AS-229 ● Nov. 13, 2024
TCEQ Water Quality Planning Division

Trophic Classification of Texas Reservoirs

2024 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)

Introduction

The primary productivity of reservoirs, as indicated by the amount of nutrients (phosphorus and nitrogen), and the extent of algae (suspended, floating, and attached) and rooted aquatic plants, can have a significant effect on water quality. Up to a point, nutrients promote ecosystem production and the healthy growth of algae, larger plants, fish, and other aquatic organisms. However, excess nutrients and algae in reservoirs can have a deleterious effect on water quality, and algae can reach nuisance levels that potentially (1) create nuisance aesthetic conditions, (2) cause taste and odor in drinking water sources, (3) contribute to reduced dissolved oxygen as algae decays, and (4) ultimately reduce the ability of a water body to support healthy, diverse aquatic communities.

Eutrophication refers to an overall condition characterized by the accumulation of nutrients that support a relatively elevated growth of algae and other organisms. Eutrophication is primarily influenced by the physical and hydrological characteristics of a water body and can be affected by natural processes and human activities in the surrounding watershed. Human activities can accelerate the eutrophication process by increasing the rate at which nutrients and organic substances enter impoundments and surrounding watersheds. Discharges of treated sewage, agricultural and urban runoff, leaking septic tanks, and the erosion of stream banks can increase the flow of nutrients and organic substances into reservoirs. In comparison to natural lakes in northern states, the eutrophication process in southern reservoirs is often enhanced by (1) warm climates with long growing seasons, (2) soils and geologic substrates that create high concentrations of sediment and nutrients in rainfall runoff, and (3) relatively high river inflows on main stem impoundments. As a result, some reservoirs in Texas can be relatively eutrophic even where nutrient loadings from human activities are relatively small.

The trophic state of a reservoir refers to its nutritional status and is indicated by measurements of nutrients and algae. Section 314 of the U.S. Clean Water Act (CWA) requires that all states classify lakes and reservoirs by their trophic state. Assessing water body conditions based on algae is accomplished by evaluating indicators that reflect the nutrient dynamics driving primary production. Various classification schemes (Table 1-1) or indices have been developed that group reservoirs into discrete quality (trophic) states along a continuum from “oligotrophic” (poorly nourished) to “hypereutrophic” (over nourished). The basis for the trophic state index concept is that in many reservoirs the degree of eutrophication may be related to increased nutrient concentrations. Typically, phosphorus is the nutrient of concern and changes in its concentration may trigger a response that influences the amount of algae, as estimated by chlorophyll *a* (Chl *a*) in the reservoir. For example, increases in phosphorus can result in higher algal biomass, which in turn decreases water transparency (as measured by a Secchi disk or submarine photometer).

Table 1-1. Types of Trophic States in Reservoirs and Lakes

Trophic State	**Water Quality Characteristics**
Oligotrophic	Clear waters with extreme clarity, low nutrient concentrations, little organic matter or sediment, and minimal biological activity.
Mesotrophic	Waters with moderate nutrient concentrations and, therefore, more biological productivity. Waters may be lightly clouded by organic matter, sediment, suspended solids, or algae.
Eutrophic	Waters relatively rich in nutrient concentrations with high biological productivity. Waters more clouded by organic matter, sediment, suspended solids, and algae.
Hypereutrophic	Murkier, highly productive waters. Dense algae, very high nutrient concentrations.

(Adapted from a variety of descriptions of trophic state characteristics)

Major Texas reservoirs have been evaluated and ranked every two years by TCEQ using Carlson's Trophic State Index (TSI). Carlson's Index was developed to compare reservoirs using in-reservoir sampling data (Carlson, 1977; Carlson and Simpson, 1996). Secchi disk depths, chlorophyll *a* concentrations, and total phosphorus concentrations are three variables that are highly correlated and considered estimators of algal biomass. The TSI uses regression analysis to relate these three parameters to determine the relevant trophic state. The TSI is determined from any of the three following computational equations:

TSI (Secchi Disk) = 60 - 14.41 ln(SD), where SD is mean Secchi disk depth in meters.

TSI (Chlorophyll *a*) = 9.81 ln(Chl *a*) + 30.6, where Chl *a* is mean chlorophyll *a* in µg/L.

TSI (Total Phosphorus) = 14.42 ln(TP) + 4.15, where TP is mean total phosphorus in µg/L.

Although chlorophyll *a* is the most direct measure of algal biomass, the TSI uses Secchi disk depth as the primary indicator. The index was scaled, so that TSI = 0 represented the largest measured Secchi disk depth (64 m) among reservoirs. Each halving of transparency represents an increase of 10 TSI units (Table 1-2). Since the relationships between Secchi disk and chlorophyll *a* was nonlinear a 10-unit TSI (Chl *a*) change does not correspond to a doubling of chlorophyll *a*. Instead, chlorophyll *a* approximately doubled for each 7-unit increase in TSI (Chl *a*).

Table 1-2. Carlson's Trophic State Index and Associated Parameters

Trophic State Index	**Secchi Disc (m)**	**Total Phosphorus (µg/L)**	**Chlorophyll *a* (µg/L)**
0	64	0.75	0.04
10	32	1.5	0.12
20	16	3	0.34
30	8	6	0.94
40	4	12	2.6
50	2	24	6.4
60	1	48	20.0
70	0.5	96	56
80	0.25	192	154
90	0.12	384	427
100	0.062	768	1,183

(Adapted from Carlson, 1977; and Carlson and Simpson, 1996)

Carlson's Index provides a useful tool for assessing a reservoir's condition and evaluating how that condition changes over time. For example, the index would provide a quantitative estimate of the degree of improvement for a reservoir in which the TSI (Chl *a*) decreased from 60 to 40 units following implementation of restoration measures. The index provides useful information which explains possible causes of the water body condition. For example, if TSI (TP) > TSI (Chl *a*), phosphorus is probably not the limiting nutrient; TSI (SD) > TSI (Chl *a*) indicates the presence of non-algal turbidity.

