Water Quality Technical Report

Eufaula Lake, Oklahoma

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Section 1
Summary

1.1 Project Overview

The U.S. Army Corps of Engineers (USACE) is preparing an environmental impact statement (EIS) for the proposed Eufaula Lake Shoreline Management Plan (SMP) Revision and Master Plan (MP) Supplement Project. As part of the EIS, this technical report has been prepared to describe existing water quality conditions and potential effects of the Eufaula Lake EIS alternatives on surface water quality.

1.2 Findings

Overall, the most significant potential water quality concerns within Eufaula Lake, both under existing conditions and under the alternatives, include increased nutrient and bacteria loading, erosion and turbidity, and potential water quality impacts associated with development along the lake shore. Potential water quality issues under both the existing conditions and the proposed alternatives could be addressed using a variety of mitigation measures (as described in Section 6).

1.3 Impact Conclusions

The proposed alternatives outlined in the EIS have the potential to cause a wide range of water quality impacts. Potential water quality impacts that may pose the greatest threat to Eufaula Lake include increased erosion along the shoreline, increased nutrient loading, increased bacteria, and increased turbidity. These potential water quality effects could compromise those amenities that are most valuable on the lake, such as recreation, water supply, and the aesthetic appeal of developing along the lake.

Alternative 1 would be most protective of water quality, followed by Alternative 2. Alternatives 1 and 2 would not be significantly impacted by existing water quality conditions. The No Action Alternative would result in a continuation of the existing water quality conditions described in Section 4 of this technical report. Alternatives 3 and 4 would be less protective of water quality, with Alternative 4 representing the most significant potential impact on water quality. Alternatives 3 and 4 would be impacted by existing water quality conditions, particularly along those shoreline areas that would be designated Public Recreation and Limited Development.

1.4 Recommended Mitigation Measures

A wide range of mitigation measures are available to address potential water quality impacts associated with the alternatives defined in Chapter 2 of the EIS. The mitigation measures presented in Section 6 of this technical report may be implemented individually or as part of a wider approach.

Section 2
Introduction

USACE is preparing an EIS for the proposed Eufaula Lake Shoreline Management Plan Revision and Master Plan Supplement. As part of the EIS, this technical report has been prepared to describe existing conditions and potential effects of the Eufaula Lake EIS alternatives on surface water quality. The information gathered in this technical report is summarized in the EIS.

Eufaula Lake is a USACE Civil Works Project located in the upper Arkansas River basin. The lake is generally defined as the area below an elevation of 585 feet above mean sea level, which is the "normal" lake level and is also referred to as the "conservation pool" elevation. Conservation pool elevation is the level at which the lake is generally maintained to optimize various water resource and recreational uses of the lake. The study includes USACE lands and adjacent private lands that may be affected by changes in shoreline designations and policies.

The USACE, Tulsa District, proposes to revise the 1998 Eufaula Lake Shoreline Management Plan (SMP) and to supplement the 1977 Eufaula Lake Master Plan (MP). The SMP is a comprehensive plan for managing the shoreline of Eufaula Lake, including the effects of human activities on the shoreline. Preparation of and periodic revisions of a SMP are mandated by federal regulations found at Title 36 of the Code of Federal Regulations (CFR), Section 327.30, which also contains requirements for a SMP. Key elements under consideration for revision include the relative amount of shoreline allocated into Limited Development, Protected, or Public Recreation, and revisions to the vegetation modification policies.

Following a public scoping process associated with the proposed revision of the SMP and MP, several requests for specific shoreline allocations were received including one project-specific request that would require a lease of USACE property in addition to a change in shoreline allocation and land use classification. USACE is considering these zoning requests and the request for a lease of USACE property.

The Eufaula Lake MP was originally written in 1977 and most recently revised, in part, in 2010. The proposed change to the MP would be limited to supplementing the MP land utilization maps to be consistent with the revised shoreline designations in the SMP (USACE 2010).

The EIS is required to address the potential impacts of the SMP revision and MP supplement from a lake-wide perspective. The purpose of this EIS is to address alternatives and environmental impacts associated with a revision of the SMP and a supplement to the MP for Eufaula Lake. This EIS will also provide an evaluation of alternatives and potential environmental impacts associated with specific proposals for the development of recreational facilities on federal lands at Eufaula Lake as identified through the SMP revision and MP supplemental process.

This technical report was prepared to evaluate potential environmental effects on water quality associated with the alternatives described in Chapter 2 of the EIS. Water quality is a critical resource to consider when revising the SMP and MP. All activities that occur in Eufaula Lake, such as boating, swimming, and fishing, are dependent upon water quality. In addition, other water uses including drinking water supply may be impacted by the water quality of Eufaula Lake. Eufaula Lake is a critical water resource for recreation, aquatic life, and the communities that benefit from the flood control and drinking water supply provided by Eufaula Lake.

Section 3
Methodology

3.1 Introduction

The purpose of this technical report is to collect information on hydrologic features, aquatic resources, and water quality in Eufaula Lake and the Eufaula Lake EIS study area, as well as the area described in the Carlton Landing development proposal. Water body and drainage features identified include, but not limited to streams, swales, wetlands, depressions, ponds, and selected outfalls. This forms the basis for assessing potential environmental impacts of the alternatives to shoreline management and to analyze potential cumulative impacts of alternatives. Each of the alternatives will be evaluated for potential effects on water resources including impacts to water quality, wetlands, streams, and to the lake.

3.2 Regulatory Framework

The National Environmental Policy Act (NEPA) was passed in 1969 and was one of the first laws to establish a broad national framework for protecting the environment. NEPA's basic policy is to assure that all branches of the federal government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment. NEPA requires federal agencies to integrate environmental values into the decision making process by considering the potential environmental impact of proposed actions and reasonable alternatives to those actions. To meet NEPA requirements, federal agencies may prepare a detailed statement known as an EIS to assess the likelihood of impacts from alternative courses of action. Section 1502.25 of NEPA regulations require that draft EISs be prepared concurrently with environmental analyses and related surveys and studies required by other federal statutes (40 CFR 1502.25).

NEPA, in combination with the Clean Water Act (CWA) and Executive Order (EO) 11990, establishes a national policy regarding the management of water resources. Where the quality of a water resource supports a diverse, productive, and ecologically sound habitat, it is a national policy that those waters be maintained and protected unless there is compelling evidence that to do so will cause significant national economic and social harm. This national policy is founded on the overall objective established in the CWA to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The purpose of this policy is to protect existing and future uses including assimilative capacity, aquatic life, drinking water supply, recreation, industrial use, and hydropower. Where water resource uses are degraded, it is the national goal to restore those degraded waters to more productive conditions.

USACE's water quality management authority is based on the CWA which strongly affirms the federal interest in water quality. However, the ultimate responsibility for managing water quality at Eufaula Lake rests with the State of Oklahoma. The USACE has developed Engineer Regulations (ER) to provide an adequate framework to ensure projects are managed in a manner consistent with federal laws and national policy. USACE ERs establish policies, procedures, and guidance for management of USACE projects. ER 1110-2-1462 and ER 1110-2-1854 address water quality interests in USACE civil works projects and are relevant to the Eufaula Lake EIS.

Regulations that protect water quality offer a basis for comparison in which water quality impacts can be understood relative to the minimum standards for water quality. This technical report will utilize the laws and policies discussed in this section as a means to evaluate the action alternatives identified in the EIS to determine whether potential impacts to water quality in Eufaula Lake are significant. An impact on water quality may be considered significant if it compromises the ability for Eufaula Lake to meet established water uses or degrades water quality as described in the national policy.

3.2.1 Clean Water Act (formerly known as Water Pollution Control Act) as amended, and Implementing Regulations 33 U.S.C. 1344 *et seq*. and 33 CFR 320 *et seq*.

The CWA, was originally enacted in 1948 as the Federal Water Pollution Control Act, and has been amended numerous times. The 1972 amendments established a national goal that waters of the United States (U.S.) should be "fishable and swimmable"; this goal was to be achieved by limiting pollutant discharges into waters of the U.S. The CWA establishes the basic structure for regulating water pollution and declares it unlawful for entities regulated as point sources to discharge any pollutant directly into navigable waters of the U.S. without a permit. In addition, the CWA authorizes the U.S. Environmental Protection Agency (EPA) to implement pollution control programs such as setting wastewater standards for industries. In most states, including Oklahoma, EPA has delegated this authority to state agencies.

The CWA establishes requirements for the determination of limits for point source discharges (*e.g.* pollution sources such as a pipe or cemented ditch) and stormwater that are consistent with state water quality standards; procedures for state issuance of water quality standards; the development of guidelines to identify and evaluate the extent of nonpoint source pollution (*e.g.* diffuse pollution sources such as urban runoff); the implementation of water quality inventory requirements; and the development of toxic and pretreatment effluent standards. The CWA further defines liability for discharges of oil and hazardous substances, and the federal role in cleanup operations.

Section 404 of the CWA authorizes USACE to issue permits for the discharge of dredged or fill material into waters of the U.S. Section 404 also establishes the requirement that EPA study and monitor water quality effects attributable to the impoundment of water by dams, and requires federal agencies, during the planning for any reservoir, to consider storage to regulate stream flow for the purpose of water quality control.

Section 401 of the CWA requires a state Water Quality Certification to show that a proposed project that would result in a discharge to a water body would also comply with state water quality standards.

Section 402, also known as the National Pollution Discharge Elimination System (NPDES) permit program, provides a regulatory mechanism for the control of point source discharges (*e.g.* a municipal or industrial

discharge at a specific location or pipe) to waters of the U.S. Two exceptions that are regulated under the NPDES program are: 1) diffuse source discharges caused by general construction activities of more than one acre, and 2) stormwater discharges as a separate system in municipal stormwater systems in which runoff is carried through a developed conveyance system to specific discharge locations.

3.2.1.1 Section 303(d)

Section 303(d) of the CWA requires states, territories, and authorized tribes to develop a list of threatened and impaired waters and to submit this list to EPA every two years. States identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities for addressing impairments based on the severity of the pollution and the sensitivity of the uses. Each state must develop Total Maximum Daily Loads (TMDLs) for all waters on the 303(d) list to meet water quality standards.

A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The TMDL provides the basis for the establishment of water quality-based controls and establishes the maximum allowable loads of a pollutant that can be assimilated by a water body while still meeting applicable water quality standards. These controls should provide the pollution reduction necessary for a water body to meet water quality standards. The allocation calculation for each waterbody must include an implicit or explicit margin of safety to ensure that the water body can be utilized for its state-designated beneficial uses. Additionally, the TMDL calculation must account for seasonal variation in water quality.

TMDLs are intended to address all significant stressors which cause or threaten to cause impairments to beneficial uses, including point sources (*e.g.*, sewage treatment plant discharges), nonpoint sources (*e.g.*, runoff from fields, streets, range, or forest land), and naturally occurring sources (*e.g.*, runoff from undisturbed lands). TMDLs may be based on readily available information and studies, however in some cases, complex studies or models are needed to understand how stressors are causing water body impairment. In many cases, simple analytical efforts provide an adequate basis for stressor assessment and implementation planning.

TMDLs provide an analytical basis for planning and implementing pollution controls, land management practices, and restoration projects needed to protect water quality. States are required to include approved TMDLs and associated implementation measures in state water quality management plans.

Implementing a TMDL generally involves developing a plan for applying pollution control practices necessary to reduce pollutant loads to the extent determined necessary in the TMDL. Pollution control practices usually consist of point source control permits and/or nonpoint source control Best Management Practices (BMPs). BMPs are techniques, measures, or structural controls to manage the quantity and/or improve the quality of stormwater runoff.

Section 4 of this technical report describes the existing condition of waterways and groundwater in the project area, established beneficial uses, and associated TMDLs. These water quality regulations would be applicable during construction and operation of the proposed alternatives identified in the EIS.

3.2.2 Executive Order 11990: Protection of Wetlands

Wetlands are lands where saturation with water is the dominant factor determining the nature of the soil, and terrestrial and aquatic flora and fauna. For regulatory purposes, the CWA defines wetlands as

"those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands provide many important benefits such as flood control, erosion control, habitat, regulation of water quantity and quality, and recreational activities. The federal government protects wetlands in order to preserve and maintain the beneficial values wetlands contribute to U.S. water resources.

EO 11990 relates to the protection of wetlands and directs all federal agencies to avoid, if possible, adverse effects on wetlands, and to preserve and enhance the natural and beneficial values of wetlands. Each agency shall provide leadership and take action to minimize the destruction, loss or degradation of wetlands. EO 11990 states each agency must avoid undertaking or assisting in wetland construction projects unless the head of the agency determines that there is no practicable alternative to such construction and that the proposed action includes measures to minimize harm. In addition, each agency shall also provide an opportunity for early public review of any plans or proposals for new construction in wetlands, in accordance with Section 2(b) of EO 11514.

EO 11990 requires federal agencies to protect wetlands located on federal lands in the event that those lands are leased or disposed of to non-federal parties. When federally-owned wetlands or portions of wetlands are proposed for lease, easement, right-of-way or disposal to non-federal public or private parties, the agency shall reference, in conveyance, those uses that are restricted under identified federal, state or local wetlands regulations, and attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successor, except where prohibited by law; or withhold such properties from disposal.

3.2.3 USACE Engineer Regulations

ER 1110-2-1462, established in 1991, provides guidance for the incorporation of USACE water quality and water control management responsibilities and considerations into the review of permit and license applications, operating agreements, and other official contracts concerning non-federal hydropower development either at or affecting USACE water resource projects. ER 1110-2-1462 establishes procedures to ensure the formulation, development, and operation of non-federal hydropower at USACE civil works projects or at other projects does not interfere with USACE water quality and water control interests and responsibilities. This ER requires consideration of upstream and downstream impacts and cumulative effects. Under ER 1110-2-1462, a developer must prove the functionality of the proposal and demonstrate that it will not adversely affect the operational or structural integrity of the project, including the ability to meet water quality management responsibilities and authorized purposes.

ER 1110-2-8154, dated 1995, establishes a policy for the water quality management program at USACE civil works projects. ER 1110-2-8154 requires USACE to take a leadership role in carrying out the goals and objectives of the national policy (discussed in Section 3.2) by managing the nation's water resources that are under control of USACE so that they are protected, maintained, and restored. This policy also requires USACE to develop and implement a holistic, environmentally sound water quality management strategy that works in concert with other project purposes.

As a steward of project resources, USACE will not allow degradation of aquatic resources unless there is compelling evidence that to do so will cause significant national economic and social harm. In situations where degradation has occurred, it is USACE's policy to restore the resource to a biologically productive,

diverse, and ecologically robust condition. USACE management responsibilities include the waters directly managed by USACE and the area influenced by those waters, which necessitates a management philosophy committed to partnering with a wide range of resource organizations and interested individuals.

ER 1110-2-8154 requires division-wide water quality management programs, and states specific water quality management objectives must be developed for each project along with procedures to meet those objectives. General water quality management objectives and water quality data collection and application procedures for all USACE water resource projects are described in ER 1110-2-1854.

3.3 Data Collection

The purpose of this technical report is to collect information on hydrologic features, aquatic resources, and the water quality associated with Eufaula Lake and the Eufaula Lake EIS study area. Baseline hydrology and water quality conditions are described for the lake with a focus on the lake shoreline. Similar information from areas upstream of the lake that flow to the lake is also evaluated. Data were collected from the following sources:

- U.S. Fish and Wildlife Service (USFWS) including the National Wetlands Inventory
- EPA including 303(d) Impaired Waters report
- U.S. Geological Survey (USGS) including quadrangle maps
- Oklahoma Water Resources Board (OWRB) 2000 to 2009 (17 sample sites on Eufaula Lake)
- USACE, Tulsa District 2001 (nine stations)
- Other relevant state and federal agencies
- Local agencies that may monitor construction activities

3.4 Analysis Methods

Documentation of the lake and other aquatic resources and the water quality of these resources will be presented in a geo-referenced GIS format. Habitat maps will be used as base maps to indicate the location of hydrologic features, selected outfalls, and selected water quality sampling stations.

Site visits were used to verify hydrologic features and aquatic resources, as needed, as well as documentation of activities that may impact water quality such as outfalls, areas with significant sedimentation and erosion, and areas with extremely high boat usage.

Water quality in the Eufaula Lake EIS study area is described in terms of the water quality monitoring points and from a watershed perspective (*e.g.*, documentation of land use and tributary water quality). This involves an evaluation of the water quality data relative to water quality standards (such as dissolved oxygen, turbidity, nutrients, coliforms, and biological integrity), a quantitative estimate of runoff and pollutant loads (*i.e.* modeling of runoff and pollutant contributions to Eufaula Lake), and a qualitative determination of the contribution of point and non-point sources to the lake. Results from the assessment of lacustrine habitats as described in the Natural Resources Technical Memo are also included as warranted. This information will form the basis to evaluate the potential effect of each alternative on water quality and aquatic resources in Eufaula Lake. An evaluation of the 303(d) impaired

waters list for Oklahoma indicates that several portions of Eufaula Lake and tributaries to the lake are impaired.

A basic model was used to quantitatively estimate runoff and pollutant loads into Eufaula Lake under existing conditions as well as for each alternative. The EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) Model employs simple algorithms to estimate annual runoff volume, and total nitrogen, phosphorus, biochemical oxygen demand (BOD), and sediment load from location and land use input information. For the purposes of the STEPL analysis, two scenarios were explored: pollutant loads contributed from USACE-owned lands only, and pollutant loads contributed from USACE-owned lands and adjacent private lands. The contributing watershed was assumed to be the USACE-owned lands around the lake, and USACE-owned lands plus ½ mile of adjacent private lands around the lake.

Section 4
Existing Conditions

The existing water quality in Eufaula Lake serves as a baseline against which to compare potential water quality impacts that may result from the proposed alternatives and to identify mitigation measures necessary to meet Oklahoma Water Quality Standards (OWRB 2011b). This section provides an inventory of the existing water quality in Eufaula Lake.

4.1 Watershed Characterization

4.1.1 Location and Description

Eufaula Lake dam is located on the Canadian River in McIntosh County, Oklahoma. The reservoir area lies in Haskell, McIntosh, Okmulgee, and Pittsburg Counties. With over 800 miles of shoreline and 105,500 surface acres, Eufaula Lake offers a variety of recreational opportunities. The watershed's terrain ranges from hills and ridges of the Northern Cross Timbers in the north and transitions southward to the diverse plains, terraces, and wooded hills of the Arkansas Valley and finally to the Fourche Mountains at the far southern border (OWRB 2012).

Mud Creek, Deep Fork of Canadian River, North Canadian River, Canadian River, Coal Creek, Brushy Creek, Gaines Creek, Ash Creek, and Longtown Creek are major streams that contribute to Eufaula Lake. Both the Canadian River and North Canadian River have periods of low to no flow due to seasonal and long-term trends in precipitation (OWRB 2012).

Eufaula Lake dam and reservoir were completed in 1964 for flood control, water supply, navigation, and hydropower purposes, and has since been modified to include recreation. Eufaula Lake has a conservation pool elevation of 585.0 feet above mean sea level (MSL), a mean depth of 20.3 feet, and cumulative a storage capacity of 2,141,422 acre feet at the conservation pool elevation (USACE 2012). Eufaula Lake has a dependable water supply yield of 56,000 acre feet per year and is an important water supply resource for the state of Oklahoma.

According to the USACE study *2001 Eufaula Lake Water Quality Report*, "the lake inflow carries a large amount of sediment that comes mostly from the Canadian, North Canadian, and Deep Fork Rivers. Based on a 1977 sediment survey, the amount of storage lost to sediment accumulation below elevation 597 feet NGVD is 125,524 ac-ft... Sediment is deposited at an average annual rate of 9,417 ac-ft per year" (USACE 2012).

4.1.2 Hydrogeology/Groundwater

Within the Eufaula Lake watershed there are eight identified aquifers: the Canadian River and North Canadian River major alluvial aquifers, the Ashland Isolated Terrace minor alluvial aquifer, the Garber-Wellington and Vamoosa-Ada major bedrock aquifers, and the East-Central Oklahoma, Kiamichi, and Pennsylvania minor bedrock aquifers (OWRB 2012).

The following represent general water quantity yields from aquifers within the Eufaula Lake EIS study area (OWRB 2012):

- Canadian River – from 100 to 400 gallons per minute (gpm) in the alluvium and from 50 to 100 gpm in the terrace
- North Canadian River – from 300 to 600 gpm in the alluvium and from 100 to 300 gpm in the terrace
- Ashland Isolated Terrace – less than 50 gpm
- Garber-Wellington – from 200 to 400 gpm
- Vamoosa-Ada – from 25 to 150 gpm

Alluvial groundwater in the Eufaula Lake watershed is predominantly of a calcium magnesium bicarbonate type and variable in dissolved solids content, and is generally suitable for most purposes (OWRB 2012).

The Garber-Wellington bedrock groundwater in the Eufaula Lake watershed is predominately of a calcium magnesium bicarbonate type and ranges from hard to very hard (OWRB 2012). Water from this aquifer is generally suitable for public water supply, but local concentrations of nitrates, sulfate, chloride, fluoride, arsenic, chromium, and selenium may exceed drinking water standards (OWRB 2012).

The Vamoosa-Ada water quality is generally good but is impacted by iron infiltration and hardness (OWRB 2012). Except for areas of local contamination resulting from past oil and gas activities, chloride and sulfate concentrations are low and water quality is generally suitable for public water supply (OWRB 2012).

4.1.3 Recreation

Eufaula Lake is shallow with a mean depth of 20.3 feet and a maximum depth of 87 feet (USACE 2012). Water clarity across the lake varies from muddy areas located generally to the west of Highway 69 with very muddy areas in Gaines Creek and Deep Fork arms, and clear areas near Longtown Creek and eastern lake areas towards Duchess Creek (Lake Area 4 as shown on Figure 3.12-1 in the Draft EIS) This varying water clarity drives recreational use across the lake where muddy areas are preferable for fishing and clearer areas are preferable for boating, swimming, and water skiing. The Highway 69 causeways bisect the lake and have the potential to create settling basins allowing the eastern areas of the lake to be clearer and for muddier conditions to be contained in the western portion of the lake.

4.1.4 Water Quality

CDM Smith evaluated water quality in the study area based on data from three sources:

- Oklahoma Water Resources Board (OWRB) provided water quality data for 17 sample sites (**Table 4-1**) at Eufaula Lake collected between 2000 and 2009 (OWRB 2011a).
- USACE, Tulsa District provided water quality data for nine sites (**Table 4-2**) collected in 2001 (USACE 2012).
- Oklahoma Conservation Commission (OCC) provided water quality data for 15 sites (**Table 4-3**) collected between 1999 and 2010 (OCC 2012).

In addition, a STEPL model was used to quantitatively estimate runoff and pollutant loads into Eufaula Lake under existing conditions as well as for each alternative as described in Section 3.4. The existing conditions as described by the model are presented in Section 4.1.5.

Figure 4-1 lists each of the water quality sites. Data from these stations over the past decade were collected and analyzed. **Appendix A** presents the mean, median, minimum, maximum, and number of observations for each of the OWRB, USACE, and OCC sample sites. Oklahoma water quality standards (WQS) are listed in **Table 4-4** (OWRB 2011b). **Table 4-5** identifies the designated beneficial use for surface waters in the Eufaula Lake watershed (OWRB 2011b).

Table 4-1. OWRB Water Quality Stations at Eufaula Lake

OWRB Station	Latitude	Longitude	Station Name
520700010020-01	35.454	-95.613	Site 1
520700010020-02	35.428	-95.600	Site 2
520500010020-03	35.382	-95.630	Site 3
520500010020-04	35.300	-95.554	Site 4
220600010020-05	35.285	-95.515	Site 5
220600010020-06	35.307	-95.438	Site 6
220600010020-07S	35.307	-95.362	Site 7A Surface
220600010020-07B	35.307	-95.360	Site 7B Bottom
220600010060-08	35.234	-95.500	Site 8
220600010050-09	35.225	-95.596	Site 9
220600010050-10	35.203	-95.697	Site 10
220600010050-11	35.229	-95.634	Site 11
220600050010-12	35.200	-95.594	Site 12
220600050010-13	35.164	-95.599	Site 13
220600050010-14	35.101	-95.647	Site 14
220600050010-15	35.050	-95.671	Site 15
220600050010-16	35.020	-95.602	Site 16
220600050010-17	34.975	-95.630	Site 17

Table 4-2. USACE Water Quality Stations at Eufaula Lake

USACE Station	Latitude	Longitude	Station Name
1EUFOKS0037	35.308	-95.363	Dam Site
1EUFOKS0038	35.259	-95.513	Longtown Channel
1EUFOKS0039	35.224	-95.638	Gas Well
1EUFOKS0040	35.218	-95.594	Oak Ridge
1EUFOKS0044	35.488	-95.680	Gentry Creek Cove
1EUFOKS0172	35.307	-95.358	Stilling Basin
1EUFOKS0173	35.106	-95.643	Crowder Point
1EUFOKS0174	35.378	-95.636	Fountainhead West
1EUFOKS0175	35.333	-95.587	Hwy 69 Bridge

Table 4-3. OCC Water Quality Stations in Eufaula Lake Watershed

OCC Station	Latitude	Longitude	Station Name
OK220600-01-0100P	35.2310	-95.839	Mill Creek, Trib. to Eufaula
OK220600-03-0010J	34.8432	-95.614	Brushy Creek
OK220600-03-0050F	34.8519	-95.6541	Peaceable Creek
OK520500-01-0170L	35.3778	-96.058	Bad Creek
OK520500-01-0200D	35.3366	-96.142	Alabama Creek
OK520500-02-0010C	35.2187	-96.213	Wewoka Creek: Downstream
OK520500-02-0010M	35.1677	-96.493	Wewoka Creek
OK520500-02-0090D	35.2318	-96.295	Little Wewoka Creek
OK520700-01-0080L	35.5368	-95.676	Gentry Creek
OK520700-03-0100B	35.6962	-96.476	Salt Creek
OK520700-03-0220D	35.766	-96.583	Camp Creek
OK520700-03-0220G	35.7559	-96.572	Camp Creek
OK520700-04-0020F	35.6848	-96.694	Dry Creek
OK520700-04-0260C	35.6221	-96.819	Quapaw Creek
OK520710-01-0010G	35.6590	-97.244	Deep Fork of North Canadian River

Table 4-4. Oklahoma Water Quality Standards

Parameter	Oklahoma Water Quality Standards[A]
Arsenic	▪ 0.04 mg/L (PPWS) ▪ 205.0 µg/L (fish consumption) ▪ 360 µg/L (FWP acute)[F] ▪ 190 µg/L (FWP chronic)[F]
Barium	▪ 1.0 mg/L (PPWS)
Cadmium	▪ 0.020 mg/L (PPWS) ▪ 14.49 µg/L (fish consumption and water) ▪ 84.13 µg/L (fish consumption) ▪ e(1.128[ln(hardness)] – 1.6774) (FWP acute)[F] ▪ e(0.7852[ln(hardness)] – 3.490) (FWP chronic)[F]
Chloride	▪ 83 mg/L (segment 220300)[E] ▪ 230 mg/L (segment 220600)[BE]
Chromium (total)	▪ 0.050 mg/L (segment 220300)[E] ▪ 166.3 µg/L (fish consumption and water) ▪ 3365.0 µg/L (fish consumption)
Color, True	▪ 70 PT-CO
Copper	▪ 1.0 mg/L (PPWS)[D] ▪ e(0.9422[ln(hardness)] – 1.3844) (FWP acute)[F] ▪ e(0.8545[ln(hardness)] – 1.386) (FWP chronic)[F]
Corrected Chlorophyll-*a*	▪ N/AB
Cyanide	▪ 0.20 mg/L (PPWS)[D] ▪ 45.93 µg/L (FWP acute)[F] ▪ 10.72 µg/L (FWP chronic)[F]
Dissolved Oxygen	▪ 6.0 mg/L (early life stages) ▪ 5.0 mg/L (other life stages)[C]
E. coli	▪ 126 per 100 mL

Parameter	Oklahoma Water Quality Standards[A]
Enterococci	▪ 33 per 100 mL
Fluoride	▪ 4.0 mg/L (PPWS)[D]
Lead	▪ 0.100 mg/L (PPWS)[D] ▪ 5.0 µg/L (fish consumption and water) ▪ 25.0 µg/L (fish consumption) ▪ e(1.273[ln(hardness)] – 1.460) (FWP acute)[F] ▪ e(1.273[ln(hardness)] – 4.705) (FWP chronic)[F]
Mercury	▪ 0.002 mg/L (PPWS)[D] ▪ 0.050 µg/L (fish consumption and water) ▪ 0.051 µg/L (fish consumption) ▪ 2.4 µg/L (FWP acute)[F] ▪ 1.302 µg/L (FWP chronic)[F]
Nickel	▪ 607.2 µg/L (fish consumption and water) ▪ 4583.0 µg/L (fish consumption) ▪ e(0.8460[ln(hardness)] + 3.3612) (FWP acute)[F] ▪ e(0.846[ln(hardness)] + 1.1645) (FWP chronic)[F]
Nitrates (as N)	▪ 10.0 mg/L (PPWS)[D]
pH	▪ 6.5 to 9.0
Selenium	▪ 0.010 mg/L (PPWS)[D] ▪ 20.0 µg/L (FWP acute)[F] ▪ 5 µg/L (FWP chronic)[F]
Silver	▪ 0.050 mg/L (PPWS)[D] ▪ 104.8 µg/L (fish consumption and water) ▪ 64620.0 µg/L (fish consumption) ▪ e(1.72[ln(hardness)] - 6.52) (FWP acute)[F]
Solids, Total Dissolved	▪ 320 mg/L (segment 220300)[E] ▪ 837 mg/L (segment 220600)[B]
Sulfate	▪ 52 mg/L (segment 220300)[E] ▪ 182 mg/L (segment 220600)[B]
Thallium	▪ 1.7 µg/L (fish consumption and water) ▪ 6.0 µg/L (fish consumption) ▪ 1400.0 µg/L (FWP acute)[F]
Total Coliform	▪ 5,000 per 100 mL
Turbidity	▪ 25 NTU
Zinc	▪ 5.0 mg/L (PPWS)[D] ▪ (0.8473[ln(hardness)] + 0.8604) (FWP acute)[F] ▪ e(0.8473[ln(hardness)] + 0.7614) (FWP chronic)[F]

Notes:

[A]Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B]Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C]Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D]Public and private water supply (PPWS)

[E]Canadian River from mouth of Eufaula Reservoir Dam

[F]Fish and Wildlife Propagation (FWP)

Table 4-5. Designated Beneficial Uses of Surface Waters in Eufaula Lake Watershed

Water Body Name	Water Body ID	Designated Beneficial Use[A]
Canadian River including Eufaula Reservoir (excluding the North Canadian River) to its confluence with Little River	220600010010, 220300010020, 220600040050, 220600010060, 220600010119, 220600050010	PPWS, WWAC, Ag, PBCR, Aes
Mud Creek	220600050060	PPWS, WWAC, Ag, PBCR, Aes
Longtown Creek	220600010070	PPWS, WWAC, Ag, PBCR, Aes
Gibson Creek	220600050020	HLAC, Ag, SBCR, Aes
Tributary of Gibson Creek	220600	HLAC, Ag, SBCR, Aes
Gaines Creek	220600040010	PPWS, WWAC, Ag, PBCR, Aes
Coal Creek	220600020010	PPWS, WWAC, Ag, PBCR, Aes
Deer Creek	220600020080	WWAC, Ag, PBCR, Aes
Sandy Creek	220600020090	WWAC, Ag, SBCR, Aes
Tributary of Sandy Creek	220600	WWAC, Ag, SBCR, Aes
Tributary of Coal Creek	220600	HLAC, Ag, SBCR, Aes
Ash Creek	220600050040	PPWS, WWAC, Ag, PBCR, Aes
Mud Creek	220600050060	WWAC, Ag, PBCR, Aes
Brushy Creek	220600030010	PPWS, WWAC, Ag, PBCR, Aes
Blue Creek	220600030020	PPWS, WWAC, Ag, PBCR, Aes
Peaceable Creek	22060030050	PPWS, WWAC, Ag, PBCR, Aes
Chun Creek	22060030060_10, 22060030060_00	EWS, WWAC, Ag, SBCR, Aes
Tributary of Chun Creek	220600	HLAC, Ag, SBCR, Aes
Bull Creek downstream from Bull Lake	220600030080	WWAC, Ag, PBCR, Aes
Mill Creek	220600010100	PPWS, WWAC, Ag, PBCR, Aes
Big Creek	220600010170	PPWS, WWAC, Ag, PBCR, Aes
Unnamed tributary of Canadian River	220600	HLAC, Ag, SBCR, Aes
Deep Fork of Canadian River downstream from Arcadia Reservoir	520700010010, 520700010060, 520700010120, 520700020010, 52070030010, 520700040010, 520700050010, 520710010010, 520710020010	PPWS, WWAC, Ag, PBCR, Aes
Wolf Creek downstream from lake Henryetta	520700010130, 520700010170	WWAC, Ag, PBCR, Aes
Coal Creek	520700010140	EWS, WWAC, Ag, SBCR, Aes
Moore Creek	520700010190	WWAC, Ag, PBCR, Aes
Burgess Creek at Montezuma Creek	52070010230	EWS, WWAC, Ag, SBCR, Aes
Cussetah (Cosseetta) Creek	520700010250	WWAC, Ag, PBCR, Aes
Tributary of Cussetah	520700	HLAC, Ag, SBCR, Aes

Water Body Name	Water Body ID	Designated Beneficial Use[A]
Salt Creek downstream from Lake Okmulgee	520700020020	PPWS, WWAC, Ag, PBCR, Aes
Flat Rock Creek	520700020090	PPWS, WWAC, Ag, PBCR, Aes
Tributary of Adams Creek	52070020100	EWS, WWAC, Ag, SBCR, Aes

Notes:

[A] *Beneficial Use Designations, from Appendix A of the Oklahoma Water Quality Standards*
EWS – Emergency water supply
PPWS – Public and private water supply
F&W Prop. – Fish and wildlife propagation
WWAC – Warm water aquatic community subcategory
HLAC – Habitat limited aquatic community subcategory
CWAC – Cool water aquatic community subcategory
Trout – Trout fishery (put and take) subcategory
Ag – Agriculture
Rec – Recreation
PBCR – Primary body contact
SBCR – Secondary body contact
Nav – Navigation
Aes - Aesthetic

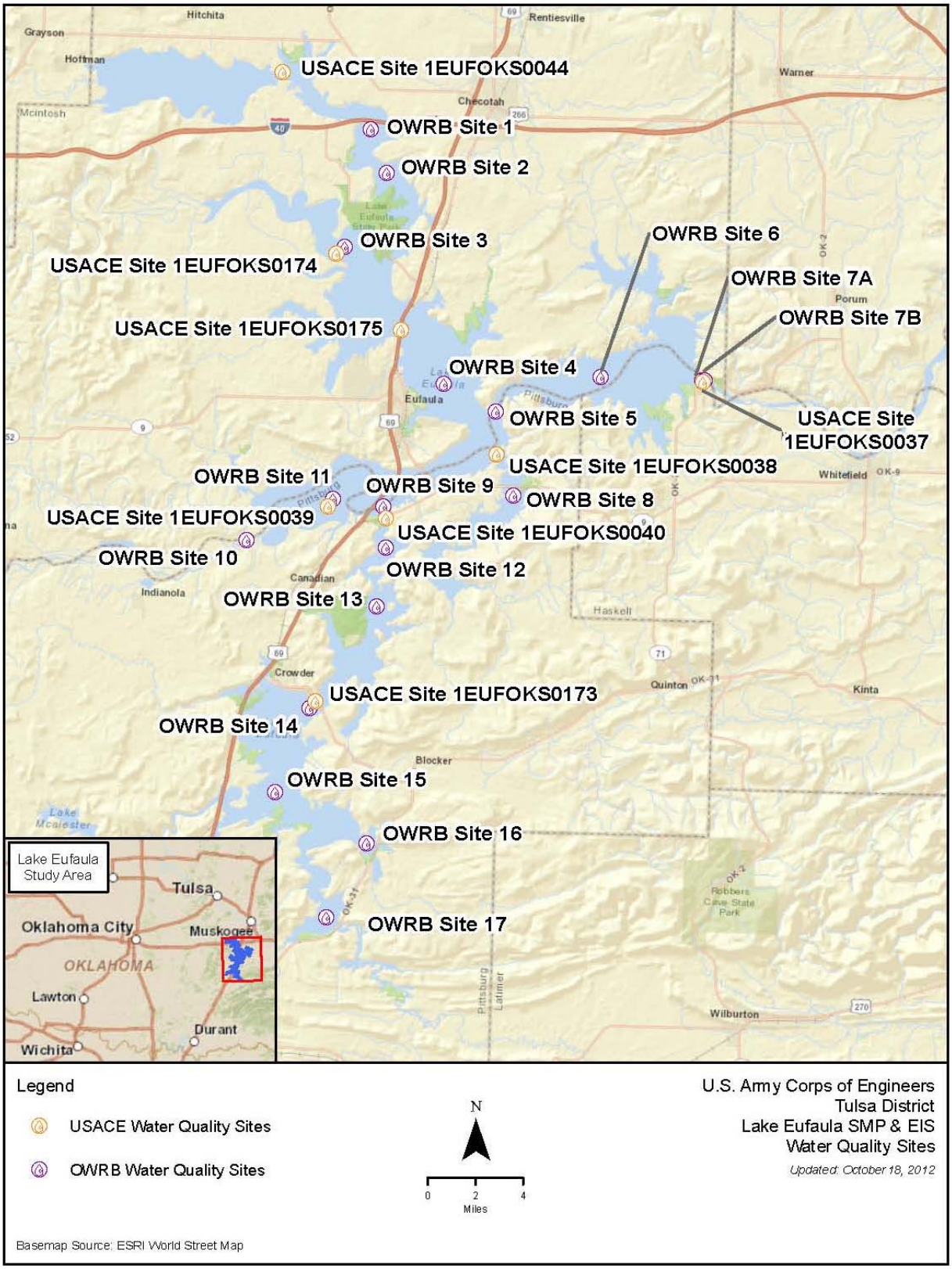


Figure 4-1. Water Quality Stations at Eufaula Lake

Water quality data were analyzed to determine trends in the data and to evaluate how water quality may affect the alternatives in the Eufaula Lake EIS and also to understand if the alternatives may have the potential to impact water quality.

