FINAL

CHLOROPHYLL-*a* TOTAL MAXIMUM DAILY LOADS FOR CARL BLACKWELL LAKE (OK620900040280_00) AND LAKE HUMPHREYS (OK310810040150_00)

Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

JUNE 2016

FINAL

CHLOROPHYLL-*a*
TOTAL MAXIMUM DAILY LOADS
FOR CARL BLACKWELL LAKE (OK620900040280_00) AND
LAKE HUMPHREYS (OK310810040150_00)

Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

8000 Centre Park Drive, Suite 200
Austin, TX 78754

JUNE 2016

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

µg/L	Microgram per liter
BUMP	Beneficial Use Monitoring Program
CAFO	Concentrated Animal Feeding Operation
CDL	Cropland Data Layer
CFR	Code of Federal Regulations
CPP	Continuing Planning Process
CV	Coefficient of Variation
CWA	Clean Water Act
DEQ	Oklahoma Department of Environmental Quality
DMR	Discharge monitoring report
DO	Dissolved oxygen
EPA	United States Environmental Protection Agency
HUC	Hydrologic unit code
kg	Kilograms
kg/ha/yr	Kilograms per hectare per year
LA	Load allocation
MCS	Monte Carlo simulation
mg/L	Milligram per liter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NASS	National Agricultural Statistics Service
NPDES	National Pollutant Discharge Elimination System
NSE	Nash-Sutcliffe Efficiency
O.S.	Oklahoma statutes
OAC	Oklahoma Administrative Code
OCC	Oklahoma Conservation Commission
ODAFF	Oklahoma Department of Food & Forestry
OPDES	Oklahoma Pollutant Discharge Elimination System
O.S.	Oklahoma Statute
OSWD	Onsite wastewater disposal
OWRB	Oklahoma Water Resources Board
r^2	Correlation coefficient
SH	State Highway
SWAT	Soil and Water Assessment Tool
SWS	Sensitive public and private water supply
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TSI	Trophic state index
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WBID	Waterbody Identification

WLA	Wasteload allocation
WQM	Water quality monitoring
WQMP	Water quality management plan
WQS	Water quality standard
WWAQ	Warm Water Aquatic Community
WWTF	Wastewater treatment facility

Executive Summary

This report documents the data and assessment methods used to establish total maximum daily loads (TMDL) for pollutants impacting chlorophyll-*a* levels for Carl Blackwell Lake [Oklahoma Waterbody ID (OK WBID) number OK620900040280_00] and Lake Humphreys (OK310810040150_00). The Oklahoma Department of Environmental Quality (DEQ) placed Carl Blackwell Lake in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2012 Integrated Report* (2012 Integrated Report) for nonsupport of the Aesthetic, Fish and Wildlife Propagation-Warm Water Aquatic Community (WWAC), and Public and Private Water Supply designated uses. Lake Humphreys was placed by DEQ in Category 5 (303(d) list) of the 2012 Integrated Report for non-support of the Public and Private Water Supply Use.

Carl Blackwell Lake is located in the Lower Cimarron River sub-basin (hydrologic unit code [HUC] 11050003) and Lake Humphreys is located in the Middle Washita River sub-basin (HUC 11130303). Carl Blackwell Lake is a 3,370-acre lake in Payne County with a conservation pool storage of 61,500 acre-feet. It was impounded in 1937, and serves as a recreational lake and water supply (Oklahoma Water Resources Board [OWRB] 2010). Most of the 59-mile shoreline is undeveloped. The contributing watershed of Carl Blackwell Lake, displayed in Figure 1-1, is 77 square miles. Stillwater Creek (10.6 miles long), Little Stillwater Creek (6.7 miles long) and Hunt Creek (5.2 miles long) are the primary tributaries flowing to Carl Blackwell Lake.

Lake Humphreys is an 882-acre lake in Stephens County with a conservation pool storage of 14,041 acre-feet. It was impounded in 1958, and serves as a recreational lake, water supply and flood control reservoir. Most of the 16-mile shoreline is undeveloped. The contributing watershed of Lake Humphreys, shown in Figure 1-2, is 32 square miles. Wildhorse Creek (7.9 miles long) and McCubbin Creek (6.9 miles long) are the primary tributaries flowing to Lake Humphreys.

Based on a review of satellite imagery from Google Earth Maps there appears to be little developed land bordering the shoreline of the two lakes. The aggregate total of low, medium, and high density developed land accounts for less than 8 percent of the land use in each watershed. The most common land use categories in both watersheds are pasture/grass and deciduous forest (from CDL layer [NASS 2013]). The contributing watersheds are herein after referred to as the Study Area.

Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), United States Environmental Protection Agency (EPA) guidance, and Oklahoma Water Quality Standards (WQS) [Oklahoma Administrative Code (OAC) Title 785, Chapter 45]. The Oklahoma Department of Environmental Quality (DEQ) is required to submit all TMDLs to EPA for review and approval. Once EPA approves a TMDL, then the waterbody may be moved to Category 4a of a State's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (EPA 2003).

The purpose of this TMDL report is to establish watershed-based nutrient load allocations necessary for reducing chlorophyll-*a* levels in the lakes, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding applicable WQS. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and water quality conditions in the waterbody. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural processes in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce nutrients within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process involving stakeholders who live and work in the watersheds, along with tribes, and local, state, and federal government agencies.

E.1 Problem Identification and Water Quality Target

This TMDL report focuses on the waterbodies identified in Table ES-1 that DEQ placed in Category 5 of the *Water Quality in Oklahoma 2012 Integrated Report* for nonsupport of the Public Private Water Supply use. Elevated levels of chlorophyll-*a* in lakes reflect excessive algae growth, which can have deleterious effects on the quality and treatment costs of drinking water. Excessive algae growth can also negatively affect the aquatic biological communities of lakes. Elevated chlorophyll-*a* levels typically indicate excessive loading of the primary growth-limiting algal nutrients such as nitrogen and phosphorus to the waterbody, a process known as eutrophication.

Table ES-1 Excerpt from the 2012 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a)

Waterbody Name and WBID	Waterbody Size (Acres)	TMDL Date	TMDL Priority	Causes of Impairment	Designated Use Not Supported
Cark Blackwell Lake (OK620900040280_00)	3,370	2017	2	▪ Chlorophyll-*a*	▪ Public and Private Water Supply
					▪ Aesthetic
					▪ Warm Water Aquatic Community
Lake Humphreys (OK310810040150_00)	882	2020	3	▪ Chlorophyll-*a*	▪ Public and Private Water Supply

Source: 2012 Integrated Report, DEQ 2010.

Sensitive Public and Private Water Supply (SWS) lakes are defined in the Oklahoma Water Quality Standards - Oklahoma Administrative Code (OAC) Title 785, Chapter 45: 785:45-5-25(c)(4)(A). In Appendix A.3 of the WQS, Carl Blackwell Lake and Lake Humphreys are both listed as SWS lakes.

The numeric criterion set for chlorophyll-*a* for SWS lakes is also found in the WQS [785:45-5-10(7)] which states, "*The long-term average concentration of chlorophyll-a at a* *depth of 0.5 meters below the surface shall not exceed 0.010 milligrams per liter in Wister Lake, Tenkiller Ferry Reservoir, nor any waterbody designated SWS in Appendix A of this Chapter. Wherever such criterion is exceeded, numerical phosphorus or nitrogen criteria or both may be promulgated.*

Surface level sampling data, collected from the lakes' Water Quality Monitoring (WQM) stations, was used to support the decision to place these lakes on the DEQ 2012 §303(d) list for non-support of the Public and Private Water Supply Use in an SWS lake:

- Between 2004 and 2013, Carl Blackwell Lake chlorophyll-*a* samples averaged 14.2 µg/L which is equivalent to a Carlson's TSI of 56.6 (Carlson 1977).
- Between 2002 and 2014, Lake Humphreys chlorophyll-*a* samples averaged 23.8 µg/L (TSI = 61.7).

Between 1998 to 2013, total nitrogen levels (TN) and total phosphorus (TP) levels were as follows for the lakes in the Study Area.

- Carl Blackwell Lake: TN levels averaged approximately 0.81 mg/L and TP levels averaged 0.04 mg/L (Table 2-5).
- Humphreys Lake: TN levels averaged approximately 1.03 mg/L, and TP levels averaged 0.04 mg/L (Table 2-6).

The Code of Federal Regulations [40 CFR §130.7(c)(1)] states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." The water quality target established for each lake must demonstrate compliance with the numeric criterion prescribed for SWS lakes in the Oklahoma WQS (OWRB 2013). Therefore, the water quality target established for each lake is to achieve a long-term average in-lake concentration of 10 µg/L for chlorophyll-*a*.

Carl Blackwell Lake is also included in the 303(d) list for turbidity and color. These water quality issues will be addressed specifically at a future date.

Determining which nutrients limit phytoplankton growth is an important step in the development of effective lake and watershed management strategies (Dodds and Priscu 1990; Elser *et al.* 1990; Smith *et al.* 2002). It is often assumed that algal productivity of most freshwater lakes and reservoirs is primarily limited by the availability of the nutrient phosphorus. However, more recent studies in reservoirs indicate that both nitrogen and phosphorus play key roles, along with light, mixing conditions, predation by zooplankton, and residence time, in limiting algal growth (Kimmel et al. 1990).

E.2 Pollutant Source Assessment

This section includes an assessment of the known and suspected sources of nutrients contributing to the eutrophication of Carl Blackwell Lake and Lake Humphreys. Nutrient sources identified are categorized and quantified to the extent that reliable information is available. Generally, nutrient loadings causing eutrophication of lakes originate from point or nonpoint sources of pollution. Point sources are permitted through the NPDES program. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from land activities that contribute nutrient loads to surface water as a result of rainfall runoff. For the

TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources.

Under 40 CFR §122.2, a point source is described as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. NPDES-permitted facilities classified as point sources that may contribute nutrient loading include:

- Continuous Point Source Discharges
    - NPDES municipal wastewater treatment facility (WWTF) discharges;
    - NPDES industrial WWTF discharges;
- NPDES municipal separate storm sewer system (MS4) discharges
    - Phase 1 MS4
    - Phase 2 MS4
- NPDES no-discharge WWTF
- Sanitary sewer overflow (SSO)
- NPDES concentrated animal feeding operations (CAFO)

There are no CAFOs, no-discharge facilities, MS4, or continuous point source discharges within the contributing watersheds of Carl Blackwell Lake or Lake Humphreys.

The entire nutrient loading to these two lakes originates from nonpoint sources. Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. The relatively homogeneous land use/land cover categories throughout the Study Area associated with forest, grasslands, and winter wheat have a strong influence on the origin and pathways of nutrient sources to surface water. Nutrient sources in rural watersheds originate from soil erosion, agricultural fertilization, residues from mowing and harvesting, leaf litter, and fecal waste deposited in the watershed by livestock. Causes of soil erosion can include natural causes such as flooding and winds, construction activities, vehicular traffic, and agricultural activities. Other sources of nutrient loading in a watershed include atmospheric deposition, failing onsite wastewater disposal (OSWD) systems, and fecal matter deposited in the watershed by wildlife and pets.

Given the lack of in-stream water quality data and pollutant source data available to quantify nutrient and sediment loading directly from the tributaries of Carl Blackwell Lake and Lake Humphreys, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2011). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. Major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management.

There are no stream flow gages or water quality monitoring stations in the tributaries to Carl Blackwell Lake and Lake Humphreys. To calibrate the SWAT model, it was necessary to extend the modeled area to encompass watersheds with stream flow gages and nutrient concentration measurements. Thus, for Carl Blackwell Lake, the SWAT model simulated portions of two adjacent watersheds: Lower Cimarron-Skeleton (HUC 11050002) and Lower Cimarron (HUC 11050003). The modeled domain displayed in Figure 3-1 is a 3,010 square mile area that includes the contributing watersheds of the lake. The main streams located in the modeled domain are the Cimarron River, Skeleton Creek, Stillwater Creek, Cottonwood Creek, and Kingfisher Creek.

For Lake Humphreys, the SWAT model simulated portions of two adjacent watersheds: Upper Washita (HUC 11130302) and Middle Washita (HUC 11130303). The modeled domain displayed in Figure 3-2 is a 2,640 square mile area that includes the contributing watershed of Lake Humphreys. The main streams located in the modeled domain are the Washita River, Little Washita River, Rush Creek, and Wildhorse Creek.

A 20-year period (1994 - 2013) was simulated in the SWAT model. However, the first four years were considered a “spin-up” period for stabilizing model initial conditions, and the model output consisted of only the latter 16 years (1998 - 2013). The variables simulated in SWAT included flow, organic phosphorus, mineral ortho-phosphorus, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and total suspended solids.

The SWAT hydrologic calibration for the Carl Blackwell Lake model was based on flow data available at the USGS gages located on Skeleton Creek at State Highway (SH) 74 near Lovell, OK (USGS Station 07160500), Cimarron River near Guthrie, OK (USGS Station 07160000), and Cimarron River near Ripley, OK (USGS Station 07161450) (Figure 3-1). Overall, the model reproduces the annual flows within the 15 percent target[1] for most years, with overall errors below the target for all three locations (-5% for Skeleton Creek, -1% for Cimarron River near Guthrie, and -3% for Cimarron River near Ripley). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.879 and 0.833 for Skeleton Creek at SH 74, 0.932 and 0.933 for Cimarron River near Guthrie, and 0.904 and 0.905 for Cimarron River near Ripley. The high resulting coefficients indicate very good model performance for annual flows.

