014 integrated report exceeded the TCEQ nutrient screening criteria of 0.11 mg/L (Figure 4). This nutrient screening criteria has been set marginally higher than the current laboratory method reporting limit of 0.10 mg/L. None of the ammonia data collected at either of the monitoring stations in this AU during the years of 2016 or 2017 exceeded the method reporting limit. The previously measured exceedances of the screening criteria occurred during periods of excessive drought, which may have led to concentration of nutrients as lake levels declined. The only water quality trend that was identified at either of the monitoring stations in AU 1805_01 was an increase in salt anion concentrations. Both chloride and sulfate were found to be increasing over time at station 12598 (Figures 5 & 6), while only chloride was found to be increasing over time at station 17443 (Figure 7). The increasing concentrations of these parameters are also likely due to the effects from several years of prolonged drought.

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Table 1

Station 12597 – Canyon Lake at Canyon Dam 03/2003 - 08/2017					
AU 1805_04 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.0	30.0	10.5	52	32.20
Temperature (°C) at All Depths	19.1	30.0	10.0	789	32.20
pH (S.U.) at 0.3 meters	8.2	9.0	7.2	51	6.5 – 9.0
pH (S.U.) at All Depths	8.0	9.0	7.0	788	6.5 – 9.0
Chloride	16.8	22.0	11.0	54	50.00
Sulfate	21.7	27.0	16.0	54	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	255	309	225	52	400.00
Total Dissolved Solids (mg/L) at All Depths	262	346	225	788	400.00
NH3-N (mg/L)	<0.05	0.18	<0.02	52	0.11
Total Phosphorus (mg/L)	<0.04	<0.06	<0.02	52	0.20
Chlorophyll-a (µg/L)	<10.0	<10.0	<3.0	33	26.70
Nitrate Nitrogen (mg/L)	0.09	0.4	<0.02	52	0.37
TKN (mg/L)	0.26	0.37	<0.2	52	N/A
AU 1805_04 Recreational Use					
E.coli (MPN/100 mL)	2 Geomean	10	<1	51	126 Geomean
AU 1805_04 Aquatic Life Use					

Table 2

Station 12600 – Canyon Lake Mid Lake South of Potters Creek Park 03/2003 - 08/2017					
AU 1805_02 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.6	31.2	10.0	53	32.20
Temperature (°C) at All Depths	20.6	31.2	9.0	559	32.20
pH (S.U.) at 0.3 meters	8.2	8.6	7.1	53	6.5 – 9.0
pH (S.U.) at All Depths	8.1	8.6	6.8	559	6.5 – 9.0
Chloride	16.8	22.0	11.0	53	50.00
Sulfate	22.0	28.3	16.0	53	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	259	332	220	52	400.00
Total Dissolved Solids (mg/L) at All Depths	268	404	220	535	400.00
NH3-N (mg/L)	<0.05	0.24	<0.02	51	0.11
Total Phosphorus (mg/L)	<0.06	0.84	<0.02	52	0.20
Chlorophyll-a (µg/L)	<10.0	13.6	<3.0	32	26.70
Nitrate Nitrogen (mg/L)	0.12	0.63	<0.02	51	0.37
TKN (mg/L)	0.26	0.46	<0.1	49	N/A
AU 1805_02 Recreational Use					
E.coli (MPN/100 mL)	2 Geomean	77	<1	46	126 Geomean
AU 1805_02 Aquatic Life Use					

Table 3

Station 12601 – Canyon Lake Headwaters Upstream of Cranes Mill Park 03/2003 - 08/2017					
AU 1805_03 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.8	31.9	9.2	50	32.20
Temperature (°C) at All Depths	22.5	31.9	9.0	386	32.20
pH (S.U.) at 0.3 meters	8.2	9.0	7.6	50	6.5 – 9.0
pH (S.U.) at All Depths	8.1	9.0	7.0	386	6.5 – 9.0
Chloride	17.1	22.0	11.0	53	50.00
Sulfate	22.0	27.0	14.0	53	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	269	348	177	50	400.00
Total Dissolved Solids (mg/L) at All Depths	274	376	177	386	400.00
NH3-N (mg/L)	<0.05	0.18	<0.02	52	0.11
Total Phosphorus (mg/L)	<0.06	0.70	<0.02	49	0.20
Chlorophyll-a (µg/L)	<10.0	<10.0	<3.0	32	26.70
Nitrate Nitrogen (mg/L)	0.16	1.01	<0.02	52	0.37
TKN (mg/L)	0.29	0.74	<0.1	51	N/A
AU 1805_03 Recreational Use					
E.coli (MPN/100 mL)	3 Geomean	54	<1	48	126 Geomean
AU 1805_03 Aquatic Life Use					