Chlorophyll-*a*. Chlorophyll-*a* measures productive algal biomass in the water column. Concentrations in Eufaula Lake ranged from a minimum of 0.7 µg/L (OWRB Site 1 January 2003) to a maximum of 92.7 µg/L (1EUFOKS0173 October 2001), with a lake wide mean of 10.47 µg/L. Generally, the OWRB sites show fairly consistent median chlorophyll-*a* levels across the lake, as shown in **Figure 4-2**. The *Oklahoma Comprehensive Water Plan* (*OCWP) Eufaula Regional Report* noted an upward trend for chlorophyll-*a* at Eufaula Lake from 1995 through 2009 (OWRB 2012). While no water quality data during the event are available, USACE staff reported an algal bloom in summer 2011. There is no applicable chlorophyll-*a* WQS for Eufaula Lake.

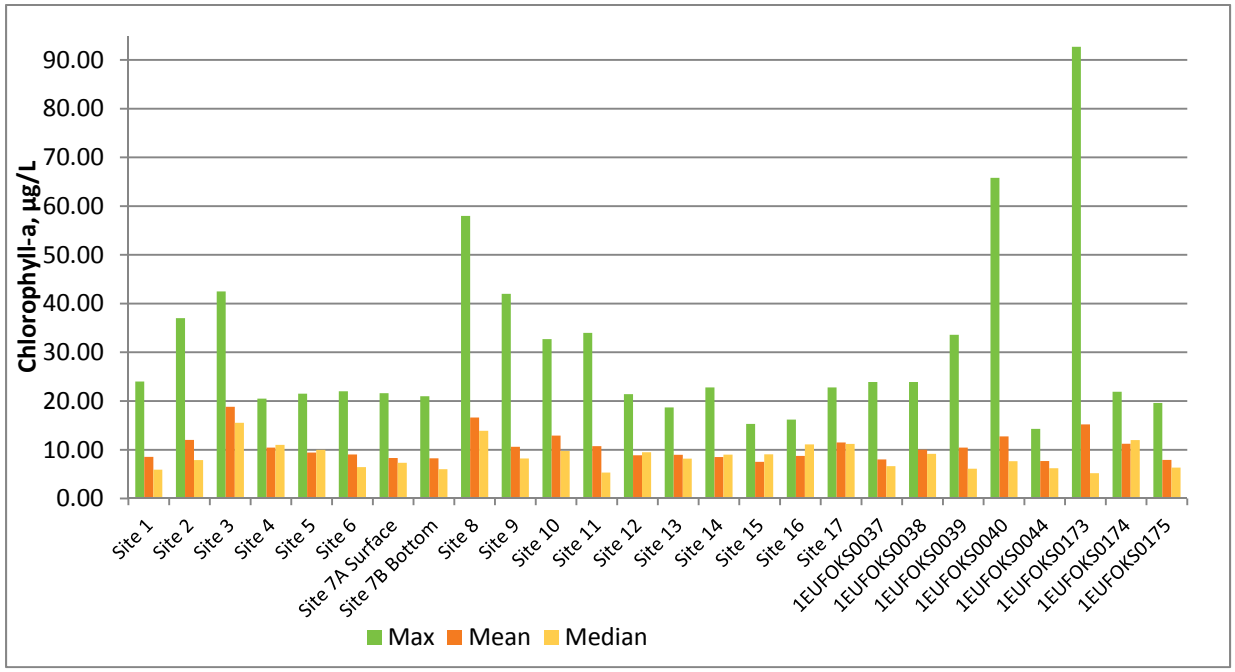


Figure 4-2. Eufaula Lake Chlorophyll-*a*

In May, June, August, and September 2012, the USACE Tulsa District collected samples from six sampling sites to evaluate the presence of cyanobacteria dominated algae, commonly referred to as blue-green algae. In May, blue-green algae was present at Porum Landing in excess of 100,000 cells/mL. June samples indicated blue-green algae levels declined at Porum Landing, but remained above 100,000 cells/mL. In August, blue-green algae were present at Brooken Cove, Highway 9 Landing, Porum Landing, and Belle Starr Park in excess of 100,000 cells/mL and cyanobacteria were present at Elm Point and Gentry Creek at levels below the 100,000 cells/mL threshold. Blue-green algae was again detected in excess of 100,000 cells/mL at Porum Landing, Brooken Cove, and Highway 9 Landing in September. Recreational surveys noted the presence of blue-green algae in Deep Fork arm, and helicopter surveys identified algae on Gaines Creek arm; these observations suggest the problem is more widespread than sampling may indicate. Overall, levels climbed at all sample sites as the summer progressed. The presence of algae is widespread throughout Eufaula Lake and given the limited sampling locations, algae could be occurring anywhere on the lake.

Specific Conductance. Only one measurement of specific conductance was taken by OWRB (1,468 µS/cm in November 2006). From the 2001 USACE data, specific conductance ranged from a minimum of 114 µS/cm (1EUFOKS0173 April 17, 2001) and a maximum of 872 µS/cm (1EUFOKS0174 April 18, 2001) with a lake wide mean of 416 µS/cm.. In the *2001 Eufaula Lake Water Quality Report* by USACE it is noted that that "sites near inflows from the North and South Canadian Rivers had statistically significant higher values while the site in the Gaines Creek Arm of the lake had a statistically significant lower mean level" (USACE 2012). From the OCC data, conductivity in streams varies from a minimum of 46.00 µS/cm (OK220600-03-0050F October 20, 2008) to a maximum of 5,099 µS/cm (OK520500-02-0010M August 19, 2008) with a mean of 629.74 µS/cm.

Total Nitrogen and Total Phosphorus. All of the total nitrogen samples were collected between 2001 and 2009. Generally only one or two samples were collected at the OWRB sites while more samples at various depths were collected at each of the USACE sites. Total nitrogen concentrations in Eufaula Lake ranged from a minimum of <0.02 mg/L (1EUFOKS0038August 2001) to a maximum of 2.58 mg/L (1EUFOKS0044 June 6, 2001) with a lake wide mean of 0.77 mg/L. The *2001 Eufaula Lake Water Quality Report* by USACE reported that total nitrogen "concentrations varied widely through the sampling period… with peak observations occurring after inflow events in early June, diminishing gradually through the summer with another moderate peak in October, also related to an inflow event" (USACE 2012). The *OCWP Eufaula Regional Report* noted an upward trend for total nitrogen at Eufaula Lake during the period of 1995 to 2009 (OWRB 2012). There is no applicable total nitrogen WQS for Eufaula Lake (**Figure 4-3**); however, the WQS for nitrates applies to Eufaula Lake under its public water supply designation (**Figure 4-4**). From the OCC data, nitrates in streams vary from a minimum of <0.02 mg/L to a maximum of 5.55 mg/L (OK520500-02-0010M October 26, 2004) with a mean of 0.22 mg/L.

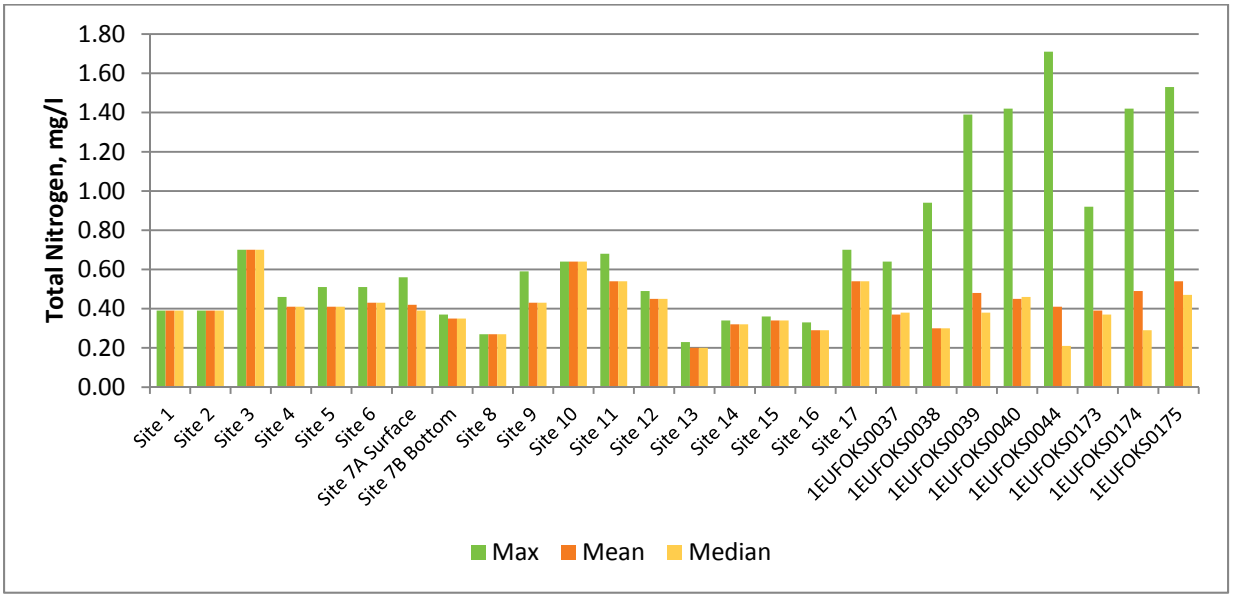


Figure 4-3. Eufaula Lake Total Nitrogen

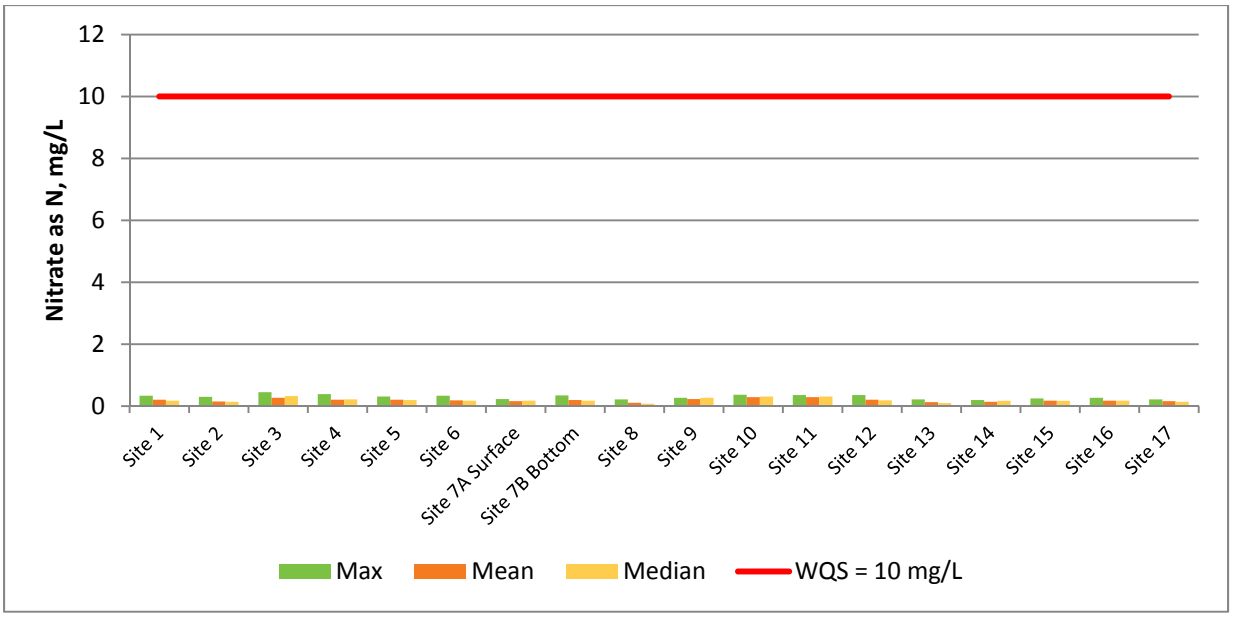


Figure 4-4. Eufaula Lake Nitrate (as N)

Total phosphorus concentrations in Eufaula Lake ranged from a minimum of 0.011 mg/L (occurring at OWRB Site 7A September 9, 2003) to a maximum of 0.460 mg/L (Site 14 January 9, 2003) with a lake wide mean of 0.06 mg/L. The *2001 Eufaula Lake Water Quality Report* by USACE reported that total phosphorus had "peak surface concentrations were observed after the early June inflow event. Peak bottom concentrations occurred in late summer associated with an anoxic hypolimnion and release of phosphorus from the bottom sediments" (USACE 2012). The *OCWP Eufaula Regional Report* noted an upward trend for total phosphorus at Eufaula Lake during the period of 1995 to 2009 (OWRB 2012). There is no applicable total phosphorus WQS for Eufaula Lake (**Figure 4-5**). From the OCC data, total phosphorus concentrations in streams varies from a minimum of 0.007mg/L (OK5250500-01-0200D January 5, 2009) to a maximum of 3.278 mg/L (OK220600-03-0050F August 17, 2009) with a mean of 0.165 mg/L.

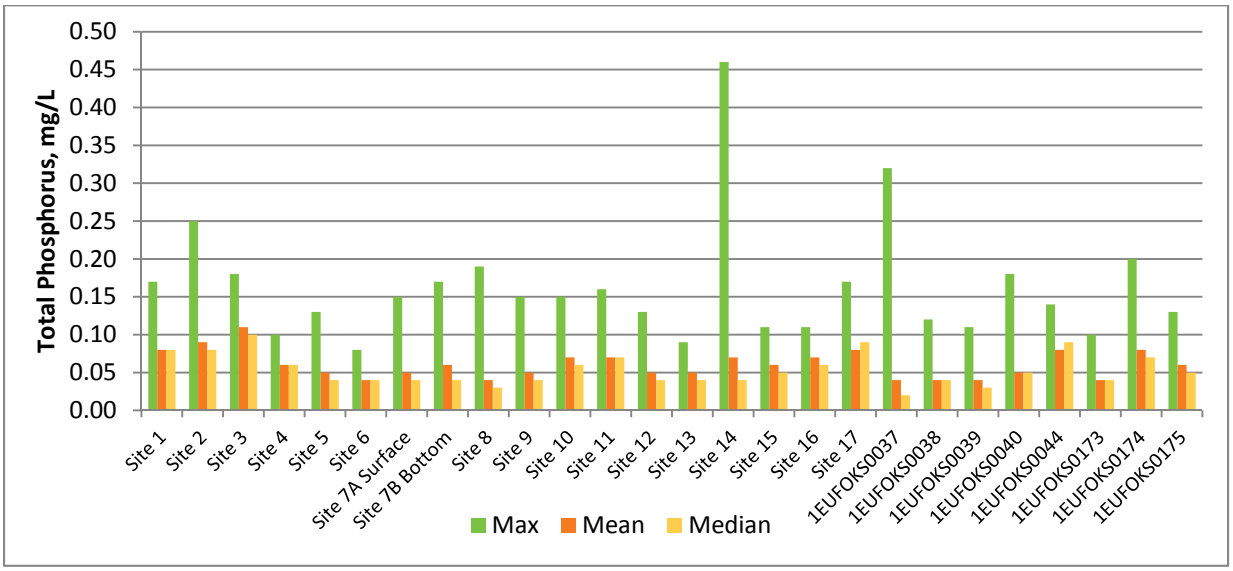


Figure 4-5. Eufaula Lake Total Phosphorus

Turbidity. Turbidity concentrations in Eufaula Lake ranged from a minimum of 0.20 NTU (1EUFOKS0037 August 2001) to a maximum of 745.40 NTU (1EUFOKS0038 September 2001) with a lake wide mean of 32.60 NTU. The *2001 Eufaula Lake Water Quality Report* by USACE reported that "lake-wide mean turbidity of 31.9 NTU represents moderately turbid water, and exceeded the State of Oklahoma lake water quality standard of 25 NTU. Highest turbidities were observed in tributary arms of the lake transitioning to moderately clear waters moving downstream toward the dam" (USACE 2012). This trend can be seen in **Figure 4-6**. Additionally, the *OCWP Eufaula Regional Report* states "Eufaula Lake clarity ranges from poor to excellent with most having average clarity (Eufaula Canadian Secchi depth of 43 cm to Dripping Springs Secchi depth of 101 cm)" (OWRB 2012). The *OCWP Eufaula Regional Report* noted "stream clarity is average to very poor, with turbidity ranging from 40 NTU (Coal Creek) to 124 NTU (North Canadian)" (OWRB 2012).

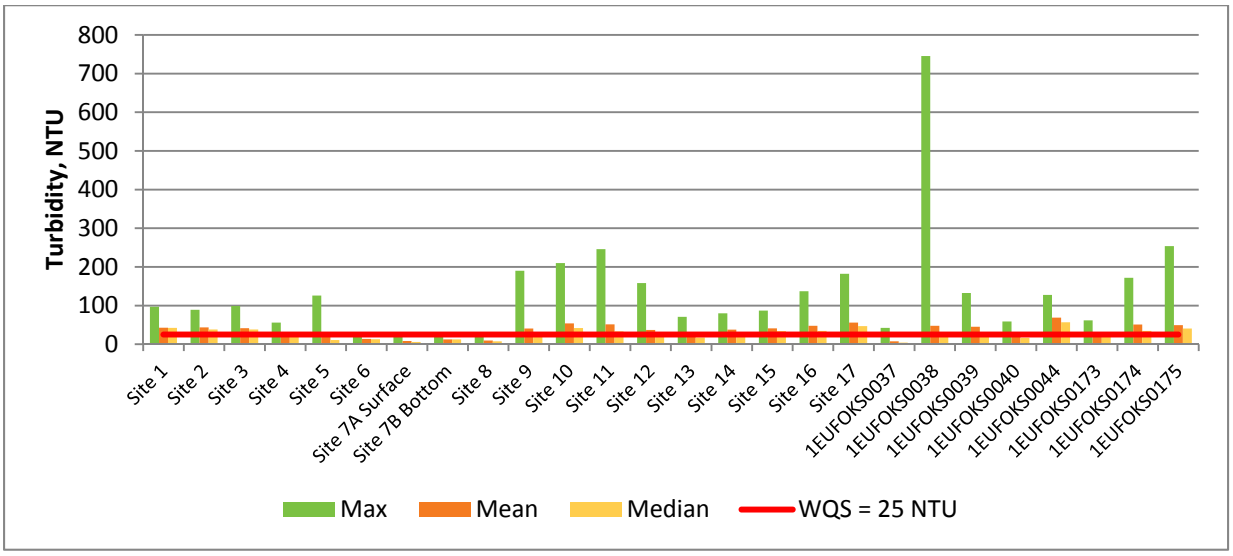


Figure 4-6. Eufaula Lake Turbidity

Alkalinity. Alkalinity (as $CaCO_3$) concentrations in Eufaula Lake ranged from a minimum of <5.0 mg/L (OWRB Site 7B April 2000) to a maximum of 161.0 mg/L (OWRB Site 4 January 2000, OWRB Site 10 May 2005) with a lake wide mean of 90.3 mg/L. The *2001 Eufaula Lake Water Quality Report* by USACE reported that "alkalinity levels in the lake were moderate implying most of the lake is reasonably well buffered; an exception may be portions of the Gaines Creek Arm where the lowest alkalinities were observed" (USACE 2012). This trend can be seen in **Figure 4-7**, as OWRB Sites 16 and 17 are located in the Gaines Creek Arm. There is no applicable alkalinity WQS for Eufaula Lake. From the OCC data, total alkalinity concentrations in streams varies from a minimum of 15.0mg/L (OK220600-03-0010J May 25, 2005) to a maximum of 367.0 mg/L (OK520700-04-0260C June 5, 2008) with a mean of 127.5 mg/L.

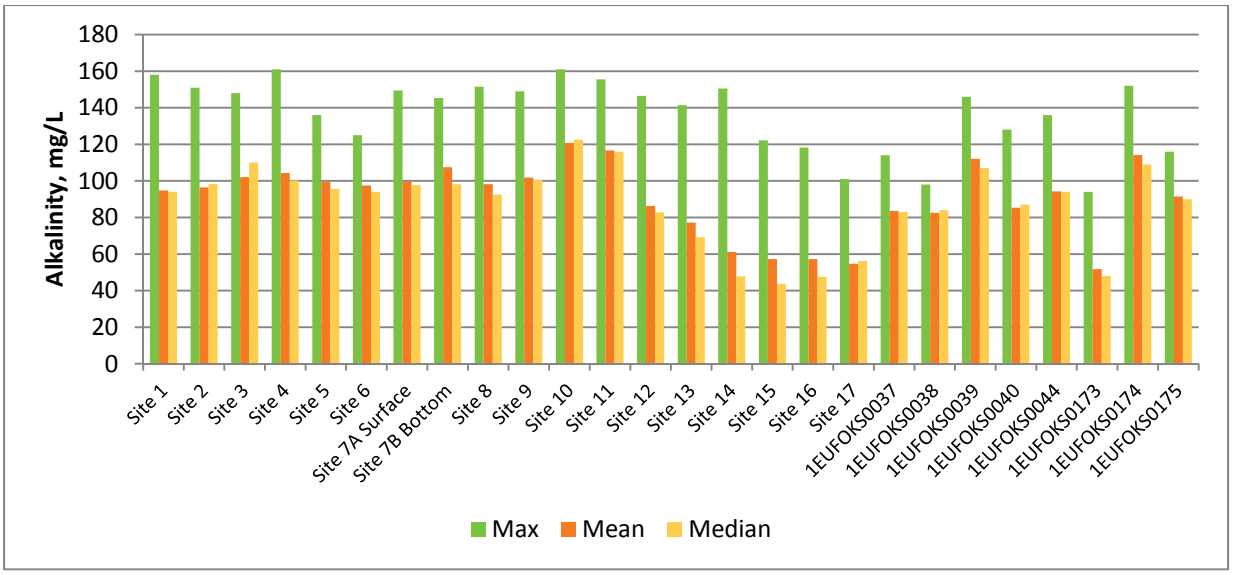


Figure 4-7. Eufaula Lake Alkalinity

Metals. Water samples were tested for arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc. No measurable concentrations were found for barium, copper, selenium, and silver. All of the measurable samples for arsenic were below the Oklahoma WQS (**Figure 4-8**).

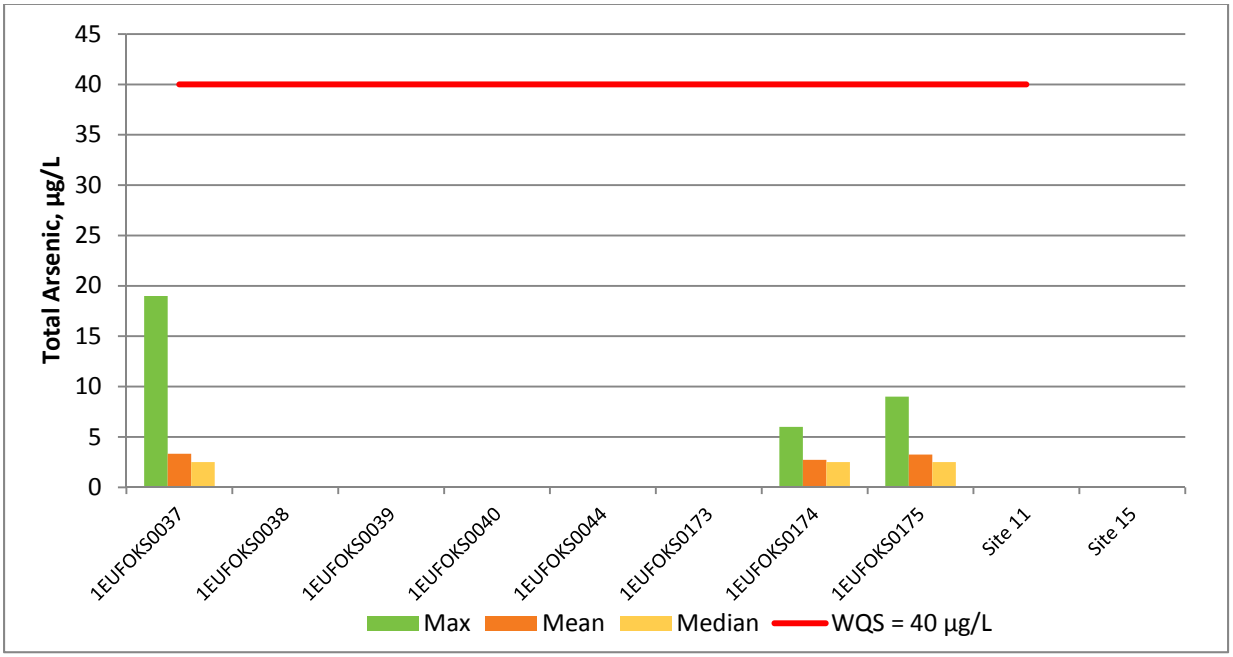


Figure 4-8. Eufaula Lake Total Arsenic

No measurable cadmium, chromium, lead, or mercury was shown in the OWRB sites. Metal testing from USACE sites is reported in the *2001 Eufaula Lake Water Quality Report,* which states "three of the nine observations [of cadmium samples] were above the Chronic Criterion" based on a lake-wide average hardness of 120.9 mg/L (USACE 2012) (**Figure 4-9**).

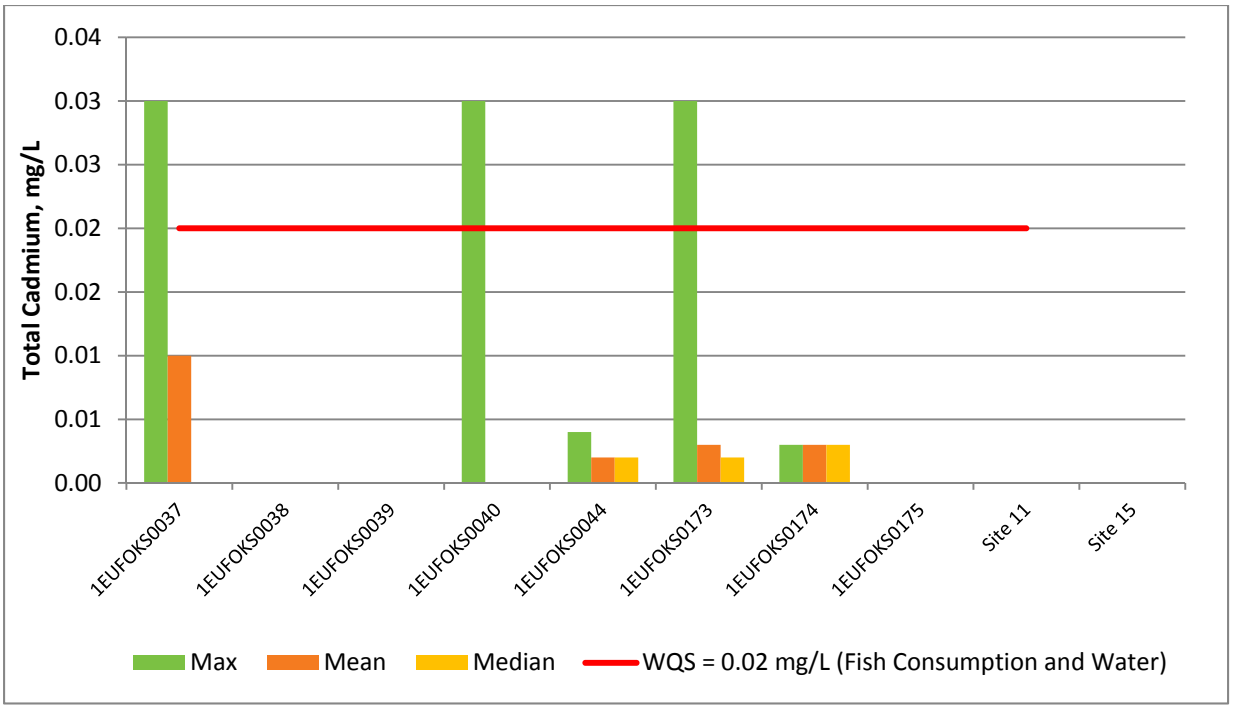


Figure 4-9. Eufaula Lake Total Cadmium

The *2001 Eufaula Lake Water Quality Report* found that "all seven observations [of lead] were below Oklahoma's Criteria for Public and Private Water Supply, but above the Chronic Criteria for Fish and Wildlife Propagation, and equal to or above the Criteria for Fish Consumption and Water" based on a lake-wide average hardness of 120.9 mg/L (USACE 2012) (**Figure 4-10**).

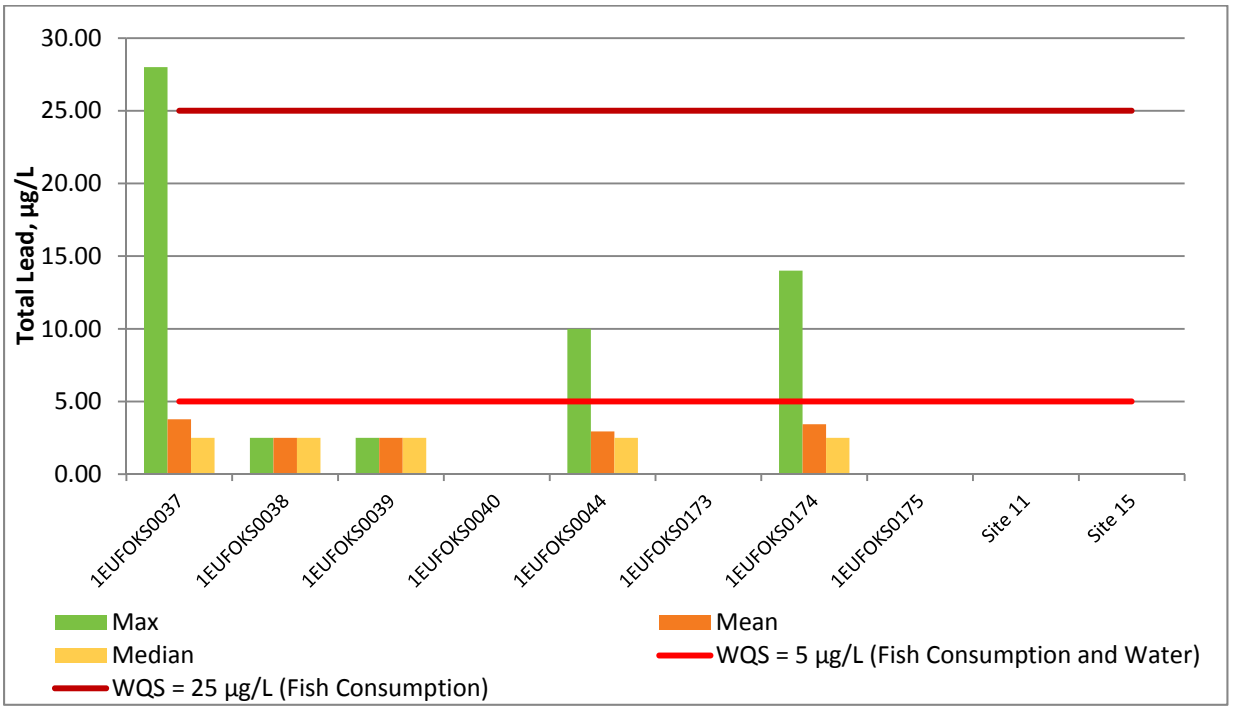


Figure 4-10. Eufaula Lake Total Lead

The *2001 Eufaula Lake Water Quality Report* also states that several of the observations of mercury were at or above the Oklahoma Criterion for Fish Consumption and Water (**Figure 4-11**) (USACE 2012).

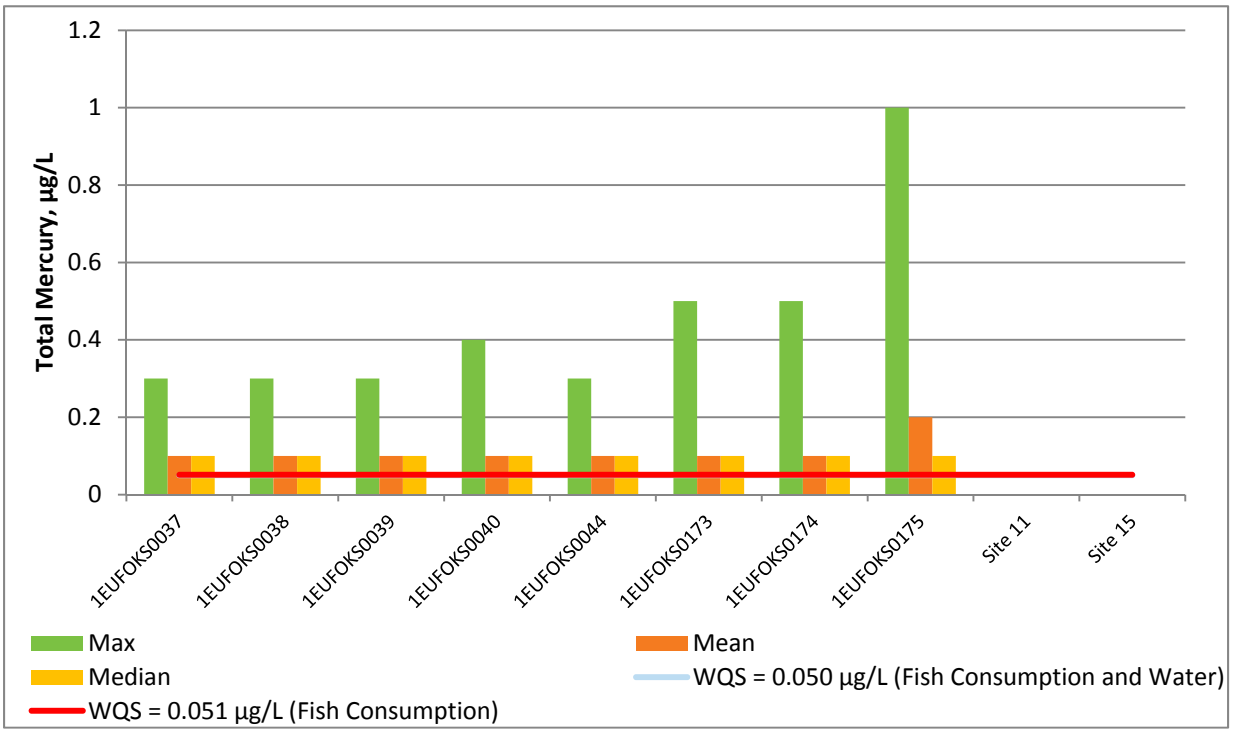


Figure 4-11. Eufaula Lake Total Mercury

Zinc was measurable in both of the OWRB site samples (Sites 11 and 15) but at levels lower than the Oklahoma WQS of 5.0 mg/L for public and private water supply (**Figure 4-12**).