After hydrologic calibration, the SWAT-predicted nutrient concentrations were calibrated to the observed nutrient concentrations at six water quality stations:

- Skeleton Creek: Lower (OWRB monitoring site 620910030010-001AT),
- Cimarron River near Ripley, OK (OWRB monitoring site 620900030010-001AT – no TSS data-),
- Cimarron River near Guthrie, OK (OWRB monitoring site 620910010010-001AT),
- Council Creek (OCC monitoring site OK620900-02-0050H),
- Stillwater Creek: Lower (OCC monitoring site OK620900-04-0040C), and
- Euchee Creek (OCC monitoring site OK620900-01-0290D).

For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. In all cases, the SWAT model reproduced the

[1] As stated in Section B7 of the approved QAPP for the project, total annual flows are to be calibrated so that predicted values are within 15% of the measured values.

average TP and TN concentrations within 25 percent of the measured averages[2]. In some instances as shown in Table 7 of Appendix C the model does not replicate particular nutrient species within the 25 percent target for a given period particular individual station. This is most likely a result of the limited amount of nutrient data available. However, the overall measures for the whole watershed are within 25 percent target for all nutrient species. Furthermore, these slight variances for some of the nutrient species are not considered critical since the data results are used to develop annual average loading estimates in the lake water quality model BATHTUB. It should also be noted that monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

The SWAT hydrologic calibration for the Lake Humphreys model was based on flow data available at the USGS gages located on the Washita River at Alex, OK (USGS Station 07328100), Washita River near Pauls Valley, OK (USGS Station 07328500), and Wildhorse Creek near Hoover, OK (USGS Station 07329700) (Figure 3-2). Overall, the model reproduces the annual flows within the 15 percent target for most years, with overall errors below the target for Washita River near Pauls Valley and Wildhorse Creek (-2% and -1%, respectively), and above the target (7%) for Washita River at Alex. Resulting NSE coefficients and r^2 values were 0.924 and 0.954 for Washita River at Alex, 0.942 and 0.941 for Washita River near Pauls Valley, and 0.749 and 0.739 for Wildhorse Creek. The high resulting coefficients indicate very good model performance for annual flows.

After hydrologic calibration, the SWAT-predicted nutrient concentrations were calibrated to the observed nutrient concentrations at six water quality stations (Figure 3-2):

- Washita River at Alex (OWRB monitoring site 310810020010-001AT-- no TSS data-),
- Washita River near Pauls Valley (OWRB monitoring site 310810010010-001AT),
- Finn Creek (OCC monitoring site OK310810-02-0020D),
- Rush Creek (OCC monitoring site OK310810-05-0010D),
- Salt Creek (OCC monitoring site OK310810-03-0080G), and
- Wildhorse Creek (OCC monitoring site OK310810-01-0020G).

For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. In all cases, the SWAT model reproduced the average TP and TN concentrations within 25 percent of the measured averages. In some instances as shown in Table 7 of Appendix D the model does not replicate particular nutrient species within the 25 percent target for a given period particular individual station. This is most likely a result of the limited amount of nutrient data available. However, the overall measures for the whole watershed are within 25 percent target for all nutrient species. Furthermore, these slight variances for some of the nutrient species are not considered critical since the data results are used to develop annual average loading estimates in the lake water quality model BATHTUB. It should also be noted that monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

[2] As stated in Section B7 of the approved QAPP for the project, nutrients are to be calibrated so that the mean of the predicted values falls within 25% of the mean of the measured values.

Based on the calibrated SWAT model, average loads of nutrients from each individual subwatersheds were estimated for the period 1998 to 2013. Under current conditions, Carl Blackwell Lake is estimated to receive a total annual load of 60,000 kg of phosphorus and 40,900 kg of nitrogen, on average, from nonpoint sources in its watershed. Lake Humphreys is estimated to receive a total annual load of 5,400 kg of phosphorus and 8,500 kg of nitrogen, on average, from nonpoint sources in its watershed.

Table ES-2 Average Flows and Nutrient Loads Discharging to Carl Blackwell Lake and Lake Humphreys

Parameter	Carl Blackwell Lake	Humphreys Lake
Watershed Size (square miles)	77	32
Flow (m^3/day)	1.30E+05	2.45E+04
Organic Phosphorus (kg/year)	50,500	4,600
Mineral Ortho-Phosphorus (kg/year)	9,500	700
Total Phosphorus (kg/year)	**60,000**	**5,400**
Organic Nitrogen (kg/year)	21,000	7,800
Ammonia Nitrogen (kg/year)	400	100
Nitrate+Nitrite Nitrogen (kg/year)	19,500	600
Total Nitrogen (kg/year)	**40,900**	**8,500**

E.3 Technical Approach and Methods

The objective of a TMDL is to estimate allowable pollutant loads and allocate those loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. To ascertain the effect of management measures on in-lake water quality, it is necessary to establish a linkage between the external loading of nutrients (TN and TP) and the waterbody response in terms of lake water quality conditions, as evaluated by chlorophyll-*a* concentrations. The following paragraphs describe the water quality analysis of the linkage between chlorophyll-*a* levels Carl Blackwell Lake or Lake Humphreys and the nutrient loadings from their watersheds.

The water quality linkage analysis was performed using the BATHTUB model (Walker 1986). BATHTUB is a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes. BATHTUB has been cited as an effective tool for reservoir and lake water quality assessment and management, particularly where data are limited. The model incorporates several empirical equations of nutrient settling and algal growth to predict steady-state water column nutrient and chlorophyll-*a* concentrations based on waterbody characteristics, hydraulic characteristics, and external nutrient loadings.

The model was run under existing average, steady-state conditions. A single, well-mixed lake was assumed for both reservoirs. Key water quality parameters for BATHTUB input include total phosphorus, inorganic ortho-phosphorus, total nitrogen, and inorganic nitrogen. Output from the SWAT model was the primary source of data input to the BATHTUB model. Although SWAT can provide daily output, BATHTUB is a steady-state model and not appropriate for interpreting short-term responses of lakes to nutrients. Therefore, the long-term average annual loads from the SWAT-modeled period were applied as inputs to BATHTUB.

The BATHTUB models for each lake were run under average existing conditions, and calibrated to measure in-lake water quality conditions (based on 1999-2013 data) using phosphorus, nitrogen, chlorophyll-a and Secchi disk calibration factors. The model-predicted concentrations of total nitrogen, total phosphorus, chlorophyll-*a*, and Secchi depth under existing average conditions are compared to average measured concentrations from each lake in Table ES-3.

Table ES-3 Model Predicted and Measured Water Quality Parameter Concentrations

Water Quality Parameter	Carl Blackwell Lake		Lake Humphreys	
	Modeled	Measured	Modeled	Measured
Total Phosphorus (mg/L)	0.04	0.04	0.04	0.04
Total Nitrogen (mg/L)	0.81	0.81	1.04	1.03
Chlorophyll-*a* (µg/L)	14.2	14.2	23.8	23.8
Secchi depth (meters)	0.5	0.46	0.6	0.63

Simulations were performed using the BATHTUB model to evaluate the effect of watershed loading reductions on chlorophyll-*a* levels. Atmospheric loads were maintained at their existing estimated levels. Simulations indicated that the water quality target of 9 µg/L chlorophyll-*a* as a long-term average concentration could be achieved if the total phosphorus and nitrogen watershed loads to Carl Blackwell Lake were reduced by 55% from the existing loads, to 27,000 kg/year of total phosphorus and 18,400 kg/year of total nitrogen. In Lake Humphreys, the water quality target of 9 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 84% to 864 kg/year of total phosphorus and 1,360 kg/year of total nitrogen. Table ES-4 summarizes the percent reduction goals for nutrient loading established for each lake. These maximum allowable loads include a 10% explicit margin of safety through the use of limits on loading of both nitrogen and phosphorus.

Table ES-4 Total Phosphorus and Nitrogen Load Reductions Needed to Meet Chlorophyll-*a* In-lake Water Quality Targets

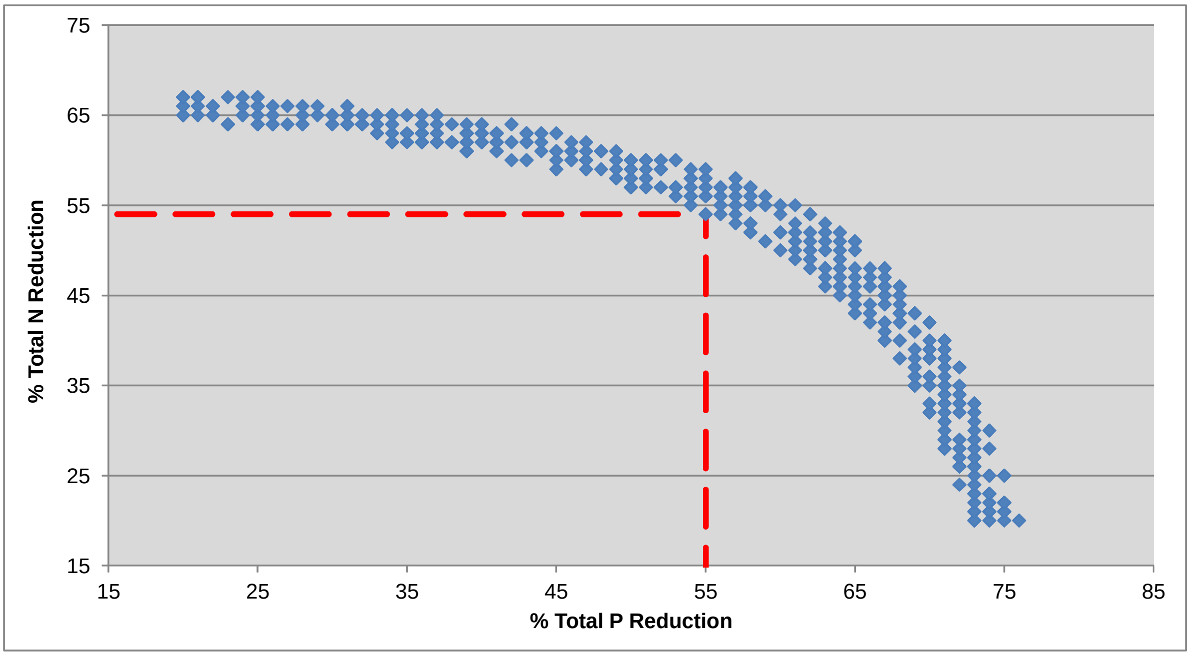
Lake	Percent Reduction	Maximum Allowable Load (kg/yr)[a]	
		Total Phosphorus	Total Nitrogen
Carl Blackwell Lake	55	27,000	18,400
Lake Humphreys	84	864	1,360

[a] Loads do not include atmospheric deposition

While the relative importance of nitrogen or phosphorus in limiting algal productivity in Carl Blackwell Lake and Lake Humphreys has not been definitively established, this TMDL calculates load allocations for both nitrogen and phosphorus as a conservative approach to ensure that water quality targets are met. Since there are infinite combinations of TN and TP concentrations that could result in the desired chlorophyll-*a* concentration and BATHTUB is not capable of discerning between them, a practical starting point for implementation is to begin with equal percent reduction goals for both nutrient parameters. For example, in Figure

ES-1, the 55% reduction goal is plotted for both nutrient parameters for Carl Blackwell Lake. However, depending on local environmental and socio-economical conditions, different percent reductions for the two nutrients based on the curve in Figure ES-1, could be used during the implementation of the TMDL for Carl Blackwell Lake and still achieve the target chlorophyll-*a* concentration in the Lake.

Figure ES-1 Total N and Total P Combinations Resulting in 9 µg/L Chlorophyll-*a* – Carl Blackwell Lake



E.4 TMDLs and Load Allocations

TMDLs for the §303(d)-listed waterbodies covered in this report were derived using the outputs from the BATHTUB model. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the uncertainty concerning the relationship between loading limitations and water quality. This definition can be expressed by the following equation:

$$TMDL = \Sigma\, WLA + \Sigma\, LA + MOS$$

There are no point sources discharging nutrient loadings to Carl Blackwell Lake or Lake Humphreys. Furthermore, Oklahoma's implementation of WQS (OAC 785:46-13-4) prohibits new point source discharges to these lakes, except for storm water with approval from DEQ (OWRB 2013a). *New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "SWS."*

Therefore, the wasteload allocation (WLA) for both lakes is zero.

The load allocation for watershed nonpoint sources to both lakes are calculated as the difference between the TMDL and the MOS since the WLA is zero:

LA = TMDL – MOS

The total allowable load to Carl Blackwell Lake was conservatively estimated as 27,000 kg/yr of TP and 18,400 kg/yr of TN, necessitating a 55 percent reduction from existing phosphorus and nitrogen loading to achieve the desired water quality target (the 10 µg/L WQS minus a 10% explicit MOS or 9 µg/L).