Table 4

Station 12598 – Canyon Lake at Canyon Park Marina Boat Ramp 12/2002 - 11/2016					
AU 1805_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.7	36.3	10.9	177	32.20
Temperature (°C) at All Depths	23.0	36.3	10.9	195	32.20
pH (S.U.) at 0.3 meters	8.2	8.5	7.5	177	6.5 – 9.0
pH (S.U.) at All Depths	8.2	8.5	7.5	195	6.5 – 9.0
Chloride	16.8	24.6	6.6	162	50.00
Sulfate	22.0	29.5	13.8	162	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	259	342	149	177	400.00
Total Dissolved Solids (mg/L) at All Depths	260	342	149	195	400.00
NH3-N (mg/L)	<0.10	0.33	<0.02	81	0.11
Total Phosphorus (mg/L)	<0.05	0.16	<0.02	177	0.20
Chlorophyll-a (µg/L)	1.8	7.5	<1.0	177	26.70
Nitrate Nitrogen (mg/L)	0.12	1.22	<0.02	177	0.37
TKN (mg/L)	0.39	2.7	<0.2	81	N/A
AU 1805_01 Recreational Use					
E.coli (MPN/100 mL)	5 Geomean	2000	<1	159	126 Geomean
AU 1805_01 Aquatic Life Use					

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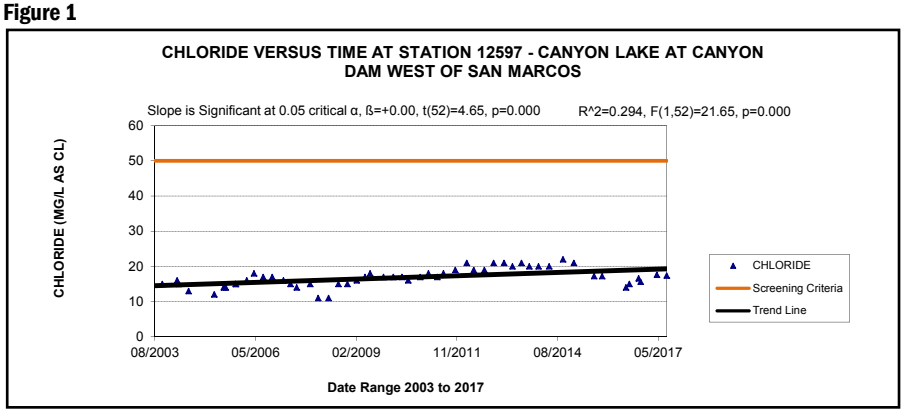
Table 5

Station 17443 – Canyon Lake at Jacob's Creek Park Boat Ramp 01/2003 - 11/2016					
AU 1805_01 General Use					
Parameter	Mean	Maximum	Minimum	# of Measurments	Screening Criteria
Temperature (°C) at 0.3 meters	22.1	31.5	11.4	54	32.20
pH (S.U.) at 0.3 meters	8.2	8.6	7.8	54	6.5 – 9.0
Chloride	16.8	32.0	7.2	54	50.00
Sulfate	22.7	78.3	11.4	54	50.00
Total Dissolved Solids (mg/L) at 0.3 meters	260	300	213	54	400.00
NH3-N (mg/L)	<0.10	0.38	<0.02	54	0.11
Total Phosphorus (mg/L)	<0.05	0.08	<0.02	54	0.20
Chlorophyll-a (µg/L)	1.6	10.8	<1.0	54	26.70
Nitrate Nitrogen (mg/L)	0.12	0.39	<0.02	53	0.37
TKN (mg/L)	0.26	0.63	<0.2	36	N/A
AU 1805_01 Recreational Use					
E.coli (MPN/100 mL)	3 Geomean	61	<1	54	126 Geomean
AU 1805_01 Aquatic Life Use					
Dissolved Oxygen at 0.3 meters	9.5	12.5	6.8	54	≥4.0 Minimum & ≥6.0 Average