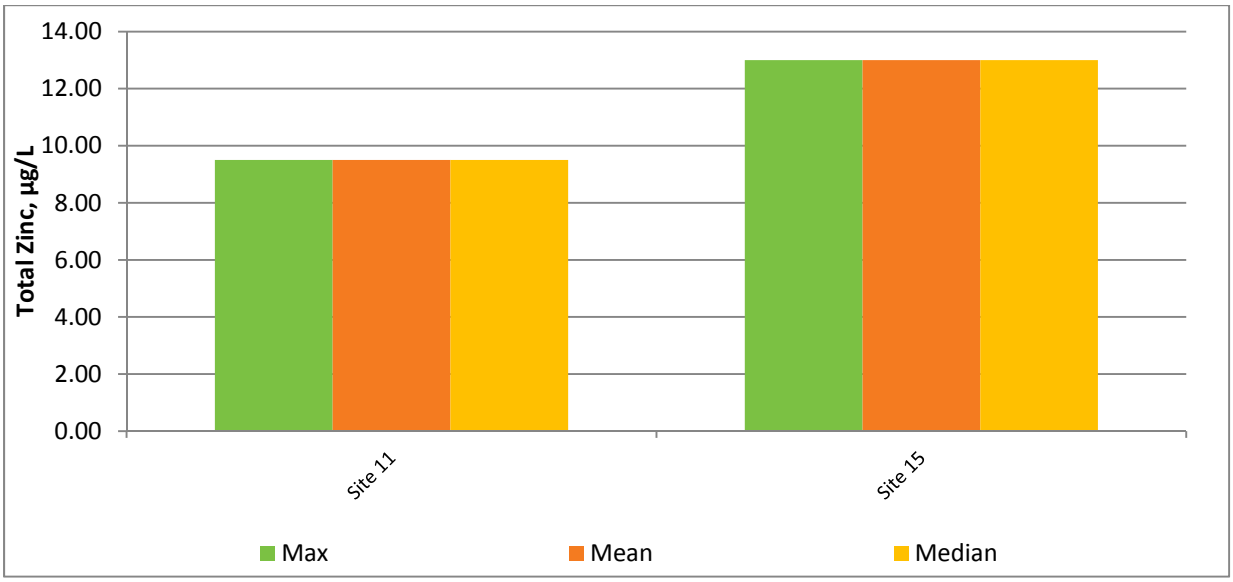
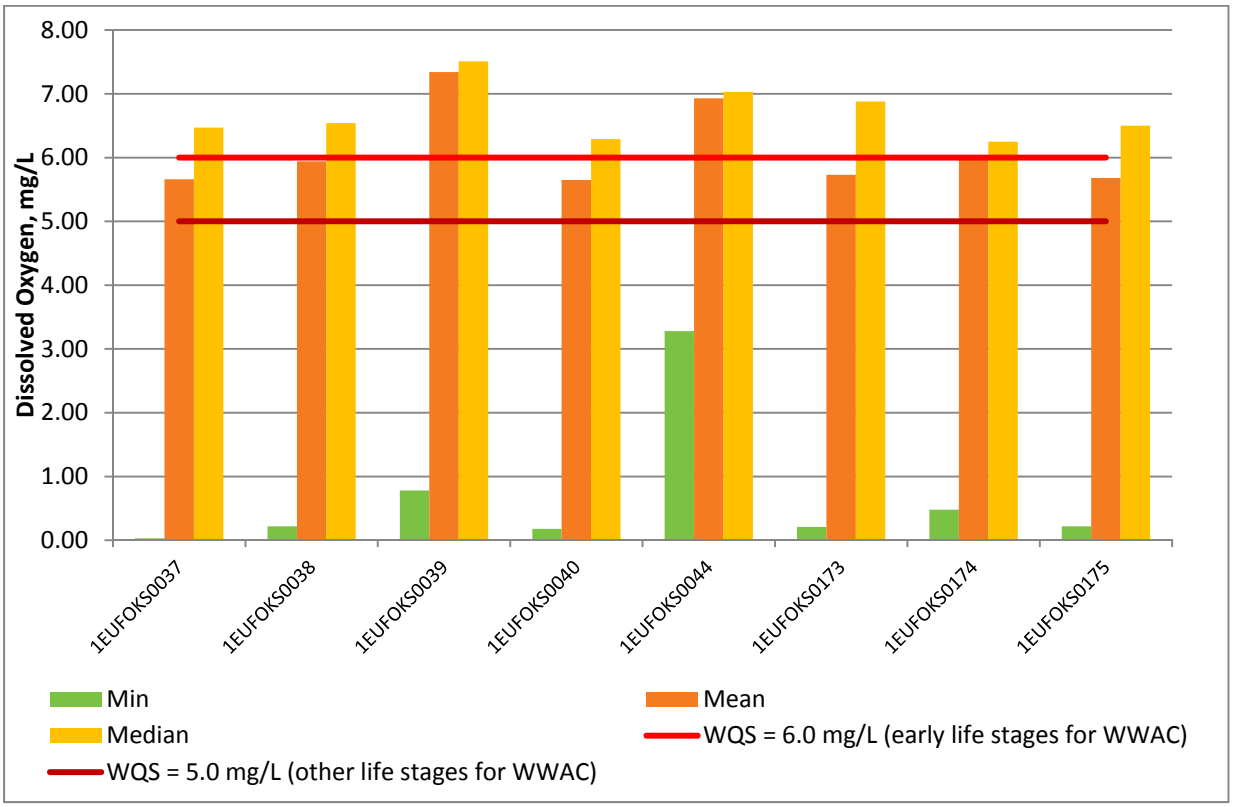


Figure 4-12. Eufaula Lake Total Zinc

Dissolved Oxygen, Temperature, and pH. At OWRB Site 4, measurements for dissolved oxygen, pH, and water temperature were collected in November 2006 (values of 12 mg/L, 8.44, 14.5 degrees Celsius respectively); no other samples were collected by OWRB. Appendix B presents the analyses of water temperature, pH, and dissolved oxygen data for samples collected near the surface (0.5 meters) and near the bottom of the water by USACE in 2001. According to the OCC data, dissolved oxygen concentrations in streams varies from a minimum of 2.79 mg/L (OK220600-01-0100P July 28, 2008) to a maximum of 15.44 mg/L (OK520500-02-0010C January 11, 2010) with a mean of 8.67 mg/L.

The *2001 Eufaula Lake Water Quality Report* states "surface concentrations (0.5 meters depth) of dissolved oxygen ranged from 4.99 mg/L (1EUFOKS0174 on 7 August 2001) to 11.63 mg/L (1EUFOKS0039 on 26 June 2001) with a mean… of 7.9 mg/L… Dissolved oxygen concentrations at depth (approximately one meter above the bottom) ranged from 0.07 mg/L (1EUFOKS0037 on 21 August 2001) to 8.85 mg/L (1EUFOKS0037 on 17 April 2001) with a mean … of 4.41 mg/L …. The lake-wide mean dissolved oxygen concentrations, incorporating all in-lake profile data, was 5.92 mg/L" (USACE 2012) (**Figure 4-13**).



Note: WWAC = Warm Water Aquatic Community

Figure 4-13. Eufaula Lake Dissolved Oxygen (across all depths)

Water temperature ranged from 12.15 degrees Celsius (1EUFOKS0037 in April 2001 at 23 meters deep) to 32.3 degrees Celsius (1EUFOKS0044 in July 2001 at 0.1 meters deep) with a lake-wide mean of 24.77 degrees Celsius (mean of all depths) (**Figure 4-14**).

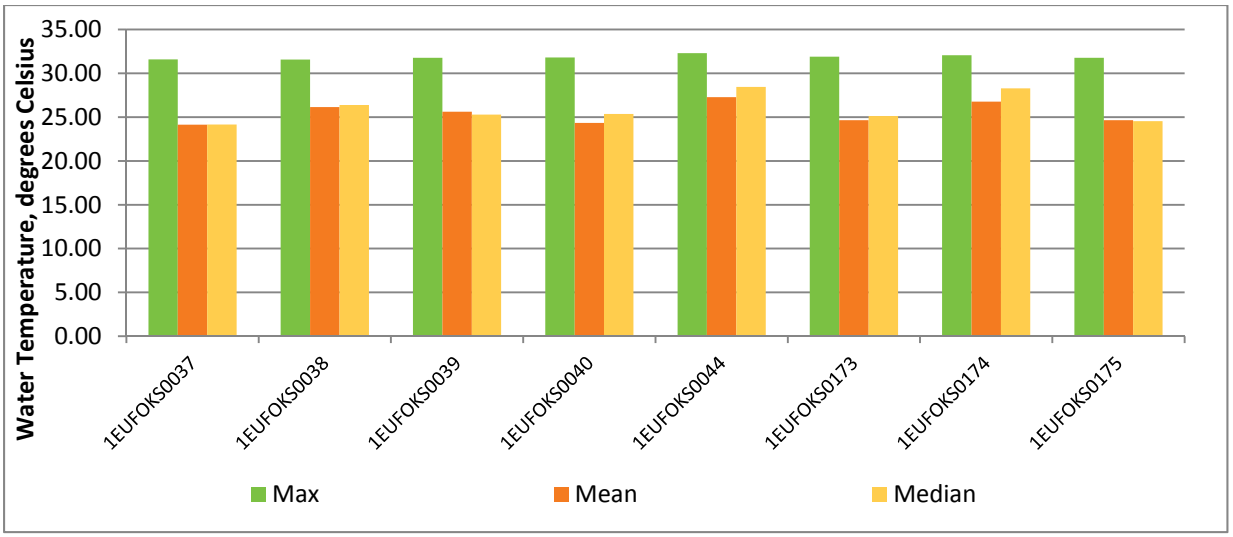


Figure 4-14. Eufaula Lake Water Temperature (across all depths)

The pH ranged from 6.75 (1EUFOKS0173 in July 2001 at 13 meters deep) to 9.12 (1EUFOKS0037 in July 2001 at 0.1 and 0.5 meters deep) with a lake wide mean of 7.86 (mean of all depths) (**Figure 4-15**). The *2001 Eufaula Lake Water Quality Report* states "most [pH] measured values fell within the range (6.5 to 9.0) specified in the Oklahoma's Water Quality Standards for fish and wildlife propagation" (USACE 2012). From the OCC data, pH in streams has a mean of 7.67.

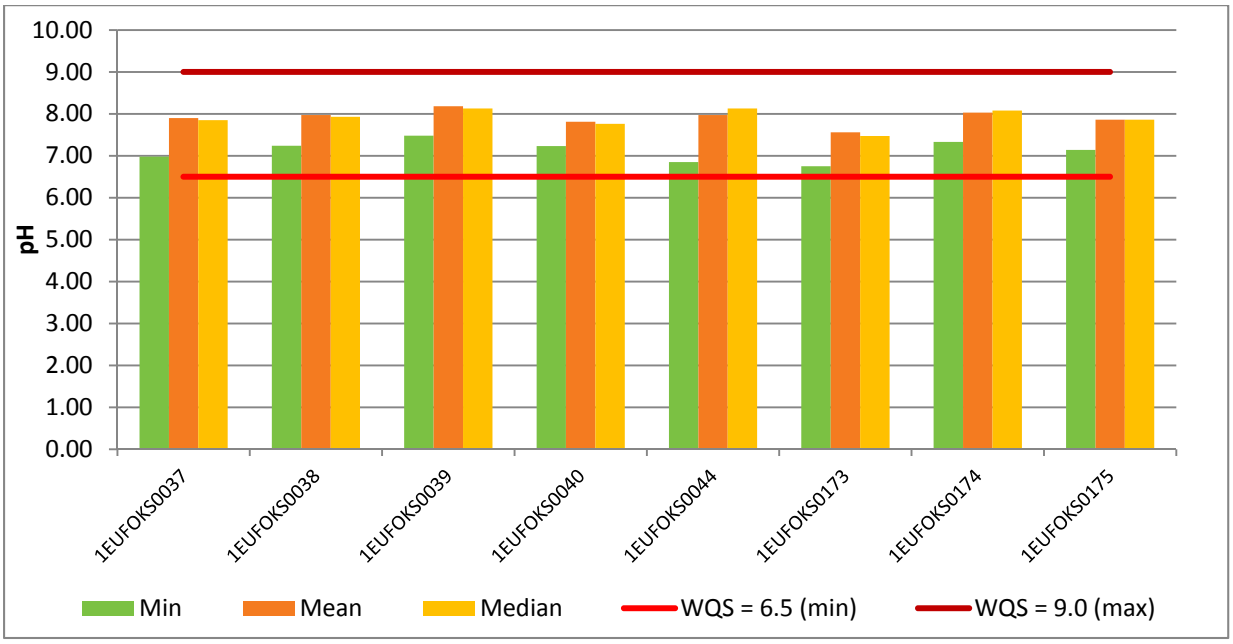


Figure 4-15. Eufaula Lake pH (across all depths)

4.1.5 STEPL Model Results

A basic model was used to quantitatively estimate existing runoff and pollutant loads into Eufaula Lake. The EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) Model employs simple algorithms to estimate annual runoff volume, and total nitrogen (N), phosphorus (P), biochemical oxygen demand (BOD), and sediment load from location and land use input information. For the purposes of the STEPL analysis, two scenarios were explored: pollutant loads contributed from USACE-owned lands only, and pollutant loads contributed from USACE-owned lands and adjacent private lands. The contributing watershed was assumed to be the USACE-owned lands around the lake, and USACE-owned lands plus ½ mile of adjacent private lands around the lake. Resulting runoff and pollutant loads are presented in **Table 4-6**.

The total pollutant loads presented in **Table 4-6** only accounts for inputs around the lakeshore and do not include pollutant loadings from the rivers that contribute to Eufaula Lake. According to ODWC (2008), Eufaula Lake receives an annual sediment inflow of 7,249 acre feet (AF) from contributing rivers. Under current conditions, the average phosphorus concentration in the lake is 0.070 ppm, and the average nitrogen concentration is 0.410 ppm. More detail on the model results are provided in Appendix D.

Table 4-6. Pollutant Loading into Eufaula Lake

	USACE-Owned Land	USACE-owned Land & Adjacent Private Land
Land Use Inputs (acres)		
Urban	2,302	8,544
Pasture	14,531	101,797
Forest	45,838	131,242
Wetlands	2,291	4,616
Total Area	64,962	246,199
Total Pollutant Loads		
Runoff (AF)	38,832	155,011
P (lb/yr)	22,661	106,200
N (lb/yr)	158,163	942,021
BOD (lb/yr)	481,656	2,950,824
Sediment (tons/yr)	3,921	14,384

4.1.6 Potential Sources of Nonpoint Source Pollution

Septic Systems. Septic systems are responsible for treating large quantities of waste. These systems, if improperly managed and/or maintained, may contribute to surface water pollution and result in elevated nutrient or bacteria loads to Eufaula Lake. According to the EPA, ten to 20 percent of septic systems fail at some point (EPA 2003). Common causes of failure include aging, inappropriate design, overloading with too much wastewater in too short a period of time, and poor maintenance.

Many homes within the Eufaula Lake watershed and along the shoreline are served by septic systems. Over 5,000 septic systems are located in the counties along Eufaula Lake. Septic system data were obtained for the entire county for Pittsburg, McIntosh, Muskogee, Haskell, and Okmulgee counties. The data set

includes 1,176 permitted septic systems in Pittsburg County; 1,012 in McIntosh County; 1,221 in Muskogee County, 387 in Haskell County; and 1,356 in Okmulgee County. The septic system data set is limited to recently installed systems and is missing significant location information that would be necessary for a geographically specific analysis. With the current data set, it is not possible to conduct a detailed analysis of septic system locations and potential impacts on water quality.

Acid Mine Drainage. Acid mine drainage (AMD) is a major nonpoint source pollution concern in many former mining regions. AMD is formed by the oxidizing action of air and water on exposed sulfidic strata and is characterized by elevated concentrations of metals (especially iron and aluminum), acidity, and sulfate. In Eufaula Lake, AMD impacts from abandoned coal mining activities are only present in Gaines Creek, which flows into the Gaines Creek arm in Lake Area 6. The AMD source is located in the Gaines Creek watershed upstream of the USACE-owned lands around the reservoir (Nairn 2000).

Lawn Fertilization. Many residences within the Limited Development areas along the lake shore apply fertilizers to their lawns and other landscaped areas. Excess amounts of fertilizer may enter streams causing nonpoint source pollution. Fertilizers most commonly enter water sources by surface runoff and leaching from agricultural lands. Increased amounts of nutrients can have negative impacts on public health and aquatic ecosystems. Over application of fertilizer can lead to nutrients entering the lake through stormwater runoff.

The impact of fertilization on water quality depends in part on the distance between the point of fertilizer application and the lake shore. Areas of natural vegetation where fertilizer is not applied can act as a buffer by filtering nutrients out of the stormwater runoff and reducing the amount of nutrients that enter the surface waters (Mayer *et al.* 2007).

4.1.7 Impaired Waterbodies

Several streams in the Eufaula Lake watershed are impaired for their designated uses (draft 303d list, ODEQ 2010). **Table 4-7** summarizes impaired waterbodies in the Eufaula Lake watershed.

Table 4-7. 303(d) List of Impaired Waterbodies in Eufaula Lake Watershed[A]

Waterbody Name	Waterbody ID	Cause of Impairment	Impaired Use	Unconfirmed Potential Sources[B]
Eufaula Lake	OK220600010020_00	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	140
	OK220600010050_00 (Canadian River Arm)	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	140
		Turbidity	FWP-Warm Water Aquatic Community	140
		Color	Aesthetic	140
	OK220600010060_00 (Longtown Creek Arm)	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	140
	OK220600050010_00 (Gaines Creek Arm)	Color	Aesthetic	140
		Oxygen, Dissolved	FWP-Warm Water Aquatic Community	140
		Turbidity	FWP-Warm Water Aquatic Community	140
	OK520500010020_00 (N. Canadian River Arm)	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	140
		Turbidity	FWP-Warm Water Aquatic Community	140
	OK520700010020_00 (Canadian River Deep	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	140

Waterbody Name	Waterbody ID	Cause of Impairment	Impaired Use	Unconfirmed Potential Sources[B]
	Fork)	Turbidity	FWP-Warm Water Aquatic Community	140
Mud Creek	OK311100040010_00	Fishes Bioassessments	FWP-Warm Water Aquatic Community	21, 46, 87, 102, 108, 140
		Lead	Fish Consumption	49, 85, 140
		Sedimentation/Siltation	Aesthetic	21, 46, 49, 87, 102, 108, 140
		Sedimentation/Siltation	FWP – Warm Water Aquatic Community	21, 46, 49, 87, 102, 108, 140
		Turbidity	FWP-Warm Water Aquatic Community	46, 87, 108, 140
	OK311100040080_00	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	92, 156, 140
		Turbidity	FWP-Warm Water Aquatic Community	156, 140
	OK410200010210_00	Lead	FWP-Warm Water Aquatic Community	140
		Zinc	FWP-Warm Water Aquatic Community	140
Longtown Creek	OK220600010070_10	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	92, 156, 140
Mill Creek	OK220600010100_20	Oxygen, Dissolved	FWP-Warm Water Aquatic Community	46, 87, 92, 108, 111, 133, 136, 140
Canadian River	OK220600010119_10	Enterococcus	Primary Body Contact Recreation	46, 59, 85, 92, 111, 133, 136, 140
		Sedimentation/ Siltation	FWP – Warm Water Aquatic Community	46, 85, 87, 108, 140
		Turbidity	FWP – Warm Water Aquatic Community,	46, 85, 87, 108, 140
		Thallium	Fish Consumption	10, 140
		Sulfates	Agriculture	49, 140
		Sedimentation/ Siltation	Aesthetic	46, 85, 87, 108, 140
		Lead	Fish Consumption	49, 85, 140
		Fish Bioassessments	FWP – Warm Water Aquatic Community	49, 85, 140
		Lead	FWP – Warm Water Aquatic Community	49, 85, 140
Canadian River, Deep Fork	OK520700020010_10	Enterococcus	Primary Body Contact Recreation	46, 85, 92, 108, 111, 133, 136, 140
		Fecal Coliform	Primary Body Contact Recreation	46, 85, 92, 108, 111, 133, 136, 140
		Lead	Fish Consumption	46, 85, 140
		Sedimentation/ Siltation	Aesthetic	46, 85, 87, 108, 140
		Turbidity	FWP – Warm Water Aquatic Community	46, 85, 87, 111, 140
Hay Creek	OK220600010130_00	Chloride	Agriculture	140
		Oil and Grease	Aesthetic	140
		Oil and Grease	FWP – Warm Water Aquatic Community	140
		Total Dissolved Solids	Agriculture	97
Big Creek	OK220600010170_00	Chloride	Agriculture	97
		Total Dissolved Solids	Agriculture	97
Brushy Creek	OK220600030010_00	Turbidity	FWP – Warm Water Aquatic Community	46, 108, 140
		Lead	Fish Consumption	49, 85, 140
		Oil and Grease	Aesthetic	49, 102, 140
		Oil and Grease	FWP – Warm Water Aquatic Community	49, 102, 140

Waterbody Name	Waterbody ID	Cause of Impairment	Impaired Use	Unconfirmed Potential Sources[B]
		Oil and Grease	Public and Private Water Supply	49, 102, 140
		Oxygen, Dissolved	FWP – Warm Water Aquatic Community	85, 92, 108, 140
		Sulfates	Agriculture	49, 102, 140
	OK220600030010_10	Oxygen, Dissolved	FWP – Warm Water Aquatic Community	46, 87, 92, 108, 111, 133, 136, 140
Peaceable Creek	OK220600030050_00	Sulfates	Agriculture	49, 62, 140
		Oxygen, Dissolved	FWP – Warm Water Aquatic Community	46, 85, 87, 92, 108, 111, 133, 136, 140
Bull Creek	OK220600030080_00	Copper	FWP – Warm Water Aquatic Community	62
		Lead	FWP – Warm Water Aquatic Community	62
		Zinc	FWP – Warm Water Aquatic Community	62
Gaines Creek	OK220600040010_00	Oil and Grease	Aesthetic	97, 140
		Oil and Grease	FWP – Warm Water Aquatic Community	97, 140
		Oil and Grease	Public and Private Water Supply	97, 140
		Oxygen, Dissolved	FWP – Warm Water Aquatic Community	92, 156, 140
		pH	FWP – Warm Water Aquatic Community	140
Beaver Creek	OK220600040030_00	Oil and Grease	Aesthetic	97, 140
		Turbidity	FWP – Warm Water Aquatic Community	156, 140
		pH	FWP – Warm Water Aquatic Community22	140
		Oxygen, Dissolved	FWP – Warm Water Aquatic Community	92, 156, 140
		Oil and Grease	FWP – Warm Water Aquatic Community	97, 140
Pit Creek	OK220600040040_00	Oxygen, Dissolved	FWP – Warm Water Aquatic Community	156, 140
		pH	FWP – Warm Water Aquatic Community	140
		Sulfates	Agriculture	2, 140
		Total Dissolved Solids	Agriculture	140
Tiger Creek	OK520500020210_00	Chloride	Agriculture	140
Carter Creek	OK520500020230_00	Chloride	Agriculture	102, 140
		Total Dissolved Solids	Agriculture	102, 140
Wewoka Creek	OK520500020240_00	Cadmium	FWP – Warm Water Aquatic Community22	140
	OK520500020240_10	Chloride	Agriculture	102, 124, 140
		Nitrates	Public and Private Water Supply	85, 92
		Sulfates	Agriculture	85, 92
		Total Dissolved Solids	Agriculture	102, 124, 140
Magnolia Creek	OK520500020250_00	Chloride	Agriculture	102
		Total Dissolved Solids	Agriculture	102
Salt Cedar Creek	OK520500020260_00	Chloride	Agriculture	102
		Total Dissolved Solids	Agriculture	102
	OK520500020260_20	Chloride	Agriculture	102
		Total Dissolved Solids	Agriculture	102
Wewoka Creek, Trib A	OK520500020270_00	Chloride	Agriculture	102
		Total Dissolved Solids	Agriculture	102
Oakwood Cemetery Creek	OK520500020280_00	Chloride	Agriculture	102
		Total Dissolved Solids	Agriculture	102

Waterbody Name	Waterbody ID	Cause of Impairment	Impaired Use	Unconfirmed Potential Sources[B]
Gentry Creek	OK520700010080_00	Enterococcus	Primary Body Contact Recreation	46, 92, 108, 111, 133, 136, 140
		Escherichia coli	Primary Body Contact Recreation	46, 92, 108, 111, 133, 136, 140
		Oxygen, Dissolved	FWP – Warm Water Aquatic Community22	46, 87, 92, 108, 136, 140
Grave Creek	OK520700010110_00	Chloride	Agriculture	102
Coal Creek	OK520700010140_00	Turbidity	FWP – Warm Water Aquatic Community22	46, 85, 87, 108, 140
Wolf Creek	OK520700010170_00	Fish Bioassessments	FWP – Warm Water Aquatic Community22	140

Note:

[A] *From Integrated Water Quality Assessment Report (ODEQ 2012)*

[B] *Codes for Potential Sources*

2 – Acid mine drainage
21 – Clean sediments
46 – Grazing in riparian or shoreline zones
49 – Highway/road/bridge runoff (non-construction related)
59 – Impacts from land application of wastes
62 – Industrial point source discharge
85 – Municipal point source discharges
87 – Non-irrigated crop production
92 – On-site treatment systems (septic systems and similar decentralized systems)
97 – Other spill related impacts
102 – Petroleum/natural gas activities (legacy)
108 – Rangeland grazing
111 – Residential districts
133 – Wastes from pets
136 – Wildlife other than waterfowl
140 – Source unknown
156 – Agriculture

Section 5
Impact Analysis

The purpose of this impact analysis is to consider the potential impacts each alternative may have on water quality and the influence existing water quality may have on each alternative. Water quality impacts are qualitatively compared between the alternatives, with the No Action Alternative serving as a baseline. In addition, a basic quantitative analysis was performed using the EPA STEPL Model to estimate runoff volume and pollutant loadings from the land around the lake using location and land use input information. Additional information about the STEPL Model analysis is included in Appendix D. Detailed information regarding each of the alternatives is included in Chapter 2 of the EIS.

The alternatives described in Chapter 2 of the EIS represent a range of scenarios that could be implemented at Eufaula Lake to revise shoreline allocations, supplement the MP land use classification maps, change policies related to vegetation management along the shoreline, and grant site-specific rezones and requests for leases of USACE property. The No Action and action alternatives analyzed in the EIS span a range of possible future scenarios from a strong emphasis on conservation of natural resources to a strong emphasis on providing recreational development opportunities.

The proposed federal actions to be analyzed under NEPA include:

- Revisions to the Eufaula Lake SMP (USACE 1998) including changes in shoreline allocations and vegetation management policies;
- Supplement the Eufaula Lake MP land use classifications (USACE 1977) to be consistent with the shoreline allocations in the SMP; and,
- Consideration of a request to lease USACE property for a marina and other public shoreline recreational facilities at the proposed Carlton Landing development.

The Carlton Landing proposed development would be located in the central part of Eufaula Lake and include development on private uplands and USACE-owned lands along the lake shore. The success of the development proposal depends in large part on approval by USACE of a change in shoreline designation and the grant of a lease for a community marina, a public nature center, and public recreation areas. More information regarding the proposed Carlton Landing development and potential water quality impacts is provided in this section.

5.1 No Action Alternative

With respect to the SMP revision and MP supplement, the No Action Alternative represents no change from current management direction or level of management intensity. Under the No Action Alternative, there would be no change to the existing shoreline designations, land use classifications under the MP, or the vegetation management policies, and none of the specific

zoning requests to change shoreline allocations would be granted. With respect to the proposed development at Carlton Landing, the grant of a lease would not be approved and proposed public shoreline recreational facilities on USACE lands would not be permitted. This would have implications for the proposed development on the private lands.

5.1.1 Shoreline Allocations and Land Use

Under the No Action Alternative, the existing distribution of shoreline allocations would remain unchanged. The areas allocated as Limited Development would be the areas where the greatest potential for shoreline effects could occur. Limited Development areas allow private boat docks and modification of shoreline vegetation. Currently, 1,673 private and community docks are located along Limited Development shorelines. Under the No Action Alternative, which would maintain the current 271 miles of Limited Development allocated shoreline, there could be a potential maximum of 8,746 docks. While the actual number of docks would likely be considerably less due to the physical constraints of the shoreline, this figure represents the potential for growth in the number of docks under the No Action Alternative.

Under the No Action Alternative, there is potential for considerable new development around the lake on private lands adjacent to the Limited Development areas. Construction and development would increase the amount of impervious surfaces. Increased impervious surfaces are associated with an increased quantity of stormwater, and therefore an increased pollutant load (*e.g.*, sediment, oil, grease, pesticides and nutrients from lawns, bacteria and nutrients from pet waste, heavy metals from roof shingles, motor vehicles and other sources) carried by the stormwater. Potential water quality impacts associated with stormwater pollution include higher turbidity, and increased nutrient and bacteria loading, and decreased dissolved oxygen (nutrients can contribute to algal growth, as the algae die and decompose, dissolved oxygen is consumed which results in decreased dissolved oxygen).

Development in these areas may cause an increase in boat docks, and a corresponding increase in boating activity. Dock construction and boating activity has the potential to cause an increase in shoreline erosion from the wave action caused by boats as well as the construction of the docks. Potential water quality impacts include oil, gas, bacteria, and nutrients from boating activities (*e.g.*, cleaning, fueling, sewage disposal), as well as an increase in turbidity caused by shoreline erosion. Wake zones can help mitigate some erosion associated with the waves caused by boats. Water quality impacts related to boating access may result in unavoidable and significant (in terms of turbidity) water quality impacts.

An increase in the installation of septic systems for new developments on private lands adjacent to the Limited Development acreage can be expected. Septic systems, if improperly managed and/or maintained, may contribute to surface water pollution and result in elevated nutrient or bacteria loads to Eufaula Lake. Common causes of water quality impacts from these systems include aging, inappropriate design, overloading with too much wastewater in too short a period of time, and poor maintenance. Aging septic systems accompanied by poor soils and lack of wastewater disposal alternatives are contributing factors to water quality degradation (USACE 2001).

5.1.2 Vegetation Management Policies

Under the No Action Alternative, there would be no change to the existing vegetation modification policies. Under existing conditions, permit applications for modification of vegetation along the shoreline are considered on a case by case basis by the Lake Manager. When issued, a vegetation modification permit

may allow mowing of an area from the private property to the shoreline within the width of the private property extended onto the public land.

Vegetation modification and mowing can alter the natural vegetation along the shoreline. Vegetation modification often results in fertilization, which can lead to nutrient loading. Vegetation modification can also increase the velocity of stormwater runoff which would otherwise be mitigated by natural vegetation and infiltration. Increased stormwater runoff has the potential to cause erosion and an increase in turbidity in Eufaula Lake.

5.1.3 Proposed Carlton Landing Development

The No Action Alternative would not grant the lease for use of USACE land to construct and operate the proposed public marina and public recreation facilities at Carlton Landing. Under existing conditions, USACE land along the shoreline in the area of Carlton Landing is zoned Protected (approximately 5.8 miles of shoreline and 301 acres). Land-side residential and commercial development would be limited to 170 residential lots, a conference and retreat facility, community parks and green spaces, and commercial/multi-family areas.

The proposed Carlton Landing development wastewater system would consist of a private sewage treatment system composed of three sewage treatment ponds that are anticipated to be sufficient for the initial phase. All of the lagoons are zero-output, total retention lagoons with a synthetic liner and under liner collection drain system. USACE Tulsa District policy does not allow the discharge of sewage and other wastes generated offsite onto USACE lands or water. A lagoon sewage treatment system operated and maintained properly per Title 252 Chapter 641 of the Oklahoma Administrative Code should have minimal to no impact on water quality.

Under the No Action Alternative, construction and development related to Carlton Landing would increase stormwater runoff from impervious surfaces. Potential water quality impacts include increased turbidity, shoreline erosion, and increased nutrient loading. The STEPL Model was run for the proposed Carlton Landing development area for both USACE-owned lands only and USACE-owned and adjacent private lands (**Table 5-1**). The results presented in **Table 5-1** estimate runoff and pollutant loads under the No Action alternative in the proposed Carlton Landing area.

Table 5-1. Proposed Carlton Landing Development Under the No Action Alternative

	Runoff Volume (AF)	Total Phosphorus Load (lb/year)	Total Nitrogen Load (lb/year)	Total Sediment Load (tons/year)
USACE-owned Lands	158	117	634	42
USACE-owned and Adjacent Private Lands	740	588	3,808	192

5.1.4 Summary of Potential Water Quality Impacts

Overall, the No Action Alternative would likely result in declining water quality conditions. Under the No Action Alternative, water quality would be expected to remain fairly consistent with current trends (*e.g.* increasing phosphorus, nitrogen, turbidity and chlorophyll-*a*). Selection of this alternative would likely result in an increase in land-based effects (*e.g.* shoreline erosion from residential clearing, impacts from

failing septic systems, increased stormwater pollution) and an increase in water-based effects (*e.g.* boating).

The STEPL Model results estimate that under the No Action Alternative, Eufaula Lake could see a four percent increase in phosphorus, a three percent increase in nitrogen, and a 0.1 percent increase in sediment inflow. These increases in pollutants assume that USACE-owned and private lands are both developed to the maximum extent possible under the No Action Alternative. **Figure 5-1** illustrates the results of the model which indicates that activity on private land adjacent to USACE-owned land could be more substantial than impacts from USACE-owned land only. These impacts would likely be more substantial locally, but compared to the lake as a whole, impacts would be minimal. It is important to note that for those parameters which already exceed water quality standards (*e.g.* turbidity, dissolved oxygen), any water quality impacts that worsen the trend toward impairment would be significant.

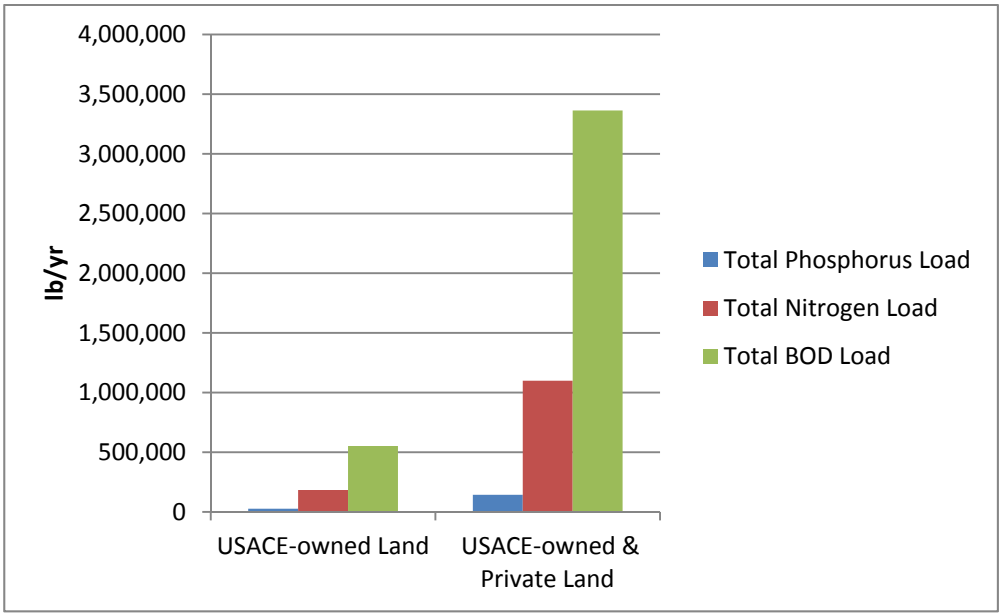


Figure 5-1. Direct and Indirect Water Quality Impacts Under the No Action Alternative

Nutrients are an existing water quality issue in Eufaula Lake, and under the No Action Alternative, nutrient transport has the potential to increase as Limited Development areas are developed. Increased nutrients may be caused by improperly managed/maintained septic systems, stormwater runoff, fertilizers, and pet waste. Increased levels of nitrogen and phosphorus can lead to algal blooms, impede recreational activities, harm wildlife habitats, and decrease the amount of oxygen that fish and aquatic life need to survive.

The potential for significant water quality impacts from increased turbidity, which is already in excess of water quality standards, is of particular concern. There is potential for significant water quality impacts related to dissolved oxygen, which exceeds water quality standards in some samples. In addition, potential impacts related to recreation are present and are caused by a variety of water quality impacts (*e.g.*, nutrients, turbidity) and other factors (*e.g.*, water clarity).

USACE water quality monitoring identified blue-green algae near Brooken Cove, Highway 9 Landing, Belle Starr Park, and Porum Landing. Recreational and helicopter surveys have also identified algae in Gaines Creek arm and Deep Fork. Overall, many areas of Eufaula Lake may be impacted by algae blooms

throughout the year. Due to elevated blue-green algae cell counts, contact with the water in affected areas is discouraged until toxicity tests can be completed (OTRD 2012). Public Recreation and Limited Development areas exist in and around the area where blue-green algae are currently a water quality concern (**Figure 5-2**). Algal blooms are caused by an increase in nutrients that leads to an overgrowth of algae. The risk associated with high algae counts is their ability to produce and release toxins into the water. People that come in contact with water high in blue-green algae may experience a wide range of symptoms, most commonly upper respiratory problems, eye irritation, vomiting, and diarrhea (ODEQ 2011). Water quality impacts of algal blooms affect public health, and the ecological and economic resources in Eufaula Lake (USGS 2007).

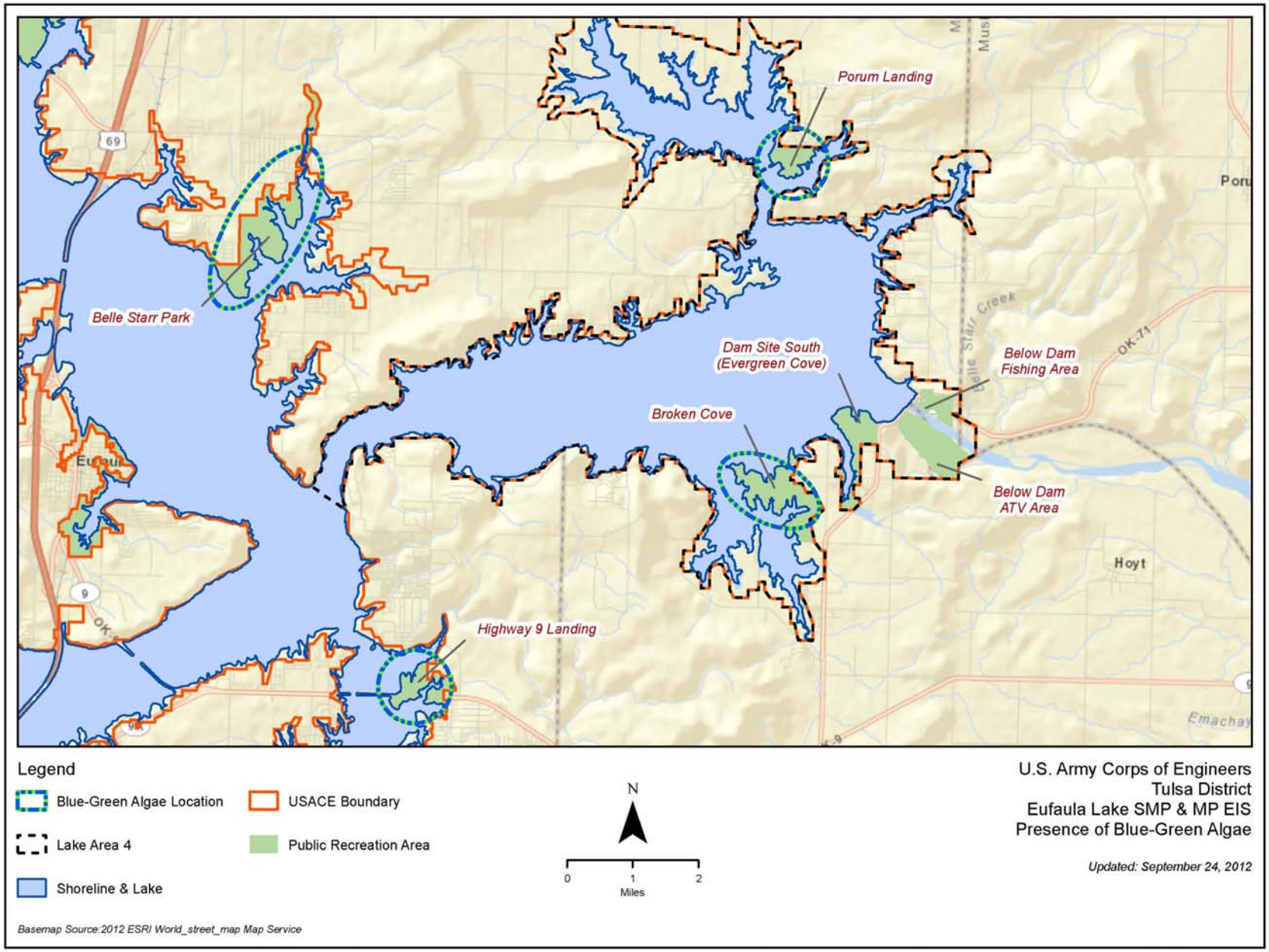


Figure 5-2. Areas Impacted by Blue-Green Algae

5.2 Alternative 1

Alternative 1 includes the shoreline allocations for Limited Development as they existed under the 1981 SMP before the Limited Development area was significantly expanded in subsequent revisions. This alternative represents the end of the range of alternatives that emphasizes natural resource conservation over private exclusive uses and recreational development opportunities. Alternative 1 would implement the extended buffer vegetation management policy, which includes the largest buffers proposed to protect shoreline habitats. The lease request for a public marina and other recreational amenities at Carlton Landing would not be granted, and individual zoning requests would not be approved.