The LA for watershed nonpoint sources to Lake Humphreys was conservatively estimated as 864 kg/yr of TP and 1,360 kg/yr of TN, necessitating an 84 percent reduction from existing loading to achieve the desired water quality target (the 10 µg/L WQS minus a 10% explicit MOS or 9 µg/L).

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained. EPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for the lack of knowledge, then the MOS is considered explicit. The TMDLs for Carl Blackwell and Humphreys Lakes include a 10% explicit MOS.

Load reduction scenario simulations were run using the BATHTUB model to calculate annual average phosphorus and nitrogen loads (in kg/yr) that, if achieved, should decrease chlorophyll-*a* concentrations to meet the water quality target. Given that transport, assimilation, and dynamics of nutrients vary both temporally and spatially, nutrient loading to both lakes from a practical perspective must be managed on a long-term basis typically as pounds or kilograms per year. However, a recent court decision (*Friends of the Earth, Inc. v. EPA, et al.*, often referred to as the Anacostia decision) states that TMDLs must include a daily load expression. It is important to recognize that the chlorophyll-*a* response to nutrient loading in Carl Blackwell Lake and Lake Humphreys is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load, and algal response. As such it is important to note that expressing this TMDL in daily time steps does not imply a daily response to a daily load is practical from an implementation perspective.

The EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA 1991a) provides a statistical method for identifying a statistical maximum daily limit based on a long-term average and considering variation in a dataset. The method is represented by the following equation:

$$MDL = LTA \times e^{z\sigma - 0.5\sigma^2}$$

where
MDL = maximum daily load
LTA = long-term average load
z = z statistic of the probability of occurrence (1.645 is used for this value)
$\sigma^2 = \ln(CV^2+1)$
CV = coefficient of variation

The coefficients of variation of daily phosphorus and nitrogen NPS loads, calculated from SWAT model output, were 4.4 and 4.1 for Carl Blackwell Lake, and 9.2 and 8.3 for Lake

Humphreys, respectively. Using equal reductions for both nutrient parameters (55% for Carl Blackwell and 84% for Humphreys), the maximum daily loads correspond to the allowable annual average loads provided in Table ES-4. In Carl Blackwell Lake the 27,000 kg of phosphorus and 18,400 kg of nitrogen per year is translated to a daily maximum load of 74.0 kg/day of phosphorus and 50.4 kg/day of nitrogen. For Lake Humphreys, the allowable average load of 864 kg of phosphorus and 1,360 kg of nitrogen per year is translated to a daily maximum load of 2.4 kg/day of phosphorus and 3.7 kg/day of nitrogen. Reduction of TP and TN loads in lake tributaries to these levels is expected to result in achievement of WQS for chlorophyll-*a* in each lake.

Table ES-5 TMDLs for Chlorophyll-*a* Expressed in Kilograms of Total Phosphorus and Nitrogen Per Day

Waterbody Name	Waterbody ID	Nutrient	TMDL	WLA	LA	MOS
Carl Blackwell Lake	OK620900040280_00	Total Phosphorus	74.0	0	66.6	7.4
		Total Nitrogen	50.4	0	45.4	5.0
Lake Humphreys	OK310810040150_00	Total Phosphorus	2.4	0	2.2	0.2
		Total Nitrogen	3.7	0	3.3	0.4

E.5 Public Participation

A public notice was sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who have requested copies of all TMDL public notices. The public notice, draft TMDL report, and draft 208 Factsheet were posted at the following DEQ website: www.deq.state.ok.us/wqdnew/index.htm. The public had 45 days (December 28, 2015 to February 11, 2016) to review the draft TMDL report and make written comments.

Comments were received during the public notice period and these comments, along with DEQ's responses, are now part of the record of this TMDL report in **Appendix E.** No changes were made to the final version of this TMDL Report.

There were no requests for a public meeting.

This TMDL report was finalized and submitted to EPA for final approval.

SECTION 1 INTRODUCTION

1.1 TMDL Program Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require states to develop total maximum daily loads (TMDLs) for all segments and pollutants identified by the Regional Administrator as suitable for TMDL calculation. Segments and pollutants identified on the approved 303(d) list as not meeting designated uses where technology-based controls are in place will be given a higher priority for development of TMDLs. TMDLs establish the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so states can implement water quality-based controls to reduce pollution from point and nonpoint sources and restore and maintain water quality (EPA 1991).

This report documents the data and assessments used to establish TMDLs for pollutants impacting chlorophyll-*a* levels for Carl Blackwell Lake (Oklahoma Waterbody ID [OK WBID] number OK620900040280_00) in the Lower Cimarron River sub-basin (hydrologic unit code [HUC] 11050003) and Lake Humphreys (OK310810040150_00) in the Middle Washita River sub-basin (HUC 11130303). The Oklahoma Department of Environmental Quality (DEQ) placed Carl Blackwell Lake in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2012 Integrated Report* (2012 Integrated Report) for non-support of the Aesthetic, Fish and Wildlife Propagation-Warm Water Aquatic Community (WWAC), and Public and Private Water Supply Uses. Lake Humphreys was placed by DEQ in Category 5 (303(d) list) of the 2012 Integrated Report for non-support of the Public and Private Water Supply Use. Figures 1-1 and 1-2 are location maps showing these Oklahoma waterbodies and their contributing watersheds. The maps display locations of the water quality monitoring (WQM) stations used as the basis for placement of these waterbodies on the Oklahoma §303(d) list. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

Elevated levels of chlorophyll-*a* in lakes reflect excessive algae growth, which can have deleterious effects on the quality and treatment costs of drinking water. Excessive algae growth can also negatively affect the aquatic biological communities of lakes. Elevated chlorophyll-*a* levels typically indicate excessive loading of the primary growth-limiting algal nutrients nitrogen and phosphorus to the waterbody, a process known as eutrophication. Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), EPA guidance, and Oklahoma Water Quality Standards (WQS) (Oklahoma Administrative Code [OAC] Title 785, Chapter 45). DEQ is required to submit all TMDLs to EPA for review and approval. Once EPA approves a TMDL, then the waterbody may be moved to Category 4a of a State's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with WQS is achieved (EPA 2003).

The purpose of this TMDL report is to establish nutrient load allocations necessary for reducing chlorophyll-*a* levels in the lakes, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding applicable WQS. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and water quality conditions in the waterbody. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes storm water discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS can be implicit and/or explicit. An implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural processes in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce nutrients within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process involving stakeholders who live and work in the watersheds, along with tribes, and local, state, and federal government agencies.

1.2 Lake and Watershed Characteristics

1.2.1 Lake Characteristics

Carl Blackwell Lake is a 3,370-acre lake in Payne County with a conservation pool storage of 61,500 acre-feet. It was impounded in 1937, and serves as a recreational lake and water supply (Oklahoma Water Resources Board [OWRB] 2010). Most of the 59-mile shoreline is undeveloped. The contributing watershed of Carl Blackwell Lake, displayed in Figure 1-1, is 77 square miles. Stillwater Creek (10.6 miles long), Little Stillwater Creek (6.7 miles long) and Hunt Creek (5.2 miles long) are the primary tributaries flowing to Carl Blackwell Lake.

Lake Humphreys is an 882-acre lake in Stephens County with a conservation pool storage of 14,041 acre-feet. It was impounded in 1958, and serves as a recreational lake, water supply and flood control reservoir. Most of the 16-mile shoreline is undeveloped. The contributing watershed of Lake Humphreys, shown in Figure 1-2, is 32 square miles. Wildhorse Creek (7.9 miles long) and McCubbin Creek (6.9 miles long) are the primary tributaries flowing to Lake Humphreys.

Table 1-1 General Lake Characteristics

Waterbody Name and WBID	Surface Area (Acres)	Conservation Pool Storage (Acre- Feet)	Normal Elevation (Feet MSL)	Average Depth (Feet)	Shoreline (Miles)	Management Agency
Carl Blackwell Lake	3,370	61,500	944	18.2	58	Oklahoma State University
Lake Humphreys	882	14,041	1,179	15.9	16	City of Duncan

MSL = Mean Sea Level

Figure 1-1 Carl Blackwell Lake

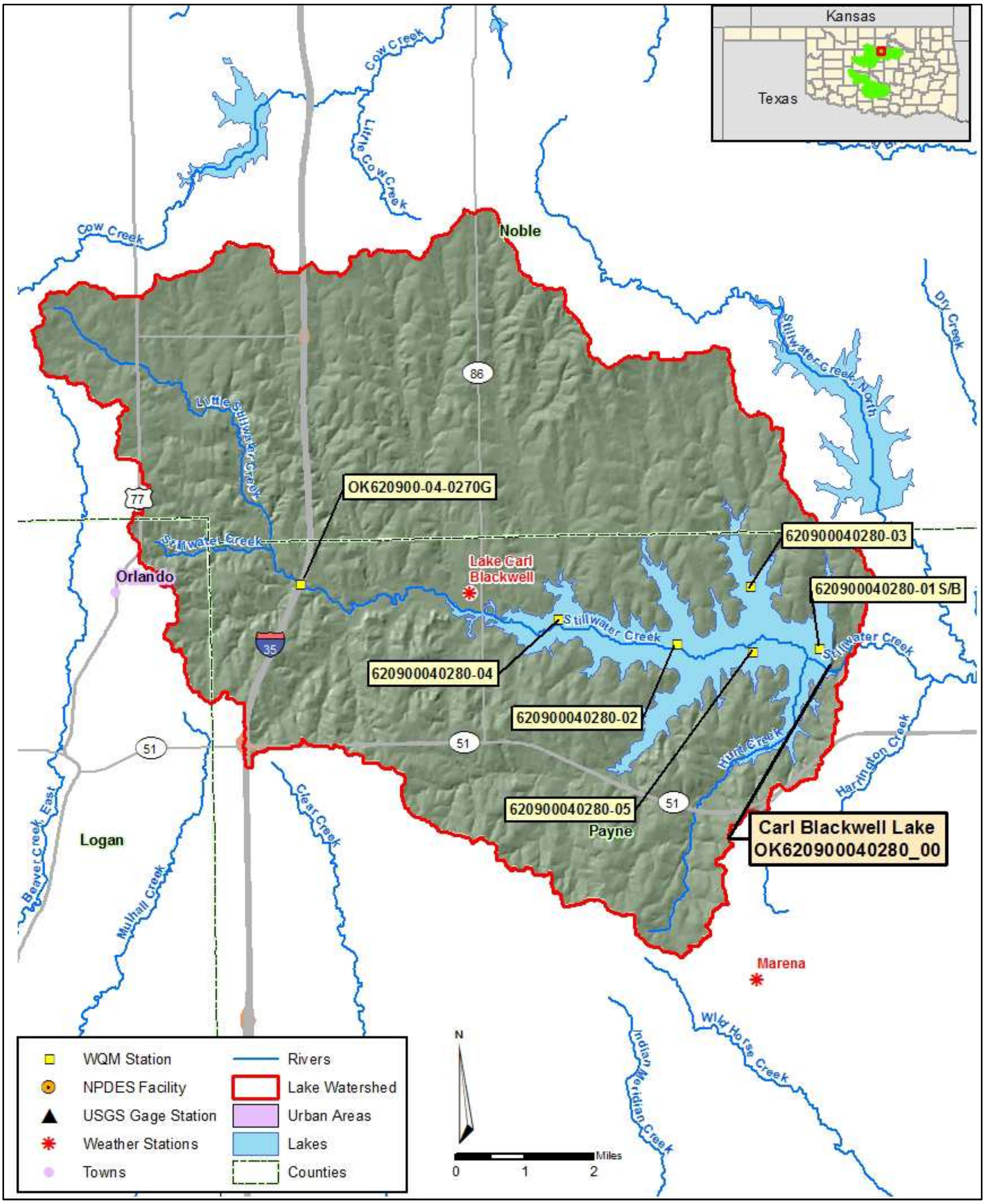
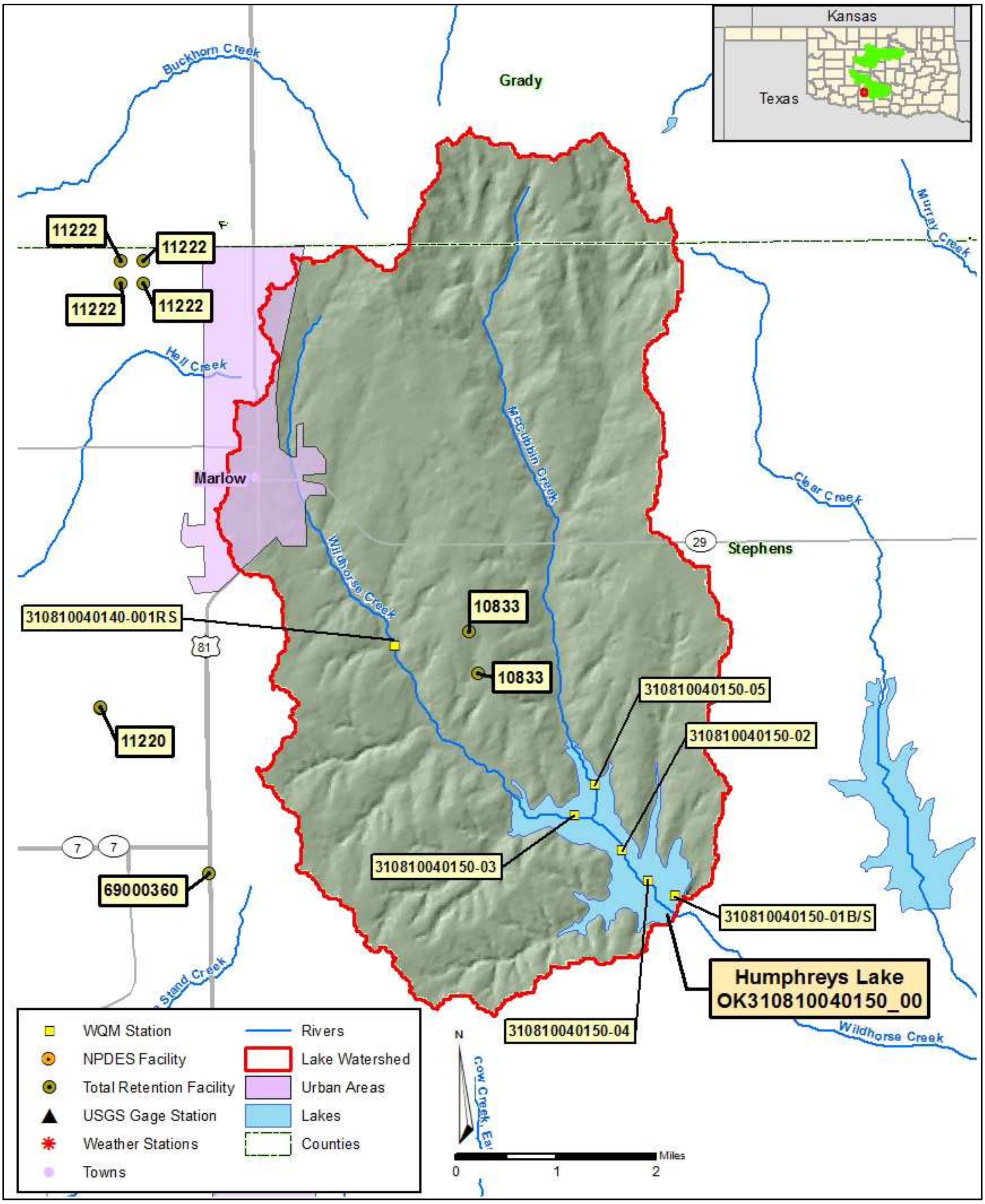