Figure 1



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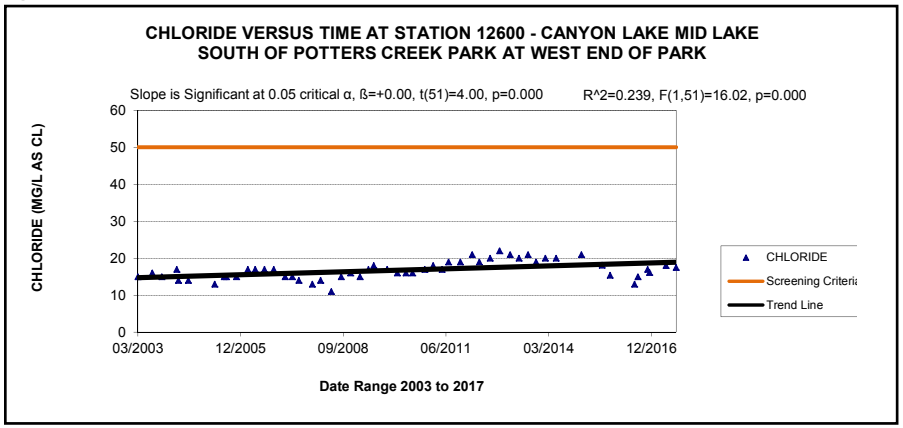

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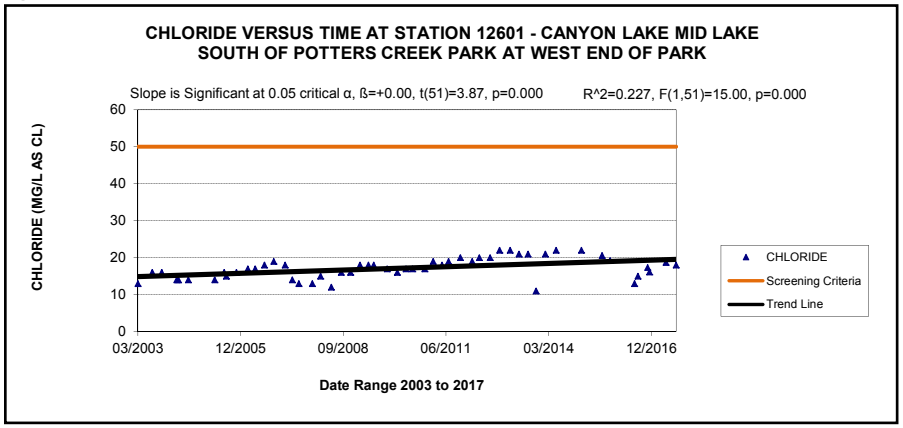