5.2.1 Shoreline Allocations and Land Use

The 1981 SMP represents the least amount of Limited Development that has ever been allocated at Eufaula Lake. Under Alternative 1, Limited Development shoreline allocation would decrease by 85 percent and Protected shoreline would increase by 53 percent. Under Alternative 1, which would reduce Limited Development allocated shoreline to 42 miles, there could be a potential maximum of 2,278 docks. Existing permitted docks in areas that would change from Limited Development to Protected would be grandfathered and allowed to remain in place as long as they continue to meet the criteria in 36 CFR 327.30(h). The Limited Development allocation under this alternative is more selectively located within suitable coves and so a greater proportion of this potential build out would be feasible than under the No Action Alternative.

Under Alternative 1, there is potential for a change in development trends compared with the No Action Alternative because less land along the lake would be available for development. Potential water quality impacts related to construction and development (discussed in Section 5.1.1) would be minimal compared to the No Action Alternative. Boating activities would still have a potential water quality impact; however, impacts would be substantially less than the No Action Alternative.

5.2.2 Vegetation Management Policies

Alternative 1 would implement the extended buffer vegetation management policy, which includes the largest buffers proposed to protect shoreline habitats. Extended buffers would protect 45 to 95 feet of vegetation along the water's edge forming a buffer between the water and upland activities. In order to limit effects on water quality, vegetation management activities on USACE land would be limited to the areas upland of these buffer zones. Clearing or mowing activities would not be allowed within the buffer zone.

Under Alternative 1, because of the location of Limited Development lands, the average width of these buffers would be 212 feet, compared with 300 feet under the No Action Alternative. According to recent research, buffer widths of approximately 50 feet are generally effective at removing sediment and nutrients from runoff (Lee, *et al.* 2003). Given the average widths of buffers under Alternative 1, the vegetative buffers would likely result in improved water quality.

5.2.3 Proposed Carlton Landing Development

The development at Carlton Landing under Alternative 1 would largely be the same as that described under the No Action Alternative; however, under Alternative 1, Limited Development areas on the south side of Longtown Arm would be rezoned Protected. With this transition in zoning, there would be a reduction in the development of docks or floating facilities in this area.

Under Alternative 1, the request for Public Recreation shoreline designation at the proposed Carlton Landing development would not be approved, and the lease request for a public marina and other recreational facilities at Carlton Landing would not be granted. The maintenance of the Protected shoreline designation would limit public recreational use of the shoreline for Carlton Landing residents which would result in final build out of approximately 170 residential units and very limited commercial or community facilities. The transition of Limited Development to Protected shoreline allocation on the south side of the Longtown Arm would further limit potential residential development on adjacent private lands in this area.

The Limited Development land and the Carlton Landing development under this alternative would not result in additional dock construction. There would continue to be shoreline activity that could contribute minor amounts of turbidity to the lake. Therefore, there would be minimal increases in turbidity compared to the other alternatives. However, because turbidity is already in excess of water quality standards, any increase would constitute a significant water quality impact.

The private sewage treatment system would be the same as described under the No Action Alternative and would have no impact on water quality as long as it is operated and maintained properly per Title 252 Chapter 641 of the Oklahoma Administrative Code.

The STEPL Model was run for the proposed Carlton Landing development area for both USACE-owned lands only and USACE-owned and adjacent private lands (**Table 5-1**). The potential water quality impacts from the proposed Carlton Landing development under Alternative 1 would be the same as those under the No Action Alternative.

5.2.4 Summary of Potential Water Quality Impacts

Overall, Alternative 1 would be expected to result in fewer docks, less potential development on adjacent private lands, and larger vegetative buffers compared to the No Action Alternative, which would have a beneficial effect on water quality. Under Alternative 1, water quality at Eufaula Lake would be expected to improve. Less activity around and on the lake could increase dissolved oxygen, decrease turbidity, and decrease nitrogen and phosphorus loading. Implementation of the extended buffer vegetation management policy and the establishment of buffers along the shoreline would reduce shoreline erosion, decrease turbidity, and reduce runoff from activities near the shoreline that may degrade water quality. The extended vegetation buffers proposed in Alternative 1 would be the largest proposed and would be most protective of water quality; extended buffers would minimize water quality degradation related to runoff, vegetation clearing, and mowing. Existing water quality conditions would not impact actions proposed under Alternative 1. Selection of this alternative could result in a decrease in both land-based and water-based effects.

The STEPL Model results estimate that Alternative 1 could result in a reduction of phosphorus, nitrogen, and sediment compared to the No Action Alternative (**Table 5-2**). Model results indicate that Alternative 1 results in the largest reduction in pollutant loads compared to all other action alternatives as well as the No Action Alternative. The percent change compared to the No Action Alternative is relative to the “near shore” loading that the model simulates. The impact of the “near-shore” loading will be tempered by the total watershed load and likely will have a lesser impact on the total lake nutrient dynamics. Pollutant loads were converted to parts per million (ppm) to measure the impact localized pollutant loading could have on the lake as a whole. The effect of a given alternative on phosphorus, nitrogen and sediment concentrations in the lake was evaluated by converting the STEPL annual loads to parts per million (ppm) using a water

volume equal to the average annual inflow to Eufaula Lake, and comparing this to the expected concentrations that would occur under the No Action Alternative. Under Alternative 1, phosphorus, nitrogen, and sediment would decrease compared to the No Action Alternative (**Table 5-3**). **Figure 5-3** illustrates that water quality impacts from private land adjacent to USACE-owned land contributes a substantial portion of pollutant loading under Alternative 1.

Table 5-2. Alternative 1 Modeled Percent Change Compared to the No Action Alternative

	Runoff Volume (AF)	Total Phosphorus Load (lb/year)	Total Nitrogen Load (lb/year)	Total Sediment Load (tons/year)
Direct Impacts[1]	-8%	-11%	-6%	-15%
Direct & Indirect Impacts[2]	-21%	-28%	-16%	-37%

[1] *Pollutant loads originating from USACE-owned land only*
[2] *Pollutant loads originating from USACE-owned and private land*

Table 5-3. Water Quality Impact Under Alternative 1

	Phosphorus Average Lake PPM	Phosphorus Percent Change	Nitrogen Average Lake PPM	Nitrogen Percent Change	Sediment Average Annual Inflow (acre feet)	Sediment Percent Change
Direct Impacts[1]	0.0726	-0.4%	0.4206	-0.5%	7,252	0.00%
Direct & Indirect Impacts[2]	0.0697	-4.4%	0.4084	-3.4%	7,249	-0.05%

[1] *Pollutant loads originating from USACE-owned land only*
[2] *Pollutant loads originating from USACE-owned and private land*

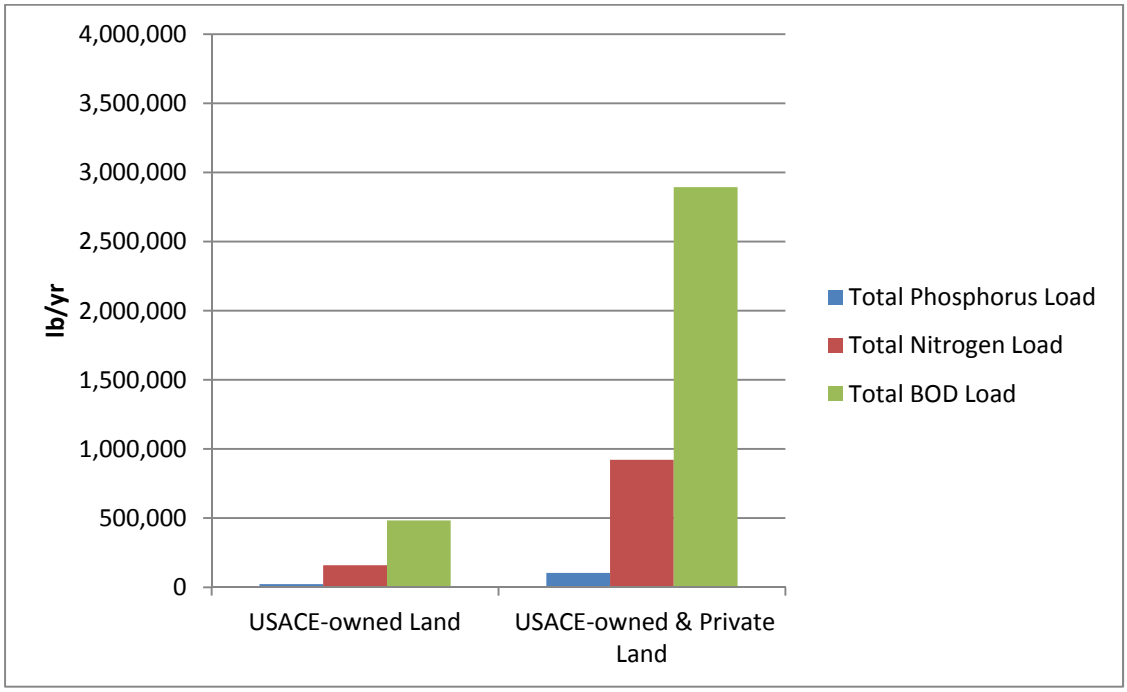


Figure 5-3. Direct and Indirect Water Quality Impacts Under Alternative 1

5.3 Alternative 2

Alternative 2 proposes to reduce the amount of Limited Development area compared to the No Action Alternative by converting Limited Development areas that are unsuitable for docks and do not have existing developments adjacent to the USACE lands to Protected shoreline allocations. Alternative 2 would represent a mid-range alternative balancing natural resource conservation with recreation.

5.3.1 Shoreline Allocations and Land Use

Alternative 2 proposes to decrease Limited Development shoreline miles by 33 percent and increase Protected allocated shoreline miles by 20 percent. The average width of USACE land under Alternative 2 would be 239 feet. Under Alternative 2, there could be a potential maximum of 5,873 docks. It is important to note that the actual number of docks could be considerably less due to the physical constraints of the shoreline, but this maximum number represents the potential for growth in docks and boating activity. Compared to the No Action Alternative, Alternative 2 would result in a 33 percent decrease in the number of docks and therefore, corresponding decreases in potential impacts from construction and boating activities.

5.3.2 Vegetation Management Policies

Under this alternative, the extended buffer vegetation management policy would be implemented, which include the largest buffers proposed. Extended buffers would range from 45 to 95 feet from the shoreline. In order to limit effects on water quality, vegetation management activities would be limited to USACE lands upland of these buffer zones. Clearing and mowing would not be allowed within the buffer zones.

According to recent research, buffer widths of approximately 50 feet are generally effective at removing sediment and nutrients from runoff (Lee, *et al.* 2003). Given the average widths of buffers under Alternative 2, the vegetative buffers would likely result in improved water quality.

5.3.3 Proposed Carlton Landing Development

Similar to the No Action Alternative, the lease agreement required for construction and operation of the proposed public marina and other recreational facilities at Carlton Landing would not be granted. Under Alternative 2, the potential scope of future development at Carlton Landing would be the same as that described for the No Action Alternative. The continued presence of the Limited Development area on the south side of Longtown Arm would allow for some additional private docks and floating facilities to be developed with the initial residential development at Carlton Landing.

The STEPL Model was run for the proposed Carlton Landing development area for both USACE-owned lands only and USACE-owned and adjacent private lands (**Table 5-1**). The potential water quality impacts from the proposed Carlton Landing development under Alternative 2 would be the same as those under the No Action Alternative.

5.3.4 Summary of Potential Water Quality Impacts

Under Alternative 2, water quality at Eufaula Lake would likely improve, but not as significantly as under Alternative 1. A reduction in the acreage under Limited Development would result in less activity around and on the lake and could increase dissolved oxygen, decrease turbidity, and decrease nitrogen and phosphorus loading. Implementation of the extended buffer vegetation management policy and the

establishment of vegetation buffers along the shoreline would reduce shoreline erosion and decrease turbidity as well as reduce runoff from activities near the shoreline that may degrade water quality, such as fertilizing lawns. The extended buffers proposed in Alternative 2 are the largest proposed and would be most protective of water quality; minimizing water quality degradation related to runoff, vegetation clearing, and mowing. Selection of this alternative would result in a decrease in both land-based and water-based effects. Existing water quality conditions would not impact actions proposed under Alternative 2.

The STEPL Model results estimate that Alternative 2 could result in a reduction of phosphorus, nitrogen, and sediment compared to the No Action Alternative (**Table 5-4**). Pollutant loads were converted to ppm to measure the impact localized pollutant loading would have on the lake as a whole. Under Alternative 2, phosphorus, nitrogen, and sediment would decrease compared to the No Action Alternative (**Table 5-5**). Similar to Alternative 1, **Figure 5-4** illustrates that water quality impacts from private land adjacent to USACE-owned land contributes a substantial portion of pollutant loading under Alternative 2.

Table 5-4. Alternative 2 Modeled Percent Change Compared to the No Action Alternative

	Runoff Volume (AF)	Total Phosphorus Load (lb/year)	Total Nitrogen Load (lb/year)	Total Sediment Load (tons/year)
Direct Impacts[1]	-4%	-9%	-8%	-9%
Direct & Indirect Impacts[2]	-8%	-11%	-6%	-15%

[1] *Pollutant loads originating from USACE-owned land only*
[2] *Pollutant loads originating from USACE-owned and private land*

Table 5-5. Water Quality Impact Under Alternative 2

	Phosphorus Average Lake PPM	Phosphorus Percent Change	Nitrogen Average Lake PPM	Nitrogen Percent Change	Sediment Average Annual Inflow (acre feet)	Sediment Percent Change
Direct Impacts[1]	0.0727	-0.3%	0.4214	-0.3%	7,252	0.00%
Direct & Indirect Impacts[2]	0.0716	-1.8%	0.4283	-1.3%	7,251	-0.02%

[1] *Pollutant loads originating from USACE-owned land only*
[2] *Pollutant loads originating from USACE-owned and private land*

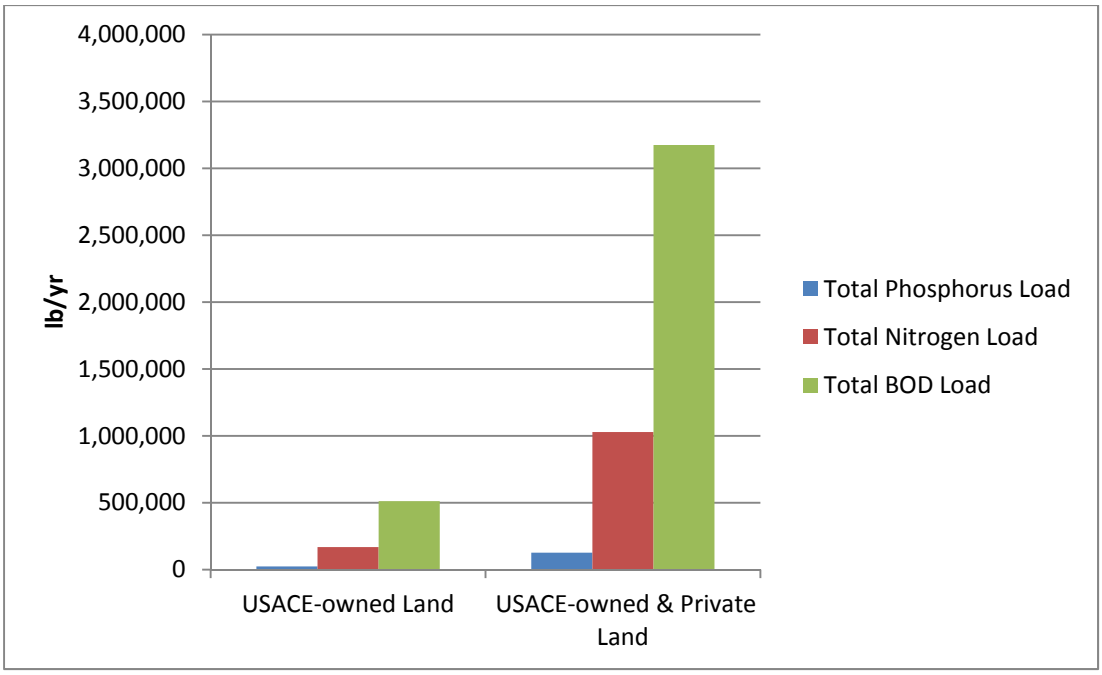


Figure 5-4. Direct and Indirect Water Quality Impacts Under Alternative 2

5.4 Alternative 3

Alternative 3 would increase the amount of Limited Development shoreline compared to the No Action Alternative by converting Protected shoreline areas that are suitable for docks and which do not have an existing lease agreement for use of the USACE shoreline to Limited Development. Alternative 3 represents a mid-range option for balancing natural resource conservation with private recreational development opportunities. Under Alternative 3, the lease request for a public marina and public shoreline recreational facilities at Carlton Landing would not be granted.

5.4.1 Shoreline Allocations and Land Use

Under Alternative 3, Limited Development shoreline miles would increase by 35 percent and Protected shoreline miles would decrease by 23 percent. Under Alternative 3, there could be a potential maximum of 11,844 docks. It is important to note that the actual number of docks could be considerably less due to the physical constrains of the shoreline, but this maximum number represents the potential for growth in docks and boating activity.

Similar to the No Action Alternative, development and dock construction has the potential to cause an increase in shoreline erosion, increased turbidity, and potential impacts related to boating (*e.g.*, oil, gas, bacteria, and nutrients). Water quality impacts related to boating access may result in unavoidable and significant (in terms of turbidity) water quality impacts.

Under Alternative 3, there would be the potential for new development on private lands adjacent to Limited Development areas. Approximately 157 miles of additional shoreline could accommodate new boat dock construction, which is about 45 percent more than is currently available under the No Action Alternative. Construction of new developments adjacent to Limited Development shorelines would be expected to result in an increase the number of new septic systems. An increase in the number of septic

systems may not have an immediate water quality impact, but as more septic systems are installed and age, an increase in nutrients and bacteria in the long term may be expected.

5.4.2 Vegetation Management Policies

Under Alternative 3, the baseline buffer vegetation management policy would be implemented. The baseline buffers would be 25 feet smaller than the extended buffers applied to Alternatives 1 and 2. Based on the criteria in this policy (described in Chapter 2 of the EIS), the baseline vegetation management buffers would extend from 20 to 70 feet from the shoreline, and the average width of USACE lands in Alternative 3 would be 366 feet. In order to limit effects on water quality, vegetation, and wildlife habitat, vegetation management activities would only be allowed on USACE land upland of these buffer zones.

According to recent research, buffer widths of approximately 50 feet are generally effective at removing sediment and nutrients from runoff (Lee, *et al.* 2003). Given the average widths of buffers under Alternative 3, the vegetative buffers would likely result in improved water quality; however, the buffer widths under Alternative 3 would not be as effective at nutrient removal as buffer widths proposed under alternatives 1 and 2.

5.4.3 Proposed Carlton Landing Development

Implementation of Alternative 3 would change the designation of Protected shoreline areas along the Carlton Landing shoreline to Limited Development. The request to change these shoreline areas to Public Recreation would not be granted under this alternative. Access to lake-based recreation would be largely limited to private home sites immediately adjacent to the USACE lands along the shoreline and in the town center area of the Carlton Landing development. Limited Development shoreline allocation would not allow for the development of public camping, hiking, swimming, horseback riding, or bicycling facilities on the USACE shoreline. Overall, the Limited Development shoreline allocation under Alternative 3 would limit the scale and extent of the proposed Carlton Landing development in a manner similar to the No Action Alternative. Under Alternative 3, the increase in Limited Development area on the north side of Longtown Arm would allow for some additional dock construction and boating access compared to the No Action Alternative. However, the number of boats that could be accommodated would be limited. Potential water quality impacts could result from the construction of boat docks at individual residences (located on private lands adjacent to Limited Development areas) which could increase activity along the shoreline. Although this effect would be minimal at Carlton Landing, they have 5.8 miles of shoreline and could theoretically place 154docks, there is not nearly enough USACE land frontage to accommodate houses. Additionally, the shoreline along the proposed Carlton Landing development has very steep slopes that would preclude dock construction. A likely outcome would be more concentrated dock construction, which may cause acute, localized erosion and turbidity.

The private sewage treatment system would be the same as described under the No Action Alternative and would have no impact on water quality as long as it is operated and maintained properly per Title 252 Chapter 641 of the Oklahoma Administrative Code.

The STEPL Model was run for the proposed Carlton Landing development area for both USACE-owned lands only and USACE-owned and adjacent private lands (**Table 5-1**). The potential water quality impacts from the proposed Carlton Landing development under Alternative 3 would be the same as those under the No Action Alternative.

5.4.4 Summary of Potential Water Quality Impacts

Water quality in Eufaula Lake would likely experience a decline if Alternative 3 is implemented. Selection of this alternative would result in an increase in both land-based and water-based effects. Increasing the activity around and on the lake could result in increased erosion, lower dissolved oxygen, higher turbidity and large phosphorus and nitrogen loads. Increases in Limited Development allocated shoreline could result in an overall increase in activity around and in the lake and an increase in boating access compared with the No Action Alternative. An increase in boating access and lake-based recreation related to the development of private home sites both at the proposed Carlton Landing development and on private lands adjacent to USACE lands associated with the expansion of Limited Development allocated shoreline could degrade water quality.

Water quality standards for turbidity are exceeded under current conditions; therefore, any impact on turbidity would be significant. Dissolved oxygen levels in Eufaula Lake have exceeded water quality standards under some conditions; therefore, water quality impacts on dissolved oxygen have the potential to be significant under Alternative 3.

Nutrients are an existing water quality concern in Eufaula Lake, and under Alternative 3 nutrient transport has the potential to increase. An increase in nutrients could contribute to blue-green algae around Porum Landing or in other areas of the lake which would compromise recreational activities, public health and wildlife habitat.

Existing water quality conditions in Eufaula Lake would not significantly affect the proposed actions in Alternative 3. Turbidity is quite high in some areas of the lake, which may be undesirable from an aesthetic perspective for swimming and recreational activities such as water skiing. The Carlton Landing development is proposed on the eastern portion of the lake which tends to have greater water clarity in general; therefore, an increase in turbidity triggered by shoreline development would have a greater effect in this area than in other parts of the lake that are currently more turbid naturally. Other areas that would be changed to Limited Development include areas where turbidity and water quality may not be suitable for certain types of recreational activities and development.

The STEPL Model results estimate that Alternative 3 could result in an increase of phosphorus, nitrogen, and sediment compared to the No Action Alternative (**Table 5-6**). Pollutant loads were converted to ppm to measure the impact localized pollutant loading would have on the lake as a whole. Under Alternative 3, phosphorus, nitrogen, and sediment could increase overall in the lake compared to the No Action Alternative (**Table 5-7**). **Figure 5-5** illustrates that water quality impacts from private land adjacent to USACE-owned land contributes a substantial portion of pollutant loading under Alternative 3.

Table 5-6. Alternative 3 Modeled Percent Change Compared to the No Action Alternative

	Runoff Volume (AF)	Total Phosphorus Load (lb/year)	Total Nitrogen Load (lb/year)	Total Sediment Load (tons/year)
Direct Impacts[1]	5%	10%	9%	11%
Direct & Indirect Impacts[2]	9%	12%	7%	16%

[1] *Pollutant loads originating from USACE-owned land only*
[2] *Pollutant loads originating from USACE-owned and private land*

Table 5-7. Water Quality Impact Under Alternative 3

	Phosphorus Average Lake PPM	Phosphorus Percent Change	Nitrogen Average Lake PPM	Nitrogen Percent Change	Sediment Average Annual Inflow (acre feet)	Sediment Percent Change
Direct Impacts[1]	0.0731	0.3%	0.4239	0.3%	7,253	0.00%
Direct & Indirect Impacts[2]	0.0743	1.9%	0.4290	1.5%	7,254	0.02%

[1] *Pollutant loads originating from USACE-owned land only*
[2] *Pollutant loads originating from USACE-owned and private land*

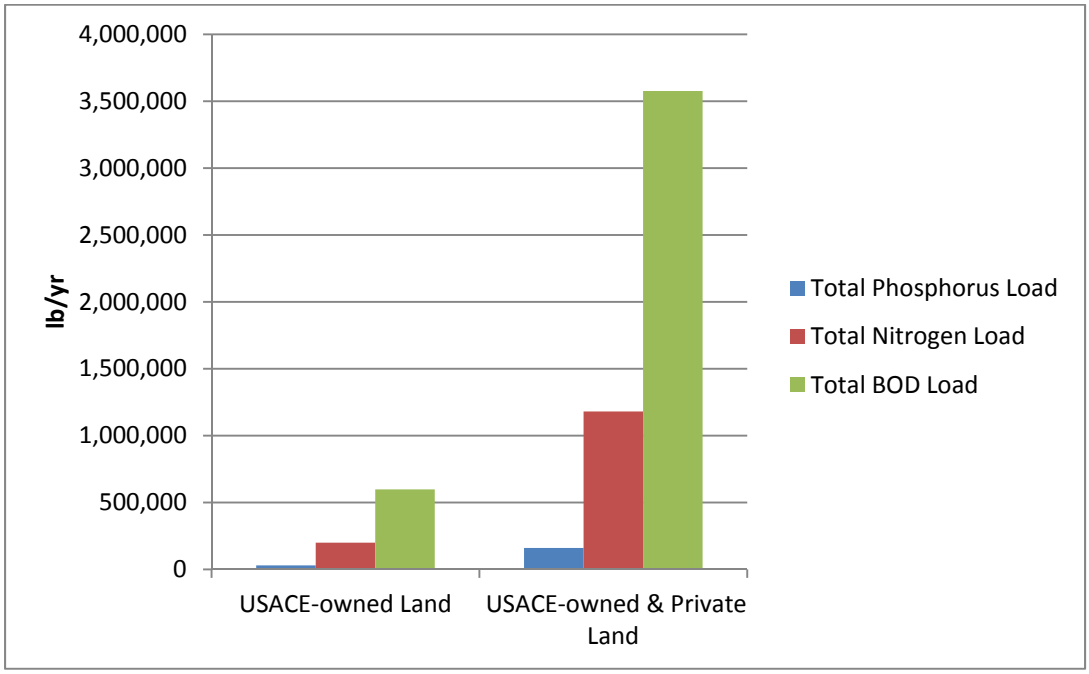


Figure 5-5. Direct and Indirect Water Quality Impacts Under Alternative 3

5.5 Alternative 4

Alternative 4 increases the amount of Limited Development area compared to the No Action Alternative by converting all Protected areas that do not have an existing lease agreement for use of the USACE shoreline to Limited Development. This alternative represents the end of the range of alternatives that emphasizes private exclusive uses and recreational development opportunities over natural resource conservation. Under Alternative 4, the lease request for a public marina and other public shoreline recreational facilities at Carlton Landing would be granted.

5.5.1 Shoreline Allocations and Land Use

Under Alternative 4, Limited Development shoreline miles would increase by 77 percent and Protected shoreline miles would decrease by 50 percent, and the average width of USACE lands would be 424 feet, the largest of all alternatives. Alternative 4 would result in the largest increase in Limited Development shoreline allocation of all the alternatives. High Density Recreation land use classifications would increase by 43 acres at the Carlton Landing area (another 258 acres is already classified as High Density Recreation and the shoreline zoning would be updated to Public Recreation to be consistent). Under Alternative 4,

there would be a potential for a maximum of 15,459 docks. While the actual number of docks would likely be considerably less, this number represents the potential for growth in docks and boating activity. Alternative 4 includes approximately 214 miles of additional shoreline available to accommodate new dock construction, which is about 96 percent more than is currently available under the No Action Alternative.

Similar to the No Action Alternative, development and dock construction has the potential to cause an increase in shoreline erosion, increased turbidity, and potential impacts related to boating (*e.g.*, oil, gas, bacteria, and nutrients). Water quality impacts related to boating access may result in unavoidable and significant (in terms of turbidity) water quality impacts.

Development on private lands adjacent to Limited Development areas would allow for new residential development and would likely increase the number of septic systems. This may not have an immediate water quality impact, but as more septic systems are installed and age, an increase in nutrients and bacteria in the long term may be expected.

5.5.2 Vegetation Management Policies

Under Alternative 4, the baseline buffer vegetation management policy would be implemented. The baseline buffers would be 25 feet smaller than the extended buffers applied to Alternatives 1 and 2. Based on the criteria in this policy (described in Chapter 2 of the EIS), the baseline vegetation management buffers would extend from 20 to 70 feet from the shoreline. In order to limit effects on water quality, vegetation, and wildlife habitat, vegetation management activities would only be allowed on USACE land upland of these buffer zones.

According to recent research, buffer widths of approximately 50 feet are generally effective at removing sediment and nutrients from runoff (Lee, *et al.* 2003). Given the average widths of buffers under Alternative 4, the vegetative buffers would likely result in improved water quality; however, the buffer widths under Alternative 4 would not be as effective at nutrient removal as buffer widths proposed under alternatives 1 and 2.

5.5.3 Proposed Carlton Landing Development

Under Alternative 4, the shoreline allocation along Carlton Landing would be changed from Protected to Public Recreation and the lease necessary for the construction and operation of a public marina and other public recreational facilities (*e.g.*, horseback riding trails, dog parks) would be granted. Following approval of a rezone and issuance of a lease, the full build out proposed for Carlton Landing would likely be implemented. Full build out of the 1,600 acres of privately-owned land is proposed to include approximately 2,570 home lots, a K-12 school, an organic farm, a town center, community pools, public open spaces, a conference center, and a 275-300 boat slip marina.

Development of Carlton Landing under Alternative 4 would include planned actions that would occur within the lake such as clearing of standing timber, dredging and silt removal, protected public swimming area, no wake area, kayaking and paddle boarding area, kids play zone, community boat docks (marina), boat fueling facilities, and boat storage. Planned shoreline recreational development includes structures, bike trails and horse riding trails, improved walkways, parking areas, vehicular access roads, utility facilities, golf cart access, a dog park, vegetation modification, and rights typical for a mowing permit.

Under Alternative 4, animal waste would be expected to increase as a result of the proposed equestrian facilities and dog parks. The proposed equestrian amenities would include a trail system, stables, paddocks, pens, and barns located on USACE-owned land to accommodate up to 100 horses. Animal waste contains several types of pollutants that contribute to water quality problems: nutrients, pathogens, and ammonia. Animal waste can be picked up by stormwater runoff and washed into Eufaula Lake where it decomposes, exerting an oxygen demand. During summer months when the water is warm, low oxygen levels can kill fish and other aquatic organisms.

Potential water quality impacts associated with the proposed horseback riding trails and dog park in Alternative 4 include increased sediment, phosphorus, nutrients, and bacteria loadings to the Lake. Activities such as heavy grazing and horse traffic on trails remove the vegetative cover and can expose the soil surface. Exposed soil is easily transported by runoff into streams and creeks. Chemicals used during horse grooming and shelter and living area maintenance may cause adverse health effects to humans and are toxic to aquatic life. Runoff from areas containing manure, bedding, or feed debris represents the most significant source of pollutants from equestrian facilities (South Orange County Permitees 2004).

Planned shoreline recreational development would increase impervious surfaces (*e.g.* roads, parking lots, roof tops) along the shoreline and contribute to increased erosion and turbidity, which already exceeds water quality standards.

The construction of a public marina at Carlton Landing could increase the number of boats on the water in the vicinity of the proposed development. A marina's location, flushing times, and circulation patterns, can affect sewage releases to surface waters. Proper siting of marina basins and adequate planning for boat sewage disposal are important factors in regards to mitigating the potential water quality impacts.

Increasing the amount of Limited Development areas along the lake could result in an increase in vegetation clearing and use of fertilizers on private property adjacent to Limited Development lands along the shoreline which could contribute to nutrient loading. In addition, septic tanks may be constructed for new private developments adjacent to USACE lands along Limited Development shorelines.

The proposed Carlton Landing development wastewater system would consist of a private sewage treatment system composed of five sewage treatment lagoons; three ponds would be built in the initial phase and two additional ponds would be added as the number of homes on the system increases (**Figure 5-6**). All of the lagoons are zero-output, total retention lagoons with a synthetic liner and under liner collection drain system. It is anticipated that this system would accommodate Carlton Landing development needs for at least the first five years of planned growth. When the community's sanitary sewer needs exceed the capacity of the five lagoons, a new approach would be developed to meet this infrastructure need. USACE Tulsa District policy does not allow the discharge of sewage and other wastes generated offsite onto USACE lands or water. A lagoon sewage treatment system operated and maintained properly per Title 252 Chapter 641 of the Oklahoma Administrative Code should have minimal to no impact on water quality.

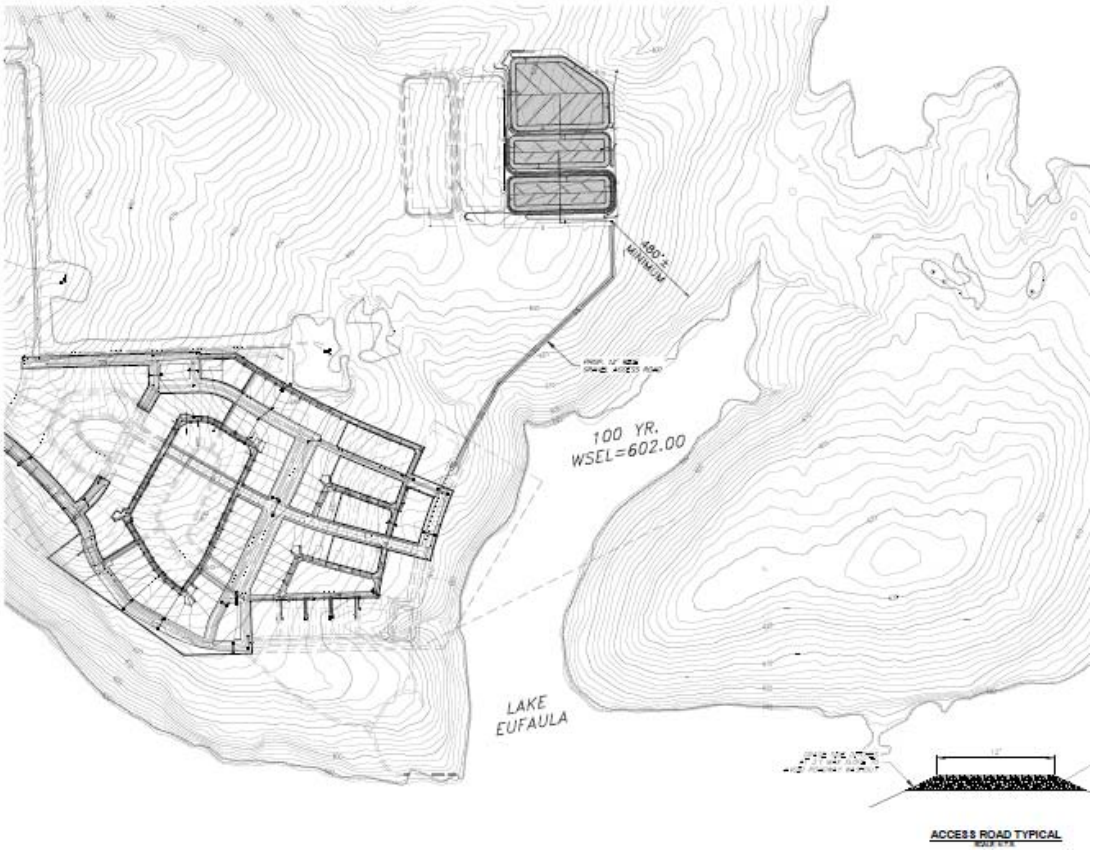


Figure 5-6. Carlton Landing Proposed Development Lagoon Sewer Treatment System Plan

The STEPL Model was run for the proposed Carlton Landing development area for both USACE-owned lands only (**Table 5-8**) and USACE-owned and adjacent private lands (**Table 5-9**). The results presented here estimate runoff and pollutant loads under Alternative 4 and compare these values to those under the No Action Alternative. These impacts may result in increased erosion and impact recreation in the area immediately surrounding the proposed Carlton Landing development.