Carlson's Index represents a simple model for evaluating a reservoir’s condition and provides both advantages and disadvantages. The trophic state is developed on a continuous numeric scale and is useful for approximating the oligotrophic-hypereutrophic nomenclature required by the Environmental Protection Agency. Secchi disk depths, total phosphorus, and chlorophyll *a* concentrations are routinely determined at fixed monitoring stations on reservoirs and lakes, so data is readily available for computing Carlson’s Index. The index does not perform well for certain water quality conditions: (1) where transparency is affected by suspended erosional materials rather than phytoplankton, (2) where primary production is controlled by attached algae or aquatic macrophytes rather than phytoplankton, and (3) when phosphorus is not the nutrient limiting phytoplankton growth.

Although the index can be used to classify and rank Texas reservoirs by trophic state, ranking priority for restoration is difficult. Carlson's Index does not replace the need to make use attainment determinations. Carlson (1977) points out that trophic state is not equivalent to an index of water quality. Assessments of reservoir water quality depend heavily on the assignment of beneficial uses and determinations to evaluate if the uses are being maintained and/or impaired. Texas reservoirs are ranked in Appendix A according to Carlson's TSI for chlorophyll *a* as an average calculated from 10 years of SWQM data (December 1, 2012, to November 30, 2022).

To maximize comparability among reservoirs, data from monitoring stations nearest to dams, with the most available data, in the main pools of each reservoir were utilized if available. In some cases, multiple stations situated within close proximity of one another were also used. For many reservoirs, these are the only sites monitored by TCEQ and the Clean Rivers Program. Chlorophyll *a* was given priority as the primary trophic state indicator because it has proven to be most useful for estimating algal biomass in most reservoirs. A minimum of four chlorophyll *a* measurements, two total phosphorus measurements, and two Secchi disk measurements were required for a reservoir to be included in the ranking. Of the 144 reservoirs surveyed, 141 had sufficient data to be included in the ranking. Based on this assessment, the 141 reservoirs show a range of eutrophication, from oligotrophic to hypereutrophic (Table 1 - 3). Rankings are also provided for total phosphorus (TP) and Secchi disk transparency (SD). Comparing TSI indicators between the reservoirs provides indications of the clearest reservoirs (low TSI SD) and identifies reservoirs with low and high total phosphorus concentrations.

Table 1-3. Number of Texas Reservoirs Assessed in Each Trophic Class

Trophic Class	TSI (Chl *a*) Index Range	Number of Texas Reservoirs
Oligotrophic	0 – 40	6
Mesotrophic	>40 – 50	21
Eutrophic	>50 – 70	109
Hypereutrophic	>70	5

Adapted from Carlson and Simpson (1996)

Reservoirs with the clearest water (highest mean Secchi disk transparency), listed in descending order are as follows: Canyon Lake (4.64 m), International Amistad Reservoir (4.00 m), Lake Travis (3.92 m), Medina Lake (3.44 m) and Stillhouse Hollow Lake (3.42 m). Reservoirs with the poorest light transparency, (lowest mean Secchi disk transparency), listed in ascending order are as follows: Rita Blanca Lake (0.10 m), Cox Lake (0.12 m), White River Lake (0.22 m), Palo Duro Reservoir (0.24 m), Lake Wichita (0.28 m), and Lake Kirby (0.28).

Thirty-four reservoirs share the lowest mean total phosphorus concentration of 0.02 mg/L. Reservoirs with the highest mean total phosphorus concentrations, listed in descending order are as follows: Rita Blanca Lake (2.82 mg/L), Lake Tanglewood (1.00 mg/L), Lake Woodlands (0.84 mg/L), Palo Duro Reservoir (0.36 mg/L), Lake Corpus Christi (0.32 mg/L), and Lake Wichita (0.30 mg/L).

Water Quality Differences in Reservoirs

Carlson’s TSI Chl *a* values for 118 reservoirs from the 2014 and 2024 reporting cycles were compared to indicate temporal differences (Appendix A). Differences could not be calculated for 23 reservoirs (16%) due to a lack of comparable reporting information from 2014. The 2014 period of record was December 1, 2002, to November 30, 2012; and for 2024, the period of record was December 1, 2012, to November 30, 2022.

TSI Chl *a* values, which estimate the amount of algal biomass, can indicate water quality improvement when values decrease. There were decreases in TSI Chl *a* values in 43 (36%) of the comparable reservoirs between the 2014 and 2024 report cycles. Reservoirs with the largest decrease in mean TSI Chl *a* values, listed in descending order are as follows: O.C. Fisher Lake (-23.32), Lake Wichita (-6.34), Red Bluff Reservoir (-5.50), Canyon Lake (-5.50), and Fairfield Lake (-5.30). Increases in algal biomass (increase in TSI Chl *a* values) are indicated in 74 (63%) of the comparable reservoirs, which may be indicative of natural or cultural eutrophication. Reservoirs with the largest differences for increasing algal content (substantial positive TSI Chl *a* values), listed in descending order are as follows: Lake Crook (+11.34), Lake Amon G. Carter (+8.26), Leon Reservoir (+7.62), Falcon Lake (+6.82), and Lake Brownwood (+6.62).