Figure 1-2 Lake Humphreys



1.2.2 General

Carl Blackwell Lake is generally located in the Lower Cimarron River sub-basin and the Central Great Plains ecoregion (Woods et al. 2005) of central Oklahoma. Carl Blackwell Lake is specifically located 9 miles west of Stillwater, in Payne County. Much of the Central Great Plains ecoregion is cropland, with the eastern boundary of the region a major winter wheat growing area of the United States.

Lake Humphreys is generally located in the Middle Washita River sub-basin and the Cross Timbers ecoregion (Woods et al. 2005) of central Oklahoma. Lake Humphreys is specifically located eleven miles northeast of Duncan, in Stephens County. The Cross Timbers ecoregion consists predominately of rangeland, with open grasslands, mesquite, and other woody areas. The secondary land use is cropland, which dominates the southwestern portion of the sub-basin.

Table 1-2, derived from the 2010 U.S. census, demonstrates that the counties in which the watersheds are located are sparsely populated (U.S. Census Bureau 2010).

Table 1-2 County Population and Density

County Name	Population (2010 Census)	Population Density (per square mile)
Payne	77,350	113
Stephens	45,048	51.8

1.2.3 Climate

Table 1-3 summarizes the average annual precipitation for each lake. Average annual precipitation values were derived from the Oklahoma Mesonet Dataset (http://www.mesonet.org) based on a period of record from 1994 to 2013 from three stations in the vicinity of the lake watersheds (Oklahoma Mesonet 2013).

Table 1-3 Average Annual Precipitation by Watershed (1994-2013)

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Carl Blackwell Lake	OK620900040280_00	32.5
Lake Humphreys	OK310810040150_00	33.6

1.2.4 Land Use

The contributing drainage areas of Carl Blackwell Lake and Lake Humphreys are approximately 77 and 32 square miles, respectively. Table 1-4 summarizes the percentages and acreages of the land use categories for the contributing watersheds. Land use/land cover data were derived from the National Agricultural Statistics Service (NASS) 2013 Cropland Data Layer (CDL). The CDL is a crop-specific land cover classification data set. Land use distributions in the watersheds of Carl Blackwell Lake and Lake Humphreys are displayed in Figures 1-3 and 1-4. The most common land use categories in both watersheds are pasture/grass and deciduous forest. Based on a review of satellite imagery from Google Earth

Maps there appears to be little developed land bordering the shoreline of the two lakes. The aggregate total of low, medium, and high density developed land accounts for less than 8 percent of the land use in each watershed (see summary of CDL data, Table 1-4).

Table 1-4 Land Use Summary by Watershed

Description	Carl Blackwell Lake		Lake Humphreys	
	Acres	Percent §	Acres	Percent §
Corn	325	0.7	65	0.3
Rye	6	<0.1	-	-
Winter Wheat	1,579	3.2	912	4.5
Alfalfa	-	-	88	0.4
Other Cultivated Land	440	0.9	68	0.3
Open Water	2,955	6.0	728	3.6
Developed/Open Space	2,618	5.3	1,096	5.4
Developed/Low Intensity	216	0.4	312	1.5
Developed/Medium Intensity	87	0.2	111	0.5
Developed/High Intensity	18	<0.1	52	0.3
Barren	9	<0.1	-	-
Deciduous Forest	8,774	17.9	3,559	17.4
Evergreen Forest	78	0.2	2	<0.1
Pasture/Grass	31,937	65.1	13,476	65.8
Woody Wetlands	3	<0.1	-	-
Total Drainage Area	49,047		20,468	

§ Rounding of numbers accounts for percentage total not equaling 100.

1.3 Flow Characteristics

Stream flow characteristics and data are key information when conducting water quality assessments such as TMDLs. However, there are no flow gages located on any of the tributaries to Carl Blackwell Lake and Lake Humphreys, or at any of the lake outlets. Given the lack of historical stream flow data, flow estimates for lake tributaries were developed using a watershed model calibrated to flow measurements at U.S. Geological Survey (USGS) gage stations in adjacent watersheds. This is discussed in further detail in Section 3.

Figure 1-3 Carl Blackwell Lake Watershed Land Use

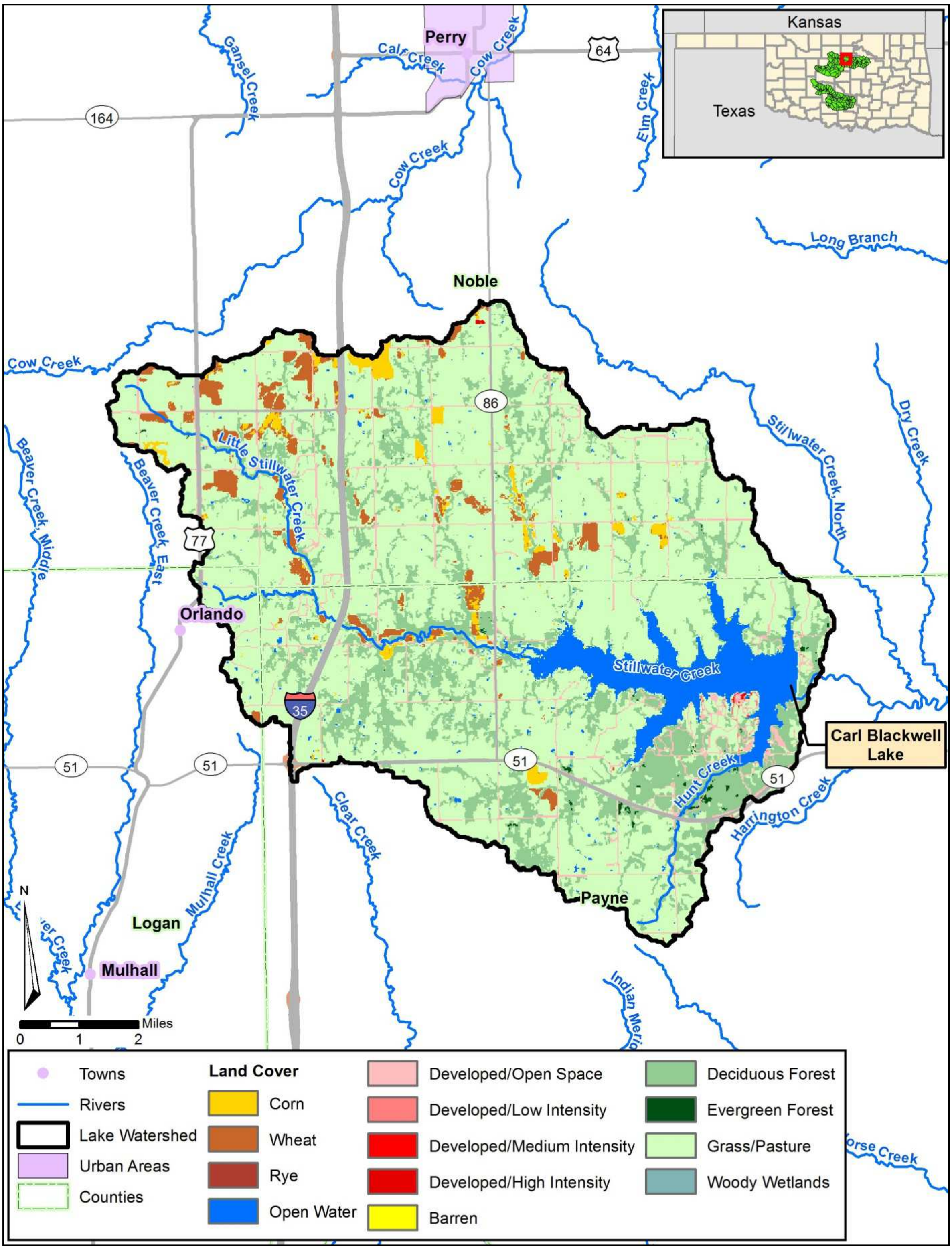
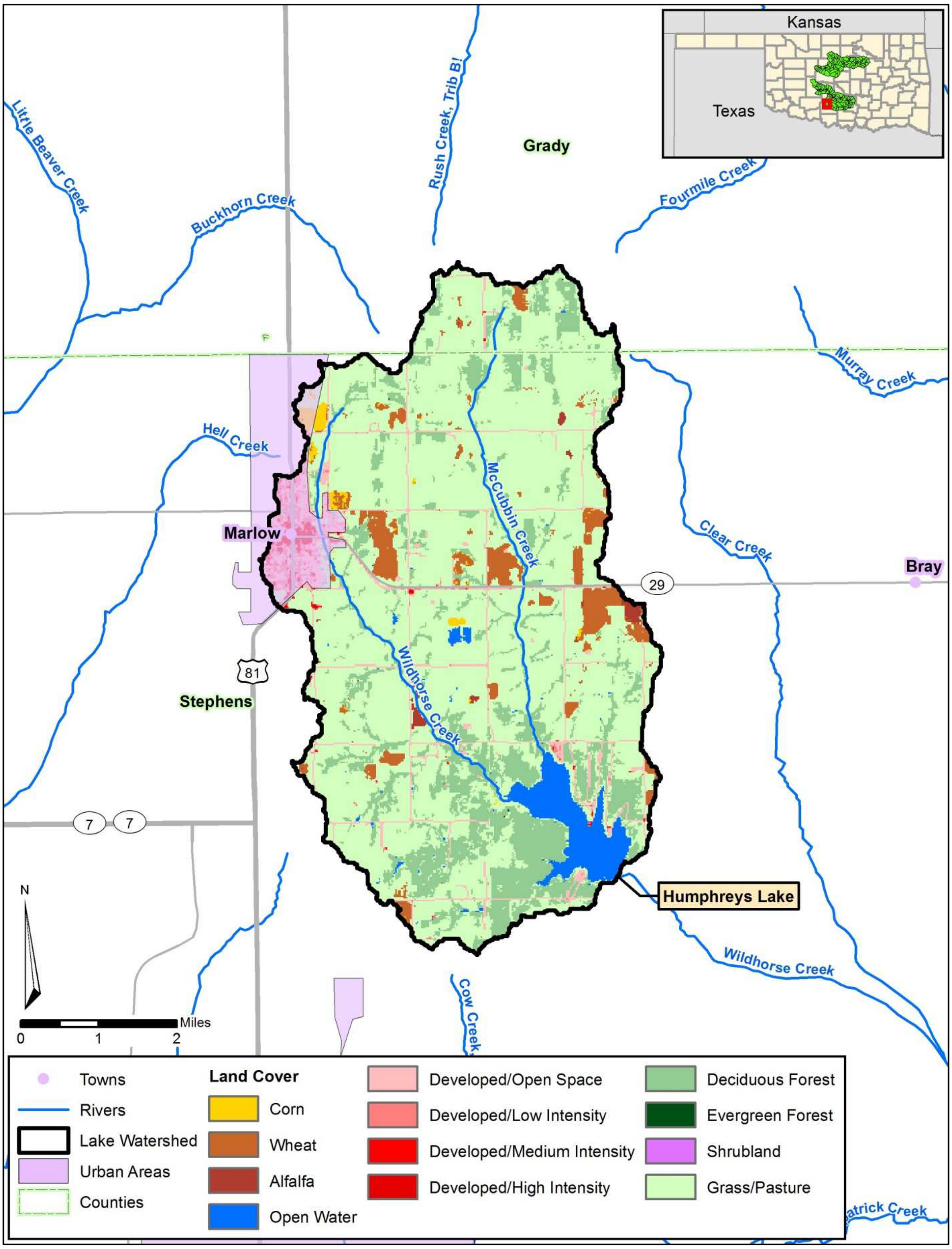