Table 5-8. Direct Impacts Associated with Carlton Landing Development Under Alternative 4 Compared with the No Action Alternative[1]

	Runoff Volume (AF)	Total P[2] Load (lb/year)	Total N[2] Load (lb/year)	Total Sediment Load (tons/year)
No Action Alternative	158	117	634	42
Alternative 4	430	888	7,172	86
Percent Change	173%	659%	1,031%	105%

1 - This analysis addresses impacts originating from USACE-owned lands only (i.e. direct impacts)

2 - P = Phosphorus. N = Nitrogen

Table 5-9. Direct and Indirect Impacts Associated with Carlton Landing Development Under Alternative 4 Compared with the No Action Alternative[1]

	Runoff Volume (AF)	Total P[2] Load (lb/year)	Total N[2] Load (lb/year)	Total Sediment Load (tons/year)
No Action Alternative	740	588	3,805	192
Alternative 4	1,991	1,934	13,764	247
Percent Change	169%	229%	262%	28%

1 - This analysis addresses impacts originating from USACE-owned lands and adjacent private lands (i.e. direct and indirect impacts, respectively)
2 - P = Phosphorus. N = Nitrogen

5.5.4 Summary of Potential Water Quality Impacts

Overall, it is anticipated that water quality in Eufaula Lake could worsen if Alternative 4 is implemented. Of all the proposed alternatives, Alternative 4 would have the greatest potential for negative impacts on water quality in Eufaula Lake because of the potential water quality degradation associated with increased development. Selection of this alternative would result in an increase in both land-based and water-based effects.

The potential for significant water quality impacts from increased turbidity, which is already in excess of water quality standards, is of particular concern. There is potential for significant water quality impacts related to dissolved oxygen, which exceeds water quality standards in some samples. In addition, potential impacts related to recreation are present and are cause by a variety of water quality impacts (*e.g.*, nutrients, turbidity) and other factors (*e.g.*, water temperature). These water quality impacts could lead to general degradation of water quality and may result in a degradation of aesthetic and recreational amenities. Increased nutrients may impact blue-green algae blooms; however, the mechanism for these blooms on Eufaula Lake are complex and adequate water quality data are not presently available to determine the likelihood or the magnitude of this impact.

Existing water quality conditions in Eufaula Lake would not significantly affect the proposed actions in Alternative 4. Turbidity is quite high in some areas of the lake and exceeds water quality standards, which may be undesirable from an aesthetic perspective for swimming and recreational activities such as water skiing. The Carlton Landing development is proposed on the eastern portion of the lake which tends to have better water clarity in general; therefore, an increase in turbidity triggered by shoreline development could have a greater effect in this area than in other parts of the lake that are currently more turbid naturally. Other areas that would be changed to Limited Development may be in areas where turbidity and water quality may not be as suitable to certain types of recreational activities and development.

The STEPL Model results estimate that Alternative 4 could result in an increase of phosphorus, nitrogen, and sediment compared to the No Action Alternative (**Table 5-10**). Model results indicate that Alternative 4 results in the largest increase in pollutant loads compared to all other action alternatives as well as the No Action Alternative. Pollutant loads were converted to ppm to measure the impact localized pollutant loading would have on the lake as a whole. Under Alternative 4, phosphorus, nitrogen, and sediment could increase overall in the lake compared to the No Action Alternative (**Table 5-11**). **Figure 5-7** illustrates that water quality impacts from private land adjacent to USACE-owned land contributes a substantial portion of pollutant loading under Alternative 4.

Table 5-10. Alternative 4 Modeled Percent Change Compared to the No Action Alternative

	Runoff Volume (AF)	Total Phosphorus Load (lb/year)	Total Nitrogen Load (lb/year)	Total Sediment Load (tons/year)
Direct Impacts[1]	5%	10%	9%	11%
Direct & Indirect Impacts[2]	9%	12%	7%	16%

1 - Pollutant loads originating from USACE-owned land only
2 - Pollutant loads originating from USACE-owned and private land

Table 5-11. Water Quality Impact Under Alternative 4

	Phosphorus Average Lake PPM	Phosphorus Percent Change	Nitrogen Average Lake PPM	Nitrogen Percent Change	Sediment Average Annual Inflow (acre feet)	Sediment Percent Change
Direct Impacts[1]	0.0731	0.3%	0.4239	0.3%	7,253	0.00%
Direct & Indirect Impacts[2]	0.0743	1.9%	0.4290	1.5%	7,254	0.02%

1 - Pollutant loads originating from USACE-owned land only
2 - Pollutant loads originating from USACE-owned and private land

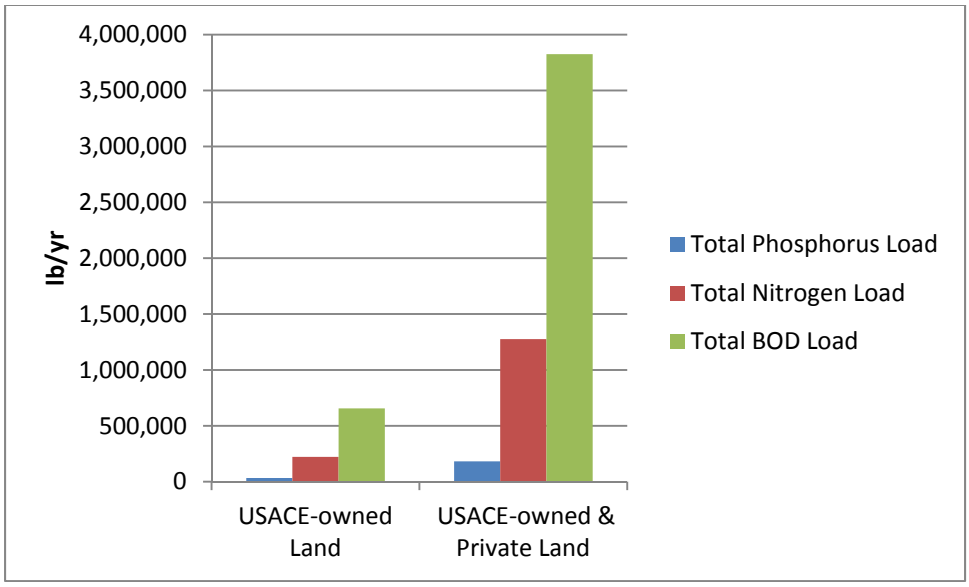


Figure 5-7. Direct and Indirect Water Quality Impacts Under Alternative 4

5.6 Summary

The alternatives outlined in the EIS have the potential to cause a wide range of impacts on water quality. The No Action Alternative would result in a continuation of the declining water quality conditions, described in Section 4 of this technical report. Alternative 1 would be most protective of water quality, followed by Alternative 2. Alternatives 1 and 2 would not be significantly impacted by existing water quality conditions. Alternatives 3 and 4 could be less protective of water quality, with Alternative 4 representing the most potential for negative impacts on water quality. **Figure 5-8** and **Figure 5-9** illustrates estimated pollutant loads based on direct impacts (USACE-owned land only) and direct plus indirect impacts (USACE-

owned and private lands) under each alternative based on the STEPL Model analysis. Under Alternative 1, phosphorus, nitrogen, and BOD would remain approximately at levels that reflect the existing conditions. All of the alternatives could be impacted by existing water quality conditions, particularly along shorelines that would be designated Public Recreation and Limited Development as a result of the widespread algal blooms throughout the lake. Overall, the quantitative analysis found that water quality impacts are not significant within the lake as a whole, but will result in localized effects. Localized effects could be most substantial under Alternatives 3 and 4 because of the increase in Limited Development shoreline and resulting development on private lands adjacent to USACE-owned lands.

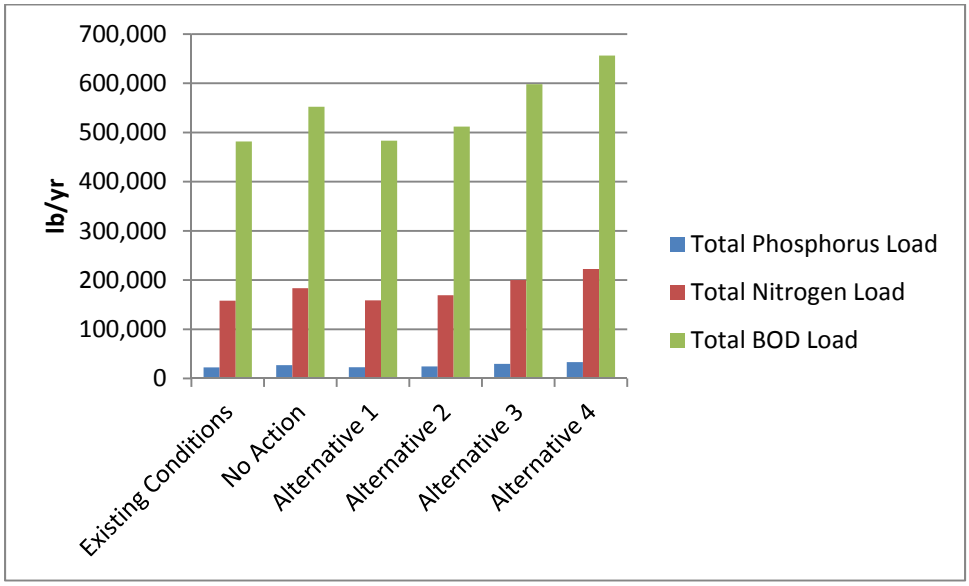


Figure 5-8. Direct Water Quality Impacts Under Each Alternative

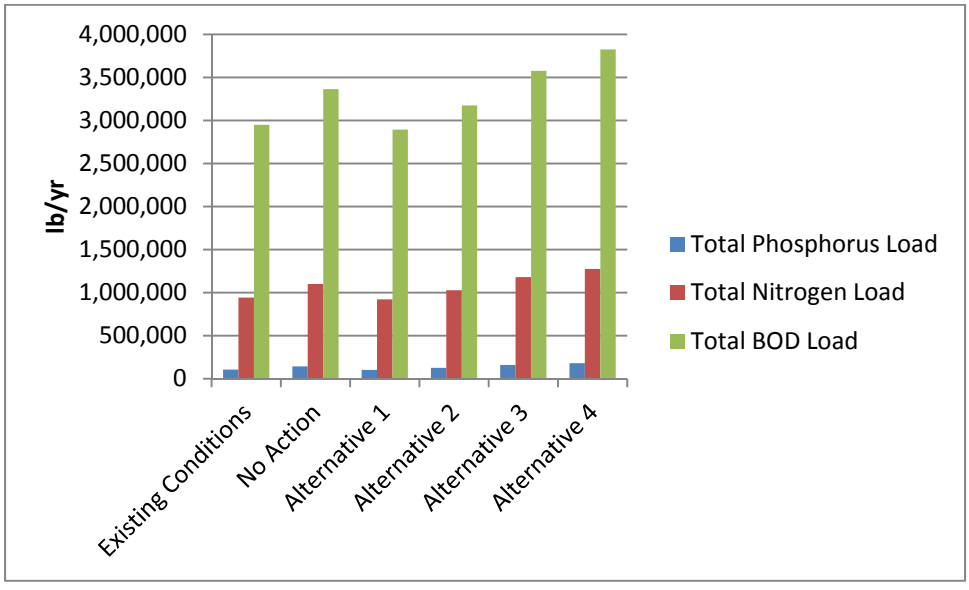


Figure 5-9. Direct and Indirect Water Quality Impacts Under Each Alternative

Alternatives 1 and 2 propose to reallocate shoreline areas from Limited Development to Protected which would preserve more natural vegetation. Buffer zones proposed under all of the alternatives would encourage preservation of natural vegetation along the shoreline which could limit erosion and reduce stormwater runoff into the lake.

Water quality monitoring indicates that Porum Landing, Highway 9 Landing, Brooken Cove, and Belle Starr parks are currently impacted by a blue-green algae bloom that has led to an advisory to visitors that it is not safe to swim in this area. Porum Landing, Highway 9 Landing, Brooken Cove, and Belle Starr parks would remain designated as Public Recreation under all of the alternatives and the No Action Alternative. While a comprehensive study of nutrient dynamics relative to recent cyanobacterial blooms has not been conducted, historic water quality data from OWRB and USACE include presentation and discussion of nutrient analyses (OWRB 2011a, USACE 2001). Nutrient ranges in Eufaula Lake indicates phosphorus loading has resulted in seasonal occurrences of nitrogen limitation. On average, Eufaula Lake borders on the boundary of nitrogen and/or phosphorus limitation. Some areas of the Lake could be co-limited while others are phosphorus limited (OWRB 2011a). Limited nitrogen availability in certain areas of the lake may provide conditions favorable for blue-green algae. A variety of factors may be contributing to the bloom, but at this time, insufficient data are available to determine the cause of this water quality issue or how the proposed alternatives may mitigate or exacerbate the algae bloom. Blue-green algae blooms are common in warm waters with high nutrient levels. Given the existing conditions, current water quality trends, and potential water quality impacts associated with these alternatives, it is likely algal blooms could expand or occur in other areas of the lake under certain conditions. These conditions are more likely under the No Action Alternative, and Alternatives 3 and 4 which have the potential to increase nutrients.

Potential water quality impacts that pose the greatest threat to Eufaula Lake include increased erosion along the shoreline, increased nutrient loading, increased bacteria, and increased turbidity. These water quality impacts have the potential to compromise those amenities that are most valuable on the lake, such as fishing, swimming, and recreation, and the aesthetic appeal of the lake. Potential mitigation measures to address these water quality impacts are discussed in Section 6 of this technical report.

Section 6
Proposed Mitigation Measures

To mitigate potential water quality impacts associated with the alternatives, the following mitigation measures are proposed. Mitigation measures are intended to lessen potential water quality impacts identified in Section 5 of this technical report. The mitigation measures presented below can be implemented individually or as part of a watershed approach. Most of the mitigation measures presented here address potential water quality impacts associated with all of the alternatives, including the No Action Alternative. Water quality impacts identified in Section 5 may originate from nonpoint source pollution associated with activity along the lake shoreline, development activities, and existing nonpoint source pollution that could be exacerbated under Alternatives 3 and 4 and lessened in Alternatives 1 and 2.

6.1 Nutrient Management Strategies

To mitigate potential impacts from nutrient inputs, USACE would ensure adequate vegetative buffers between residential development and the shoreline of Lake Eufaula to filter out nutrients from stormwater runoff. USACE may influence the amount of adjacent residential development that occurs by minimizing the amount of Limited Development shoreline allocated.

USACE may incorporate into the lease for the proposed Carlton Landing development, terms ensuring the trails, picnic sites, campsites, and other public recreation facilities are constructed and maintained to ensure access to the water is limited to controlled locations. In addition, the development of and adherence to a Water Quality Management Plan (WQMP) could reduce potential nutrient loading associated with the equestrian trails proposed under Alternative 4. Proposed mitigation measures to address potential water quality impacts associated with the proposed equestrian facility are outlined in Section 6.4.1.

The shoreline vegetation management buffer policies proposed in the alternatives address the potential water quality impacts of vegetation modification; therefore additional mitigation measures would not be needed for the alternatives.

6.2 Preserving Natural Vegetation

Preserving natural vegetation along the shoreline can mitigate potential water quality impacts associated with nutrients as well as erosion that leads to increased turbidity. The principal advantage to preserving natural vegetation along Eufaula Lake is providing erosion control and reducing stormwater runoff which carries nutrients and other pollutants into the lake. Natural vegetation can mitigate water quality impacts by intercepting rainfall, filtering stormwater runoff, and preventing sediments and other pollutants from entering the lake.

Under the action alternatives, the buffer vegetation management policy would be implemented and could reasonably mitigate potential water quality impacts related to vegetation modification. Under Alternatives 3 and 4, baseline buffers (20 to 70 feet) would be

implemented, and could be protective of potential water quality impacts, such as erosion, increased turbidity, increased nutrient and bacteria loading, and decreased dissolved oxygen. Extended buffers (45 to 95 feet) would be implemented under Alternatives 1 and 2, which would provide greater water quality protection.

6.3 Stormwater Best Management Practices

To mitigate potential water quality impacts from construction associated with proposed access trails to private docks along Limited Development shoreline as well as development on USACE lands associated with the Carlton Landing development under Alternative 4, USACE would incorporate mitigation measures into the lease terms to ensure stormwater BMPs are implemented.

EPA has developed a National Menu of BMPs for Stormwater that provides a wide array of BMPs for all types of water quality impacts related to stormwater runoff. Mitigation measures that could be implemented are summarized in **Table 6-1**.

Table 6-1. Stormwater BMPs

Activity	BMP(s)
Construction on USACE-owned lands at Carlton Landing	Maintain vegetated buffers and berms along trails and around structures to reduce erosion and pollutant transport into Eufaula Lake
	Construct wetlands or biofiltration swales around parking lots and other pervious pavements that have the potential to contribute nonpoint source pollution to Eufaula Lake
	Land grading to direct and control surface runoff, soil erosion, and sedimentation during and after construction
Construction of access trails to private docks along Limited Development shorelines	Use of pervious pavement where practical
	Maintain vegetated buffers and berms to reduce erosion and pollutant transport

6.3.1 Vegetated Buffers

Research has shown buffers to be most effective at trapping particulate pollutants (*i.e.* sediment), but they can also reduce the transport of nitrogen and phosphorus in stormwater runoff. When the vegetation root zone in the buffer intercepts shallow groundwater, buffers have been shown to reduce nitrate-nitrogen concentrations. Recent research indicates that the sediment trapping efficiency in buffers depends primarily on buffer width, vegetation type, density and spacing, sediment particle size, slope gradient and length, and flow convergence. Other factors include soil properties, initial soil water content, and rainfall characteristics (Yuan, *et al.* 2009). Recent studies indicate that under conditions of relatively shallow flow, gently sloping, densely vegetated three meter (9.8 feet) buffers are likely to limit transport of sediment into surface waters (Lee, *et al.* 1999; Blanco-Canqui, *et al.* 2004a; Blanco-Canqui, *et al.* 2004b). The first three to six meters (9.8 to 19.6 feet) of a buffer plays a dominant role in sediment removal (Daniels and Gilliam, 1996; Robinson, *et al.* 1996). Generally, buffers four to six meters (13 to 19.6 feet) in width can reduce sediment loading by more than 50 percent (Blanco-Canqui, *et al*. 2004a; Blanco-Canqui, *et al*. 2004b; Borin, *et al.* 2005; Helmers, *et al.* 2012; Lee, *et al.* 1999). However, this efficiency is likely reduced on slopes above five degrees due to the vegetation becoming flattened by surface runoff during high rainfall events (Yuan, *et al.* 2009). Vegetative buffers with widths greater than six meters (19.6 feet) are effective in removing sediment from most situations (Yuan, *et al.* 2009; Hook 2003).

Riparian buffers can significantly reduce nitrogen loads entering streams and thus represent important nutrient BMPs. According to Mayer *et al.* (2007), while some narrow buffers (up to 25 meters) proved effective, buffers wider than 50 meters more consistently removed significant amounts of nitrogen. Lee, Isenhardt, and Schultz (2003) found that a buffer width of seven meters (23 feet) was effective at removing sediment in runoff, but that increasing the buffer width to 16.3 meters (53.5 feet) increased the removal efficiency of soluble nutrients by more than 20 percent.

The size of a vegetative buffer is an important variable influencing effectiveness because the period of contact between stormwater runoff and vegetation in the buffer increases as the strip's width increases. Vegetated buffers should be considered based on a combination of slope, soil type, and vegetation cover. This approach is adopted for the proposed shoreline buffer zones in the action alternatives, and would be reasonably protective of water quality. The minimum buffer proposed anywhere would be 20 feet, which would be applied in non-erodible areas with slopes greater than 15 percent and with more than 75 percent vegetation cover. The minimum buffer would effectively mitigate some of the potential water quality impacts.

6.4 Recreational Best Management Practices

Recreational water quality impacts would be most severe under Alternative 4 in which the proposed Carlton Landing development would construct a marina and equestrian trails on USACE lands along the lakeshore. To mitigate potential water quality impacts from recreational activities, USACE would require BMPs related to the construction and operation of the equestrian trails and marina, both of which would be located on leased USACE lands.

To mitigate potential water quality impacts from the proposed recreational activities that would be located on USACE lands under Alternative 4, USACE would incorporate mitigation measures into the lease terms to ensure adequate construction and operation of these facilities. If Alternative 4 were selected, mitigation measures may include the implementation of BMPs to address recreational facilities in general (**Table 6-2**), as well as specific mitigation measures to address potential impacts related to equestrian trails, and the marina (Section 6.4.1 and Section 6.4.2).

Table 6-2. General Mitigation Measures and BMPs for Recreation Facilities on USACE Lands

Mitigation Measure Category	BMP	Performance Measure(s)
Building and Site Design	Site design conducted with USACE input and approval to incorporate mitigation measures	Develop and implement site design plan with coordination/approval of USACE
	Site layout should ensure that structures are placed where adverse effects are minimized and the natural topography, drainage patterns, and vegetation remain undisturbed	Develop and implement site design plan with coordination/approval of USACE
	Design diversion terraces that drain into areas with sufficient vegetation to filter the flow	Develop and implement site design plan with coordination/approval of USACE
Erosion Control	Maintain vegetation and replant bare areas to reduce erosion	Area of land re-vegetated each year, frequency of vegetation maintenance
	Maintain culverts and ditches, keep ditches vegetated with grass to help maintain stability and capture sediments	Number of culverts and ditches cleaned and/or re-vegetated each year
	Watch for accelerated erosion on steep slopes, trails, and gullies, and stabilize slopes with vegetation or other applicable erosion control measures, such as erosion control blankets	Area of land/trails inspected for erosion, and area repaired
Construction and Maintenance of Trails	Provide a vegetated buffer area between trails and waterways	Area of land covered by vegetated buffers, size of vegetated buffers
	The grade on any new trail should not exceed 10 percent and trails should be avoided at all costs on slopes steeper than 20 percent. If a trail must be built on a steep slope, the trail should switch back and forth down the slope	Number of trails with slopes less than 20 percent, number of switch-back trails with slopes of greater than 20 percent Develop and implement approved WQMP[1]
	Consider drainage patterns when building new trails. To reduce potential erosion on the trail, trails should be built so that water sheet flows across the trail	Develop and implement approved WQMP[1] Assessment of trail drainage patterns, and type and number erosion mitigation measures taken
	Maintenance of trails to address erosion	Number of miles of trails maintained, annual trail assessment
	Berms should be constructed as appropriate to direct stormwater away from the trail	Number and location of berms installed

1 - Water Quality Management Plan for equestrian trails and facilities is discussed in more detail in Section 6.4.1

6.4.1 Equestrian-Related Best Management Practices

To mitigate potential water quality impacts from the proposed equestrian trails and facilities associated with the Carlton Landing development under Alternative 4, USACE would incorporate mitigation measures into the lease terms to ensure adequate construction and operation of equestrian facilities. If Alternative 4 were selected, mitigation measures may include the implementation of individual BMPs (**Table 6-3**), a

Water Quality Management Plan (WQMP), and implementation of mitigation measures for site design prior to construction of the equestrian facilities.

USACE would require the development and implementation of a WQMP, or similar document, for their review and approval prior to construction of the equestrian trails and facilities. A WQMP would describe commitments to installation and maintenance of site design, source control, and treatment control BMPs that have been demonstrated to mitigate potential water quality impacts. A WQMP would also include a water quality monitoring program to monitor the effectiveness of mitigation measures and BMPs and ensure water quality protection. The WQMP would include a mechanism for periodic assessment of the effectiveness of the WQMP, and a process to update of the WQMP if necessary. The water quality monitoring program would be important to assess the success of the WQMP and identify additional mitigation measures needed to protect water quality. In addition to a WQMP, additional BMPs may be implemented.

The BMPs presented in **Table 6-3** are the most commonly recognized effective BMPs for mitigating potential water quality impacts associated with equestrian trails and facilities, and should be implemented in conjunction with the mitigation measures recommended for general recreational facilities in **Table 6-2** (Florida Department of Agriculture and Consumer Services 2011). The equine-related BMPs focus primarily on maintaining adequate vegetation, separating contaminated water and manure, and mitigating erosion and nutrient transport.

Success of these BMPs would be determined by a set of performance measures. Performance measures ensure consistent implementation of the mitigations measures, and would serve as a mechanism for requiring improvements if water quality protection is not achieved. Performance measures for equestrian facility mitigation measures are included in **Table 6-3**.

Table 6-3. Equestrian-Related Mitigation Measures and BMPs

Mitigation Measure Category	BMP	Performance Measure(s)
Building and Site Design	Install gutters that divert runoff from livestock area	Develop and implement site design plan with coordination/approval of USACE
	Place gravel below the sand in corrals and paddocks to percolate wastes and extra water, and these facilities not be built in areas with a greater than 10% slope	Develop and implement site design plan with coordination/approval of USACE
Waste Management	Remove manure regularly, daily is best, and provide temporary storage for manure that cannot be disposed of daily (about 15 cubic feet of storage per horse per week)	Frequency of manure removal, capacity of temporary waste storage facility (if present)
	Protect manure storage faculties from rainfall and surface runoff, grade the area surrounding the storage facility to prevent surface water reaching the storage area	Develop and implement approved WQMP
	Store horse waste on an impervious surface and under cover during rains to prevent leaching or runoff, and locate manure storage areas away from waterways so that floods or runoff will not wash away waste	Develop and implement approved WQMP
	Divert surface water runoff around areas with pollutants by constructing berms, ditches, underground pipes, or	Develop and implement approved WQMP

Mitigation Measure Category	BMP	Performance Measure(s)
	other methods	
	Collect soiled bedding and manure daily from stalls and paddocks and place in temporary or long-term storage units. Store in sturdy, insect resistant and seepage free units such as plastic garbage cans with lids, composters, or pits lined with an impermeable layer	Frequency of manure and soiled bedding removal, capacity of temporary or long-term storage units Storage units designed according to WQMP
	Compost soiled bedding and manure or transport manure to topsoil companies or composting facilities, if possible	Develop and implement approved WQMP
	Confine animals in properly fenced areas except during exercise and grazing periods	Develop and implement approved WQMP
Erosion Control	Establish healthy pastures with at least three inches of leafy material, and subdivide grazing areas into three or more units of equal size and rotate horses to ensure adequate vegetative cover	Develop and implement approved WQMP
	If no pastures are on site, filter strips should be used to separate trails and manure collection from waterways	Area of land covered by filter strips, size of filter strips
Wash Rack Design	Do not allow water from horse wash areas to flow into Eufaula Lake	Develop and implement approved WQMP
	Connect wash racks to the sanitary sewer system or septic system, if possible. Infiltration of wash rack water, if possible, is an acceptable means of disposal. Verify that soil conditions allow percolation prior to construction	Develop and implement approved WQMP
	Elevate the wash area from the surrounding ground	Develop and implement approved WQMP
	Wash water should drain to a filter strip or other vegetated area	Area of land covered by vegetated buffers, size of vegetated buffers
	Use horse grooming and health products properly, and clean up spills, avoid using soap as much as possible	Develop and implement approved WQMP
Trails and Access to Waterbodies	Utilize fencing to keep horses away from environmentally sensitive areas and protect the lakeshore from contamination	Develop and implement approved WQMP
	Restrict horse access in creeks, on the lakeshore, and along steep hillsides	Develop and implement approved WQMP
	If water access is determined acceptable, designate access points by using a designated crossing/entry point to reduce and control contaminants and to prevent shoreline erosion	Develop and implement approved WQMP

6.4.2 Boating Best Management Practices

To mitigate potential water quality impacts from the proposed marina associated with the Carlton Landing development under Alternative 4, USACE would incorporate mitigation measures into the lease terms to ensure adequate construction and operation of the marina. USACE would require the Carlton Landing development to develop a Marina Management Plan that would ensure compliance with lease terms, and outline required mitigation measures and BMPs set forth by USACE to satisfy those terms. Lease terms may include that Carlton Landing incorporate mitigation measures into the marina slip user contract. General

mitigation measures that may be included in lease terms and/or marina contract are listed in **Table 6-4** (Oregon Department of Environmental Quality 2002, EPA 2012).

Depending on the capacity of the fuel station at the proposed marina at Carlton Landing, and the potential of the site to impact waters of the U.S., the site may be subject to the EPA's Spill Prevention, Control, and Countermeasure (SPCC) Rule. The SPCC Rule requires SPCC plans for exterior storage of petroleum products and waste in tanks or containers in excess of 660 gallons in any one tank or in excess of 1320 gallons cumulatively. SPCC Plans require secondary containment of 110% of the volume of the largest container and written spill prevention and response measures approved as adequate by a professional engineer. These rules apply to aboveground tanks (40 CFR 112).

To mitigate potential water quality impacts caused by boating activities, USACE would implement no wake zones (5 mph or less) around boating recreational areas. Because hull shape strongly influence wake formation, no wake zones are more effective than speed limits in shallow surface waters for reducing turbidity and erosion caused by boat passage. No wake zones are typically required within 150 to 200 feet of the shoreline.

Table 6-4. Boating Mitigation Measures

Mitigation Measure	BMPs	Performance Measure
Education, Training, and Notification	Post informational signs regarding proper practices on cleaning, fueling, and waste management	Number and location of advisory signs in appropriate locations
	Communicate proper practices to marina users	Incorporation of proper practices into user contracts
Marina Rules and Regulations	Designate activities prohibited at the marina	Number and location of advisory signs in appropriate locations, incorporation into user contracts
	Clearly designate areas for restricted activities (*e.g.* painting and scraping, waste handling)	Number and location of advisory signs in appropriate locations
	Designate activities restricted to performance by authorized personnel	Number and location of advisory signs in appropriate locations
	Marina rules should be incorporated into user contracts, where approved methods and means of enforcement are clearly described	Incorporation into user contracts
	Establish no wake zones in and around the marina	Post signs for no wake zones, include in user contracts
Fuel Storage	Regularly inspect above ground fuel storage tanks (ASTs) and associated piping for leaks	Frequency of inspections
	ASTs should have a secondary containment area that contains spills and allows leaks to be more easily detected. Secondary ASTs should be impermeable to the materials being stored	Construction and maintenance of secondary containment
	Develop a Spill Contingency Plan for all fuel storage and dispensing areas	Development and implementation of a Spill Contingency Plan
Fuel Station Operation	Locate fuel docks in protected areas to reduce potential for accidents due to passing boat traffic	Location and siting of fuel docks
	Design station so that spill containment equipment can	Fuel station design

Mitigation Measure	BMPs	Performance Measure
	be easily deployed to surround a spill and any boats that may be tied to the fuel dock	incorporates spill containment measures
	Keep oil absorbent pads and pillows available at the fuel dock for staff and customers to mop up drips and small spills	Adequate number of oil absorbent pads, and periodic inspection and maintenance of these materials
	Routinely inspect and repair fuel transfer equipment, such as hoses and pipes	Frequency of inspection
	Place plastic or nonferrous drip trays lined with oil absorbent materials beneath fuel connections	Adequate drip trays, frequency of inspection and maintenance of these materials
	Post emergency phone numbers in a conspicuous location at the fuel station	Presence of signs displaying emergency contact information
Solid Waste Handling	Construction and maintenance of adequate pump-out facilities for boats with holding tanks	Adequate number of pump-out stations[1], frequency of inspection and maintenance of facilities
	Covered recycling and trash receptacles should be placed in convenient locations away from the water for use by marina patrons	Number and location of recycling and trash receptacles, schedule and frequency of pick up
	Provide designated fish cleaning areas	Number and location of fish cleaning areas
Stormwater Runoff Management	All areas of the marina should be cleaned on a regular basis to prevent oil, paint, dust, and other wastes from washing into surface waters	Frequency of cleaning, incorporate into Marina Management Plan
	Runoff and rinse water from boat maintenance and repair areas should be directed into a dedicated oil/water separator and sediment trap	Incorporate into site design, Develop and implement Marina Management Plan
	Sediment traps and oil/water separators in the storm water drainage system should be inspected on a monthly basis and after each storm event	Develop and implement Marina Management Plan

1 - EPA suggests one pump-out facility for every 200 – 250 boats with holding tanks. The State of Michigan mandates one pump-out facility for every 100 boats with holding tanks. Based on these numbers, USACE would require Carlton Landing to construct two to four pump-out facilities to accommodate sewage disposal at the proposed marina.

6.5 Summary

In summary, a wide range of mitigation measures are available to address potential water quality impacts associated with the alternatives. The approach to selecting and implementing mitigation measures should be strategic and consider the potential for water quality improvement.

If Alternative 1, Alternative 2, or Alternative 3 is selected, USACE would assess no-wake zones and speed limit zones to determine if additional zones should be implemented to minimize shoreline erosion resulting from boating activities. Many of the potential water quality impacts associated with these alternatives would be largely the result of activities on private lands and could not be mitigated by USACE. The vegetation buffer policies proposed under these alternatives would provide some mitigation of potential water quality impacts with respect to sedimentation and nutrient inputs. Vegetative buffers may be very effective at filtering out these potential pollutants; however, the application of the vegetation

management buffers alone may not be sufficient to bring the lake into compliance with water quality standards because the sources of potential pollutants are not only along shorelines where these buffers would be applied. For example, the Canadian River and other major creeks that enter Eufaula Lake are significant contributors of turbidity in the lake and these sources would not be affected by this mitigation measure.

If Alternative 4 is selected, USACE would address activities located on USACE land by requiring mitigation measures to address equestrian and boating activities as well as stormwater BMPs to mitigate construction impacts. Specific mitigation measures are described in more detail in Section 6.2, and Section 6.3. For boating-related impacts, USACE would implement measures such as no wake zones, marina rules and regulations, and a waste management plan including pump-out stations for watercraft and waste receptacles. For construction-related impacts, USACE would require the Carlton Landing development to implement stormwater BMPs such as vegetative buffers, silt fences, and pervious pavement. To address equine-related impacts, USACE would require a WQMP that addresses waste management, trail construction and maintenance, and animal access to the shoreline. These mitigation measures would be required as part of the lease granted for use of USACE lands.

EPA has an extensive database of BMPs which can serve as a valuable resource during consideration and selection of mitigation measures. The mitigation measures included in this section are not an exhaustive list of all available mitigation measures, but represent a strategic selection of relevant measures that have been proven effective.

Section 7
Conclusions

Potential water quality impacts under the No Action Alternative would result in continued water quality trends, which include increased sediment and nutrient transport associated with an increase in residential development on private lands adjacent to Limited Development shorelines, which would cause increased turbidity and nutrients, and decreased dissolved oxygen in Eufaula Lake. An increase in turbidity would cause a significant water quality impact because turbidity in the lake already exceeds water quality standards. Decreased dissolved oxygen levels could potentially cause Eufaula Lake to not attain water quality standards for this parameter, but this is uncertain given current data.

Under Alternative 1, water quality in Eufaula Lake would be expected to improve slightly compared to existing conditions. If Alternative 1 is selected, current water quality trends would change and could increase dissolved oxygen, decrease turbidity, and decrease nitrogen and phosphorus loading. Mitigation measures could reasonably be applied to address some of these potential impacts, and an overall improvement in water quality could be likely.

Under Alternative 2, water quality would also likely improve compared to the No Action Alternative. Current water quality trends would change and Eufaula Lake would benefit from an increase in dissolved oxygen, a decrease in turbidity and a decrease in nutrient loading. Mitigation measures could reasonably be applied to address some of these potential impacts, and an overall improvement in water quality would be likely.

Potential water quality impacts under Alternative 3 could include increased sediment and nutrient transport, increased turbidity, decreased dissolved oxygen, and an increase in those conditions that are shown to contribute to blue-green algae blooms. Mitigation measures could reasonably be applied to address some of these potential impacts, but an overall decline in water quality could be likely. Alternative 3 would result in a significant impact to water quality, particularly in relation to turbidity and dissolved oxygen as these parameters would continue to exceed water quality standards.

Potential water quality impacts under Alternative 4 would be the most severe, and could include increased sediment and nutrient transport, increased turbidity, decreased dissolved oxygen, and an increase in those conditions that are shown to contribute to blue-green algae blooms. Mitigation measures could reasonably be applied to address some of these potential impacts, but an overall decline in water quality would be likely. Alternative 4 could result in a significant impact to water quality, particularly in relation to turbidity and dissolved oxygen as these parameters would continue to exceed water quality standards. The proposed Carlton Landing development has the potential to result in significant water quality impacts (*e.g.*, turbidity and dissolved oxygen) even with mitigation measures in place.