It should be noted that a reservoir's trophic rank may differ from that in the previous TSI Report due to improvements in data reporting and analytical capabilities or a change in monitoring station(s) rather than changes in water quality. Many individual values in the Surface Water Quality Monitoring Information System database are reported below analytical reporting limits (non-detects or censored data). There is no generalized way to determine the true value for an individual result in the range between zero and the reporting limit. For the trophic classification assessment of Texas reservoirs, 50% of an analytical reporting limit is computed for censored results. This is done to maximize the amount of data used in this analysis and to indicate the level of monitoring effort. For more information, please contact the Surface Water Quality Monitoring Team at swqm@tceq.texas.gov.

Reservoir Control Programs

Texas implements several reservoir pollution control procedures to ensure high-quality water for recreational, aquatic life, domestic, and industrial uses. Surface water quality standards have been adopted for significant reservoirs throughout the state in Title 30, Texas Administrative Code (TAC), Chapter 307 the Texas Surface Water Quality Standards (TSWQS). The TSWQS establish uses for classified segments and unclassified waterbodies. It also includes numerical criteria to protect those uses. Designated uses are determined by considering the reservoir's physical and biological characteristics, natural water quality, and existing uses. Criteria, depending on parameter, are based on background levels or accepted levels of water quality constituents for the protection of human health and aquatic life. TCEQ issues Texas Pollutant Discharge Elimination System (TPDES) permits that include limits designed to protect these uses. Each major reservoir is routinely monitored to assess the overall condition of the water body in comparison to TSWQS criteria and determine short-term and long-term water quality trends. Reservoirs with non-supported uses are placed on the State of Texas 303(d) List. This includes Sub-category 5n, which is established to focus management actions that address nutrients in reservoirs with numeric Chl *a* criteria. When a water body is identified as impaired and in need of remedial efforts, in some cases a Total Maximum Daily Load (TMDL) is assessed to determine the assimilative capacity of a water body for a pollutant under consideration. A TMDL allocates waste loads for permits and load allocations from unregulated sources to ensure attainment with water quality standards. Compliance with wastewater permits is monitored through on-site inspections by TCEQ personnel and through self-reporting procedures. When noncompliance with permits is found, enforcement actions are required to attain compliance. The uses, criteria, TMDL Implementation Plans, and permits are periodically reviewed and, if necessary, revised.

TCEQ has several specific rules that prescribe permit limitations for the discharge of domestic wastewater into reservoirs. The rules in 30 TAC, Chapter 309 Domestic Wastewater Effluent Limitation and Plant Siting, specifically Section 309.3(c), require discharges located within five stream miles upstream of certain reservoirs to achieve a minimum effluent quality. For example, a wastewater plant might be assigned a 5-day biological oxygen demand (BOD_5) of 10 mg/L and total suspended solids (TSS) of 15 mg/L, both expressed as a 30-day average. This rule applies to reservoirs that are subject to on-site/private sewage facility regulation or that may be used as a source for a public drinking water supply. Currently, 95 reservoirs are designated for the public water supply use in TSWQS Section 307.10, Appendices A and B. Additional rules under 30 TAC, Chapter 311 Watershed Protection, have been promulgated that protect specific reservoirs. These rules are listed in the following sections.

Subchapters A, B, and F

These rules apply to a series of reservoirs on the Colorado River, which are commonly referred to as the Highland Lakes, including Lake Austin (Segment 1403), Lake Travis (Segment 1404), Lake Marble Falls (Segment 1405), Lake LBJ, (Segment 1406), Inks Lake (Segment 1407), and Lake Buchanan (Segment 1408). Water quality areas, those portions of the watersheds within 10 river miles of these reservoirs, were established for each reservoir. New wastewater facilities constructed in these areas will be issued no-discharge permits, meaning that treated wastewater will not be discharged to surface waters. Any existing facility that requires a permit amendment for expansion or that is not meeting permit requirements because of sewage overloading will be issued a no-discharge permit. Proposed new or expanded treatment facilities in the watersheds of these reservoirs will be issued no-discharge permits, unless the applicant can establish that any alternative proposed wastewater disposal will protect and maintain the existing quality of the reservoirs. Allowable stormwater runoff and certain non-stormwater discharges that may be authorized by a TPDES or National Pollution Discharge Elimination System permit are also included in these watershed rules.

Subchapter D

This rule requires all domestic and industrial permittees in the entire Lake Houston (Segment 1002) watershed to meet effluent limitations as specified in the rule. For example, 10 mg/L of carbonaceous $BOD_{5,}$ 15 mg/L of TSS, and 3 mg/L of ammonia-nitrogen (NH3-N); all expressed as a 30-day average (domestic discharges). All wastewater effluents disposed of on land shall meet an effluent quality as specified in Sections 309.1-309.4 and 311.34. Domestic facilities must submit a solids management plan. Additionally, all domestic and industrial facilities with gaseous chlorination disinfection systems must have dual-feed chlorination systems and must meet a minimum chlorine residual of 1 mg/L and a maximum chlorine residual of 4.0 mg/L (instantaneous grab sample).

Subchapter G

This rule applies to Lakes Worth (Segment 0807), Eagle Mountain Lake (Segment 0809), Lake Bridgeport (Segment 0811), Cedar Creek Reservoir (Segment 0818), Lake Arlington (Segment 0828), Benbrook Lake (Segment 0830), and Richland-Chambers Reservoir (Segment 0836). Except for oxidation pond systems, domestic discharges within the water quality areas of these reservoir watersheds are required to meet advanced treatment limits. For example, BOD_5 of 10 mg/L and 15 mg/L TSS (30-day average), and filtration was required to supplement suspended solids removal by January 1, 1993. Section 311.67 specifies effluent limitations to control nutrients from certain new domestic wastewater facilities and discharge permit amendments that increase permitted flow (after January 1, 2015) discharging to the Benbrook Lake watershed and Benbrook Lake water quality area. Based on the discharge point location and discharge size, permittees must meet a daily effluent limit for TP of 1.0 mg/L, based on a 30-day average.