Figure 1-4 Lake Humphreys Watershed Land Use



SECTION 2
PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Oklahoma Water Quality Standards

Title 785 of the Oklahoma Administrative Code contains Oklahoma Water Quality Standards in Chapter 45 (OWRB 2013) and implementation procedures in Chapter 46 (OWRB 2013a). The Oklahoma Water Resources Board has statutory authority and responsibility concerning establishment of State water quality standards, as provided under 82 Oklahoma Statute (O.S.), §1085.30. This statute authorizes the OWRB to promulgate rules *…which establish classifications of uses of waters of the State, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* (O.S. 82:1085:30(A)). Beneficial uses are designated for all waters of the State. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2013). An excerpt of the Oklahoma WQS (Chapter 45, Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in Appendix A. Beneficial uses designated for Carl Blackwell Lake and Lake Humphreys include aesthetics, the WWAC subcategory of the fish and wildlife propagation use, agricultural water supply, primary body contact recreation, fish consumption, and sensitive public and private water supply. The aesthetics, WWAC subcategory of the fish and wildlife propagation use, and public and private water supply uses are not supported in Carl Blackwell Lake. In Lake Humphreys, only the sensitive public and private water supply use is deemed not supported. The TMDL priority shown in Table 2-1 is directly related to the TMDL target date. The TMDLs established in this report, which are a necessary step in the process of restoring water quality, only address the non-attainment of the public and private water supply use.

Table 2-1 Excerpt from the 2012 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a)

Waterbody Name and OKWBID	Waterbody Size (Acres)	TMDL Date	TMDL Priority	Causes of Impairment	Designated Use Not Supported
Cark Blackwell Lake (OK620900040280_00)	3,370	2017	2	▪ Chlorophyll-*a*	▪ Public and Private Water Supply
				▪ Color	▪ Aesthetic
				▪ Turbidity	▪ Warm Water Aquatic Community
Lake Humphreys (OK310810040150_00)	882	2020	3	▪ Chlorophyll-*a*	▪ Public and Private Water Supply

Source: 2012 Integrated Report, DEQ 2012.

Carl Blackwell Lake and Lake Humphreys are designated as SWS lakes. The definition of SWS is summarized by the following excerpt from the Oklahoma Administrative Code (OAC) 785:45-5-25 of the Oklahoma WQS (OWRB 2013).

Sensitive Public and Private Water Supplies (SWS)

(A) Waters designated "SWS" are those waters of the State which constitute sensitive public and private water supplies as a result of their unique physical conditions and are listed in Appendix A of this Chapter as "SWS" waters. These are waters (a) currently used as water supply lakes, (b) that generally possess a watershed of less than approximately 100 square miles or (c) as otherwise designated by the Board.

(B) New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of this Chapter with the limitation "SWS". Any discharge of any pollutant to a waterbody designated "SWS" which would, if it occurred, lower existing water quality shall be prohibited, provided however that new point source discharge(s) or increased load of specified pollutants described in 785:45-5-25(b) may be approved by the permitting authority in those circumstances where the discharger demonstrates to the satisfaction of the permitting authority that a new point source discharge or increased load from an existing point source discharge will result in maintaining or improving the water quality of both the direct receiving water and any downstream waterbodies designated SWS.

The SWS lakes are defined in the Oklahoma Water Quality Standards - OAC Title 785, Chapter 45: 785:45-5-25(c)(4)(A). In Appendix A.3 of the WQS, Carl Blackwell Lake and Lake Humphreys are listed as SWS lakes.

The numeric criterion for chlorophyll-a for SWS lakes is also found in the WQS (785:45-5-10(7)), which states, “The long-term average concentration of chlorophyll-a at a depth of 0.5 meters below the surface shall not exceed 0.010 milligrams per liter in Wister Lake, Tenkiller Ferry Reservoir, nor any waterbody designated SWS in Appendix A of this Chapter. Wherever such criterion is exceeded, numerical phosphorus or nitrogen criteria or both may be promulgated.”

2.2 Problem Identification

In this subsection, water quality data indicating waterbody impairment caused by elevated levels of chlorophyll-*a* are summarized. Water quality data available for other nutrient parameters are also summarized. Table 2-2 provides the locations of WQM stations on each lake. These WQM stations are part of the Oklahoma Beneficial Use Monitoring Program (BUMP) network (OWRB 2012). Table 2-2 also provides a hyperlink to the OWRB Data Viewer from which lake water quality data were obtained. Locations of the WQM stations for Carl Blackwell Lake and Lake Humphreys are illustrated in Figures 1-1 and 1-2, respectively.

Table 2-2 Water Quality Monitoring Stations used for 2012 §303(d) Listing Decision

Waterbody ID	Station ID	Latitude	Longitude	Site Description
Carl Blackwell Lake				
620900040208_00	620900040280-01B	36.134231	-97.194942	Bottom
620900040208_00	620900040280-01S	36.134231	-97.194942	Near Surface
620900040208_00	620900040280-02	36.135719	-97.231956	Near Surface
620900040208_00	620900040280-03	36.147764	-97.212683	Near Surface
620900040208_00	620900040280-04	36.141481	-97.263028	Near Surface
620900040208_00	620900040280-05	36.133741	-97.212473	Near Surface
Lake Humphreys				
310810040150_00	310810040150-01B	34.586667	-97.885278	Bottom
310810040150_00	310810040150-01S	34.586667	-97.885278	Near Surface
310810040150_00	310810040150-02	34.593333	-97.894444	Near Surface
310810040150_00	310810040150-03	34.598611	-97.902778	Near Surface
310810040150_00	310810040150-04	34.58891	-97.890036	Near Surface
310810040150_00	310810040150-05	34.602962	-97.899259	Near Surface

[*] Hyperlinks are active in the electronic version of this document. Source: OWRB Data Viewer 2014

2.2.1 Chlorophyll-*a* Data Summary

Table 2-3 summarizes chlorophyll-*a* data collected from Carl Blackwell Lake WQM stations from 2004 through 2013. The data summary in Table 2-3 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criterion of 10 µg/L chlorophyll-*a*, as a long-term average at a depth of one-half meter. Chlorophyll-*a* in surface level samples averaged 14.2 µg/L, which is equivalent to a Carlson's trophic state index (TSI) of 56.6 (Carlson 1977). According to the 2013 BUMP Report, using water quality samples collected between October 2012 and July 2013, the TSI calculated for Carl Blackwell Lake was 61 (OWRB 2013). As stipulated in the Implementation Procedures for Oklahoma's Water Quality Standards (785:46-15-3(c)) the most recent 10 years of water quality data are used as the basis for evaluating the beneficial use support for lakes (OWRB 2013a). Chlorophyll-*a* data collected from Carl Blackwell Lake WQM stations between 2004 and 2013 were used to support the decision to place the lake on the DEQ 2012 §303(d) list (DEQ 2013) for non-support of the Public and Private Water Supply Use in an SWS lake. Water quality data are provided in Appendix B.

Table 2-3 Summary of Chlorophyll-*a* Measurements in Carl Blackwell Lake (all values in µg/L)

Station ID	Minimum Date	Maximum Date	Number of Samples	Minimum	Maximum	Average	Median
620900040280-01B†	09/14/2004	07/28/2008	8	3.6	28.5	13.8	13.2
620900040280-01S	09/07/2004	07/01/2013	16	2.8	33.5	12.7	10.7
620900040280-02	09/14/2004	07/01/2013	16	3.6	45.3	16.2	11.4
620900040280-03	09/14/2004	07/01/2013	16	3.5	34.0	14.1	9.3
620900040280-04	09/14/2004	07/01/2013	14	3.1	38.9	15.1	11.8
620900040280-05	09/14/2004	07/28/2008	8	1.9	25.7	12.5	14.3
Overall Surface Samples*			70	1.9	45.3	14.2	11.3

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.

*Bottom data were excluded

Table 2-4 summarizes chlorophyll-*a* measurements collected from Lake Humphreys from 2002 through 2014. Pooling data from surface level sites, chlorophyll-*a* levels averaged 23.8 µg/L (TSI = 61.7). According to the 2013 BUMP Report, using water quality samples collected between October 2011 and August 2012, the TSI calculated for Lake Humphreys was 65 (OWRB 2013). As stipulated in the Implementation Procedures for Oklahoma's Water Quality Standards (785:46-15-3(c)) the most recent 10 years of water quality data are used as the basis for evaluating the beneficial use support for lakes (OWRB 2013a). Chlorophyll-*a* data collected from Lake Humphreys WQM stations between 2002 and 2014 were used to support the decision to place the lake on the DEQ 2012 §303(d) list (DEQ 2013) for non-support of the Public and Private Water Supply Use in an SWS lake. Water quality data are provided in Appendix B.

Table 2-4 Summary of Chlorophyll-*a* Measurements in Lake Humphreys (all values in µg/L)

Station ID	Minimum Date	Maximum Date	Number of Samples	Minimum	Maximum	Average	Median
310810040150-01B†	11/20/2002	10/07/2008	11	5.2	38.6	18.6	15.8
310810040150-01S	11/20/2002	07/09/2014	21	2.9	81.9	25.6	23.3
310810040150-02	11/20/2002	07/09/2014	22	5.1	79.5	26.9	22.5
310810040150-03	11/20/2002	07/09/2014	22	5.0	84.7	28.5	26.4
310810040150-04	11/20/2002	08/22/2007	11	1.0	33.9	13.7	11.4
310810040150-05	11/20/2002	08/22/2007	11	4.8	41.0	20.7	16.2
Overall Surface Samples*			87	1.0	84.7	23.8	17.7

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.

*Bottom data were excluded

2.2.2 Nutrient Data Summary

During the years from 1998 to 2013, total nitrogen levels in Carl Blackwell Lake averaged approximately 0.81 mg/L, and total phosphorus levels averaged 0.04 mg/L (Table 2-5). In Lake Humphreys, total nitrogen levels averaged approximately 1.03 mg/L, and total phosphorus levels averaged 0.04 mg/L (Table 2-6). Total nitrogen is calculated as the sum of Kjeldahl nitrogen and two inorganic forms in different oxidation states: nitrate and nitrite nitrogen. Kjeldahl nitrogen is the sum of organic nitrogen and ammonia nitrogen. Total phosphorus is measured directly and composed of organic phosphorus, inorganic orthophosphorus, and inorganic polyphosphates.

Table 2-5 Summary of Average Nutrient Measurements in Carl Blackwell Lake (all values in mg/L)‡

Station ID	Data Period	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate + Nitrite	Phosphorus, Ortho	Phosphorus, Total
620900040280-01B†	05/98 – 07/13	0.23	0.73	0.19	0.04	0.08
620900040280-01S	05/98 – 07/13	0.06	0.63	0.19	0.02	0.03
620900040280-02	05/98 – 07/13	0.08	0.65	0.19	0.02	0.04
620900040280-03	05/98 – 07/13	0.06	0.61	0.19	0.02	0.03
620900040280-04	05/98 – 07/13	006	0.67	0.18	0.03	0.05
620900040280-05	10/01 – 07/08	0.06	0.58	0.13	0.01	0.03
Overall Surface Samples*		0.06	0.63	0.18	0.02	0.04

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.

*Bottom data were excluded

‡ Non-detects were averaged at the detection limit. Detection limits for nitrogen and phosphorus species are 0.05 and 0.005 mg/L, respectively (Appendix B-1 includes all the measurements used for this summary table).

Table 2-6 Summary of Average Nutrient Measurements in Lake Humphreys (all values in mg/L)‡

Station ID	Data Period	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate + Nitrite	Phosphorus, Ortho	Phosphorus, Total
310810040150-01B†	11/00 – 02/07	0.31	1.2	0.22	0.08	0.12
310810040150-01S	11/00 – 07/14	0.08	0.99	0.12	0.01	0.04
310810040150-02	11/00 – 07/14	0.07	0.98	0.13	0.02	0.04
310810040150-03	11/00 – 07/14	0.07	1.0	0.12	0.02	0.05
310810040150-04	05/03 – 08/07	0.05	0.76	0.12	0.01	0.04
310810040150-05	05/03 – 08/07	0.06	0.84	0.12	0.01	0.05
Overall Surface Samples*		0.07	0.91	0.12	0.01	0.04

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.