Section 8
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Appendix A
Acronyms and Abbreviations

BMP	best management practice
BOD	Biological oxygen demand
BTEX	Benzene, toluene, ethylbenzene, and total xylene
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWA	Clean Water Act
DDT	dichloro-diphenyl-trichloroethane
DO	dissolved oxygen
EIS	Environmental impact statement
EO	Executive Order
EPA	Environmental Protection Agency
ER	Engineer Regulation
ESA	Endangered Species Act
FC	fecal coliform
GIS	Geographic information system
gpm	Gallons per minute
hp	horsepower
HUC	hydrologic unit code
L	liter
lb	pound
m	meter
mg	milligram
mgd	million gallons per day
mg/L	milligrams per liter
mL	milliliter
MSD	marine sanitation device
MSDS	Material Safety Data Sheets
MSL	mean sea level
N/A	not available
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWI	National Wetlands Inventory
OCC	Oklahoma Conservation Commission
ODEQ	Oklahoma Department of Environmental Quality

ODWC	Oklahoma Department of Wildlife Conservation
OWRB	Oklahoma Water Resources Board
PAH	polycyclic aromatic hydrocarbon
ppm	parts per million
PWC	personal watercraft
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
SMP	shoreline management plan
SWT	Southwest Division, Tulsa District
TMDL	Total Maximum Daily Load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
µg	microgram
µg/L	Micrograms per liter
USACE	U.S. Army Corps of Engineers
USDOC	U.S. Department of Commerce
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
WQS	Water Quality Standards
WQMP	Water Quality Management Plan

Appendix B
Water Quality Sampling Statistics

The following tables summarize the water quality data over the past decade from 17 OWRB sampling sites, 9 USACE sites, and 15 OCC sites. Samples that were above or below the detection limits were included in the minimum, maximum, mean and median calculations. Samples collected that were measured as below the detection limit were assigned a value of half the detection limit. Samples collected that were measured as above the detection limit were assigned a value equal to the detection limit.

Table B-1. OWRB Water Quality Statistics for Station 520700010020-01

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	20	<10.00	158.00	85.81	92.70	2	0	<10.00	N/A
Chloride	mg/L	18	<10.00	74.10	43.18	47.25	2	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Coliform, Fecal	CFU/100 mL	4	<10.00	10.00	6.25	5.00	3	0	<10.00	N/A
Color, Apparent	Units	3	122.00	>250.00	207.33	250.00	0	2	>250.00	N/A
Color, True	Units	16	9.00	168.00	62.06	50.00	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	0.70	24.00	8.54	5.90	0	0	N/A	N/A
E. coli	MPN/100mL	4	<10.00	10.00	6.25	5.00	3	0	<10.00	126 per 100 mL
Enterococci	CFU/100mL	4	<10.00	20.00	10.00	7.50	2	0	<10.00	33 per 100 mL
Hardness, Total (as CaCO3)	mg/L	5	83.00	162.00	109.80	97.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	13	<0.05	0.09	0.03	0.03	12	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	19	0.25	1.19	0.57	0.53	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	11	<0.05	0.34	0.15	0.17	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	8	<0.05	0.34	0.16	0.16	2	0	<0.05	N/A
Nitrogen, Organic	mg/L	1	0.39	0.39	0.39	0.39	0	0	<0.05	N/A
Nitrogen, Total	mg/L	1	0.39	0.39	0.39	0.39	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	5.98	2.25	1.79	2	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.12	0.04	0.04	1	0	<0.005	N/A
Phosphorous, Total	mg/L	19	0.02	0.17	0.08	0.08	0	0	N/A	N/A
Secchi Depth	cm	7	16.00	58.00	32.57	32.00	0	0	N/A	N/A
Solids, Settleable	mg/L	3	<0.10	0.05	0.05	0.05	3	0	<0.10	N/A
Solids, Suspended	mg/L	3	16.00	38.00	28.00	30.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	161.00	271.00	216.00	216.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	13	10.60	70.90	40.61	41.20	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	10	4.00	97.00	42.90	42.50	0	0	N/A	25 NTU

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

Table B-2. OWRB Water Quality Statistics for Station 520700010020-02

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	16	37.50	151.00	96.47	98.30	0	0	<10.00	N/A
Chloride	mg/L	14	11.20	70.60	46.86	50.40	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	3	126.00	>250.00	208.67	250.00	0	2	>250.00	N/A
Color, True	Units	14	11.00	238.00	70.36	61.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	12	1.47	37.00	12.02	7.87	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	5	85.00	159.00	116.80	117.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	11	<0.05	0.03	0.03	0.03	11	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	17	0.25	1.08	0.58	0.60	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	9	<0.05	0.30	0.15	0.14	2	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	8	<0.05	12.00	1.65	0.17	2	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	9	<0.05	0.06	0.03	0.03	7	0	<0.05	N/A
Nitrogen, Organic	mg/L	1	0.25	0.25	0.25	0.25	0	0	<0.05	N/A
Nitrogen, Total	mg/L	1	0.39	0.39	0.39	0.39	0	0	<0.05	N/A
Pheophytin A	mg/m^3	12	<0.10	6.88	3.22	2.42	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	15	0.00	0.12	0.04	0.03	0	0	<0.005	N/A
Phosphorous, Total	mg/L	17	0.04	0.25	0.09	0.08	0	0	N/A	N/A
Secchi Depth	cm	7	17.00	55.00	34.00	31.00	0	0	N/A	N/A
Solids, Settleable	mg/L	3	[C]	[C]	[C]	[C]	3	0	<0.10	N/A
Solids, Suspended	mg/L	3	13.00	32.00	24.00	27.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	178.00	270.00	224.00	224.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	11	10.90	59.20	38.41	39.70	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	9	10.00	89.00	43.67	38.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-3. OWRB Water Quality Statistics for Station 520500010020-03

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	17	55.40	148.00	102.03	110.00	0	0	<10.00	N/A
Chloride	mg/L	15	29.00	81.50	61.13	66.40	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Coliform, Fecal	CFU/100 mL	3	<10.00	10.00	6.67	5.00	2	0	<10.00	N/A
Color, Apparent	Units	4	141.00	>250	206.00	216.50	0	1	>250.00	N/A
Color, True	Units	15	16.00	119.00	59.20	60.00	0	0	N/A	70 PT-CO
Corrected Chlorophyll-*a*	mg/m^3	12	3.90	42.50	18.82	15.55	0	0	N/A	N/A
E. coli	MPN/100mL	3	<10.00	10.00	6.67	5.00	2	0	<10.00	126 per 100 mL
Enterococci	CFU/100mL	3	<10.00	10.00	8.33	10.00	1	0	<10.00	33 per 100 mL
Hardness, Total (as CaCO3)	mg/L	5	87.00	158.00	129.40	146.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.13	0.04	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	18	0.35	1.43	0.72	0.68	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.45	0.25	0.29	1	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	8	<0.05	0.56	0.22	0.21	2	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.08	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	1	0.35	0.35	0.35	0.35	0	0	<0.05	N/A
Nitrogen, Total	mg/L	1	0.70	0.70	0.70	0.70	0	0	<0.05	N/A
Pheophytin A	mg/m^3	12	0.40	28.20	8.64	7.27	0	0	<0.10	N/A
Phosphorous, Ortho	mg/L	16	0.00	0.18	0.06	0.04	0	0	<0.005	N/A
Phosphorous, Total	mg/L	18	0.06	0.18	0.11	0.10	0	0	N/A	N/A
Secchi Depth	cm	5	30.00	52.00	37.40	36.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	16.00	70.00	33.50	24.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	3	177.00	345.00	256.67	248.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	11	35.70	85.10	58.04	58.60	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	9	12.00	99.00	41.33	38.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-4. OWRB Water Quality Statistics for Station 520500010020-04

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	19	75.10	161.00	104.36	100.25	0	0	<10.00	N/A
Chloride	mg/L	16	20.00	73.40	53.16	55.95	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Color, Apparent	Units	4	29.00	188.00	109.50	110.50	0	0	>250.00	N/A
Color, Borger Color System	Code	1	56.00	56.00	56.00	56.00	0	0	N/A	N/A
Color, True	Units	16	9.00	119.00	41.81	26.00	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	2.35	20.50	10.44	11.00	0	0	N/A	N/A
Dissolved Oxygen Saturation	percent	1	118.30	118.30	118.30	118.30	0	0	N/A	N/A
Dissolved Oxygen, Analysis by Probe	mg/L	1	12.00	12.00	12.00	12.00	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
Hardness, Total (as CaCO3)	mg/L	7	102.00	160.00	134.17	133.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.07	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	19	0.21	1.26	0.57	0.51	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.39	0.13	0.08	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	9	0.03	0.34	0.19	0.19	1	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.11	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.14	0.31	0.23	0.23	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.36	0.46	0.41	0.41	0	0	<0.05	N/A
pH (field)	std units	1	8.44	8.44	8.44	8.44	0	0	N/A	6.5 to 9.0
Pheophytin A	mg/m^3	13	<0.10	6.00	2.97	3.13	2	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.07	0.03	0.03	1	0	<0.005	N/A
Phosphorous, Total	mg/L	19	0.03	0.10	0.06	0.06	0	0	N/A	N/A
Salinity (field)	g/L	1	0.74	0.74	0.74	0.74	0	0	N/A	N/A
Secchi Depth	cm	5	38.00	100.00	65.20	60.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	10.00	14.00	12.50	13.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	3	251.00	953.00	499.00	293.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Specific Conductance	UMHOS/cm	1	1468.00	1468.00	1468.00	1468.00	0	0	N/A	N/A
Sulfate	mg/L	12	25.70	68.90	53.03	57.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Turbidity, Field	NTU	11	6.00	56.00	21.00	21.00	0	0	N/A	25 NTU
Turbidity, Type (1=inorganic, 2=organic, 3=mix)	code	1	1.00	1.00	1.00	1.00	0	0	N/A	N/A
Water Temperature	Deg C	1	14.53	14.53	14.53	14.53	0	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Qualitative parameters such as debris, flow, foaming, odor, oil and grease, and scum are not included in this document as these parameters were monitored only at this site and none of them raised a water quality concern.

Table B-5. OWRB Water Quality Statistics for Station 220600010020-05

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	17	74.70	136.00	99.54	95.60	0	0	<10.00	N/A
Chloride	mg/L	16	<5.00	74.20	46.28	51.00	1	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	22.00	155.00	78.50	68.50	0	0	>250.00	N/A
Color, True	Units	16	3.00	196.00	43.13	24.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	2.84	21.50	9.42	10.00	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	5	94.00	159.00	138.20	154.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.07	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	19	0.28	2.65	0.72	0.54	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.31	0.14	0.16	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	9	<0.05	0.34	0.18	0.18	1	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.05	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.21	0.31	0.26	0.26	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.31	0.51	0.41	0.41	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	13.00	3.21	3.10	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.13	0.03	0.03	2	0	<0.005	N/A
Phosphorous, Total	mg/L	19	0.02	0.13	0.05	0.04	0	0	N/A	N/A
Secchi Depth	cm	5	28.00	120.00	72.20	58.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	<0.10	0.10	0.06	0.05	3	0	<0.10	N/A
Solids, Suspended	mg/L	4	3.00	14.00	7.00	5.50	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	264.00	318.00	291.00	291.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	26.70	100.00	58.15	59.85	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	9	3.00	126.00	24.44	11.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

Table B-6. OWRB Water Quality Statistics for Station 220600010020-06

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	17	77.60	125.00	97.54	94.00	0	0	<10.00	N/A
Chloride	mg/L	16	19.20	72.70	51.84	54.25	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	20.00	91.00	52.00	48.50	0	0	>250.00	N/A
Color, True	Units	16	5.00	106.00	33.06	21.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	12	2.30	22.00	9.02	6.44	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	5	103.00	151.00	128.80	130.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.05	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	19	0.21	1.30	0.55	0.54	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.34	0.14	0.15	3	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	9	<0.05	0.32	0.17	0.16	1	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	[C]	[C]	[C]	[C]	10	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.23	0.27	0.25	0.25	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.34	0.51	0.43	0.43	0	0	<0.05	N/A
Pheophytin A	mg/m^3	12	<0.10	5.08	2.26	2.47	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.06	0.02	0.02	4	0	<0.005	N/A
Phosphorous, Total	mg/L	19	0.01	0.08	0.04	0.04	0	0	N/A	N/A
Secchi Depth	cm	7	41.00	140.00	93.86	94.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	0.50	8.00	3.63	3.00	1	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	275.00	282.00	278.50	278.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	30.50	70.10	53.48	58.20	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	9	2.00	30.00	13.67	13.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-7. OWRB Water Quality Statistics for Station 220600010020-07S

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	22	29.80	149.50	99.56	97.65	0	0	<10.00	N/A
Chloride	mg/L	23	<5.00	64.40	42.53	46.50	3	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Coliform, Fecal	CFU/100 mL	5	<10.00	10.00	6.00	5.00	4	0	<10.00	N/A
Color, Apparent	Units	9	0.00	<250.00	64.56	39.00	0	1	>250.00	N/A
Color, True	Units	23	0.00	<250.00	34.96	16.00	0	1	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	16	2.59	21.60	8.32	7.34	0	0	N/A	N/A
E. coli	MPN/100mL	5	<10.00	10.00	7.00	5.00	3	0	<10.00	126 per 100 mL
Enterococci	CFU/100mL	5	<10.00	10.00	7.00	5.00	3	0	<10.00	33 per 100 mL
Hardness, Total (as CaCO3)	mg/L	2	146.00	168.00	157.00	157.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	21	<0.05	0.08	0.03	0.03	19	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	25	0.22	0.78	0.44	0.42	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	18	<0.05	0.23	0.11	0.12	6	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	7	<0.05	0.31	0.19	0.24	2	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	18	<0.05	0.07	0.03	0.03	16	0	<0.05	N/A
Nitrogen, Organic	mg/L	4	0.19	0.36	0.29	0.30	0	0	<0.05	N/A
Nitrogen, Total	mg/L	4	0.32	0.56	0.42	0.39	0	0	<0.05	N/A
Pheophytin A	mg/m^3	16	<0.10	5.08	2.21	1.69	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	23	<0.005	0.08	0.02	0.02	6	0	<0.005	N/A
Phosphorous, Total	mg/L	25	0.01	0.15	0.05	0.04	0	0	N/A	N/A
Secchi Depth	cm	2	98.00	153.00	125.50	125.50	0	0	N/A	N/A
Solids, Settleable	mg/L	9	[C]	[C]	[C]	[C]	9	0	<0.10	N/A
Solids, Suspended	mg/L	9	2.00	39.00	10.56	8.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	5	113.00	295.00	250.20	284.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	14	30.70	66.50	52.81	55.65	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	7	3.00	21.00	8.29	6.00	0	0	N/A	25 NTU

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

Table B-8. OWRB Water Quality Statistics for Station 220600010020-07B

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	10	<5.00	145.40	96.97	97.55	1	0	<10.00	N/A
Chloride	mg/L	10	<5.00	63.20	41.19	46.30	1	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	0.00	99.00	45.00	40.50	0	0	>250.00	N/A
Color, True	Units	10	0.00	56.00	18.40	19.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	7	3.04	21.00	8.25	6.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	10	<0.05	0.38	0.07	0.03	6	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	10	0.14	0.82	0.38	0.35	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.35	0.16	0.17	2	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrite as N	mg/L	10	[C]	[C]	[C]	[C]	10	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.09	0.31	0.20	0.20	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.32	0.37	0.35	0.35	0	0	<0.05	N/A
Pheophytin A	mg/m^3	7	0.79	4.87	2.57	2.60	0	0	<0.10	N/A
Phosphorous, Ortho	mg/L	10	<0.005	0.13	0.04	0.02	1	0	<0.005	N/A
Phosphorous, Total	mg/L	10	<0.005	0.17	0.06	0.04	1	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	0.50	10.00	6.13	7.00	1	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	6.00	310.00	158.00	158.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	6	30.30	60.00	46.34	44.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	2	4.00	21.00	12.50	12.50	0	0	N/A	25 NTU

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

Table B-9. OWRB Water Quality Statistics for Station 220600010060-08

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	16	67.20	151.50	98.16	92.50	0	0	<10.00	N/A
Chloride	mg/L	15	29.50	70.50	49.87	49.80	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	3	63.00	>250.00	137.33	99.00	0	1	>250.00	N/A
Color, True	Units	15	11.00	78.00	29.93	22.00	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	6.00	58.00	16.62	13.90	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	6	113.00	160.00	130.33	128.50	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	11	<0.05	0.12	0.04	0.03	9	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	19	0.27	1.20	0.55	0.54	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	9	<0.05	0.22	0.07	0.08	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.34	0.08	0.03	7	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	9	[C]	[C]	[C]	[C]	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	1	0.27	0.27	0.27	0.27	0	0	<0.05	N/A
Nitrogen, Total	mg/L	1	0.27	0.27	0.27	0.27	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	8.00	4.23	3.89	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	16	<0.005	0.05	0.01	0.01	4	0	<0.005	N/A
Phosphorous, Total	mg/L	19	<0.005	0.19	0.04	0.03	1	0	N/A	N/A
Secchi Depth	cm	7	49.00	114.00	91.14	95.00	0	0	N/A	N/A
Solids, Settleable	mg/L	3	<0.10	0.65	0.27	0.10	1	0	<0.10	N/A
Solids, Suspended	mg/L	3	4.00	122.00	45.33	10.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	250.00	269.00	259.50	259.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	31.50	71.30	52.08	55.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	8	5.00	21.00	9.50	7.50	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-10. OWRB Water Quality Statistics for Station 220600010050-09

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	18	64.00	149.00	101.81	100.50	0	0	<10.00	N/A
Chloride	mg/L	16	31.20	73.90	50.46	46.95	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	40.00	212.00	92.00	58.00	0	0	>250.00	N/A
Color, True	Units	16	5.00	243.00	51.13	28.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl A	mg/m3	13	1.21	42.00	10.61	8.22	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	6	104.00	167.00	123.50	114.50	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.10	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.10	1.20	0.53	0.51	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.27	0.13	0.09	5	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.29	0.15	0.16	4	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	0.03	0.05	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.27	0.32	0.30	0.30	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.27	0.59	0.43	0.43	0	0	<0.05	N/A
Pheophytin A	mg/m3	13	<0.10	38.00	5.48	2.32	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.20	0.03	0.02	3	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.02	0.15	0.05	0.04	0	0	N/A	N/A
Secchi Depth	cm	6	15.00	121.00	65.33	64.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	<0.10	0.10	0.06	0.05	3	0	<0.10	N/A
Solids, Suspended	mg/L	4	0.50	16.00	6.38	4.50	1	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	270.00	363.00	316.50	316.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	54.00	121.00	71.17	68.55	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	9	4.00	190.00	40.44	27.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

Table B-11. OWRB Water Quality Statistics for Station 220600010050-10

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	18	66.90	161.00	120.77	122.50	0	0	<10.00	N/A
Chloride	mg/L	16	34.60	137.00	73.99	68.75	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	67.00	146.00	108.00	109.50	0	0	>250.00	N/A
Color, True	Units	16	7.00	203.00	50.44	33.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	2.34	32.70	12.90	9.76	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	6	97.00	212.00	162.00	166.50	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.07	0.04	0.03	8	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.28	1.00	0.63	0.67	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.37	0.19	0.21	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	0.06	0.33	0.19	0.20	0	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.05	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	1	0.28	0.28	0.28	0.28	0	0	<0.05	N/A
Nitrogen, Total	mg/L	1	0.64	0.64	0.64	0.64	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	8.25	3.01	2.70	2	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	0.00	0.21	0.04	0.03	0	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.03	0.15	0.07	0.06	0	0	N/A	N/A
Secchi Depth	cm	7	12.00	85.00	34.86	27.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	3.00	20.00	10.25	9.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	3	253.00	449.00	356.00	366.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	65.90	139.00	100.19	92.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	10	11.00	210.00	53.80	42.00	0	0	N/A	25 NTU

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

Table B-12. OWRB Water Quality Statistics for Station 220600010050-11

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	18	68.00	155.50	116.62	116.00	0	0	<10.00	N/A
Arsenic, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<10.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Barium, Total	µg/L	1	164.00	164.00	164.00	164.00	0	0	N/A	1.0 mg/L (PPWS)
Cadmium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<1.00	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chloride	mg/L	16	31.40	113.00	67.72	62.45	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Chromium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Coliform, Fecal	CFU/100 mL	4	<10.00	100.00	30.00	7.50	2	0	<10.00	N/A
Color, Apparent	Units	4	80.00	>250.00	171.00	177.00	0	2	>250.00	N/A
Color, True	Units	16	22.00	238.00	61.19	42.00	0	0	N/A	70 PT-CO
Copper, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	1.0 mg/L (PPWS)
Corrected Chlorophyl-*a*	mg/m^3	13	1.72	34.00	10.75	5.34	0	0	N/A	N/A
E. coli	MPN/100mL	4	<10.00	41.00	15.25	7.50	2	0	<10.00	126 per 100 mL
Enterococci	CFU/100mL	4	<10.00	122.00	35.50	7.50	2	0	<10.00	33 per 100 mL
Hardness, Total (as CaCO3)	mg/L	7	89.00	211.00	167.57	172.00	0	0	N/A	N/A
Lead, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Mercury, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<0.05	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)
Nickel, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	607.2 µg/L (fish consumption and water) 4583.0 µg/L (fish consumption)

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Nitrogen, Ammonia	mg/L	12	<0.05	0.13	0.04	0.03	9	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.32	1.05	0.59	0.53	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.36	0.18	0.21	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.32	0.21	0.21	1	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.07	0.03	0.03	8	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.32	0.34	0.33	0.33	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.39	0.68	0.54	0.54	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	9.20	3.58	3.20	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.23	0.04	0.03	1	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.03	0.16	0.07	0.07	0	0	N/A	N/A
Secchi Depth	cm	5	18.00	104.00	49.00	29.00	0	0	N/A	N/A
Selenium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	0.010 mg/L (PPWS)
Silver, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<2.00	0.050 mg/L (PPWS) 104.8 µg/L (fish consumption and water) 64620.0 µg/L (fish consumption)
Solids, Settleable	mg/L	4	<0.10	0.10	0.06	0.05	3	0	<0.10	N/A
Solids, Suspended	mg/L	4	2.00	31.00	17.50	18.50	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	343.00	570.00	456.50	456.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	63.60	128.00	90.79	84.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Thallium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<10.00	1.7 µg/L (fish consumption and water) 6.0 µg/L (fish consumption)
Turbidity, Field	NTU	10	9.00	246.00	51.60	33.00	0	0	N/A	25 NTU
Zinc, Total	µg/L	1	9.50	9.50	9.50	9.50	0	0	N/A	5.0 mg/L (PPWS)

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-13. OWRB Water Quality Statistics for Station 220600050010-12

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	17	49.00	146.50	86.32	82.80	0	0	<10.00	N/A
Chloride	mg/L	16	12.10	79.60	41.03	39.90	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	41.00	209.00	118.25	111.50	0	0	>250.00	N/A
Color, True	Units	16	18.00	>250.00	63.63	40.50	0	1	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	1.41	21.40	8.88	9.50	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	6	71.00	155.00	106.17	97.50	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.07	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.23	0.94	0.51	0.50	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.36	0.14	0.14	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.27	0.13	0.07	3	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	0.03	0.08	0.04	0.03	7	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.26	0.34	0.30	0.30	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.40	0.49	0.45	0.45	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	15.50	3.80	2.63	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.16	0.03	0.02	2	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.02	0.13	0.05	0.04	0	0	N/A	N/A
Secchi Depth	cm	6	17.00	90.00	61.00	64.50	0	0	N/A	N/A
Solids, Settleable	mg/L	4	<0.10	0.15	0.08	0.05	3	0	<0.10	N/A
Solids, Suspended	mg/L	4	6.00	16.00	12.00	13.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	188.00	526.00	357.00	357.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	25.80	99.50	59.48	55.80	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Thallium, Total	µg/L	1	102.00	102.00	102.00	102.00	0	0	<10.00	1.7 µg/L (fish consumption and water) 6.0 µg/L (fish consumption)
Turbidity, Field	NTU	10	3.00	158.00	36.90	19.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

Table B-14. OWRB Water Quality Statistics for Station 220600050010-13

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	18	31.10	141.40	77.18	69.20	0	0	<10.00	N/A
Chloride	mg/L	16	11.40	44.90	29.11	30.75	0	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	29.00	218.00	117.00	110.50	0	0	>250.00	N/A
Color, True	Units	16	16.00	185.00	70.00	39.50	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	1.01	18.70	8.98	8.19	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	6	60.00	158.00	101.83	99.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.05	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.17	0.67	0.45	0.45	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.22	0.10	0.09	3	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.31	0.11	0.03	6	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	[C]	[C]	[C]	[C]	10	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.13	0.17	0.15	0.15	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.17	0.23	0.20	0.20	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	5.64	2.79	2.57	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.07	0.02	0.01	2	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.02	0.09	0.05	0.04	0	0	N/A	N/A
Secchi Depth	cm	6	30.00	88.00	62.33	64.50	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	2.00	16.00	8.50	8.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	176.00	275.00	225.50	225.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	24.60	68.90	49.08	50.80	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	10	6.00	71.00	31.60	17.50	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-15. OWRB Water Quality Statistics for Station 220600050010-14

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	17	14.90	150.50	61.09	47.80	0	0	<10.00	N/A
Chloride	mg/L	16	<10.00	40.20	18.39	13.35	2	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	31.00	176.00	98.75	94.00	0	0	>250.00	N/A
Color, True	Units	16	13.00	242.00	93.31	51.00	0	0	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	1.03	22.80	8.52	9.00	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	5	46.00	154.00	89.00	82.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.05	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.25	2.18	0.55	0.46	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.20	0.09	0.06	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.28	0.11	0.04	5	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.06	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.30	0.34	0.32	0.32	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.30	0.34	0.32	0.32	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	1.30	9.48	3.74	3.03	0	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.06	0.02	0.02	2	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.02	0.46	0.07	0.04	0	0	N/A	N/A
Secchi Depth	cm	5	30.00	90.00	59.60	65.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	4.00	12.00	8.00	8.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	121.00	231.00	176.00	176.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	20.10	58.50	41.68	41.70	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	9	5.00	80.00	37.89	26.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-16. OWRB Water Quality Statistics for Station 220600050010-15

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	17	<10.00	122.20	54.16	42.20	1	0	<10.00	N/A
Arsenic, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<10.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Barium, Total	µg/L	1	68.20	68.20	68.20	68.20	0	0	N/A	1.0 mg/L (PPWS)
Cadmium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<1.00	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chloride	mg/L	16	<5.00	37.20	13.04	10.25	5	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Chromium, Total	µg/L	1	5.60	5.60	5.60	5.60	0	0	<5.00	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Coliform, Fecal	CFU/100 mL	4	<10.00	10.00	6.25	5.00	3	0	<10.00	N/A
Color, Apparent	Units	4	42.00	236.00	130.50	122.00	0	0	>250.00	N/A
Color, True	Units	16	11.00	>250.00	115.50	88.00	0	1	N/A	70 PT-CO
Copper, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	1.0 mg/L (PPWS)
Corrected Chlorophyl-*a*	mg/m^3	13	0.76	15.30	7.54	9.06	0	0	N/A	N/A
E. coli	MPN/100mL	4	<10.00	10.00	6.25	5.00	3	0	<10.00	126 per 100 mL
Enterococci	CFU/100mL	4	<10.00	10.00	7.50	7.50	2	0	<10.00	33 per 100 mL
Hardness, Total (as CaCO3)	mg/L	7	49.00	111.00	63.53	55.70	0	0	N/A	N/A
Lead, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Mercury, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<0.05	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)
Nickel, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	607.2 µg/L (fish consumption and water) 4583.0 µg/L (fish consumption)

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Nitrogen, Ammonia	mg/L	12	<0.05	0.06	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.31	1.01	0.50	0.47	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.25	0.10	0.05	5	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.32	0.12	0.04	5	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.06	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.30	0.31	0.31	0.31	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.31	0.36	0.34	0.34	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	1.20	4.43	2.92	3.06	0	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.06	0.03	0.02	1	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.01	0.11	0.06	0.05	0	0	N/A	N/A
Secchi Depth	cm	4	32.00	60.00	42.75	39.50	0	0	N/A	N/A
Selenium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<5.00	0.010 mg/L (PPWS)
Silver, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<2.00	0.050 mg/L (PPWS) 104.8 µg/L (fish consumption and water) 64620.0 µg/L (fish consumption)
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	2.00	15.00	8.75	9.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	116.00	141.00	128.50	128.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	18.70	59.80	40.28	37.55	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Thallium, Total	µg/L	1	[C]	[C]	[C]	[C]	1	0	<10.00	1.7 µg/L (fish consumption and water) 6.0 µg/L (fish consumption)
Turbidity, Field	NTU	10	7.00	87.00	40.90	34.00	0	0	N/A	25 NTU
Zinc, Total	µg/L	1	13.00	13.00	13.00	13.00	0	0	N/A	5.0 mg/L (PPWS)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

Table B-17. OWRB Water Quality Statistics for Station 220600050010-16

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	18	<10.00	118.20	51.44	43.15	2	0	<10.00	N/A
Chloride	mg/L	16	<10.00	31.70	11.09	8.10	5	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	4	36.00	>250.00	147.00	151.00	0	1	>250.00	N/A
Color, True	Units	16	13.00	>250.00	128.63	125.50	0	2	N/A	70 PT-CO
Corrected Chlorophyl-*a*	mg/m^3	13	0.89	16.20	8.75	11.10	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	6	40.00	108.00	61.00	52.50	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.07	0.03	0.03	10	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.24	0.77	0.56	0.62	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.27	0.10	0.06	5	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.29	0.10	0.04	5	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	[C]	[C]	[C]	[C]	10	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.24	0.33	0.29	0.29	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.24	0.33	0.29	0.29	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	0.20	5.46	3.11	3.17	0	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	<0.005	0.07	0.03	0.04	1	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.02	0.11	0.07	0.06	0	0	N/A	N/A
Secchi Depth	cm	6	28.00	57.00	38.67	38.00	0	0	N/A	N/A
Solids, Settleable	mg/L	4	[C]	[C]	[C]	[C]	4	0	<0.10	N/A
Solids, Suspended	mg/L	4	2.00	18.00	12.75	15.50	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	2	113.00	128.00	120.50	120.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	12	16.80	59.90	39.24	38.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	10	13.00	137.00	47.60	34.50	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.
[C] No samples above the detection limit.

Table B-18. OWRB Water Quality Statistics for Station 220600050010-17

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Alkalinity, Total	mg/L	18	<10.00	101.00	46.42	42.40	3	0	<10.00	N/A
Chloride	mg/L	16	<10.00	83.20	12.94	5.60	7	0	<10.00	83 mg/L (segment 220300) 230 mg/L [B] (segment 220600)
Color, Apparent	Units	5	41.00	>250.00	168.80	245.00	0	2	>250.00	N/A
Color, True	Units	16	18.00	>250.00	122.19	91.50	0	2	N/A	70 PT-CO
Corrected ChlorophyL-*a*	mg/m^3	13	0.86	22.80	11.50	11.20	0	0	N/A	N/A
Hardness, Total (as CaCO3)	mg/L	5	29.00	69.00	48.60	44.00	0	0	N/A	N/A
Nitrogen, Ammonia	mg/L	12	<0.05	0.26	0.06	0.03	7	0	<0.05	N/A
Nitrogen, Kjeldahl	mg/L	20	0.36	0.89	0.62	0.63	0	0	<0.05	N/A
Nitrogen, Nitrate as N	mg/L	10	<0.05	0.22	0.10	0.11	4	0	<0.05	10 mg/L (PPWS)
Nitrogen, Nitrate/Nitrite as N	mg/L	10	<0.05	0.29	0.09	0.04	5	0	<0.05	N/A
Nitrogen, Nitrite as N	mg/L	10	<0.05	0.05	0.03	0.03	9	0	<0.05	N/A
Nitrogen, Organic	mg/L	2	0.33	0.37	0.35	0.35	0	0	<0.05	N/A
Nitrogen, Total	mg/L	2	0.37	0.70	0.54	0.54	0	0	<0.05	N/A
Pheophytin A	mg/m^3	13	<0.10	7.68	3.89	3.00	1	0	<0.10	N/A
Phosphorous, Ortho	mg/L	17	0.00	0.11	0.03	0.03	0	0	<0.005	N/A
Phosphorous, Total	mg/L	20	0.03	0.17	0.08	0.09	0	0	N/A	N/A
Secchi Depth	cm	7	20.00	52.00	31.86	29.00	0	0	N/A	N/A
Solids, Settleable	mg/L	5	<0.10	0.10	0.06	0.05	4	0	<0.10	N/A
Solids, Suspended	mg/L	5	8.00	46.00	21.80	19.00	0	0	N/A	N/A
Solids, Total Dissolved	mg/L	3	<1.00	104.00	68.83	102.00	1	0	N/A	320 mg/L (segment 220300) 837 mg/L [B] (segment 220600)
Sulfate	mg/L	11	12.70	59.40	39.61	42.70	0	0	N/A	52 mg/L (segment 220300) 182 mg/L [B] (segment 220600)
Turbidity, Field	NTU	10	8.00	182.00	55.80	47.00	0	0	N/A	25 NTU

Notes:
[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.
[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

Table B-19. USACE Water Quality Statistics for Station 1EUFOKS0037

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	214	0.10	23.00	9.98	10.00	0	N/A	N/A
Water Temp	deg C	214	12.15	31.59	24.13	24.15	0	N/A	N/A
Turbidity	NTU	121	0.20	42.10	7.46	4.10	0	N/A	25 NTU
Secchi	m	10	0.42	3.00	1.51	1.50	0	N/A	N/A
Sp. Conductance	µS/cm	214	325.00	475.00	407.89	422.00	0	N/A	N/A
Oxygen, Diss	mg/L	214	0.03	11.04	5.66	6.47	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	214	6.98	9.12	7.90	7.85	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	20	64.00	114.00	83.60	83.00	0	N/A	N/A
Solids, Susp.	mg/L	20	<2	10.00	3.30	3.00	9	<2.00	N/A
Nitrogen, Organic	mg/L	20	0.13	0.47	0.34	0.33	0	<0.02	N/A
Ammonia, Tot	mg/L	20	<0.02	0.91	0.08	0.03	9	<0.02	N/A
Nitrogen, Tot	mg/L	25	0.22	1.12	0.70	0.67	5	N/A	N/A
Phos, Tot	mg/L	20	<0.02	0.320	0.040	0.020	10	<0.02	N/A
Ortho, Phos, Diss	mg/L	20	<0.02	0.35	0.05	0.03	7	<0.02	N/A
Hardness, Tot	mg/L	20	54.00	160.00	119.90	132.00	0	N/A	N/A
Chloride, Tot	mg/L	20	35.00	53.00	44.85	45.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	20	50.00	82.00	60.15	59.40	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	20	<5.00	19.00	3.33	2.50	19	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	37	0.00	0.03	0.01	0.00	17	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	20	[C]	[C]	[C]	[C]	20	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	20	<0.02	1.96	0.60	0.24	2	<0.02	N/A
Lead, Tot	ppb	20	<5.00	28.00	3.78	2.50	19	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	20	<0.02	0.43	0.08	0.02	10	<0.02	N/A
CHL A, FL, COR	µg/L	10	1.60	23.90	8.01	6.65	0	N/A	N/A
TDS-Field	g/L	214	0.20	0.31	0.26	0.28	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	39	<0.0002	0.0003	0.0001	0.0001	19	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-20. USACE Water Quality Statistics for Station 1EUFOKS0038

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	114	0.10	15.00	6.13	6.00	0	N/A	N/A
Water Temp	deg C	112	16.45	31.57	26.14	26.38	0	N/A	N/A
Turbidity	NTU	45	1.10	745.40	47.84	20.00	0	N/A	25 NTU
Secchi	m	9	0.56	1.86	1.07	1.10	0	N/A	N/A
Sp. Conductance	µS/cm	112	351.00	542.00	429.86	420.00	0	N/A	N/A
Oxygen, Diss	mg/L	112	0.22	11.04	5.94	6.54	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	112	7.24	8.99	7.97	7.93	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	19	30.00	98.00	82.53	84.00	0	N/A	N/A
Solids, Susp.	mg/L	24	<2.00	15.00	6.42	5.00	5	<2.00	N/A
Nitrogen, Organic	mg/L	19	0.16	0.52	0.37	0.37	0	<0.02	N/A
Ammonia, Tot	mg/L	29	<0.02	0.28	0.06	0.01	10	<0.02	N/A
Nitrogen, Tot	mg/L	23	0.01	1.04	0.49	0.58	4	N/A	N/A
Phos, Tot	mg/L	25	<0.02	0.120	0.040	0.040	6	<0.02	N/A
Ortho, Phos, Diss	mg/L	27	<0.02	0.08	0.03	0.02	8	<0.02	N/A
Hardness, Tot	mg/L	19	9.00	248.00	123.58	136.00	0	N/A	N/A
Chloride, Tot	mg/L	19	38.00	64.00	47.95	47.00	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	19	50.00	89.00	66.51	64.00	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	38	[C]	[C]	[C]	[C]	19	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	38	[C]	[C]	[C]	[C]	19	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	38	[C]	[C]	[C]	[C]	19	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	19	0.09	1.97	0.59	0.52	0	<0.02	N/A
Lead, Tot	ppb	38	<5.00	2.50	2.50	2.50	19	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	31	<0.02	1.43	0.11	0.01	12	<0.02	N/A
CHL A, FL, COR	µg/L	10	2.00	23.90	10.02	9.15	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
TDS-Field	g/L	96	0.20	0.40	0.28	0.30	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	37	<0.0002	0.0003	0.0001	0.0001	18	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-21. USACE Water Quality Statistics for Station 1EUFOKS0039