Reservoir and Lake Restoration Efforts

Section 314 of the Clean Water Act makes federal grant funds available to states for Clean Lakes Program purposes. TCEQ is currently not administering any grant funding under this program. There are several lakes and reservoirs throughout the state where restoration efforts are currently under way to improve water quality. Watershed Protection Plans (WPPs) are voluntary stakeholder-driven plans that may be developed to protect high-quality waters, to address threatened waters before they become impaired, or to restore water impacted by nonpoint source pollutants. TMDLs, which are regulatory in nature, are also developed to restore water bodies. The lakes and reservoirs with ongoing restoration efforts include the following:

- **Lake O’ the Pines** – TMDL Implementation Plan
- **E.V. Spence Reservoir** – TMDL Implementation Plan
- **Lake Austin** – TMDL Implementation Plan
- **Lake Worth** – TMDL Implementation Plan
- **Lake Houston** – TMDL Implementation Plan
- **Aquilla Reservoir** – TMDL Implementation Plan
- **Mountain Creek Lake** – TMDL Implementation Plan
- **Lake Como** – TMDL Implementation Plan
- **Fosdic Lake** – TMDL Implementation Plan
- **Echo Lake** – TMDL Implementation Plan
- **Donna Reservoir** – TMDL Implementation Plan
- **Lake Arlington** – Watershed Protection Plan

- **Lake Granbury** – Watershed Protection Plan
- **Lake Lavon** – Watershed Protection Plan
- **Joe Pool Lake** – Watershed Protection Plan
- **Bois d'Arc Lake/Lake Bonham** – Watershed Protection Plan

High and Low pH in Texas Water Bodies

The trophic status of a water body can impact several water quality parameters, including pH. Photosynthesis, respiration, and decomposition. All of these parameters contribute to pH fluctuations by influencing available carbon dioxide levels in the water column. Elevations in pH are typically highest in mid-afternoon, and lowest just before sunrise. Section 314 of the CWA requires states to include methods and procedures to evaluate and mitigate pH as part of the trophic classification.

Instantaneous and diel pH data collected as part of routine water quality monitoring and special studies are evaluated to determine attainment with site-specific water quality standards for high and low pH as part of the Integrated Report[1]. If a water body's pH is impaired, TCEQ considers this information when developing restoration strategies such as TMDLs and WPPs to determine if the pH impairment is related to excessive enrichment.

Low pH in Texas Water Bodies

Data from two freshwater streams and one tidal stream (Table 1-4) have indicated low pH (high acidity) in at least one assessment location, resulting in the water bodies being included in the 2024 Index of Water Quality Impairments (Categories 4 and 5). During respiration, dissolved carbon dioxide reacts with water to form carbonic acid, which may lower pH. Most of these water bodies are in the eastern portion of the state, where natural geologic buffering capacity is limited.

Table 1-4. Texas Water Bodies with Low pH

Segment Number	Water Body Name
0511	Cow Bayou Tidal
0615	Angelina River/Sam Rayburn Reservoir
1407A	Clear Creek

High pH in Texas Water Bodies

Data from 11 reservoirs and 2 freshwater streams (Table 1-5) have indicated elevated pH (high basicity) in at least one assessment location which resulted in the water bodies being included on the 2024 Texas 303(d) List. A likely cause of elevated pH is the consumption of dissolved carbon dioxide by photosynthetic processes. Excessive

[1] www.tceq.texas.gov/waterquality/assessment/2024-integrated-report/24txir

amounts of photosynthetically active algae and macrophytes can increase the consumption of carbon dioxide during the day, increasing pH in the water column. Many of these water bodies are in the eastern portion of the state, where natural geologic buffering capacity is limited.

Table 1-5. Texas Water Bodies with High pH

Segment Number	Water Body Name
0105	Rita Blanca Lake
0229	Upper Prairie Dog Town Fork Red River
0302	Wright Patman Lake
0403	Lake O' the Pines
0405	Lake Cypress Springs
0512	Lake Fork Reservoir
0514	Big Sandy Creek
0605	Lake Palestine
0610	Sam Rayburn Reservoir
0818	Cedar Creek Reservoir
0826	Grapevine Lake
1002	Lake Houston
1212	Somerville Lake

Appendix A. Carlson's Trophic State Index (TSI)

Chl *a* – chlorophyll *a*

TP – total phosphorus

The Carlson's TSI (Chl a), (TP), and (Secchi) were computed for each reservoir by calculating the arithmetic average for the TSI values from each sample date. The effect of these computations is that the ranking of Carlson's TSI (Chl a), (TP), and (Secchi) values may vary slightly from a ranking based on the arithmetic average of chlorophyll a, total phosphorus, and Secchi disk values.