*Bottom data were excluded

‡ Non-detects were averaged at the detection limit. Detection limits for nitrogen and phosphorus species are 0.05 and 0.005 mg/L, respectively (Appendix B-2 includes all the measurements used for this summary table).

2.3 Water Quality Target

The Code of Federal Regulations (40 CFR §130.7(c)(1)) states that, "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." The water quality target established for each lake must demonstrate compliance with the numeric criterion prescribed for SWS lakes in the Oklahoma WQS (OWRB 2013). Therefore, the water quality target established Carl Blackwell Lake and Lake Humphreys is to achieve a long-term average in-lake concentration of 10 µg/L for chlorophyll-*a*. Carl Blackwell Lake is also included in the 303(d) list for turbidity and color. These water quality issues will be addressed specifically at a future date.

SECTION 3
POLLUTANT SOURCE ASSESSMENT

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. This section includes an assessment of the known and suspected sources of nutrients contributing to the eutrophication of Carl Blackwell Lake and Lake Humphreys. Nutrient sources identified are categorized and quantified to the extent that reliable information is available. Generally, nutrient loadings causing eutrophication of lakes originate from point or nonpoint sources of pollution. Point sources are permitted through the NPDES program. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from land activities that contribute nutrient loads to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources. The following discussion provides a general summary of the point and nonpoint sources of nutrients emanating from the contributing watersheds of each lake.

3.1 Assessment of Point Sources

Under 40 CFR §122.2, a point source is described as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. NPDES-permitted facilities classified as point sources that may contribute nutrient loading include:

- Continuous Point Source Dischargers
  - NPDES municipal wastewater treatment facilities (WWTF)
  - NPDES Industrial WWTF Discharges
- NPDES municipal separate storm sewer system (MS4) discharges
  - Phase 1 MS4
  - Phase 2 MS4
- NPDES No-discharge WWTF
- Sanitary sewer overflow (SSO)
- NPDES Concentrated Animal Feeding Operation (CAFO)

There are no CAFOs, no-discharge facilities, MS4, or continuous point source discharges within the contributing watersheds of Carl Blackwell Lake or Lake Humphreys.

3.2 Estimation of Existing Pollutant Loads

As previously stated, there are no continuous point source or MS4 discharge facilities within the watersheds of Carl Blackwell Lake or Lake Humphreys. Therefore, external loading to the lakes originate only from nonpoint sources. Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. The relatively homogeneous land use/land cover categories throughout the Study Area associated with forest, grasslands, and winter wheat have a strong influence on the origin and pathways of nutrient sources to surface water. Nutrient sources in rural watersheds originate from soil erosion, agricultural fertilization, residues from mowing and harvesting, leaf litter, and fecal waste deposited in the watershed by livestock. Causes of soil erosion can include natural causes such as flooding and winds, construction activities, vehicular traffic, and agricultural activities. Other sources of nutrient loading in a watershed include atmospheric deposition, failing onsite wastewater disposal (OSWD) systems, and fecal matter deposited in the watershed by wildlife, livestock, and pets. The following sections provide general information on nonpoint sources contributing nutrient loading within the Study Area.

3.2.1 SWAT Model Development for Pollutant Source Loadings

Given the lack of in-stream water quality data and pollutant source data available to quantify nutrient and sediment loading directly from the tributaries of Carl Blackwell Lake and Lake Humphreys, a watershed loading model – the Soil and Water Assessment Tool (SWAT 2012) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2011). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. Major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management. Two separate SWAT models were developed: one to determine watershed loadings to Lake Carl Blackwell and a second one to estimate watershed loadings to Lake Humphreys. Brief descriptions of inputs and calibration of each SWAT model are presented in Appendices C and D. A summary of the SWAT modeling of pollutant sources is provided below.

There are no stream flow gages or water quality monitoring stations in the tributaries to Carl Blackwell Lake. To calibrate the SWAT model, it was necessary to extend the modeled area to encompass watersheds with stream flow gages and nutrient concentration measurements. Thus, the SWAT model simulated portions of two adjacent watersheds: Lower Cimarron-Skeleton (HUC 11050002) and Lower Cimarron (HUC 11050003). The modeled domain displayed in Figure 3-1 is a 3,010 square mile area that includes the contributing watershed of the lake. The main streams located in the modeled domain are the Cimarron River, Skeleton Creek, Stillwater Creek, Cottonwood Creek, and Kingfisher Creek.

The modeled watershed is predominantly rural with a few small cities and towns, including all or parts of Stillwater, Guthrie, Piedmont, The Village, Warr Acres, and Cushing. The modeled area was divided into 97 sub-watersheds (Figure 3-1) based on the National Elevation Dataset (http://ned.usgs.gov) and the National Hydrography Dataset (http://nhd.usgs.gov) of the USGS. The watershed of Carl Blackwell Lake is outlined in black in Figure 3-1. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

Point source discharges of pollutants in the modeled watershed that included Carl Blackwell Lake were included in the SWAT model using discharge monitoring reports (DMR) to indicate flows and loads. OSWD systems (primarily septic systems) were not included in the SWAT model. Using data from the 1990 census to estimate a density of household with OSWD systems, it was estimated that there were 17,989 OSWD systems within the simulated watershed. Of these, approximately 210 OSWD systems were estimated to lie within the Carl Blackwell Lake watershed (< 0.1 per acre). More recent OSWD system data are not available. Because of the very low density of OSWD systems within the model watershed, they are not expected to be a major contributor of nutrient loadings and, thus, they were not included in the SWAT model for Carl Blackwell Lake.

There are no stream flow gages or water quality monitoring stations on the tributaries to Lake Humphreys. To calibrate the SWAT model, it was necessary to extend the modeled area to encompass watersheds with stream flow gages and nutrient concentration measurements. Thus, the SWAT model simulated portions of two adjacent watersheds: Upper Washita (HUC 11130302) and Middle Washita (HUC 11130303). The modeled domain displayed in Figure 3-2 is a 2,640 square mile area that includes the contributing watershed of Lake Humphreys. The main streams located in the modeled domain are the Washita River, Little Washita River, Rush Creek, and Wildhorse Creek.

The modeled watershed for Lake Humphreys is predominantly rural with a few small cities and towns, including all or parts of Chickasha, Pauls Valley, Anadarko, Ninnekah, Bradley, Lindsay, and Erin Springs. The modeled area was divided into 106 subwatersheds (Figure 3-2) based on the National Elevation Dataset (http://ned.usgs.gov) and the National Hydrography Dataset (http://nhd.usgs.gov) of the USGS. The watershed of Lake Humphreys is outlined in black in Figure 3-2. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

Point source discharges of pollutants in the modeled watershed were included in the SWAT model using DMRs to indicate flows and loads. OSWD systems were not included in the SWAT model. Using data from the 1990 census to estimate a density of household with OSWDs, it was estimated that there were 9,997 OSWD systems within the modeled watershed. Of these, approximately 136 OSWD systems were estimated to lie within the Lake Humphreys watershed (< 0.01 system per acre). More recent OSWD data are not available. Because of the very low density of OSWD systems within the model watershed, they are not expected to be a major contributor of nutrient loadings and, thus, they were not included in the SWAT model of the Lake Humphreys watershed.

For both SWAT models, soil data were derived from the STATSGO State Soil Geographic Database of the United States Department of Agriculture (USDA) Natural Resource Conservation Service (http://soils.usda.gov/survey/geography/statsgo/). Land use and land cover data were derived from the USDA NASS 2013 Cropland Data Layer (http://www.nass.usda.gov/research/Cropland/SARS1a.htm) (USDA 2014). County-level summaries of annual cattle population estimates from the NASS were evenly distributed across pasture land (USDA 2012). Soil available phosphorus concentrations were the county averages for the period 1994 to 2001 from the Oklahoma State University Department of Plant and Soil Science (Storm et al. 2000).

Figure 3-1 SWAT Model Segmentation and Calibration Stations (Carl Blackwell Lake Model)

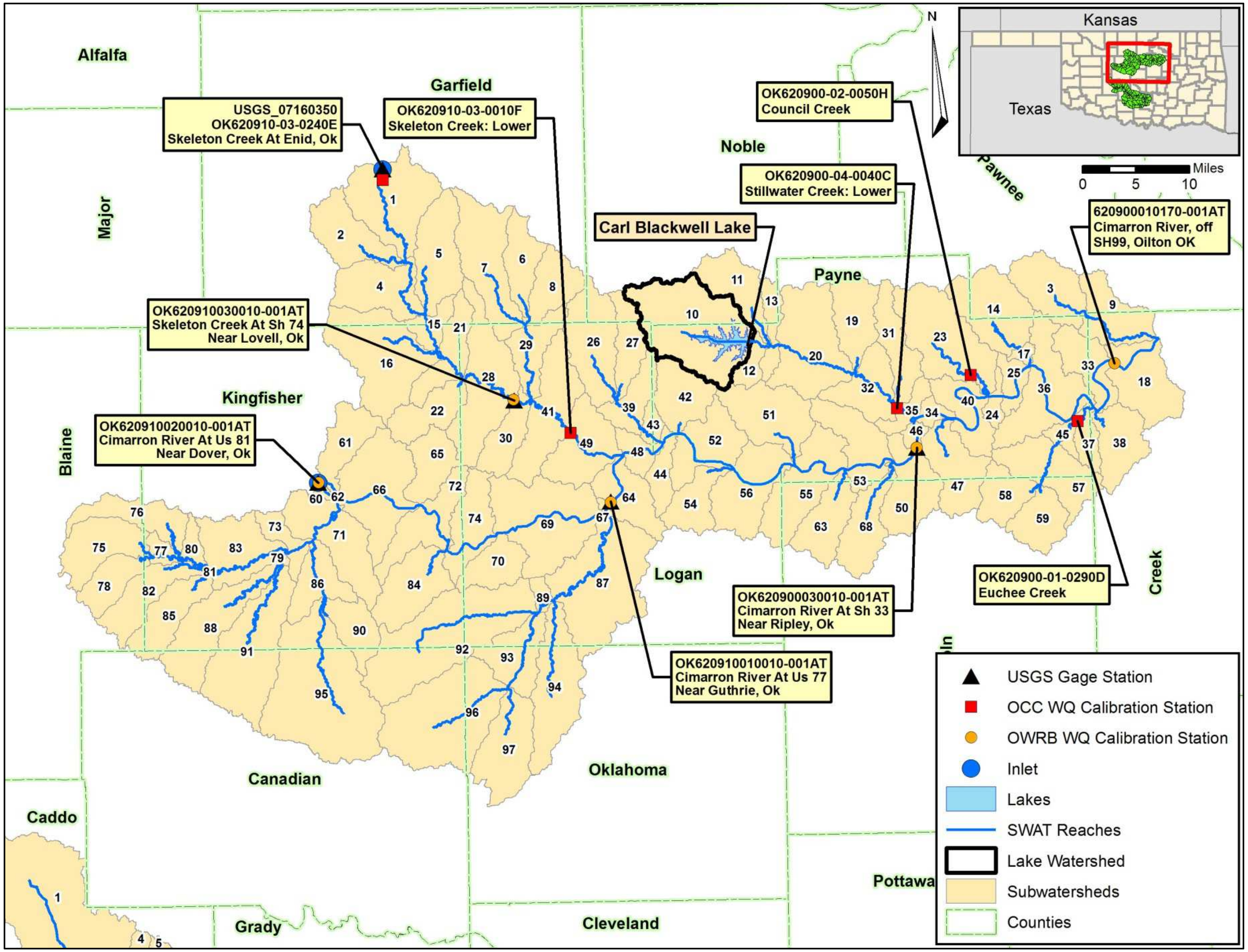
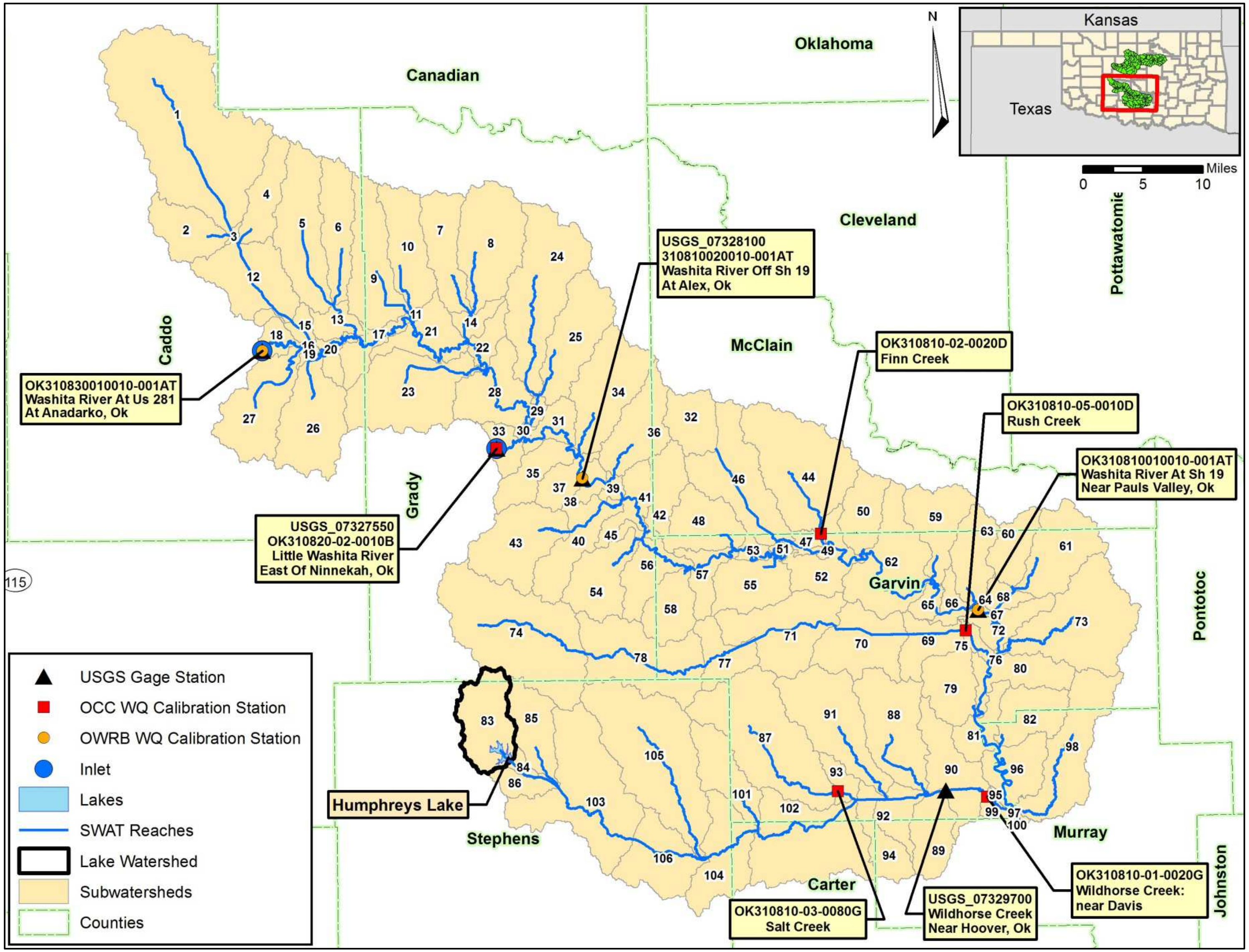