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	77	0.10	8.00	3.00	3.00	0	N/A	N/A
Water Temp	deg C	77	17.20	31.76	25.61	25.28	0	N/A	N/A
Turbidity	NTU	32	1.90	132.60	45.25	28.55	0	N/A	25 NTU
Secchi	m	10	0.18	1.60	0.65	0.56	0	N/A	N/A
Sp. Conductance	µS/cm	77	447.00	797.00	611.73	613.00	0	N/A	N/A
Oxygen, Diss	mg/L	77	0.78	11.63	7.34	7.51	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	77	7.48	8.84	8.18	8.13	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	20	92.00	146.00	112.10	107.00	0	N/A	N/A
Solids, Susp.	mg/L	23	<2.00	61.00	16.55	10.00	3	<2.00	N/A
Nitrogen, Organic	mg/L	20	0.28	0.69	0.48	0.48	0	<0.02	N/A
Ammonia, Tot	mg/L	28	<0.02	0.16	0.05	0.03	8	<0.02	N/A
Nitrogen, Tot	mg/L	25	0.33	2.01	0.89	0.84	5	N/A	N/A
Phos, Tot	mg/L	29	<0.02	0.110	0.040	0.030	9	<0.02	N/A
Ortho, Phos, Diss	mg/L	27	<0.02	0.08	0.03	0.03	7	<0.02	N/A
Hardness, Tot	mg/L	20	50.00	240.00	164.50	170.00	0	N/A	N/A
Chloride, Tot	mg/L	20	44.00	87.00	62.45	59.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	20	70.20	141.00	106.11	105.50	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	40	[C]	[C]	[C]	[C]	20	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	40	[C]	[C]	[C]	[C]	20	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	40	[C]	[C]	[C]	[C]	20	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	20	0.06	3.17	1.03	0.86	0	<0.02	N/A
Lead, Tot	ppb	40	<5.00	2.50	2.50	2.50	20	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	22	<0.02	0.20	0.07	0.06	2	<0.02	N/A
CHL A, FL, COR	µg/L	9	1.70	33.60	10.46	6.10	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
TDS-Field	g/L	67	0.29	0.50	0.39	0.40	0	N/A	320 mg/L (segment 220300) [B] 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	38	<0.0002	0.0003	0.0001	0.0001	18	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-22. USACE Water Quality Statistics for Station 1EUFOKS0040

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	175	0.10	19.00	7.89	8.00	0	N/A	N/A
Water Temp	deg C	175	15.97	31.81	24.33	25.36	0	N/A	N/A
Turbidity	NTU	64	4.90	59.00	24.99	16.45	0	N/A	25 NTU
Secchi	m	12	0.20	1.26	0.54	0.42	0	N/A	N/A
Sp. Conductance	µS/cm	175	231.00	639.00	439.03	414.00	0	N/A	N/A
Oxygen, Diss	mg/L	175	0.18	9.57	5.65	6.29	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	175	7.23	8.86	7.81	7.76	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	20	50.00	128.00	85.30	87.00	0	N/A	N/A
Solids, Susp.	mg/L	22	<2.00	35.00	12.85	11.00	2	<2.00	N/A
Nitrogen, Organic	mg/L	20	0.14	0.74	0.38	0.35	0	<0.02	N/A
Ammonia, Tot	mg/L	25	<0.02	0.39	0.09	0.05	5	<0.02	N/A
Nitrogen, Tot	mg/L	22	0.25	1.85	0.87	0.90	2	N/A	N/A
Phos, Tot	mg/L	25	<0.02	0.180	0.050	0.050	5	<0.02	N/A
Ortho, Phos, Diss	mg/L	25	<0.02	0.13	0.05	0.04	5	<0.02	N/A
Hardness, Tot	mg/L	20	38.00	200.00	118.50	124.00	0	N/A	N/A
Chloride, Tot	mg/L	20	25.00	63.00	44.35	42.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	20	40.00	106.00	71.83	67.00	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	40	[C]	[C]	[C]	[C]	20	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	38	0.00	0.03	0.00	0.00	18	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	40	[C]	[C]	[C]	[C]	20	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	20	0.14	2.37	1.03	0.80	0	<0.02	N/A
Lead, Tot	ppb	20	[C]	[C]	[C]	[C]	20	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	22	<0.02	1.74	0.31	0.07	2	<0.02	N/A
CHL A, FL, COR	µg/L	10	2.00	65.80	12.74	7.65	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
TDS-Field	g/L	145	0.18	0.66	0.28	0.27	0	N/A	320 mg/L (segment 220300) [B] 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	39	<0.0002	0.0004	0.0001	0.0001	19	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-23. USACE Water Quality Statistics for Station 1EUFOKS0044

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	48	0.10	6.00	1.90	1.55	0	N/A	N/A
Water Temp	deg C	45	18.21	32.30	27.27	28.45	0	N/A	N/A
Turbidity	NTU	26	6.17	127.60	68.63	56.90	0	N/A	25 NTU
Secchi	m	7	0.10	0.40	0.23	0.22	0	N/A	N/A
Sp. Conductance	µS/cm	45	154.00	575.00	340.91	357.00	0	N/A	N/A
Oxygen, Diss	mg/L	45	3.28	9.47	6.93	7.03	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	45	6.85	8.45	7.97	8.13	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	17	40.00	136.00	94.24	94.00	0	N/A	N/A
Solids, Susp.	mg/L	17	4.00	50.00	19.76	18.00	0	<2.00	N/A
Nitrogen, Organic	mg/L	17	0.31	0.73	0.54	0.55	0	<0.02	N/A
Ammonia, Tot	mg/L	20	<0.02	0.34	0.08	0.06	3	<0.02	N/A
Nitrogen, Tot	mg/L	18	0.41	2.58	1.01	0.83	1	N/A	N/A
Phos, Tot	mg/L	20	<0.02	0.140	0.080	0.090	3	<0.02	N/A
Ortho, Phos, Diss	mg/L	18	<0.02	0.14	0.06	0.06	1	<0.02	N/A
Hardness, Tot	mg/L	17	15.00	158.00	103.71	108.00	0	N/A	N/A
Chloride, Tot	mg/L	17	22.00	74.00	40.41	35.00	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	17	25.00	63.00	34.18	30.00	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	34	[C]	[C]	[C]	[C]	17	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	32	0.002	0.004	0.002	0.002	15	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	32	<0.05	0.11	0.03	0.03	15	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	17	1.01	6.40	2.73	2.20	0	<0.02	N/A
Lead, Tot	ppb	33	<5.00	10.00	2.94	2.50	16	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	17	0.08	0.40	0.17	0.13	0	<0.02	N/A
CHL A, FL, COR	µg/L	9	2.50	14.30	7.68	6.20	0	N/A	N/A
TDS-Field	g/L	45	0.10	0.40	0.22	0.23	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Mercury, Tot	mg/L	33	<0.0002	0.0003	0.0001	0.0001	16	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-24. USACE Water Quality Statistics for Station 1EUFOKS0172 *

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	38	0.10	8.00	3.13	2.50	0	N/A	N/A
Water Temp	deg C	36	14.05	26.11	19.37	18.81	0	N/A	N/A
Turbidity	NTU	5	3.20	30.90	15.40	17.30	0	N/A	25 NTU
Secchi	m	0	[C]	[C]	[C]	[C]	0	N/A	N/A
Sp. Conductance	µS/cm	36	327.00	480.00	383.14	338.00	0	N/A	N/A
Oxygen, Diss	mg/L	36	0.58	9.18	5.94	6.95	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	36	7.20	8.05	7.49	7.58	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	10	58.00	146.00	85.80	79.00	0	N/A	N/A
Solids, Susp.	mg/L	13	<2.00	10.00	5.40	6.00	3	<2.00	N/A
Nitrogen, Organic	mg/L	10	0.06	0.53	0.36	0.40	0	<0.02	N/A
Ammonia, Tot	mg/L	11	<0.02	0.56	0.16	0.09	1	<0.02	N/A
Nitrogen, Tot	mg/L	10	0.58	1.06	0.81	0.81	0	N/A	N/A
Phos, Tot	mg/L	14	<0.02	0.290	0.080	0.040	4	<0.02	N/A
Ortho, Phos, Diss	mg/L	11	<0.02	0.22	0.08	0.04	1	<0.02	N/A
Hardness, Tot	mg/L	10	60.00	160.00	119.20	130.00	0	N/A	N/A
Chloride, Tot	mg/L	10	36.00	60.00	49.70	51.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	10	53.00	73.00	62.37	64.50	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	20	[C]	[C]	[C]	[C]	10	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	20	[C]	[C]	[C]	[C]	10	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	20	[C]	[C]	[C]	[C]	10	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	10	0.22	2.52	0.99	0.69	0	<0.02	N/A
Lead, Tot	ppb	20	[C]	[C]	[C]	[C]	10	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	12	<0.02	1.13	0.40	0.33	2	<0.02	N/A
CHL A, FL, COR	µg/L	1	1.10	1.10	1.10	1.10	0	N/A	N/A
TDS-Field	g/L	30	0.20	0.40	0.23	0.20	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Mercury, Tot	mg/L	17	<0.0002	0.0008	0.0002	0.0001	7	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

* Note – Station 1EUFOKS0172 is located below the dam and because it is not located on the lake it is not included in the analyses in the report.

Table B-25. USACE Water Quality Statistics for Station 1EUFOKS0173

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	138	0.10	18.00	7.10	7.00	0	N/A	N/A
Water Temp	deg C	138	17.28	31.89	24.65	25.13	0	N/A	N/A
Turbidity	NTU	61	9.10	61.80	24.98	23.10	0	N/A	25 NTU
Secchi	m	8	0.30	0.80	0.54	0.55	0	N/A	N/A
Sp. Conductance	µS/cm	138	114.00	513.00	231.05	207.00	0	N/A	N/A
Oxygen, Diss	mg/L	138	0.21	8.87	5.73	6.88	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	138	6.75	8.47	7.56	7.47	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	18	28.00	94.00	51.78	48.00	0	N/A	N/A
Solids, Susp.	mg/L	20	<2.00	21.00	10.61	11.50	2	<2.00	N/A
Nitrogen, Organic	mg/L	19	<0.02	0.62	0.39	0.39	1	<0.02	N/A
Ammonia, Tot	mg/L	24	<0.02	0.26	0.05	0.03	6	<0.02	N/A
Nitrogen, Tot	mg/L	21	0.07	1.60	0.77	0.75	3	N/A	N/A
Phos, Tot	mg/L	23	<0.02	0.100	0.040	0.040	5	<0.02	N/A
Ortho, Phos, Diss	mg/L	26	<0.02	0.10	0.03	0.02	8	<0.02	N/A
Hardness, Tot	mg/L	18	30.00	160.00	76.33	71.00	0	N/A	N/A
Chloride, Tot	mg/L	18	11.00	44.00	23.22	18.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	17	27.00	87.00	40.52	34.40	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	36	[C]	[C]	[C]	[C]	18	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	37	0.00	0.03	0.00	0.00	18	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	36	[C]	[C]	[C]	[C]	18	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	18	0.42	3.58	1.75	1.54	0	<0.02	N/A
Lead, Tot	ppb	36	[C]	[C]	[C]	[C]	18	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	18	0.03	3.20	0.42	0.13	0	<0.02	N/A
CHL A, FL, COR	µg/L	9	1.50	92.70	15.20	5.20	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
TDS-Field	g/L	114	0.10	0.44	0.15	0.14	0	N/A	320 mg/L (segment 220300) [B] 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	35	<0.0002	0.0005	0.0001	0.0001	17	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-26. USACE Water Quality Statistics for Station 1EUFOKS0174

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	71	0.10	9.50	3.63	3.00	0	N/A	N/A
Water Temp	deg C	69	17.38	32.05	26.77	28.28	0	N/A	N/A
Turbidity	NTU	38	10.10	172.00	51.18	34.50	0	N/A	25 NTU
Secchi	m	8	0.16	0.65	0.39	0.34	0	N/A	N/A
Sp. Conductance	µS/cm	69	352.00	872.00	564.91	561.00	0	N/A	N/A
Oxygen, Diss	mg/L	69	0.48	8.58	6.00	6.25	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	69	7.33	8.91	8.03	8.08	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	16	88.00	152.00	114.13	109.00	0	N/A	N/A
Solids, Susp.	mg/L	16	8.00	84.00	36.69	32.50	0	<2.00	N/A
Nitrogen, Organic	mg/L	16	0.31	0.78	0.62	0.67	0	<0.02	N/A
Ammonia, Tot	mg/L	18	<0.02	0.26	0.13	0.15	2	<0.02	N/A
Nitrogen, Tot	mg/L	20	0.45	2.27	1.12	1.00	4	N/A	N/A
Phos, Tot	mg/L	16	0.020	0.200	0.080	0.070	0	<0.02	N/A
Ortho, Phos, Diss	mg/L	18	0.01	0.15	0.06	0.06	2	<0.02	N/A
Hardness, Tot	mg/L	16	54.00	240.00	142.13	146.00	0	N/A	N/A
Chloride, Tot	mg/L	16	41.00	102.00	68.56	67.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	16	48.00	118.00	75.44	70.50	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	31	<5.00	6.00	2.72	2.50	15	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	32	[C]	[C]	[C]	[C]	16	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	32	[C]	[C]	[C]	[C]	16	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	16	0.31	7.64	2.62	2.28	0	<0.02	N/A
Lead, Tot	ppb	30	<5.00	14.00	3.44	2.50	14	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	16	0.03	1.00	0.22	0.13	0	<0.02	N/A
CHL A, FL, COR	µg/L	8	1.90	21.90	11.24	12.00	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
TDS-Field	g/L	69	0.20	0.60	0.35	0.36	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	31	<0.0002	0.0005	0.0001	0.0001	15	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-27. USACE Water Quality Statistics for Station 1EUFOKS0175

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Depth	m	122	0.10	17.50	7.43	7.00	0	N/A	N/A
Water Temp	deg C	120	14.86	31.76	24.65	24.54	0	N/A	N/A
Turbidity	NTU	57	4.30	253.60	49.47	40.70	0	N/A	25 NTU
Secchi	m	8	0.20	1.45	0.68	0.50	0	N/A	N/A
Sp. Conductance	µS/cm	120	341.00	564.00	427.63	415.00	0	N/A	N/A
Oxygen, Diss	mg/L	120	0.22	9.07	5.68	6.50	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [D]
pH	units	120	7.14	8.94	7.86	7.86	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	16	80.00	116.00	91.50	90.00	0	N/A	N/A
Solids, Susp.	mg/L	17	<2.00	54.00	17.44	15.00	1	<2.00	N/A
Nitrogen, Organic	mg/L	16	0.32	1.07	0.53	0.50	0	<0.02	N/A
Ammonia, Tot	mg/L	20	<0.02	0.27	0.07	0.04	4	<0.02	N/A
Nitrogen, Tot	mg/L	19	0.34	2.28	1.04	0.95	3	N/A	N/A
Phos, Tot	mg/L	18	<0.02	0.130	0.060	0.050	2	<0.02	N/A
Ortho, Phos, Diss	mg/L	19	<0.02	0.15	0.06	0.05	3	<0.02	N/A
Hardness, Tot	mg/L	15	58.00	140.00	114.00	128.00	0	N/A	N/A
Chloride, Tot	mg/L	16	42.00	65.00	49.63	49.50	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Sulfate, Tot	mg/L	15	36.00	78.00	57.60	57.00	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Arsenic, Tot	ppb	30	<5.00	9.00	3.25	2.50	14	<5.00	0.04 mg/L (PPWS) 205.0 µg/L (fish consumption)
Cadmium, Tot	mg/L	32	[C]	[C]	[C]	[C]	16	<0.003	0.020 mg/L (PPWS) 14.49 µg/L (fish consumption and water) 84.13 µg/L (fish consumption)
Chromium, Tot	mg/L	32	[C]	[C]	[C]	[C]	16	<0.05	0.050 mg/L (PPWS) 166.3 µg/L (fish consumption and water) 3365.0 µg/L (fish consumption)
Iron, Tot	mg/L	16	0.20	6.40	2.14	1.44	0	<0.02	N/A
Lead, Tot	ppb	16	[C]	[C]	[C]	[C]	16	<5.00	0.100 mg/L (PPWS) 5.0 µg/L (fish consumption and water) 25.0 µg/L (fish consumption)
Manganese, Tot	mg/L	21	<0.02	1.81	0.29	0.08	5	<0.02	N/A
CHL A, FL, COR	µg/L	8	2.30	19.60	7.93	6.35	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
TDS-Field	g/L	120	0.20	0.36	0.28	0.29	0	N/A	320 mg/L (segment 220300) [B] 837 mg/L (segment 220600) [B]
Mercury, Tot	mg/L	30	<0.0002	0.0005	0.0002	0.0001	14	<0.0002	0.002 mg/L (PPWS) 0.050 µg/L (fish consumption and water) 0.051 µg/L (fish consumption)

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] No samples above the detection limit.

[D] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table B-28. OCC Water Quality Statistics for Station OK220600-01-0100P

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	38	2.79	13.59	7.65	7.15	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	32	34.20	99.30	73.07	76.05	0	0	N/A	N/A
DO (Riffle)	mg/L	22	2.13	10.39	6.82	7.32	0	0	N/A	N/A
DO (Riffle), Saturation	%	7	26.50	81.00	59.16	54.50	0	0	N/A	N/A
DO (Pool Top)	mg/L	4	1.22	3.48	2.24	2.13	0	0	N/A	N/A
DO (Pool Top), Saturation	%	3	13.20	34.10	20.23	13.40	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	4	1.15	3.44	2.19	2.08	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	61	2.79	490.00	54.64	36.40	0	0	N/A	25 NTU
Alkalinity	mg/L	62	27.00	158.00	63.31	56.50	0	0	N/A	N/A
Temperature	deg C	62	0.60	34.20	17.16	18.90	0	0	N/A	N/A
Conductivity	µS	62	46.00	910.00	185.31	161.15	0	0	N/A	N/A
pH	SU	58	5.48	8.80	7.48	7.40	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	92	<0.05	0.45	0.04	0.02	32	0	<0.011 to <0.05	N/A
Chloride	mg/L	65	2.50	20.00	8.41	8.00	5	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	64	<0.02	0.80	0.14	0.09	11	0	<5 [E]	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	9	<0.05	0.32	0.15	0.19	2	0	N/A	N/A
Nitrite	mg/L	94	0.00	0.11	0.01	0.01	41	0	<0.001 to <0.02	N/A
Sulfate	mg/L	66	0.05	40.40	14.12	12.45	6	0	<0.1 to <28.6	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	0.16	246.00	131.45	128.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Total Hardness	mg/L	41	24.00	134.00	53.34	46.10	0	0	N/A	N/A
TKN	mg/L	67	<0.11	1.21	0.50	0.52	7	0	<0.11	N/A
Total Ortho Phos	mg/L	69	<0.005	0.14	0.02	0.02	10	0	<0.002 to <0.005 [E]	N/A
Total Phosphorus	mg/L	60	0.016	0.380	0.094	0.078	0	0	N/A	N/A
Total Suspended Solids	mg/L	78	<10.00	300.00	27.93	14.75	18	0	<10 [E]	N/A
E. *coli*	cfu/100 mL	31	<10.00	2300.00	240.50	46.00	7	0	<10 to <400	126 per 100 mL
Enterococcus	cfu/100 mL	24	30.00	>1000.00	626.74	150.00	0	1	N/A	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

Table B-29. OCC Water Quality Statistics for Station OK220600-03-0010J

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	28	4.25	11.66	7.55	7.65	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	28	47.10	98.20	73.92	75.13	0	0	N/A	N/A
DO (Riffle)	mg/L	2	3.10	11.29	7.20	7.20	0	0	N/A	N/A
DO (Riffle), Saturation	%	2	31.10	102.40	66.75	66.75	0	0	N/A	N/A
DO (Pool Top)	mg/L	12	2.52	8.94	5.71	6.03	0	0	N/A	N/A
DO (Pool Top), Saturation	%	12	33.40	93.00	61.07	57.70	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	7	2.52	7.30	4.96	5.65	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	2	27.80	74.60	51.20	51.20	0	0	N/A	N/A
Turbidity	NTU	41	5.17	302.00	45.20	32.40	0	0	N/A	25 NTU
Alkalinity	mg/L	40	17.10	90.00	49.98	48.80	0	0	N/A	N/A
Temperature	deg C	42	4.70	31.90	17.69	18.55	0	0	N/A	N/A
Conductivity	µS	42	78.20	240.10	149.43	146.85	0	0	N/A	N/A
pH	SU	42	4.95	8.87	7.16	7.24	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	60	<0.015	0.10	0.03	0.01	20	0	<0.015	N/A
Chloride	mg/L	40	2.90	33.40	8.29	6.50	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	60	<0.02	0.22	0.05	0.03	20	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	79	<0.02	0.07	0.01	0.01	39	0	<0.02	N/A
Sulfate	mg/L	45	3.60	57.10	17.99	15.00	5	0	<7.2 to <85.6 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	68.00	160.00	103.20	99.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	27.10	83.60	53.80	47.60	0	0	N/A	N/A
TKN	mg/L	53	<0.11	1.48	0.32	0.19	13	0	<0.11	N/A
Total Ortho Phos	mg/L	44	<0.005	0.12	0.02	0.01	4	0	N/A	N/A
Total Phosphorus	mg/L	40	0.025	0.358	0.094	0.085	0	0	N/A	N/A
Total Suspended Solids	mg/L	63	<10.00	164.00	20.48	5.00	23	0	<10	N/A
E. *coli*	cfu/10	27	<5.00	>2000.00	323.38	125.00	3	4	<5 to <80	126 per 100 mL

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
	0 mL								and >500 to >1000 [E]	
Enterococcus	cfu/100 mL	21	10.00	>1000.00	252.75	87.50	0	1	N/A	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

Table B-30. OCC Water Quality Statistics for Station OK220600-03-0050F

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	30	2.98	11.78	7.43	7.53	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	30	35.00	99.10	73.73	73.60	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	12	3.18	7.64	4.92	4.65	0	0	N/A	N/A
DO (Pool Top), Saturation	%	12	39.00	80.70	51.21	48.00	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	8	3.03	6.51	4.05	3.45	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	2	36.40	39.60	38.00	38.00	0	0	N/A	N/A
Turbidity	NTU	41	3.08	203.00	42.26	26.20	0	0	N/A	25 NTU
Alkalinity	mg/L	41	31.00	332.00	66.79	58.00	0	0	N/A	N/A
Temperature	deg C	42	4.30	29.20	17.60	18.25	0	0	N/A	N/A
Conductivity	µS	41	70.80	1448.00	446.53	358.00	0	0	N/A	N/A
pH	SU	42	4.50	8.20	7.20	7.16	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	55	<0.015	0.24	0.04	0.02	15	0	<0.015	N/A
Chloride	mg/L	40	3.00	138.80	41.98	37.60	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	50	<0.02	2.24	0.24	0.12	10	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	73	<0.02	0.20	0.03	0.01	33	0	<0.02	N/A
Sulfate	mg/L	44	6.95	414.40	97.09	59.50	4	0	<13.9 to <828.8 E	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	71.00	869.00	290.83	240.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	38.80	250.70	92.38	82.40	0	0	N/A	N/A
TKN	mg/L	48	<0.11	1.29	0.51	0.53	8	0	N/A	N/A
Total Ortho Phos	mg/L	41	<0.005	0.38	0.10	0.06	1	0	N/A	N/A
Total Phosphorus	mg/L	40	0.059	3.278	0.251	0.150	0	0	N/A	N/A
Total Suspended Solids	mg/L	61	<10.00	171.00	18.30	5.00	21	0	<10.00	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
E. *coli*	cfu/100 mL	25	<5.00	>1000.00	182.13	65.00	3	2	N/A	126 per 100 mL
Enterococcus	cfu/100 mL	22	<10.00	>1000.00	177.50	80.00	1	1	N/A	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

Table B-31. OCC Water Quality Statistics for Station OK520500-01-0170L

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	27	6.30	14.98	9.45	9.21	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	27	72.10	108.00	89.96	91.40	0	0	N/A	N/A
DO (Riffle)	mg/L	4	6.91	10.98	8.48	8.02	0	0	N/A	N/A
DO (Riffle), Saturation	%	4	88.30	99.50	93.25	92.60	0	0	N/A	N/A
DO (Pool Top)	mg/L	10	2.05	12.27	6.47	6.30	0	0	N/A	N/A
DO (Pool Top), Saturation	%	10	26.00	128.50	71.50	74.50	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	1	1.78	1.78	1.78	1.78	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	42	1.78	965.00	61.98	19.05	0	0	N/A	25 NTU
Alkalinity	mg/L	42	15.00	110.00	53.39	54.00	0	0	N/A	N/A
Temperature	deg C	42	1.90	30.90	17.52	19.75	0	0	N/A	N/A
Conductivity	µS	41	78.80	1359.00	721.07	709.00	0	0	N/A	N/A
pH	SU	38	6.67	9.77	7.44	7.40	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	63	<0.015	0.19	0.03	0.01	23	0	<0.015	N/A
Chloride	mg/L	40	8.90	365.80	173.83	159.30	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	59	<0.02	3.01	0.15	0.04	19	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	40	[F]	[F]	[F]	[F]	40	0	<0.02	N/A
Sulfate	mg/L	36	4.70	33.70	20.34	19.80	0	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	94.00	700.00	412.15	372.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	25.50	203.00	104.11	106.00	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
TKN	mg/L	44	<0.11	1.81	0.50	0.43	4	0	<0.11	N/A
Total Ortho Phos	mg/L	53	<0.005	0.12	0.02	0.01	13	0	<0.005	N/A
Total Phosphorus	mg/L	41	<0.005	0.422	0.074	0.063	1	0	N/A	N/A
Total Suspended Solids	mg/L	65	<10.00	1902.00	72.15	5.00	25	0	<10.00	N/A
E. *coli*	cfu/100 mL	31	<10.00	>10000.00	672.62	20.00	8	2	<5 to <50 and >1000 to >10000	126 per 100 mL
Enterococcus	cfu/100 mL	24	<10.00	>10000.00	657.14	50.00	2	1	<10 to >10000 [E]	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-32. OCC Water Quality Statistics for Station OK520500-01-0200D

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	30	4.60	14.40	8.47	8.52	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	30	56.70	101.50	79.93	82.75	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	11	1.94	15.27	6.54	5.22	0	0	N/A	N/A
DO (Pool Top), Saturation	%	11	24.40	149.50	70.39	56.00	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	1	3.34	3.34	3.34	3.34	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	42	3.14	>1000.00	52.78	17.65	0	0	N/A	25 NTU
Alkalinity	mg/L	42	21.70	169.00	74.59	66.50	0	0	N/A	N/A
Temperature	deg C	42	1.00	28.30	16.95	19.10	0	0	N/A	N/A
Conductivity	µS	41	63.20	2296.00	706.59	601.00	0	0	N/A	N/A
pH	SU	38	6.47	9.02	7.23	7.16	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	60	<0.015	0.32	0.03	0.01	20	0	<0.015	N/A
Chloride	mg/L	40	4.40	587.20	164.81	111.95	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	58	<0.02	0.94	0.09	0.05	18	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	40	[F]	[F]	[F]	[F]	40	0	<0.02	N/A
Sulfate	mg/L	44	5.00	40.10	18.95	18.65	4	0	<14.4 to <23.8 E	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	90.00	1210.00	404.45	349.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	17.30	248.60	115.10	108.50	0	0	N/A	N/A
TKN	mg/L	46	<0.11	1.39	0.40	0.34	7	0	<0.11	N/A
Total Ortho Phos	mg/L	48	<0.005	0.11	0.02	0.01	8	0	<0.005	N/A
Total Phosphorus	mg/L	40	0.01	0.342	0.071	0.059	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Total Suspended Solids	mg/L	64	<10.00	804.00	47.80	5.00	24	0	<10.00	N/A
E. *coli*	cfu/100 mL	28	<10.00	>10000.00	687.50	80.00	6	1	<5 to <30 and >10000	126 per 100 mL
Enterococcus	cfu/100 mL	27	<10.00	>10000.00	737.62	75.00	5	1	<10 to <20 and >10000	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-33. OCC Water Quality Statistics for Station OK520500-02-0010C

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	39	4.50	15.44	9.20	9.02	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	39	55.50	134.00	92.32	93.40	0	0	N/A	N/A
DO (Riffle)	mg/L	3	5.67	12.47	8.88	8.51	0	0	N/A	N/A
DO (Riffle), Saturation	%	3	72.00	180.00	116.00	96.00	0	0	N/A	N/A
DO (Pool Top)	mg/L	1	11.12	11.12	11.12	11.12	0	0	N/A	N/A
DO (Pool Top), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	1	7.85	7.85	7.85	7.85	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	44	3.46	>1000.00	115.11	36.75	2	0	N/A	25 NTU
Alkalinity	mg/L	42	46.30	189.00	108.91	108.50	0	0	N/A	N/A
Temperature	deg C	43	0.50	35.50	18.31	20.70	0	0	N/A	N/A
Conductivity	µS	40	141.20	2266.00	1039.58	1034.00	0	0	N/A	N/A
pH	SU	39	6.72	9.07	7.86	7.85	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	56	<0.015	0.44	0.05	0.03	16	0	<0.015	N/A
Chloride	mg/L	40	23.80	569.10	238.71	205.50	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	57	<0.02	0.56	0.14	0.08	17	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	40	[F]	[F]	[F]	[F]	40	0	<0.02	N/A
Sulfate	mg/L	40	4.90	36.10	20.13	21.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
TotDisSolids	mg/L	40	111.00	1271.00	590.95	537.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
TotHardness	mg/L	21	43.10	397.50	202.11	216.60	0	0	N/A	N/A
TKN	mg/L	42	<0.11	1.65	0.69	0.58	2	0	<0.11	N/A
TotOrthoPhos	mg/L	44	<0.005	0.36	0.06	0.04	4	0	N/A	N/A
TotPhosphorus	mg/L	40	0.031	1.066	0.160	0.107	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
TotSusSolids	mg/L	48	<10.00	3253.00	186.25	37.50	8	0	<10	N/A
E. *coli*	cfu/100 mL	30	<10.00	>10000.00	666.67	30.00	8	1	<10 to <350 and >10000	126 per 100 mL
Enterococcus	cfu/100 mL	28	<10.00	>10000.00	656.19	55.00	6	1	<10 and >10000	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-34. OCC Water Quality Statistics for Station OK520500-02-0010M

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	25	5.75	13.60	9.40	9.20	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	25	62.90	179.20	100.07	91.60	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	18	4.99	13.30	10.27	10.40	0	0	N/A	N/A
DO (Pool Top), Saturation	%	18	65.90	182.00	106.41	102.15	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	42	6.50	>1000.00	94.64	28.05	2	0	N/A	25 NTU
Alkalinity	mg/L	40	65.00	217.00	124.38	126.50	0	0	N/A	N/A
Temperature	deg C	42	3.50	32.10	18.49	20.30	0	0	N/A	N/A
Conductivity	µS	42	293.20	5099.00	1365.04	1000.50	0	0	N/A	N/A
pH	SU	39	7.18	9.05	8.09	8.14	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	58	<0.015	0.78	0.05	0.02	18	0	<0.015	N/A
Chloride	mg/L	40	41.90	1247.10	268.00	218.20	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	47	<0.02	5.55	0.58	0.21	7	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	73	<0.02	0.23	0.03	0.01	34	0	<0.02	N/A
Sulfate	mg/L	41	9.40	90.50	27.94	21.60	1	0	<24.2 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	127.00	1781.00	624.20	543.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	22	62.90	395.50	192.38	177.85	0	0	N/A	N/A
TKN	mg/L	43	<0.11	3.60	0.80	0.57	3	0	<0.11	N/A
Total Ortho Phos	mg/L	41	<0.005	2.50	0.25	0.07	1	0	<0.005	N/A
Total Phosphorus	mg/L	40	0.026	3.106	0.423	0.169	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Total Suspended Solids	mg/L	45	<10.00	4820.00	240.65	26.50	5	0	<10	N/A
E. *coli*	cfu/100 mL	26	<5.00	9900.00	614.17	60.00	5	0	<5 to <30 and >10000	126 per 100 mL
Enterococcus	cfu/100 mL	26	<5.00	>10000.00	930.48	60.00	4	1	<5 to <20 and >10000	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

Table B-35. OCC Water Quality Statistics for Station OK520500-02-0090D

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	29	5.17	14.28	9.40	9.50	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	29	62.80	125.00	91.44	90.10	0	0	N/A	N/A
DO (Riffle)	mg/L	4	4.85	14.45	9.48	9.32	0	0	N/A	N/A
DO (Riffle), Saturation	%	4	54.00	107.00	91.68	102.85	0	0	N/A	N/A
DO (Pool Top)	mg/L	8	3.15	11.96	6.95	6.16	0	0	N/A	N/A
DO (Pool Top), Saturation	%	8	37.00	116.70	76.84	76.05	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	43	2.98	>1000.00	80.06	21.00	0	1	N/A	25 NTU
Alkalinity	mg/L	41	21.60	188.00	91.33	86.00	0	0	N/A	N/A
Temperature	deg C	42	0.90	32.30	17.57	20.40	0	0	N/A	N/A
Conductivity	µS	41	80.50	1246.00	679.58	671.00	0	0	N/A	N/A
pH	SU	39	6.05	8.57	7.39	7.43	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	58	<0.015	0.12	0.03	0.02	18	0	<0.015	N/A
Chloride	mg/L	40	13.70	379.10	152.39	147.85	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	62	<0.02	0.24	0.06	0.01	22	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	40	[F]	[F]	[F]	[F]	40	0	<0.02	N/A
Sulfate	mg/L	43	2.80	23.70	13.17	12.25	3	0	<15.6 to <18.5 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	138.00	802.00	389.53	384.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	27.40	252.60	146.57	139.20	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
TKN	mg/L	43	<0.11	1.45	0.49	0.42	3	0	<0.11	N/A
TotOrthoPhos	mg/L	49	<0.005	0.14	0.03	0.01	9	0	<0.005	N/A
TotPhosphorus	mg/L	41	<0.005	0.824	0.095	0.066	1	0	N/A	N/A
TotSusSolids	mg/L	61	<10.00	2092.00	108.98	5.00	21	0	<10	N/A
E. *coli*	cfu/100 mL	31	<10.00	>10000.00	658.10	35.00	9	1	<10 to <120 and >10000	126 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-36. OCC Water Quality Statistics for Station OK520700-01-0080L

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	5	5.34	10.14	7.46	6.83	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	5	62.10	86.60	70.18	66.20	0	0	N/A	N/A
DO (Riffle)	mg/L	2	2.19	2.62	2.41	2.41	0	0	N/A	N/A
DO (Riffle), Saturation	%	2	24.00	25.60	24.80	24.80	0	0	N/A	N/A
DO (Pool Top)	mg/L	15	2.10	10.88	5.83	4.80	0	0	N/A	N/A
DO (Pool Top), Saturation	%	16	22.90	79.10	56.11	56.95	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	15	2.08	10.74	5.46	4.70	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	4	20.80	59.90	41.93	43.50	0	0	N/A	N/A
Turbidity	NTU	20	8.94	234.00	63.62	39.90	0	0	N/A	25 NTU
Alkalinity	mg/L	22	40.00	127.00	75.26	76.50	0	0	N/A	N/A
Temperature	deg C	22	2.20	28.90	17.75	19.65	0	0	N/A	N/A
Conductivity	µS	22	161.80	545.00	287.09	265.50	0	0	N/A	N/A
pH	SU	21	6.99	8.76	7.77	7.79	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	31	<0.015	0.29	0.04	0.02	10	0	<0.015 to < 0.11	N/A
Chloride	mg/L	21	3.70	33.40	9.88	9.00	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	28	<0.02	0.56	0.11	0.08	7	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	40	<0.02	0.15	0.02	0.01	19	0	<0.02	N/A
Sulfate	mg/L	21	17.90	109.40	47.63	44.00	0	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	21	119.00	327.00	191.00	183.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	62.60	201.60	107.55	101.00	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
TKN	mg/L	28	<0.11	0.96	0.37	0.28	7	0	<0.11	N/A
Total Ortho Phos	mg/L	23	<0.005	0.07	0.03	0.03	2	0	<0.005	N/A
Total Phosphorus	mg/L	21	0.027	0.231	0.115	0.115	0	0	N/A	N/A
Total Suspended Solids	mg/L	26	<10.00	221.00	33.10	22.00	5	0	<10	N/A
E. *coli*	cfu/100 mL	12	20.00	1060.00	281.25	187.50	0	0	N/A	126 per 100 mL
Enterococcus	cfu/100 mL	13	10.00	600.00	217.50	95.00	1	0	>500 E	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

Table B-37. OCC Water Quality Statistics for Station OK520700-03-0100B

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	39	4.80	14.90	9.09	8.65	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	39	61.40	115.50	90.16	91.10	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	2	1.40	2.36	1.88	1.88	0	0	N/A	N/A
DO (Pool Top), Saturation	%	2	17.00	29.00	23.00	23.00	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	43	<0.015	184.00	24.19	11.40	0	0	N/A	25 NTU
Alkalinity	mg/L	42	78.00	311.00	168.88	169.50	0	0	N/A	N/A
Temperature	deg C	42	0.40	29.90	17.18	18.00	0	0	N/A	N/A
Conductivity	µS	41	255.00	1120.00	672.92	694.00	0	0	N/A	N/A
pH	SU	40	6.94	8.96	7.68	7.68	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	56	0.01	0.17	0.04	0.03	16	0	<0.015	N/A
Chloride	mg/L	40	16.90	351.60	111.55	106.75	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	59	<0.02	0.25	0.08	0.04	19	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	40	[F]	[F]	[F]	[F]	40	0	<0.02	N/A
Sulfate	mg/L	47	5.55	31.90	17.81	17.65	7	0	<11.1 to <25.9 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	0.08	709.00	379.25	396.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	54.20	306.30	187.26	189.30	0	0	N/A	N/A
TKN	mg/L	47	<0.11	1.65	0.47	0.41	7	0	<0.11	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Total Ortho Phos	mg/L	45	<0.005	0.08	0.02	0.02	5	0	<0.005	N/A
Total Phosphorus	mg/L	40	0.011	0.162	0.072	0.066	0	0	N/A	N/A
Total Suspended Solids	mg/L	64	<10.00	606.00	27.93	5.00	24	0	<10.00	N/A
E. *coli*	cfu/100 mL	26	<10.00	>1000.00	187.25	167.50	5	1	<10 to < 180 and >1000	126 per 100 mL
Enterococcus	cfu/100 mL	21	<10.00	650.00	209.50	150.00	1	0	<10.00	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-38. OCC Water Quality Statistics for Station OK520700-03-0220D