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
1805	12597	CANYON LAKE	1	29	1.56	34.94	40.44	-5.5	1	28	4.64	37.9	1	28	0.02	37.4
1904	12825, 12826	MEDINA LAKE	2	17	1.8	36.34			4	48	3.44	42.2	2	50	0.02	38
2305	13835	INTERNATIONAL AMISTAD RESERVOIR	3	24	2.16	38.12	40.4	-2.28	2	23	4	40	5	22	0.02	41.3
1241B	18414	LAKE ALAN HENRY	4	19	2.16	38.16	42.64	-4.48	8	23	3	44.22	111	21	0.08	67
1216	11894	STILLHOUSE HOLLOW LAKE	5	38	2.4	39.16	42.1	-2.94	5	40	3.42	42.26	29	38	0.02	50.6
0302G	20813	TP LAKE	6	8	2.52	39.68	38.4	1.28	39	15	1.32	56.02	57	10	0.04	55.8
1404	12302	LAKE TRAVIS	7	71	2.64	40.14	42.28	-2.14	3	71	3.92	40.3	4	71	0.02	41.1
0506M	21823	TYLER STATE PARK LAKE	8	23	2.98	41.3			6	26	3.34	42.64	6	25	0.02	41.4
0404N	17337	LAKE DAINGERFIELD	9	20	3.28	42.24			9	24	2.72	45.62	39	22	0.04	53.6
1249	12111	LAKE GEORGETOWN	10	38	3.62	43.24	47.46	-4.22	16	38	1.84	51.18	29	38	0.02	50.6
0611R	17824	LAKE STRIKER	12	37	3.68	43.38	43.3	0.08	86	39	0.8	63.06	84	37	0.04	60.3

[1] Reservoirs are ranked in priority by TSI (Chl *a*). A true rank was used which can result in a tied rank for reservoirs with the same TSI (Chl *a*). Therefore, some ranking assignments are skipped by the computational data model. The rank resumes with subsequent rank value.

[2] A positive value indicates increased algal content. A negative value indicates decreased algal content. Missing values indicate a comparison could not be made due to the absence of comparable data.

[3] Total phosphorus concentrations converted from µg/L to mg/L.

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
0614	10639	LAKE JACKSONVILLE	12	28	3.68	43.38	44.78	-1.4	11	39	2.6	46.22	7	31	0.02	42.1
1234	12005	LAKE CISCO	13	23	3.88	43.92	43.18	0.74	76	25	0.88	61.88	46	24	0.04	54.8
0506I	14422	LAKE HAWKINS	14	36	5.08	46.54	47.8	-1.26	10	36	2.62	46.16	8	31	0.02	42.4
1604	15377	LAKE TEXANA	15	38	5.24	46.84	41.54	5.3	138	115	0.3	77.48	132	38	0.18	79
1220	11921	BELTON LAKE	16	38	5.32	46.98	47.38	-0.4	15	39	2.04	49.76	25	38	0.02	50
0611Q	15801	LAKE NACOGDOCHES	17	39	5.62	47.56	47.26	0.3	26	40	1.64	52.88	31	39	0.02	50.9
0505E	13703	BRANDY BRANCH RESERVOIR	18	36	5.9	48.02	42.42	5.6	7	40	3.06	43.86	13	35	0.02	45.1
1403	12294	LAKE AUSTIN	19	67	6.3	48.66	44.08	4.58	18	69	1.84	51.26	12	67	0.02	45
0204B	15447	MOSS LAKE	20	33	6.44	48.86	48	0.86	40	34	1.28	56.34	93	31	0.06	62
0213	10143	LAKE KICKAPOO	21	34	6.52	48.98	48.24	0.74	131	35	0.38	74.16	96	32	0.06	62.6
1233	12002	HUBBARD CREEK RESERVOIR	22	22	6.54	49.02	46.6	2.42	56	26	1.02	59.86	29	23	0.02	50.6
0610	14906	SAM RAYBURN RESERVOIR	23	34	6.64	49.18	48.58	0.6	22	38	1.72	52.12	76	33	0.04	59
0203	20545	LAKE TEXOMA	24	82	6.82	49.42			36	82	1.42	54.9	76	81	0.04	59
0228	10188	MACKENZIE RESERVOIR	25	22	6.9	49.54	50.5	-0.96	44	23	1.16	57.96	14	21	0.02	45.9
1426A	12180	OAK CREEK RESERVOIR	26	27	6.98	49.66	51.8	-2.14	30	24	1.52	54.04	15	24	0.02	46.8
0811	10970	LAKE BRIDGEPORT	27	43	7.04	49.74	47.36	2.38	53	43	1.04	59.42	27	44	0.02	50.3
0504	10404	TOLEDO BEND RESERVOIR	29	108	7.26	50.04	47.96	2.08	19	109	1.78	51.62	58	104	0.04	55.9
1433	12511	O. H. IVIE RESERVOIR	29	18	7.26	50.04	48.52	1.52	17	19	1.84	51.2	17	19	0.02	48.1
0202Q	16945	PICKENS LAKE	31	30	7.44	50.3			27	33	1.62	53.08	74	30	0.04	58.8
1419	12398	LAKE COLEMAN	31	19	7.44	50.3	49.54	0.76	62	21	0.96	60.64	26	20	0.02	50.1
0840	14039, 17834, 22314	RAY ROBERTS LAKE	32	44	7.78	50.74			46	51	1.12	58.36	18	54	0.02	48.3
1418C	12178	HORDS CREEK RESERVOIR	33	12	7.96	50.94	50.98	-0.04	54	14	1.02	59.84	20	14	0.02	48.8
1207	11865	POSSUM KINGDOM LAKE	34	114	8.62	51.72	54.52	-2.8	12	116	2.58	46.32	51	114	0.04	55.3
0605F	17575	LAKE ATHENS	35	33	8.7	51.82	50.9	0.92	14	39	2.06	49.54	9	30	0.02	43.5
1408	12344	LAKE BUCHANAN	36	71	9.02	52.16	53.42	-1.26	21	71	1.72	52.1	21	71	0.02	49.3