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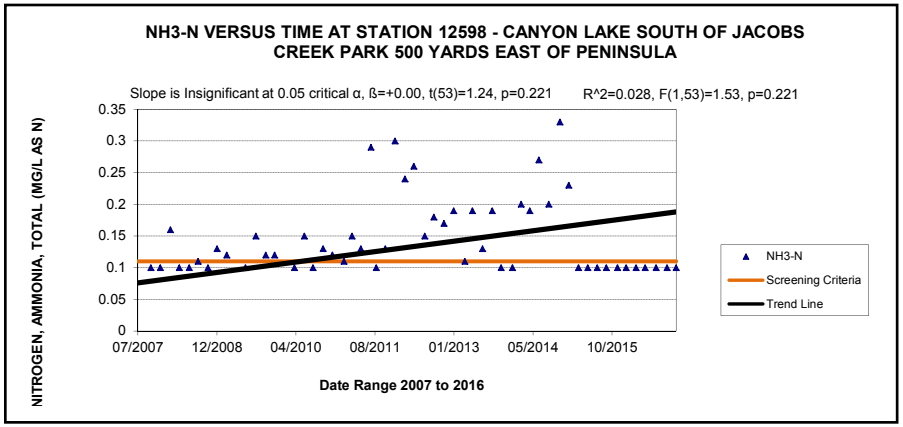
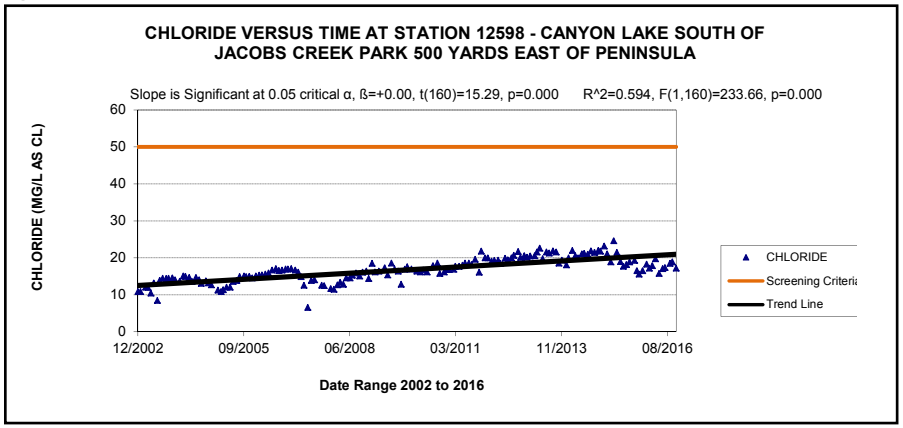


CANYON LAKE

Figure 5



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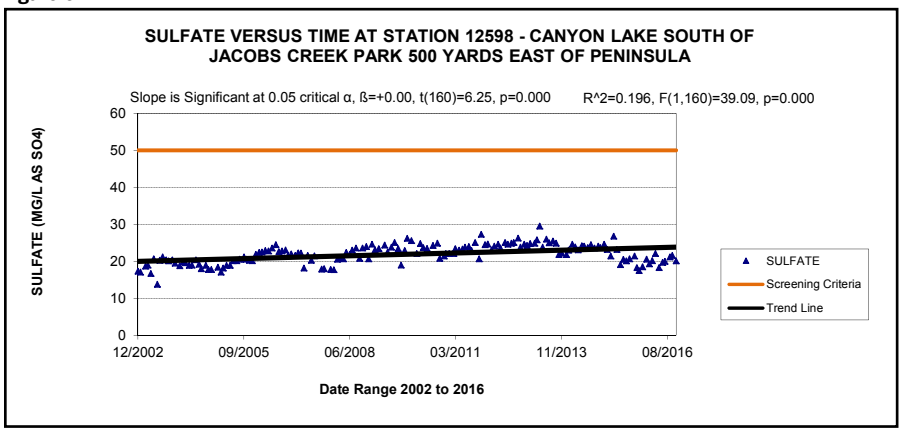
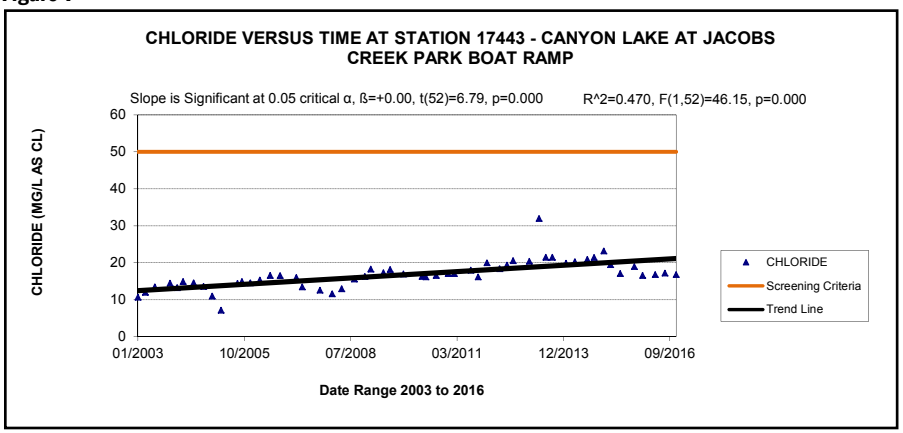


Figure 7



CANYON LAKE