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	16	5.19	15.04	8.08	7.36	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	16	62.60	114.00	83.03	77.85	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	5	6.40	12.95	10.13	10.35	0	0	N/A	N/A
DO (Pool Top), Saturation	%	5	70.70	97.20	83.72	78.50	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	1	6.38	6.38	6.38	6.38	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	1	77.10	77.10	77.10	77.10	0	0	N/A	N/A
Turbidity	NTU	21	3.58	24.70	9.33	8.09	0	0	N/A	25 NTU
Alkalinity	mg/L	21	91.00	322.00	222.33	228.00	0	0	N/A	N/A
Temperature	deg C	20	2.60	25.50	15.46	16.30	0	0	N/A	N/A
Conductivity	µS	21	244.60	1032.00	678.13	717.00	0	0	N/A	N/A
pH	SU	19	7.45	8.04	7.74	7.73	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	27	<0.015	0.18	0.04	0.03	8	0	<0.015	N/A
Chloride	mg/L	19	10.40	185.20	91.85	98.40	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	30	<0.02	0.15	0.04	0.01	11	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	19	[F]	[F]	[F]	[F]	19	0	<0.02	N/A
Sulfate	mg/L	25	2.00	20.60	10.84	11.40	6	0	<4 to <12.1	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	19	139.00	523.00	383.95	399.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
TKN	mg/L	24	<0.11	0.77	0.31	0.28	5	0	<0.11	N/A
Total Ortho Phos	mg/L	29	<0.005	0.02	0.01	0.00	10	0	<0.005	N/A
Total Phosphorus	mg/L	20	<0.005	0.406	0.046	0.022	1	0	<0.005	N/A
Total Suspended	mg/L	36	<10.00	30.00	7.00	5.00	17	0	<10.00	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Solids										
E. *coli*	cfu/100 mL	14	<10.00	240.00	74.44	40.00	5	0	<10 to <120 and >10000	126 per 100 mL
Enterococcus	cfu/100 mL	10	60.00	>2000.00	583.33	240.00	0	1	>2000.00	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-39. OCC Water Quality Statistics for Station OK520700-03-0220G

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	18	4.11	13.77	8.37	8.08	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	18	42.40	100.40	79.14	84.05	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	2	0.65	1.15	0.90	0.90	0	0	N/A	N/A
DO (Pool Top), Saturation	%	2	8.00	14.00	11.00	11.00	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	1	6.82	6.82	6.82	6.82	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	1	65.00	65.00	65.00	65.00	0	0	N/A	N/A
Turbidity	NTU	21	2.20	110.00	25.25	11.70	0	0	N/A	25 NTU
Alkalinity	mg/L	21	87.00	288.00	181.57	170.00	0	0	N/A	N/A
Temperature	deg C	21	1.30	27.00	15.62	16.70	0	0	N/A	N/A
Conductivity	µS	20	178.00	1235.00	614.67	618.50	0	0	N/A	N/A
pH	SU	21	6.92	9.01	7.58	7.54	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	29	<0.015	0.29	0.06	0.02	9	0	<0.015 to <0.11	N/A
Chloride	mg/L	20	8.80	221.60	84.11	54.40	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	25	<0.02	0.22	0.08	0.07	5	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	20	[F]	[F]	[F]	[F]	20	0	<0.02	N/A
Sulfate	mg/L	20	0.45	404.90	28.63	9.35	0	0	N/A	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
TotDisSolids	mg/L	20	131.00	681.00	364.90	311.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
TotHardness	mg/L	20	89.70	419.10	241.03	244.60	0	0	N/A	N/A
TKN	mg/L	27	<0.11	0.96	0.38	0.32	7	0	<0.11	N/A
TotOrthoPhos	mg/L	22	<0.005	0.08	0.02	0.01	2	0	<0.005	N/A
TotPhosphorus	mg/L	20	0.014	0.177	0.075	0.070	0	0	N/A	N/A
TotSusSolids	mg/L	29	<10.00	82.00	17.80	13.50	9	0	<10	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
E. *coli*	cfu/100 mL	14	<10.00	615.00	189.55	135.00	2	1	<10 to <20 and >500 [E]	126 per 100 mL
Enterococcus	cfu/100 mL	13	20.00	>1000.00	462.73	390.00	0	2	>1000	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-40. OCC Water Quality Statistics for Station OK520700-04-0020F

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	39	5.27	14.34	9.31	8.96	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	39	69.70	131.90	93.02	92.90	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	3	4.32	8.62	5.79	4.44	0	0	N/A	N/A
DO (Pool Top), Saturation	%	3	45.50	108.70	70.63	57.70	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	1	5.08	5.08	5.08	5.08	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	41	3.80	769.00	76.67	20.40	0	0	N/A	25 NTU
Alkalinity	mg/L	42	63.30	359.00	226.65	233.00	0	0	N/A	N/A
Temperature	deg C	42	2.60	33.30	17.51	17.10	0	0	N/A	N/A
Conductivity	µS	42	282.10	1755.00	644.09	635.00	0	0	N/A	N/A
pH	SU	40	6.62	8.83	8.04	8.10	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	59	<0.015	0.42	0.04	0.02	19	0	<0.015	N/A
Chloride	mg/L	40	18.30	566.10	77.93	64.35	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	57	<0.02	0.37	0.09	0.05	17	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	39	[F]	[F]	[F]	[F]	39	0	<0.02	N/A
Sulfate	mg/L	42	3.80	22.10	14.61	13.80	2	0	<19.1 to <22.2 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	205.00	948.00	386.50	384.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	116.50	387.20	268.59	261.90	0	0	N/A	N/A
TKN	mg/L	49	<0.11	1.37	0.45	0.34	9	0	<0.11	N/A
Total Ortho Phos	mg/L	44	<0.005	0.27	0.04	0.03	4	0	<0.005	N/A
Total Phosphorus	mg/L	40	0.008	0.389	0.112	0.084	0	0	N/A	N/A
Total Suspended Solids	mg/L	58	<10.00	734.00	55.58	17.00	18	0	<10	N/A
E. *coli*	cfu/100 mL	25	<5.00	5600.00	598.93	140.00	3	1	<5 to <120 and >500	126 per 100 mL

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Enterococcus	cfu/100 mL	23	<5.00	8500.00	785.36	230.00	2	0	<5 to <20	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit

Table B-41. OCC Water Quality Statistics for Station OK520700-04-0260C

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	37	5.91	15.18	9.96	9.28	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	37	67.50	128.20	98.64	96.30	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	4	5.70	9.17	7.69	7.95	0	0	N/A	N/A
DO (Pool Top), Saturation	%	4	73.90	104.50	92.03	94.85	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	2	7.76	7.93	7.85	7.85	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	43	2.96	>1000.00	64.05	11.65	0	1	>1000.00	25 NTU
Alkalinity	mg/L	41	65.00	367.00	256.10	277.00	0	0	N/A	N/A
Temperature	deg C	42	0.30	34.70	17.38	18.70	0	0	N/A	N/A
Conductivity	µS	42	134.30	855.00	572.57	572.00	0	0	N/A	N/A
pH	SU	39	7.53	8.89	8.25	8.23	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	63	<0.015	0.50	0.03	0.01	23	0	<0.015	N/A
Chloride	mg/L	40	6.10	62.50	34.70	33.05	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	51	<0.02	0.70	0.14	0.09	11	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	78	0.01	0.11	0.01	0.01	38	0	<0.02	N/A
Sulfate	mg/L	44	3.50	50.80	22.60	23.55	4	0	<20.5 to <33.2 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	40	105.00	492.00	340.00	355.50	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	21	118.50	351.50	223.86	220.20	0	0	N/A	N/A
TKN	mg/L	52	<0.11	2.53	0.36	0.22	12	0	<0.11	N/A
Total Ortho Phos	mg/L	45	<0.005	0.42	0.04	0.02	5	0	<0.005	N/A
Total Phosphorus	mg/L	41	<0.005	0.776	0.100	0.061	1	0	<0.005	N/A
Total Suspended Solids	mg/L	63	<10.00	1692.00	71.58	5.00	23	0	<10.00	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
E. *coli*	cfu/100 mL	28	5.00	3150.00	355.48	55.00	5	2	<20 to <6300 and >500 to >1000 E	126 per 100 mL
Enterococcus	cfu/100 mL	22	10.00	>10000.00	688.81	120.00	0	1	>10000.00	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

[F] No samples above the detection limit.

Table B-42. OCC Water Quality Statistics for Station OK520710-01-0010G

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Dissolved Oxygen	mg/L	40	4.13	13.88	9.30	9.20	0	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [C]
Dissolved Oxygen Saturation	%	40	50.40	194.00	97.55	96.30	0	0	N/A	N/A
DO (Riffle)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Riffle), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Top)	mg/L	1	8.68	8.68	8.68	8.68	0	0	N/A	N/A
DO (Pool Top), Saturation	%	1	93.30	93.30	93.30	93.30	0	0	N/A	N/A
DO (Pool Bottom)	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
DO (Pool Bottom), Saturation	%	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Turbidity	NTU	40	3.25	713.00	38.33	11.35	0	0	N/A	25 NTU
Alkalinity	mg/L	41	78.00	332.00	228.61	227.00	0	0	N/A	N/A
Temperature	deg C	42	2.10	35.60	18.58	19.95	0	0	N/A	N/A
Conductivity	µS	40	228.50	1059.00	776.73	887.00	0	0	N/A	N/A
pH	SU	39	7.42	8.82	8.20	8.25	0	0	N/A	6.5 to 9.0
Ammonia	mg/L	49	<0.015	0.82	0.08	0.04	10	0	<0.015	N/A
Chloride	mg/L	39	26.10	799.40	117.79	102.10	0	0	N/A	83 mg/L (segment 220300) 230 mg/L (segment 220600) [B]
Nitrate	mg/L	40	<0.02	5.44	1.18	0.75	1	0	<0.02	10.0 mg/L (PPWS)
Nitrate/Nitrite	mg/L	0	[D]	[D]	[D]	[D]	0	0	N/A	N/A
Nitrite	mg/L	66	<0.02	0.73	0.06	0.01	27	0	<0.02	N/A
Sulfate	mg/L	42	11.90	83.70	42.41	41.50	3	0	<42.1 to <69.7 [E]	52 mg/L (segment 220300) 182 mg/L (segment 220600) [B]
Total Dissolved Solids	mg/L	39	163.00	1642.00	478.21	505.00	0	0	N/A	320 mg/L (segment 220300) 837 mg/L (segment 220600) [B]
Total Hardness	mg/L	20	114.10	478.50	266.89	263.65	0	0	N/A	N/A
TKN	mg/L	45	<0.11	4.72	0.59	0.43	6	0	<0.11	N/A
Total Ortho Phos	mg/L	39	0.02	2.93	0.65	0.40	0	0	N/A	N/A
Total Phosphorus	mg/L	39	0.122	3.082	0.752	0.427	0	0	N/A	N/A

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	No Obs. Above Detection	Detection Limit	Oklahoma WQS [A]
Total Suspended Solids	mg/L	55	<10.00	1691.00	94.15	16.00	16	0	<10.00	N/A
E. *coli*	cfu/100 mL	27	<5.00	>10000.00	698.93	75.00	4	2	<5 to <100 and >2000 to >10000	126 per 100 mL
Enterococcus	cfu/100 mL	23	<10.00	>10000.00	735.24	90.00	1	1	<10 and >10000	33 per 100 mL

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Yearly Mean Standard from historical data for identified stream segment, from Appendix F of the Oklahoma Water Quality Standards.

[C] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[D] No samples taken.

[E] Readings may be above or below detection limit shown because of differences between sampling laboratories.

Appendix C
Water Quality within the Water Column

Table C-1. USACE Water Column Statistics for Station 1EUFOKS0037

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	10	14.92	31.59	26.10	27.14	0	N/A	N/A
Turbidity	NTU	10	0.40	30.80	8.45	4.95	0	N/A	25 NTU
Oxygen, Diss	mg/L	10	6.20	11.04	8.12	8.16	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	10	7.77	9.12	8.41	8.40	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	10	74.00	92.00	82.00	81.00	0	N/A	N/A
Bottom of Water Column (18-23 m)									
Water Temp	deg C	35	12.15	25.64	19.71	20.99	0	N/A	N/A
Turbidity	NTU	21	2.6	42.1	15.78	8.7	0	N/A	25 NTU
Oxygen, Diss	mg/L	35	0.07	9.19	4.56	5.44	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	35	7.04	8.11	7.51	7.4	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	8	64	114	85	87	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-2. USACE Water Column Statistics for Station 1EUFOKS0038

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	10	16.45	31.53	26.21	27.53	0	N/A	N/A
Turbidity	NTU	9	1.30	126.10	24.52	10.40	0	N/A	25 NTU
Oxygen, Diss	mg/L	10	6.73	10.92	8.48	8.13	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	10	7.74	8.99	8.39	8.62	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	10	30.00	94.00	74.40	77.00	0	N/A	N/A
Bottom of Water Column (10-15 m)									
Water Temp	deg C	25	19.86	28.68	25.24	25.59	0	N/A	N/A
Turbidity	NTU	10	6.5	745.4	91.9	21.1	0	N/A	25 NTU
Oxygen, Diss	mg/L	25	0.22	7.69	2.94	2.06	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	25	7.24	7.97	7.48	7.42	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	7	84	98	93.43	96	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-3. USACE Water Column Statistics for Station 1EUFOKS0039

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	10	17.40	31.70	26.13	27.02	0	N/A	N/A
Turbidity	NTU	10	1.90	117.20	27.69	15.95	0	N/A	25 NTU
Oxygen, Diss	mg/L	10	6.17	11.63	8.03	8.00	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	10	7.62	8.82	8.30	8.26	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	10	92.00	146.00	111.40	106.00	0	N/A	N/A
Bottom of Water Column (5-8 m)									
Water Temp	deg C	22	17.2	31.48	25.38	26.19	0	N/A	N/A
Turbidity	NTU	8	7.1	132.6	52.98	30.6	0	N/A	25 NTU
Oxygen, Diss	mg/L	22	0.78	8.94	6.11	6.37	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	22	7.48	8.61	7.98	8.05	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	9	92	146	114.22	114	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-4. USACE Water Column Statistics for Station 1EUFOKS0040

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	10	16.58	31.81	26.26	27.32	0	N/A	N/A
Turbidity	NTU	10	4.90	42.80	20.08	14.50	0	N/A	25 NTU
Oxygen, Diss	mg/L	10	6.26	9.51	7.90	7.78	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	10	7.70	8.86	8.24	8.25	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	10	50.00	110.00	71.80	71.00	0	N/A	N/A
Bottom of Water Column (14-19 m)									
Water Temp	deg C	31	15.97	27.19	22.13	22.04	0	N/A	N/A
Turbidity	NTU	12	8.3	59	35.13	42.05	0	N/A	25 NTU
Oxygen, Diss	mg/L	31	0.22	8.07	4.01	4.88	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	31	7.23	7.92	7.49	7.42	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	9	68	128	99.11	100	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-5. USACE Water Column Statistics for Station 1EUFOKS0044

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	7	18.36	32.13	27.69	29.39	0	N/A	N/A
Turbidity	NTU	7	6.17	91.70	48.61	44.80	0	N/A	25 NTU
Oxygen, Diss	mg/L	7	6.42	8.40	7.36	7.24	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	7	7.00	8.38	8.07	8.17	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	9	40.00	132.00	94.44	94.00	0	N/A	N/A
Bottom of Water Column (4-6 m)									
Water Temp	deg C	9	24.31	30.16	26.67	25.59	0	N/A	N/A
Turbidity	NTU	3	126.1	127.6	126.7	126.4	0	N/A	25 NTU
Oxygen, Diss	mg/L	9	3.28	7.49	5.94	6.66	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	9	6.85	8.39	7.63	7.78	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	5	40	96	78.8	92	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-6. USACE Water Column Statistics for Station 1EUFOKS0172

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	8	14.12	26.11	21.62	22.35	0	N/A	N/A
Turbidity	NTU	5	3.20	30.90	15.40	17.30	0	N/A	25 NTU
Oxygen, Diss	mg/L	8	1.40	9.06	5.70	6.38	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	8	7.21	8.05	7.55	7.54	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	10	58.00	146.00	85.80	79.00	0	N/A	N/A
Bottom of Water Column (5-8 m)									
Water Temp	deg C	12	14.05	23.27	18.52	18.79	0	N/A	N/A
Turbidity	NTU	0	[C]	[C]	[C]	[C]	0	N/A	25 NTU
Oxygen, Diss	mg/L	12	0.58	9.18	5.84	7.26	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	12	7.21	7.70	7.50	7.59	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	0	[C]	[C]	[C]	[C]	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

[C] No samples taken.

Table C-7. USACE Water Column Statistics for Station 1EUFOKS0173

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	9	17.55	31.84	26.60	28.60	0	N/A	N/A
Turbidity	NTU	9	9.10	58.20	27.11	22.20	0	N/A	25 NTU
Oxygen, Diss	mg/L	9	6.95	8.76	7.87	7.81	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	9	7.25	8.47	7.97	7.98	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	9	30.00	52.00	42.44	44.00	0	N/A	N/A
Bottom of Water Column (13-18 m)									
Water Temp	deg C	21	17.28	25.69	22.59	25.08	0	N/A	N/A
Turbidity	NTU	12	25	61.8	33.83	28.3	0	N/A	25 NTU
Oxygen, Diss	mg/L	21	0.27	8.74	4.87	6.85	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	21	6.75	7.97	7.44	7.25	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	5	28	70	49.2	50	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-8. USACE Water Column Statistics for Station 1EUFOKS0174

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	7	17.88	31.80	27.32	28.91	0	N/A	N/A
Turbidity	NTU	8	12.90	171.20	46.18	29.95	0	N/A	25 NTU
Oxygen, Diss	mg/L	7	4.99	8.55	7.02	7.02	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	7	7.47	8.91	8.21	8.14	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	8	88.00	150.00	108.75	101.00	0	N/A	N/A
Bottom of Water Column (6-9.5 m)									
Water Temp	deg C	20	17.38	31.61	26.09	26.42	0	N/A	N/A
Turbidity	NTU	12	26.3	172	84.26	77.55	0	N/A	25 NTU
Oxygen, Diss	mg/L	20	0.48	8.56	4.86	5.02	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	20	7.33	8.26	7.79	7.87	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	8	92	152	119.5	115	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Table C-9. USACE Water Column Statistics for Station 1EUFOKS0175

Parameter	Units	No Obs.	Min.	Max.	Mean	Median	No Obs. Below Detection	Detection Limit	Oklahoma WQS [A]
Top of Water Column (0.5 m)									
Water Temp	deg C	7	16.96	31.74	26.73	28.98	0	N/A	N/A
Turbidity	NTU	8	4.50	101.70	30.29	20.75	0	N/A	25 NTU
Oxygen, Diss	mg/L	7	6.75	9.01	8.04	7.96	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	7	7.50	8.94	8.36	8.26	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	8	80.00	116.00	89.75	85.00	0	N/A	N/A
Bottom of Water Column (12-17.5 m)									
Water Temp	deg C	30	14.86	28.54	21.61	23.19	0	N/A	N/A
Turbidity	NTU	13	26.9	253.6	83.19	66.8	0	N/A	25 NTU
Oxygen, Diss	mg/L	30	0.22	8.4	4.07	3.39	0	N/A	6.0 mg/L (early life stages) 5.0 mg/L (other life stages) [B]
pH	units	30	7.14	8.06	7.5	7.45	0	N/A	6.5 to 9.0
Alkalinity, Tot	mg/L	8	88	116	93.25	90	0	N/A	N/A

Notes:

[A] Taken from Title 785 Oklahoma Water Resources Board, Chapter 45 Oklahoma's Water Quality Standards.

[B] Dissolved oxygen criteria to protect fish and wildlife propagation and all subcategories thereof for warm water aquatic community, from Appendix G of the Oklahoma Water Quality Standards.

Appendix D
STEPL Modeling Results

The EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) Model was used to estimate water quality impacts to Eufaula Lake. The STEPL Model estimates annual runoff volume and total phosphorus, nitrogen, biochemical oxygen demand (BOD), and sediment load from location and land use input information (EPA 2012).

D.1 STEPL Analysis Overview

For purposes of the STEPL analysis, two scenarios were explored to determine direct and indirect impacts to water quality in Eufaula Lake. Water quality impacts were considered for two categories of land use: impacts resulting from land use on USACE-owned lands only (i.e. direct impacts) as well as impacts stemming from land use on private lands adjacent to USACE-owned lands (i.e. direct and indirect impacts). For this reason, the model was run for scenarios using only USACE-owned lands as well as for scenarios using USACE-owned lands and adjacent private lands within a ½ mile buffer.

Land use categories used in the STEPL Model include urban, cropland, pastureland, forest, feedlot, and wetlands. Areas for each category at Eufaula were estimated using GIS analysis. Cropland and feedlot land uses within the contributing watershed were considered negligible and not used in the analysis.

D.2 Urban Development

The primary difference between the alternatives was the amount of urban development on private lands adjacent to USACE-owned land along the lake. Urban development was considered to include roads, parking areas, buildings and other land use modifications within the USACE-owned lands adjacent to the lake. Urban development on the adjacent private land included housing structures.

The urban development area was adjusted for each alternative, based on an estimate of the existing level of shoreline development and the maximum expected level of development allowed under each alternative. Other land use categories were adjusted based on the expected amount of urban development (including mowed grass, which was categorized as urban cultivated land use within the model) and the relative proportion of each land use category to the total. The specific process used to adjust the land use categories based on shoreline development is described in more detail below.

Future urban development was dependent on the amount of Limited Development shoreline allowed under each alternative. For purposes of this analysis, all private land adjacent to Limited Development shoreline is considered susceptible to urban development at levels comparable to those found adjacent to existing Limited Development shorelines that have already been developed. The ultimate build-out condition assumed for the No Action and other alternatives is the condition that would occur with full development adjacent to all Limited Development shorelines. Limited Development shoreline designations by alternative are listed in **Table D-1**.

Table D-1. Lake Eufaula Limited Development Shoreline Lengths (miles)

Shoreline Designation	No Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Limited Development	271	42	182	367	479

Limited Development areas may allow private boat docks while other shoreline designations do not allow boat docks. The current shoreline management plan allows 271 miles of Limited Development; however, not all of this area is developed under existing conditions. An estimate of the area that has been developed under existing conditions was obtained from shoreline areas currently containing private boat docks. Areas with boat docks were considered developed and areas without boat docks were considered undeveloped.

Under existing conditions, 1,673 known private boat docks are located on the lake. Based on a sampling of representative areas developed with boat docks, it was determined that there is approximately 115 linear feet of shoreline, on average, for each boat dock. Therefore, the total shoreline length currently developed is 36 miles.

The No Action Alternative allows 271 shoreline miles of Limited Development, or approximately 7.53 times the amount currently at the lake. An estimate of the total urban land use under the No Action Alternative build-out for USACE-owned lands was obtained by the following calculation:

- GIS estimates indicate 2,302 acres of urban land on USACE-owned land under existing conditions. Of this 2,302 acres, 451 acres are adjacent to shorelines designated as Limited Development, which results in 1,851 acres of urban land adjacent to other shoreline designations. No appreciable future change in urban land is expected in the other shoreline designations.
- Future development adjacent to the 271 miles of Limited Development shoreline has the capacity for 3,396 acres of urban development.
- Total urban land use under the No Action Alternative at build-out is therefore 5,247 acres.
- Assuming ultimate urban build-out for the No Action Alternative, other land use categories within the model were adjusted according to their proportion to the total under existing conditions.

D.3 Model Inputs

Land use values for private land and the action alternatives for input into the STEPL Model were estimated using a similar procedure as described above. The following tables provide model input land use acreage for USACE-owned land (**Table D-2**) and USACE-owned lands plus private lands (**Table D-3**) around Eufaula Lake for each EIS alternative.

Table D-2. STEPL Model Land Use Area Input for USACE-owned Land (acres)

Alternative	Urban[2]	Pastureland	Forest	Wetlands	Total Area
Existing Condition[1]	2,302	14,531	45,838	2,291	64,962
No Action	5,247	13,848	43,684	2,184	64,962
Alternative 1	2,377	14,513	45,783	2,288	64,962
Alternative 2	3,562	14,239	44,916	2,245	64,962
Alternative 3	7,144	13,408	42,296	2,114	64,962
Alternative 4	9,312	12,905	40,710	2,035	64,962

[1]Existing Condition is not an alternative, but is used as a baseline for No Action, which at build-out will have more urban area than in the current condition. No Action is the baseline against which the other alternatives are compared.

[2]Urban areas are improved areas only. Sub categories for urban lands are given below. Applicable for all alternatives.

Urban Land Use Sub Categories (percent of total urban area)		
Urban Cultivated	**Transportation (Roads)**	**Single Family**
60	36	4

Table D-3. STEPL Model Land Use Area Input for USCAE-owned Plus Private Land (acres)

Alternative	Urban[2]	Pastureland	Forest	Wetlands	Total Area
Existing Condition[1]	8,544	101,797	131,242	4,616	246,199
No Action	52,234	80,796	109,203	3,967	246,200
Alternative 1	9,659	101,261	130,679	4,600	246,199
Alternative 2	35,465	88,709	117,797	4,229	246,200
Alternative 3	71,123	71,883	99,522	3,672	246,200
Alternative 4	92,710	61,696	88,459	3,335	246,200

[1]Existing Condition is not an alternative, but is used as a baseline for No Action, which at build-out will have more urban area than in the current condition. No Action is the baseline against which the other alternatives are compared.

[2]Urban areas are improved areas only. Sub categories for urban lands are given below. Applicable for all alternatives.

Urban Land Use Sub Categories (percent of total urban area)		
Urban Cultivated	**Transportation (Roads)**	**Single Family**
60	20	20

In addition to land use inputs, the STEPL Model also uses rainfall and soils data to estimate annual runoff and pollutant loads. The model automatically populates these inputs based on the location of the watershed by county. The entire contributing area was treated as one watershed, therefore, Pittsburg County was chosen as a representative county from the five counties within which Eufaula Lake is located. The STEPL Model allows for modification of these inputs if more accurate local data is available. For the purposes of this analysis, model default values for soils and rainfall were used. The model default for precipitation was an annual rainfall value of 45 inches, an average rain event of 1.118 inches, and 82.4 rain days. The average soil hydrologic group selected for the model analysis was B.

D.4 STEPL Model Results

The STEPL Model results are summarized on the follow tables, and demonstrate substantial decreases, compared to the No Action Alternative, in all outputs for Alternatives 1 and 2 (**Table D-4**), and substantial increases for Alternatives 3 and 4 (**Table D-5**). **Table D-6** and **Table D-7** present the model results in terms of percent change compared to the No Action Alternative. These increases represent pollutant loads from runoff originating on the USACE-owned lands and an adjacent ½-mile strip of private land only. Runoff volumes, depending on land area and alternative, are at most 235,738 acre feet per year (for USACE-owned plus private land under Alternative 4). These pollutant loads, being generated from the small fraction of the Eufaula Lake watershed that could be influenced by the project alternatives, are not representative of the actual impact to pollutant concentrations in the lake because the volume of Eufaula Lake and inflow from contributing streams will have a diluting effect.

Table D-4. STEPL Model Results for USACE-owned Lands

Alternatives	Runoff Volume (AF)	Total P^2 Load (lb/year)	Total N^2 Load (lb/year)	Total BOD^2 Load (lb/year)	Total Sediment Load (tons/year)
Existing Condition[1]	38,832	22,661	158,163	481,656	3,921
No Action	41,783	26,999	183,579	552,489	4,691
Alternative 1	38,907	22,771	158,805	483,444	3,941
Alternative 2	40,095	24,517	169,039	511,966	4,251
Alternative 3	43,683	29,793	199,950	598,113	5,186
Alternative 4	45,855	32,986	218,659	650,252	5,753

[1] *Existing Condition is not an alternative, but is used as a baseline for No Action, which at build-out will have more urban area than in the current condition. No Action is the baseline against which the other alternatives are compared.*

[2] *P = Phosphorus. N = Nitrogen. BOD = Biochemical Oxygen Demand.*

Table D-5. STEPL Model Results for USACE-owned and Private Land

Alternatives	Runoff Volume (AF)	Total P^2 Load (lb/year)	Total N^2 Load (lb/year)	Total BOD^2 Load (lb/year)	Total Sediment Load (tons/year)
Existing Condition[1]	155,011	106,200	942,021	2,950,825	14,384
No Action	196,840	142,981	1,099,811	3,363,701	22,134
Alternative 1	155,989	103,141	921,627	2,893,814	13,972
Alternative 2	180,725	127,208	1,028,504	3,174,993	18,906
Alternative 3	214,993	160,748	1,180,136	3,576,276	25,770
Alternative 4	235,738	181,053	1,271,927	3,819,191	29,925

[1] *Existing Condition is not an alternative, but is used as a baseline for No Action, which at build-out will have more urban area than in the current condition. No Action is the baseline against which the other alternatives are compared.*

[2] *P = Phosphorus. N = Nitrogen. BOD = Biochemical Oxygen Demand.*

Table D-6. STEPL Model Results as Percent Change Compared to the No Action Alternative (USACE-owned Land)

Alternatives	Runoff Volume (AF)	Total P[1] Load (lb/year)	Total N[1] Load (lb/year)	Total BOD[1] Load (lb/year)	Total Sediment Load (tons/year)
Alternative 1	-7%	-16%	-13%	-12%	-16%
Alternative 2	-4%	-9%	-8%	-7%	-9%
Alternative 3	5%	10%	9%	8%	11%
Alternative 4	10%	22%	19%	18%	23%

[1]*P = Phosphorus. N = Nitrogen. BOD = Biochemical Oxygen Demand.*

Table D-7. STEPL Model Results as Percent Change Compared to the No Action Alternative (USACE-owned and Private Land)

Alternatives	Runoff Volume (AF)	Total P[1] Load (lb/year)	Total N[1] Load (lb/year)	Total BOD[1] Load (lb/year)	Total Sediment Load (tons/year)
Alternative 1	-21%	-28%	-16%	-14%	-37%
Alternative 2	-8%	-11%	-6%	-6%	-15%
Alternative 3	9%	12%	7%	6%	16%
Alternative 4	20%	27%	16%	14%	35%

[1]*P = Phosphorus. N = Nitrogen. BOD = Biochemical Oxygen Demand.*

D.5 Water Quality Impacts in Eufaula Lake

The effect of the various alternatives on phosphorus, nitrogen and sediment concentrations in the lake was evaluated by converting the STEPL annual loads to parts per million (ppm) using a water volume equal to the average annual inflow to Eufaula Lake, and comparing this to the expected concentrations that would occur under the No Action Alternative.

Under current conditions, the average phosphorus, nitrogen and sediment concentrations in the lake are:

Phosphorus: 0.070 PPM

Nitrogen: 0.410 PPM

Sediment inflow: 7,249 acre feet per year (ODWC 2008)

A review of records from the U.S. Geological Survey stream gage #07245000 on the Canadian River just downstream of Eufaula Dam indicates the average annual inflow to Eufaula Lake (as measured by outflow) is 4,611,880 acre feet (USGS 2012). Converting STEPL loads to ppm, the following future build-out concentrations are expected in the lake, on average, under the No Action Alternative:

Phosphorus: 0.0729 PPM

Nitrogen: 0.4226 PPM

Sediment inflow: 7,257 acre feet per year

According to the STEPL Model, the No Action Alternative would result in a four percent increase in phosphorus, a three percent increase in Nitrogen, and a 0.1 percent increase in sediment inflow compared to existing conditions. These adjusted No Action concentrations assume that USACE-owned and private lands are both developed to the maximum extent possible under No Action shoreline designations.

Anticipated phosphorus, nitrogen and sediment concentrations in ppm given the STEPL loads, average annual inflow to the lake, and the adjusted No Action concentrations are provided in **Table D-8** and **Table D-9**.

Table. D-8. Water Quality Impact Comparison for Pollutants Originating on USACE-owned Land[1]

Alternative	Phosphorus Average Lake PPM	Phosphorus Percent Change	Nitrogen Average Lake PPM	Nitrogen Percent Change	Sediment Average Annual Inflow, in Acre Feet	Sediment Percent Change
No Action	0.0729	0.0%	0.4226	0.0%	7,252.6	0.00%
Alternative 1	0.0726	-0.4%	0.4206	-0.5%	7,252.2	0.00%
Alternative 2	0.0727	-0.3%	0.4214	-0.3%	7,252.4	0.00%
Alternative 3	0.0731	0.3%	0.4239	0.3%	7,252.8	0.00%
Alternative 4	0.0734	0.7%	0.4254	0.7%	7,253.0	0.01%

[1]*Concentrations are average for the entire lake assuming average annual inflow of 4,611,880 acre feet and pollutant loads estimated by STEPL analysis.*

Table D-9. Water Quality Impact Comparison for Pollutants Originating on USACE-owned and Private Lands[1]

Alternative	Phosphorus Average Lake PPM	Phosphorus Percent Change	Nitrogen Average Lake PPM	Nitrogen Percent Change	Sediment Average Annual Inflow, in Acre Feet	Sediment Percent Change
No Action	0.0729	0.0%	0.4226	0.0%	7,252.6	0.00%
Alternative 1	0.0697	-4.4%	0.4084	-3.4%	7,248.86	-0.05%
Alternative 2	0.0716	-1.8%	0.4283	1.3%	7,251.1	-0.02%
Alternative 3	0.0743	1.9%	0.4290	1.5%	7,254.2	0.02%
Alternative 4	0.0760	4.3%	0.4363	3.2%	7,256.1	0.05%

[1]*Concentrations are average for the entire lake assuming average annual inflow of 4,611,880 acre feet and pollutant loads estimated by STEPL analysis.*

Sediment impacts are negligible for all alternatives for USACE-owned as well as USACE-owned plus private lands. Compared to the No Action Alternative, phosphorus, nitrogen, and sediment impacts from USACE-owned lands are less than a one percent increase for all action alternatives. Alternatives 1 and 2 would result in slight reductions in concentrations, and Alternative 4 would have the greatest effect. Compared to the No Action Alternative, phosphorus, nitrogen, and sediment impacts from USACE-owned lands plus private lands are less than a five percent increase for all action alternatives. Alternatives 1 and 2 would result in slight concentration reductions, and Alternative 4 would have the greatest effect.

The water quality impacts are negligible to slight, and are considered to be high conservative estimates. In practice, future development is unlikely to reach the high levels assumed in this analysis for many years, if

ever. Not included in the analysis are best management practices (BMPs), which are recommended as mitigation measures for each alternative. These BMPs, when implemented should reduce potential pollutant loads below those concentrations discussed here.

Under Alternative 4, the Carlton Landing development is comprised of private and USACE-owned lands. The STEPL model was employed to estimate the pollutant load resulting from only the Carlton Landing development under existing conditions and full build-out on both USACE-owned lands and private lands. STEPL model results for the Carlton Landing development are presented in **Table D-10** and **Table D-11**. Water quality impacts on Eufaula Lake as a whole resulting from Carlton Landing are included in the analysis for Alternative 4, discussed earlier in this appendix. STEPL model runs for the Carlton Landing development focus on potential localized water quality impacts from the proposed development. Compared to existing conditions, full build-out of the Carlton Landing development under Alternative 4 could result in localized water quality impacts in terms of runoff volume and potential erosion, as well as pollutant loads. An increase in runoff may result in an increase in localized erosion if measures are not taken to mitigate these impacts.

Table D-10. Water Quality Impact Comparison for Pollutants Originating on USACE-owned Lands Comprising the Carlton Landing Development

	Runoff Volume (AF)	Total P[2] Load (lb/year)	Total N[2] Load (lb/year)	Total BOD[2] Load (lb/year)	Total Sediment Load (tons/year)
Existing Condition[1]	158	117	634	1,841	42
Full build-out of Carlton Landing under Alternative 4	430	888	7,172	15,190	86
Percent Change from Existing Conditions to full build-out	173%	659%	1,031%	725%	105%

[1]*Existing Condition is not an alternative, but is used as a baseline for No Action, which at build-out will have more urban area than in the current condition. No Action is the baseline against which the other alternatives are compared.*

[2]*P = Phosphorus. N = Nitrogen. BOD = Biochemical Oxygen Demand.*

Table D-11. Water Quality Impact Comparison for Pollutants Originating on USACE-owned and Private Lands Comprising the Carlton Landing Development

	Runoff Volume (AF)	Total P[2] Load (lb/year)	Total N[2] Load (lb/year)	Total BOD[2] Load (lb/year)	Total Sediment Load (tons/year)
Existing Condition[1]	740	588	3,805	11,438	192
Full build-out of Carlton Landing under Alternative 4	1,991	1,934	13,764	41,560	247
Percent Change from Existing Conditions to full build-out	169%	229%	262%	263%	28%

[1]*Existing Condition is not an alternative, but is used as a baseline for No Action, which at build-out will have more urban area than in the current condition. No Action is the baseline against which the other alternatives are compared.*

[2]*P = Phosphorus. N = Nitrogen. BOD = Biochemical Oxygen Demand.*

D.6 References

U.S. EPA. 2012. Welcome to STEPL and Region 5 Model. http://it.tetratech-ffx.com/stepl/

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