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
1230	11977	LAKE PALO PINTO	37	16	9.42	52.6	49.68	2.92	91	14	0.78	63.74	55	16	0.04	55.7
0612G	21435	NACONICHE LAKE	38	34	9.62	52.8			32	37	1.48	54.32	19	36	0.02	48.7
0217	10159	LAKE KEMP	39	35	9.86	53.04	54.06	-1.02	42	36	1.16	57.94	34	33	0.02	52.6
0603	10582	B A. STEINHAGEN LAKE	40	36	10.6	53.76	54.02	-0.26	133	37	0.36	74.64	98	33	0.06	63.3
0604T	17339	LAKE RATCLIFF	41	39	10.74	53.9	58.68	-4.78	91	39	0.78	63.74	90	37	0.06	61.6
1429	12476	LADY BIRD LAKE (FORMERLY TOWN LAKE)	42	56	10.86	54	51.28	2.72	20	55	1.76	51.9	82	50	0.04	60
0510	15514	LAKE CHEROKEE	43	33	11.22	54.32	51.68	2.64	61	66	0.96	60.58	36	2	0.04	53.2
0212	10142	LAKE ARROWHEAD	44	35	11.46	54.54	54.52	0.02	116	35	0.5	69.84	130	32	0.16	77.4
0836	15168	RICHLAND-CHAMBERS RESERVOIR	45	41	11.58	54.62	56.06	-1.44	51	42	1.06	59.3	62	41	0.04	56.3
0838	11073	JOE POOL LAKE	46	9	11.78	54.8			109	9	0.58	67.94	10	9	0.02	44.2
1418	12395	LAKE BROWNWOOD	47	16	11.86	54.86	48.24	6.62	57	20	1	59.94	37	17	0.04	53.5
0408	10329, 17059	LAKE BOB SANDLIN	48	35	12.04	55	50.52	4.48	24	37	1.7	52.42	11	34	0.02	44.4
0223	10173	GREENBELT RESERVOIR	49	23	12.46	55.34	48.94	6.4	95	24	0.74	64.42	61	24	0.04	56.1
1423	12422	TWIN BUTTES RESERVOIR	50	23	12.62	55.48	60.14	-4.66	67	25	0.94	60.88	41	25	0.04	53.9
1203	11851, 13987	LAKE WHITNEY	51	31	12.88	55.66			23	40	1.72	52.24	23	31	0.02	49.8
1231	11979	LAKE GRAHAM	52	21	12.92	55.7	49.98	5.72	99	22	0.7	65.14	72	20	0.04	57.9
0214H	20162	NORTH FORK BUFFALO CREEK RESERVOIR	53	20	12.98	55.74			120	20	0.46	70.9	124	18	0.1	70.7
1406	12324	LAKE LYNDON B. JOHNSON	54	69	13.16	55.88	54.16	1.72	33	70	1.48	54.36	24	70	0.02	49.9
0613	10637, 10638	LAKE TYLER EAST	55	64	13.2	55.92	54.24	1.68	31	74	1.48	54.26	16	66	0.02	47
0506L	18847	LAKE HOLBROOK	56	15	13.24	55.94	55.36	0.58	28	16	1.58	53.46	23	14	0.02	49.8
1434I	21959	BUESCHER STATE PARK LAKE	57	7	13.46	56.1			52	10	1.04	59.36	71	8	0.04	57.8
0823	11025, 11027, 17830	LEWISVILLE LAKE	59	23	14.06	56.52	56.76	-0.24	101	19	0.68	65.52	35	35	0.02	52.9
1407	12336	INKS LAKE	59	70	14.04	56.52	57.76	-1.24	35	69	1.42	54.86	63	70	0.04	56.7

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
2454A	12514	COX LAKE	60	28	14.22	56.64	55.6	1.04	143	30	0.12	90.76	133	25	0.2	80.7
1247	12095	GRANGER LAKE	61	38	14.34	56.72	55.78	0.94	121	38	0.44	71.78	46	38	0.04	54.8
0834	11063	LAKE AMON G. CARTER	62	22	14.52	56.84	48.58	8.26	49	22	1.08	58.96	33	19	0.02	52.4
2103	12967	LAKE CORPUS CHRISTI	63	40	14.64	56.92	58.44	-1.52	135	41	0.34	75.82	139	40	0.32	87.7
1413	21614	LAKE J. B. THOMAS	64	16	14.98	57.16			71	17	0.9	61.36	65	17	0.04	57.1
0512	10458	LAKE FORK RESERVOIR	66	108	15.14	57.26	54.92	2.34	47	112	1.12	58.46	82	104	0.04	60
0818	16748, 16749	CEDAR CREEK RESERVOIR	66	89	15.16	57.26			63	86	0.94	60.74	53	88	0.04	55.6
0303A	16856	BIG CREEK LAKE	67	27	15.38	57.42	57.98	-0.56	122	28	0.44	71.92	122	25	0.1	69.4
1405	12319	LAKE MARBLE FALLS	68	68	15.44	57.46	53.36	4.1	29	68	1.54	53.82	85	68	0.04	60.5
0809	10944	EAGLE MOUNTAIN RESERVOIR	69	43	15.62	57.56	61.46	-3.9	79	45	0.86	62.22	87	44	0.06	61
0830	15151	BENBROOK LAKE	70	46	15.7	57.62	61.78	-4.16	89	47	0.78	63.56	57	45	0.04	55.8
1411	13863	E. V. SPENCE RESERVOIR	71	19	16.02	57.82	62.28	-4.46	41	18	1.24	57.02	78	19	0.04	59.5
0816	10980	LAKE WAXAHACHIE	72	37	16.06	57.84	58.3	-0.46	113	39	0.54	68.98	52	40	0.04	55.4
2312	13267	RED BLUFF RESERVOIR	73	16	16.44	58.06	63.56	-5.5	84	14	0.82	62.84	32	15	0.02	51
0806G	22142	MARINE CREEK LAKE	74	12	16.46	58.08			64	12	0.94	60.78	43	12	0.04	54.4
0215	10157	DIVERSION LAKE	75	28	16.82	58.28	55.08	3.2	112	29	0.54	68.66	55	26	0.04	55.7
0506H	17062	LAKE GLADEWATER	76	36	17.34	58.58	60.12	-1.54	73	40	0.9	61.46	69	35	0.04	57.6
0307	13855	JIM L. CHAPMAN LAKE (FORMERLY COOPER LAKE)	77	35	17.38	58.62	58.32	0.3	106	38	0.64	66.56	110	33	0.08	66.9
1012	11342	LAKE CONROE	79	37	17.5	58.68	57.12	1.56	70	113	0.92	61.18	104	112	0.06	64.4
1422	12418	LAKE NASWORTHY	79	25	17.52	58.68	55.16	3.52	81	24	0.84	62.5	71	26	0.04	57.8
0818J	17949	PURTIS CREEK STATE PARK LAKE	80	19	17.62	58.74			58	24	1	60.06	106	21	0.06	64.9
0208	10137	LAKE CROOK	81	36	17.64	58.76	47.42	11.34	136	38	0.32	76.62	126	36	0.14	74.5
0505F	13601	MARTIN CREEK RESERVOIR	82	37	17.76	58.82	58.4	0.42	44	40	1.16	57.96	42	35	0.04	54
0826	11035, 17827, 22316	GRAPEVINE LAKE	83	45	17.78	58.84			85	51	0.82	62.9	51	54	0.04	55.3