Figure 3-2 SWAT Model Segmentation and Calibration Stations (Lake Humphreys Model)



A 20-year period (1994 - 2013) was simulated in the SWAT models. However, the first four years were considered a "spin-up" period for stabilizing model initial conditions, and the model output consisted of only the latter 16 years (1998 - 2013). The variables simulated in SWAT included flow, organic phosphorus, mineral ortho-phosphorus, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and total suspended solids.

Calibration of SWAT Model for Carl Blackwell Lake

The SWAT hydrologic calibration was based on flow data available at the USGS gages located on Skeleton Creek at State Highway (SH) 74 near Lovell, OK (USGS Station 07160500), Cimarron River near Guthrie, OK (USGS Station 07160000), and Cimarron River near Ripley, OK (USGS Station 07161450) (Figure 3-1). Primary calibration targets were annual flows, but modeled monthly flows, which are displayed in the graphs shown in Figure 3-3 and the resulting flow duration curves, were also compared to measured values. Overall, the model reproduces the annual flows within the 15 percent target[3] for most years, with overall errors below the target for all three locations (-5% for Skeleton Creek, -1% for Cimarron River near Guthrie, and -3% for Cimarron River near Ripley). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.879 and 0.833 for Skeleton Creek at SH 74, 0.932 and 0.933 for Cimarron River near Guthrie, and 0.904 and 0.905 for Cimarron River near Ripley. The high resulting coefficients indicate very good model performance for annual flows. Additional model calibration information is provided in Appendix C.

After hydrologic calibration, the SWAT-predicted nutrient concentrations were calibrated to the observed nutrient concentrations at six water quality stations (Figure 3-1):

- Skeleton Creek: Lower (OWRB monitoring site 620910030010-001AT),
- Cimarron River near Ripley, OK (OWRB monitoring site 620900030010-001AT – no TSS data-),
- Cimarron River near Guthrie, OK (OWRB monitoring site 620910010010-001AT),
- Council Creek (OCC monitoring site OK620900-02-0050H),
- Stillwater Creek: Lower (OCC monitoring site OK620900-04-0040C), and
- Euchee Creek (OCC monitoring site OK620900-01-0290D).

For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. In all cases, the SWAT model reproduced the average TP and TN concentrations within 25 percent of the measured averages[4] (Figure 3-4). In some instances, as shown in Table 7 of Appendix C, the model does not replicate particular nutrient species within the 25 percent target for a given period particular individual station. This is most likely a result of the limited amount of nutrient data available. However, the overall measures for the whole watershed are within the 25 percent target for all nutrient species. Furthermore, these slight variances for some of the nutrient species are not considered critical since the data results are used to develop annual average loading estimates in the lake

[3] As stated in Section B7 of the approved QAPP for the project, total annual flows are to be calibrated so that predicted values are within 15% of the measured values.

[4] As stated in Section B7 of the approved QAPP for the project, nutrients are to be calibrated so that the mean of the predicted values falls within 25% of the mean of the measured values.

water quality model BATHTUB. It should also be noted that monitoring data available for calibration are primarily from low to moderate flow conditions. As a result, there is more uncertainty on loading associated with high flow conditions.

Figure 3-3 Observed and SWAT Modeled Average Monthly Flows (Carl Blackwell Lake Model)

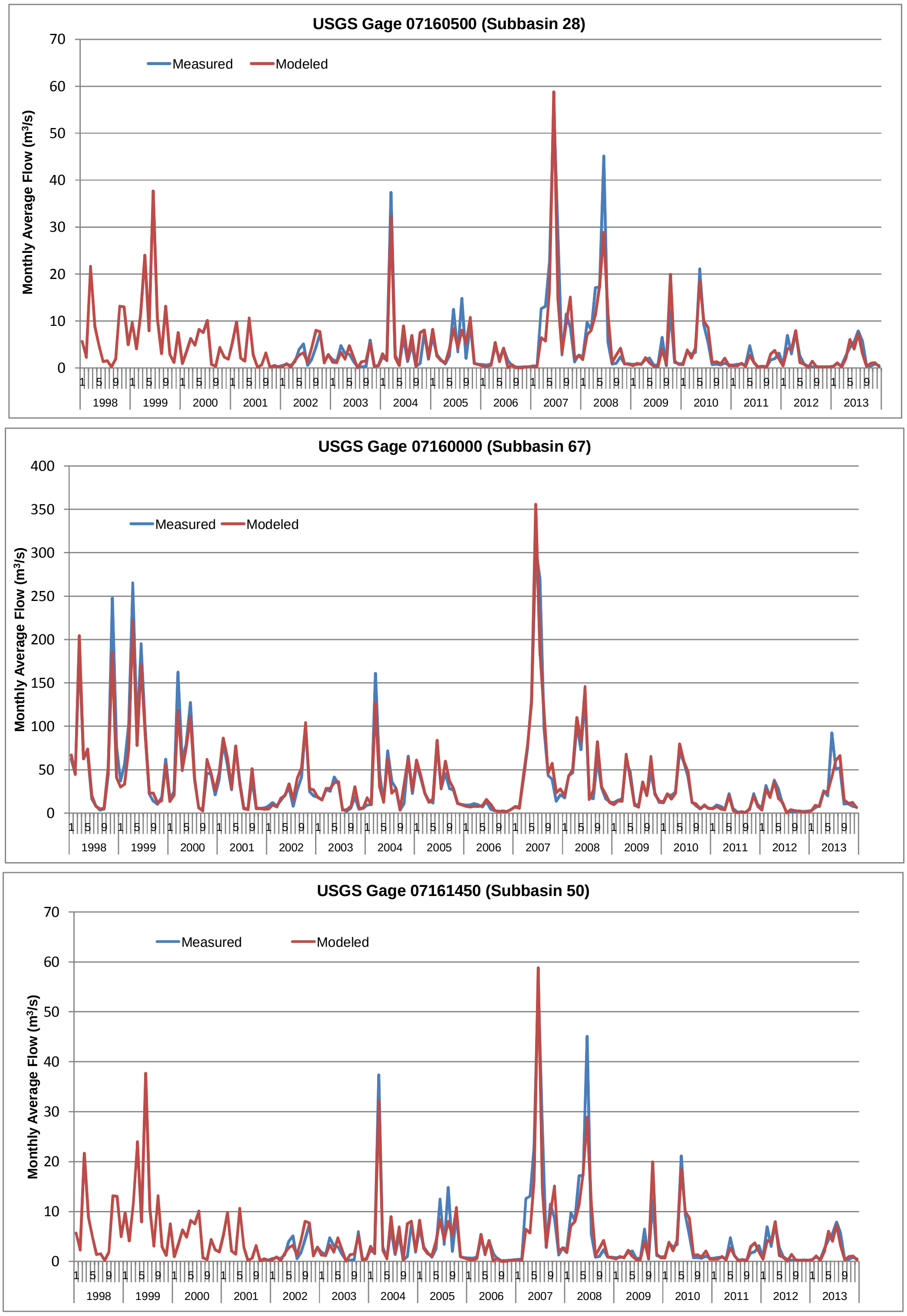
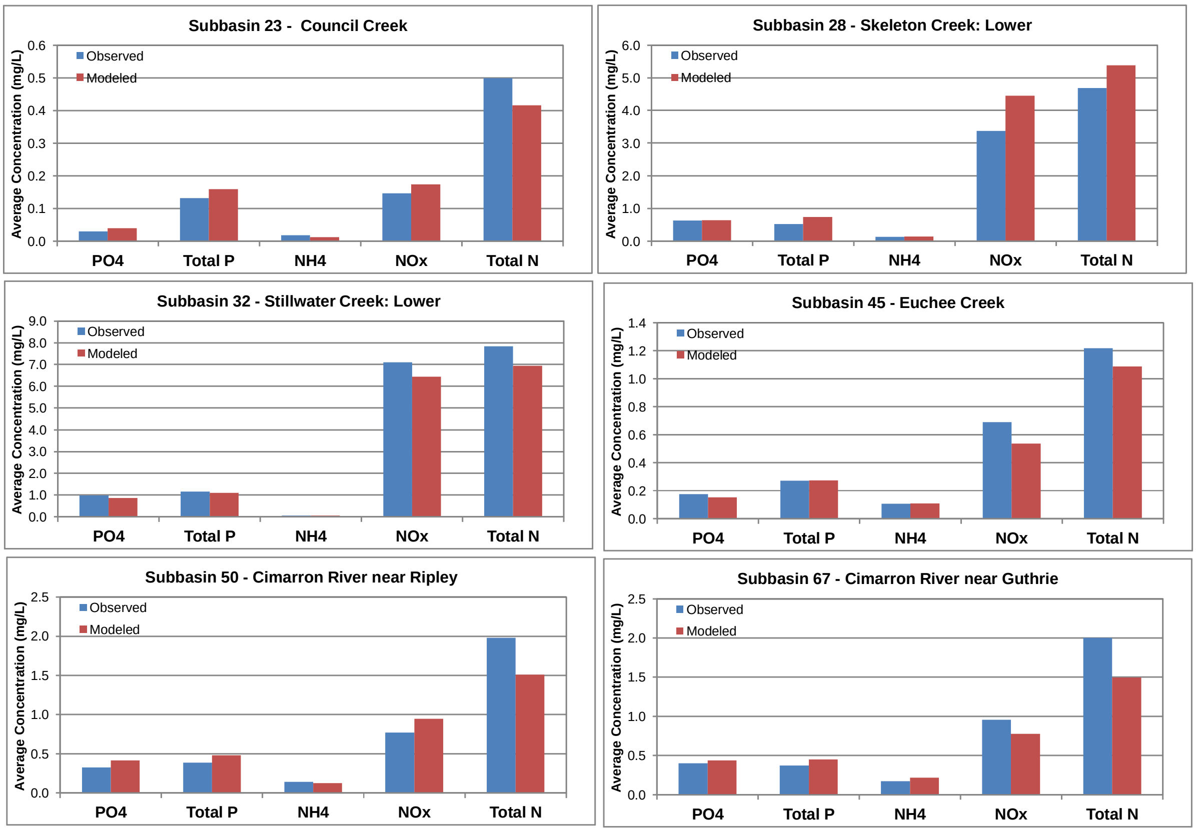


Figure 3-4 Observed and SWAT Modeled Nutrient Concentrations (Carl Blackwell Lake Model)



PO4 = mineral phosphate phosphorus; Total P = total phosphorus; NH4 = ammonia nitrogen; NOx = nitrate+nitrite nitrogen; Total N = total nitrogen