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
0102	10036	LAKE MEREDITH	84	26	17.92	58.92	54.66	4.26	70	28	0.92	61.18	40	25	0.04	53.8
0209	16343	PAT MAYSE RESERVOIR	85	37	18.12	59.02	58.68	0.34	50	39	1.08	59	39	36	0.04	53.6
0210	10139	FARMERS CREEK RESERVOIR (ALSO KNOWN AS LAKE NOCONA)	86	36	18.18	59.04	53.88	5.16	89	37	0.78	63.56	68	34	0.04	57.5
0214G	17947	LAKE IOWA PARK	87	20	18.24	59.08			131	20	0.38	74.16	112	18	0.08	67.3
1254	12127	AQUILLA RESERVOIR	88	33	18.58	59.26	55.2	4.06	111	35	0.56	68.12	66	29	0.04	57.4
1434C	17020	LAKE BASTROP	89	59	18.94	59.46	62.2	-2.74	37	59	1.42	55	114	58	0.08	67.4
0817	10981	NAVARRO MILLS LAKE	90	33	19.04	59.5	55.28	4.22	114	35	0.52	69.28	100	34	0.06	63.5
0401	10283	CADDO LAKE	92	38	19.22	59.6	57.76	1.84	96	117	0.72	64.66	102	37	0.06	63.9
0813	10973	HOUSTON COUNTY LAKE	92	34	19.22	59.6	54.94	4.66	45	37	1.12	58.3	44	34	0.04	54.6
1225	11942	WACO LAKE	93	33	19.26	59.62	57.44	2.18	87	35	0.8	63.08	68	31	0.04	57.5
2116	13019, 13020	CHOKE CANYON RESERVOIR	94	58	19.46	59.72	56.42	3.3	118	59	0.5	70.12	123	59	0.1	70.3
1232D	17941	LAKE DANIEL	95	27	19.86	59.92			129	31	0.38	74.02	115	28	0.08	67.6
0409D	17478	LAKE GILMER	97	35	20.1	60.04	58.14	1.9	34	39	1.46	54.54	59	33	0.04	56
0815	10979	BARDWELL RESERVOIR	97	36	20.12	60.04	59.48	0.56	127	38	0.38	73.82	88	39	0.06	61.1
1242H	18457	TRADINGHOUSE CREEK RESERVOIR	98	35	20.34	60.16	60.16	0	77	34	0.88	62	80	34	0.04	59.8
1237	12021	LAKE SWEETWATER	99	25	20.5	60.24			78	28	0.86	62.18	79	26	0.04	59.7
1236	12010	FORT PHANTOM HILL LAKE	100	28	20.64	60.3	58.1	2.2	98	29	0.7	64.96	97	27	0.06	63.1
1425	12429	O. C. FISHER RESERVOIR	101	20	20.96	60.44	83.76	-23.32	102	18	0.68	65.6	107	20	0.08	65.4
0828	13904	LAKE ARLINGTON	102	45	21.14	60.54	65.46	-4.92	97	45	0.72	64.7	86	45	0.06	60.7
0807	10942	LAKE WORTH	103	44	21.24	60.58	63.96	-3.38	105	44	0.64	66.32	83	45	0.04	60.1
0803	10899	LAKE LIVINGSTON	104	35	21.78	60.82	59.9	0.92	125	36	0.4	73.48	120	35	0.08	68.9
0820	10998, 21365	LAKE RAY HUBBARD	105	44	21.96	60.9			73	52	0.9	61.46	49	57	0.04	55.2
1205	11860	LAKE GRANBURY	106	113	22.68	61.22	62.86	-1.64	74	113	0.9	61.64	61	112	0.04	56.1
1224	11939	LEON RESERVOIR	107	23	22.8	61.28	53.66	7.62	56	23	1.02	59.86	64	21	0.04	56.8

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
0701D	10642	SHALLOW PRONG LAKE	108	32	23.22	61.46	58.8	2.66	117	38	0.5	69.88	117	34	0.08	68.3
0821	15685	LAVON LAKE	110	80	24.44	61.96			104	84	0.64	66.24	99	84	0.06	63.4
1428K	20161	WALTER E. LONG LAKE	110	23	24.48	61.96	60.18	1.78	38	23	1.38	55.38	73	19	0.04	58
2303	13189	INTERNATIONAL FALCON RESERVOIR	111	29	26.04	62.58	55.76	6.82	59	33	0.98	60.26	102	28	0.06	63.9
1252	12123	LAKE LIMESTONE	112	85	26.16	62.62	62.52	0.1	94	89	0.74	64.28	94	86	0.06	62.5
0405	10312	LAKE CYPRESS SPRINGS	113	39	26.18	62.64	58.22	4.42	48	45	1.1	58.6	48	40	0.04	55
1228	11974	LAKE PAT CLEBURNE	114	37	27.6	63.14	59.54	3.6	100	40	0.68	65.44	77	38	0.04	59.3
1008F	16482	LAKE WOODLANDS	115	40	28.74	63.54	61.84	1.7	119	117	0.48	70.64	141	40	0.84	101.1
1240	12027	WHITE RIVER LAKE	116	34	29.78	63.9	57.66	6.24	142	41	0.22	81.26	105	36	0.06	64.8
0605	16159	LAKE PALESTINE	117	36	29.84	63.92	63.9	0.02	60	40	0.98	60.4	129	33	0.16	77.1
0507	10434	LAKE TAWAKONI	118	104	30.02	63.96	65.66	-1.7	82	108	0.82	62.74	91	101	0.06	61.8
0403	10296	LAKE O' THE PINES	119	36	30.78	64.22	59.58	4.64	75	40	0.88	61.72	48	37	0.04	55
1416B	12179	BRADY CREEK RESERVOIR	120	26	32.6	64.78	60.16	4.62	80	26	0.84	62.36	96	26	0.06	62.6
1235	12006	LAKE STAMFORD	121	21	33.18	64.96	58.98	5.98	123	23	0.42	72.18	108	21	0.08	65.9
1002	11204	LAKE HOUSTON	122	29	33.44	65.04	61.54	3.5	124	31	0.42	72.72	137	30	0.24	82.7
0302	10213, 14097	WRIGHT PATMAN LAKE	123	75	34.36	65.3	67.74	-2.44	107	159	0.64	66.6	109	71	0.08	66.2
0827	11038	WHITE ROCK LAKE	124	35	34.7	65.4	65.22	0.18	111	38	0.56	68.12	114	36	0.08	67.4
0832	11061	LAKE WEATHERFORD	125	39	35.56	65.64	61.02	4.62	108	39	0.6	67.18	89	37	0.06	61.2
1210	17586	LAKE MEXIA	126	36	35.78	65.7	65.48	0.22	134	41	0.36	74.88	131	36	0.16	77.7
1222	11935	PROCTOR LAKE	127	18	36.46	65.88	65.62	0.26	115	20	0.52	69.6	127	18	0.14	74.7
0804J	17951	FAIRFIELD LAKE	128	31	36.68	65.94	71.24	-5.3	65	35	0.94	60.82	119	32	0.08	68.7
0199A	10005	PALO DURO RESERVOIR	129	16	37.84	66.24	62.46	3.78	141	17	0.24	80.78	140	15	0.36	88.7
0509	10444	MURVAUL LAKE	130	35	37.94	66.26	67.2	-0.94	93	39	0.74	64.24	93	34	0.06	62
0515A	17948	LAKE QUITMAN	131	38	41.4	67.12			92	38	0.76	63.84	103	30	0.06	64.3
1212	11881	SOMERVILLE LAKE	132	31	42.68	67.42	68.14	-0.72	103	32	0.68	65.78	125	28	0.1	71.1

Segment	Station ID	Reservoir	Chl *a* Rank [1]	Chl *a* Records	Chl *a* Mean (µg/L)	Chl *a* TSI	Chl *a* TSI (2012)	10 Year Change [2]	Secchi Rank	Secchi Records	Secchi Mean (m)	Secchi TSI	TP Rank	TP Records	TP Mean (mg/L) [3]	TP TSI
0202M	16943, 21032	LAKE BONHAM (BONHAM CITY LAKE)	133	99	44.56	67.84	70.2	-2.36	132	94	0.36	74.6	119	98	0.08	68.7
1402G	17017	CEDAR CREEK RESERVOIR/ LAKE FAYETTE	134	59	47.62	68.5	62.7	5.8	68	57	0.92	61.08	128	58	0.14	75.6
1241C	11529	BUFFALO SPRINGS LAKE	135	20	50.5	69.08	68.52	0.56	83	23	0.82	62.82	116	22	0.08	67.8
1242A	16781	NEW MARLIN CITY LAKE	136	35	52.36	69.42	71.1	-1.68	128	35	0.38	73.92	135	31	0.22	81.4
0229A	10192	LAKE TANGLEWOOD	137	25	67.84	71.96	70.54	1.42	67	27	0.94	60.88	142	21	1	103.6
0219	10163	LAKE WICHITA	138	33	69.16	72.16	78.5	-6.34	139	32	0.28	78.24	138	32	0.3	86.8
1253A	16247	SPRINGFIELD LAKE	139	36	79.44	73.52	69.7	3.82	137	37	0.3	77	136	36	0.22	82.2
1236B	11521	KIRBY LAKE	140	22	115.3	77.18			140	24	0.28	78.8	135	22	0.22	81.4
0105	10060	RITA BLANCA LAKE	141	19	727.04	95.24	96.34	-1.1	144	21	0.1	92.18	143	20	2.82	118.7

Works Cited

Carlson, Robert E. 1977. "A trophic state index for lakes." *Limnology and Oceanography* 22 (2): 361-369.

Carlson, R. E., and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*." North American Lake Management Society.