Calibration of SWAT Model for Lake Humphreys

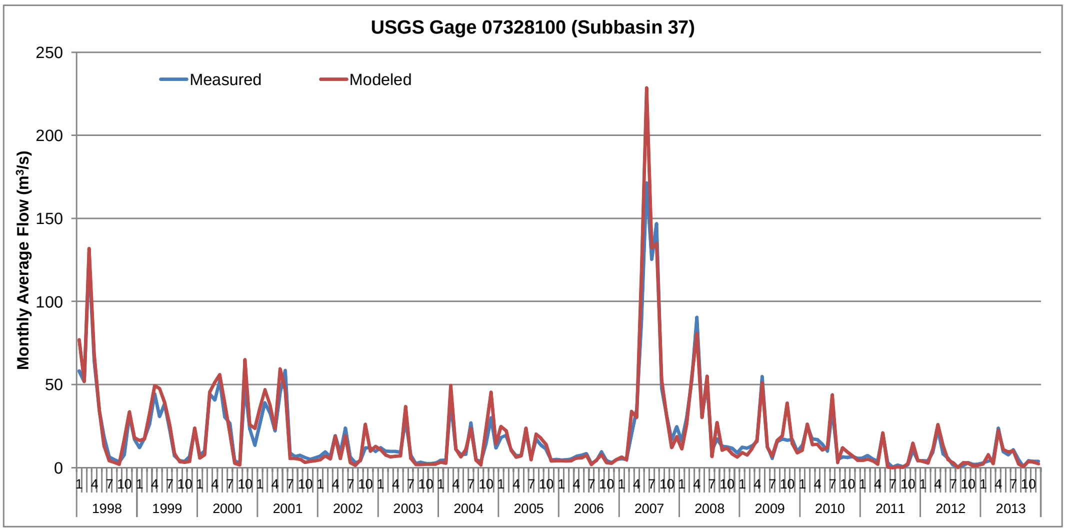
The SWAT hydrologic calibration was primarily performed based on flow data available at the USGS gages located on the Washita River at Alex, OK (USGS Station 07328100), Washita River near Pauls Valley, OK (USGS Station 07328500), and Wildhorse Creek near Hoover, OK (USGS Station 07329700) (Figure 3-2). Primary calibration targets were annual flows, but modeled monthly flows, which are displayed in the graphs shown in Figure 3-5 and the resulting flow duration curves, were also compared to measured values. Overall, the model reproduces the annual flows within the 15 percent target for most years, with overall errors below the target for Washita River near Pauls Valley and Wildhorse Creek (-2% and -1%, respectively), and above the target (7%) for Washita River at Alex. Resulting NSE coefficients and r^2 values were 0.924 and 0.954 for Washita River at Alex, 0.942 and 0.941 for Washita River near Pauls Valley, and 0.749 and 0.739 for Wildhorse Creek. The high resulting coefficients indicate very good model performance for annual flows. Additional model calibration information is provided in Appendix D.

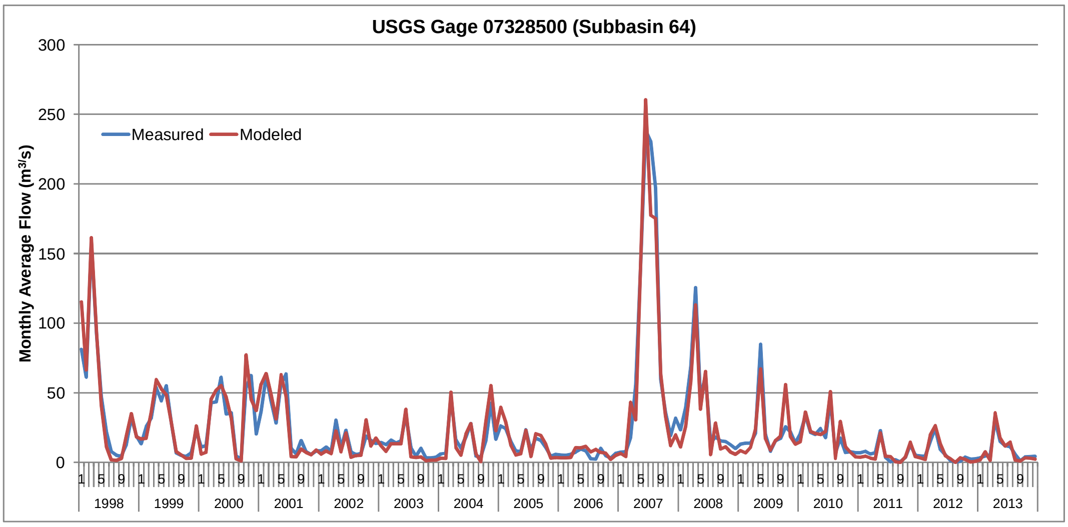
After hydrologic calibration, the SWAT-predicted nutrient concentrations were calibrated to the observed nutrient concentrations at six water quality stations (Figure 3-2):

- Washita River at Alex (OWRB monitoring site 310810020010-001AT-- no TSS data-),
- Washita River near Pauls Valley (OWRB monitoring site 310810010010-001AT),
- Finn Creek (OCC monitoring site OK310810-02-0020D),
- Rush Creek (OCC monitoring site OK310810-05-0010D),
- Salt Creek (OCC monitoring site OK310810-03-0080G), and
- Wildhorse Creek (OCC monitoring site OK310810-01-0020G).

For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. In all cases, the SWAT model reproduced the average TP and TN concentrations within 25 percent of the measured averages (Figure 3-4). In some instances, as shown in Table 7 of Appendix D, the model does not replicate particular nutrient species within the 25 percent target for a given period at a particular individual station. This is most likely a result of the limited amount of nutrient data available. However, the overall measures for the whole watershed are within 25 percent target for all nutrient species. Furthermore, these slight variances for some of the nutrient species are not considered critical since the data results are used to develop annual average loading estimates in the lake water quality model BATHTUB. It should also be noted that monitoring data available for calibration are primarily from low to moderate flow conditions. As a result, there is more uncertainty on loading under high flow conditions.

Figure 3-5 Observed and SWAT Modeled Average Monthly Flows (Lake Humphreys Model)





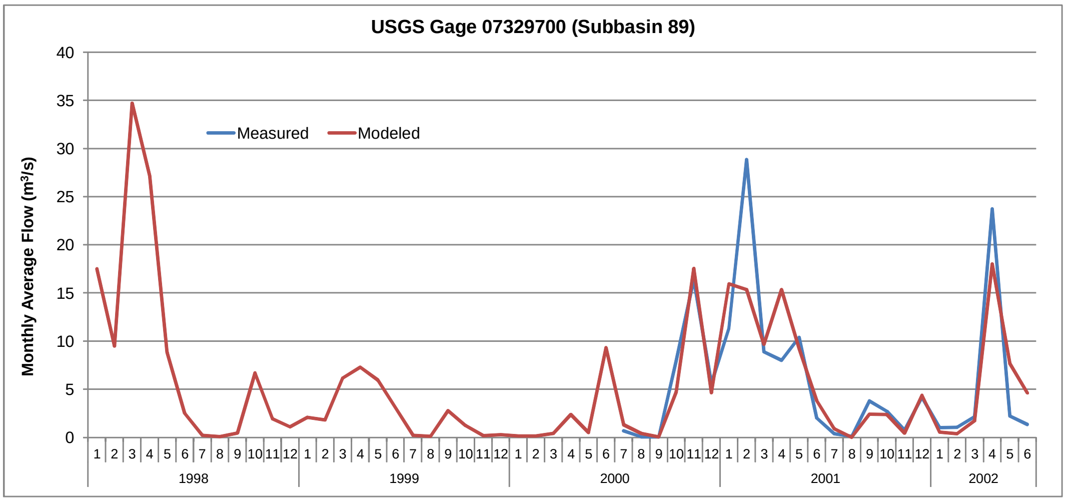
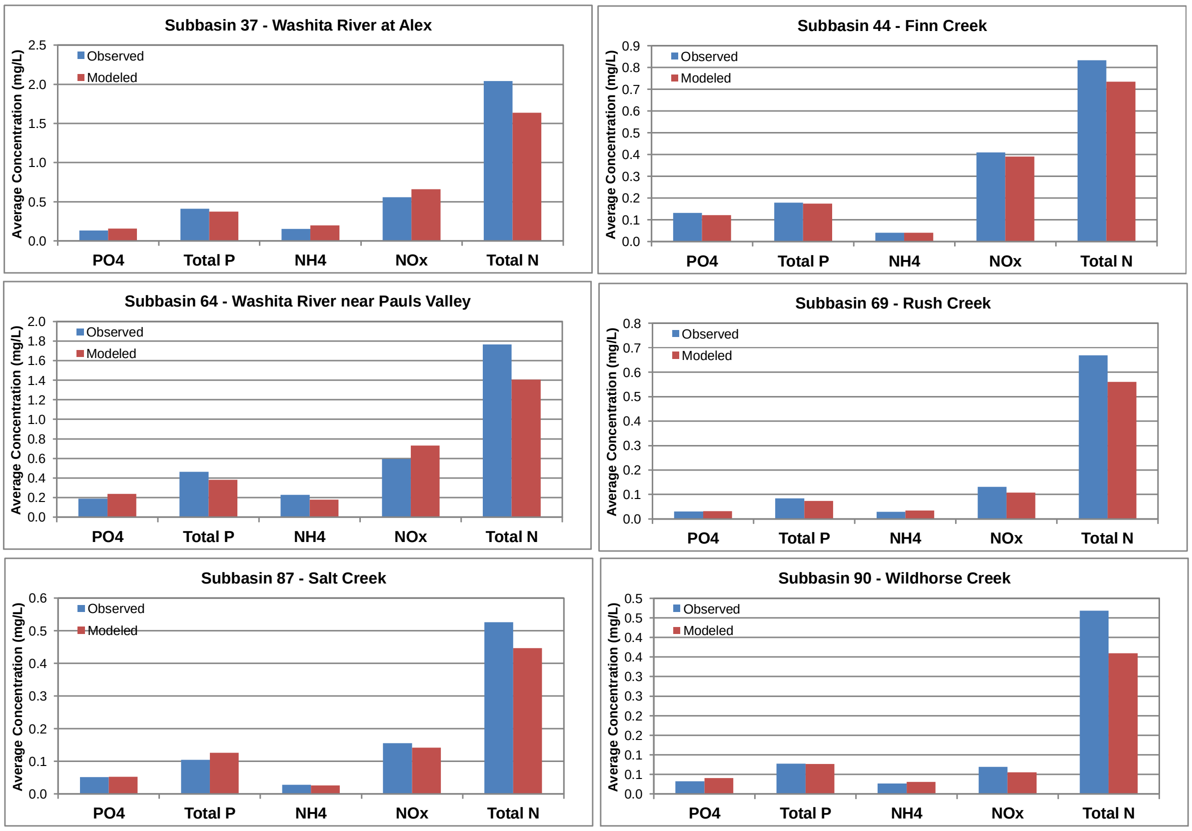


Figure 3-6 Observed and SWAT Modeled Nutrient Concentrations (Lake Humphreys Model)



PO4 = mineral phosphate phosphorus; Total P = total phosphorus; NH4 = ammonia nitrogen; NOx = nitrate+nitrite nitrogen; Total N = total nitrogen

3.2.2 Model-Estimated Nutrient Loading from Point and Nonpoint Sources

The SWAT models were used to estimate nutrient loads from processes such as soil erosion, agricultural fertilization, residues from mowing and harvesting, and fecal waste deposited in the field by livestock. Nutrient loading associated with atmospheric deposition is incorporated into the lake model BATHTUB (see Section 4). Fecal waste deposited in the watersheds by wildlife and pets is not considered to be a significant source of nutrient loading to the lake watersheds so it was not quantified as a model input. Nutrient loading from developed lands was simulated using land use-specific regression equations of Driver and Tasker (1988), as implemented in SWAT.

Based on the calibrated SWAT models, average loads of nutrients from each individual subwatershed were estimated for the period 1998 to 2013. For comparative purposes, phosphorus and nitrogen loads are expressed on an area basis in kilograms per hectare per year (kg/ha/yr) in Figures 3-7 through 3-10 for the two lakes. The average daily flows and loads into Carl Blackwell Lake and Lake Humphreys are displayed in Table 3-1. Under current conditions, Carl Blackwell Lake is estimated to receive a total annual load of 60,000 kg of phosphorus and 40,900 kg of nitrogen, on average, from nonpoint sources in its watershed.

Lake Humphreys is estimated to receive a total annual load of 5,400 kg of phosphorus and 8,500 kg of nitrogen, on average, from nonpoint sources in its watershed.

Table 3-1 Average Flows and Nutrient Loads Discharging to Carl Blackwell Lake and Lake Humphreys

Parameter	Carl Blackwell Lake	Lake Humphreys
Watershed Size (square miles)	77	32
Flow (m^3/day)	1.30E+05	2.45E+04
Organic Phosphorus (kg/year)	50,500	4,600
Mineral Ortho-Phosphorus (kg/year)	9,500	700
Total Phosphorus (kg/year)	**60,000**	**5,400**
Organic Nitrogen (kg/year)	21,000	7,800
Ammonia Nitrogen (kg/year)	400	100
Nitrate+Nitrite Nitrogen (kg/year)	19,500	600
Total Nitrogen (kg/year)	**40,900**	**8,500**

Figure 3-7 Average Total Phosphorus Loading from SWAT Subwatersheds (Carl Blackwell Lake Model)

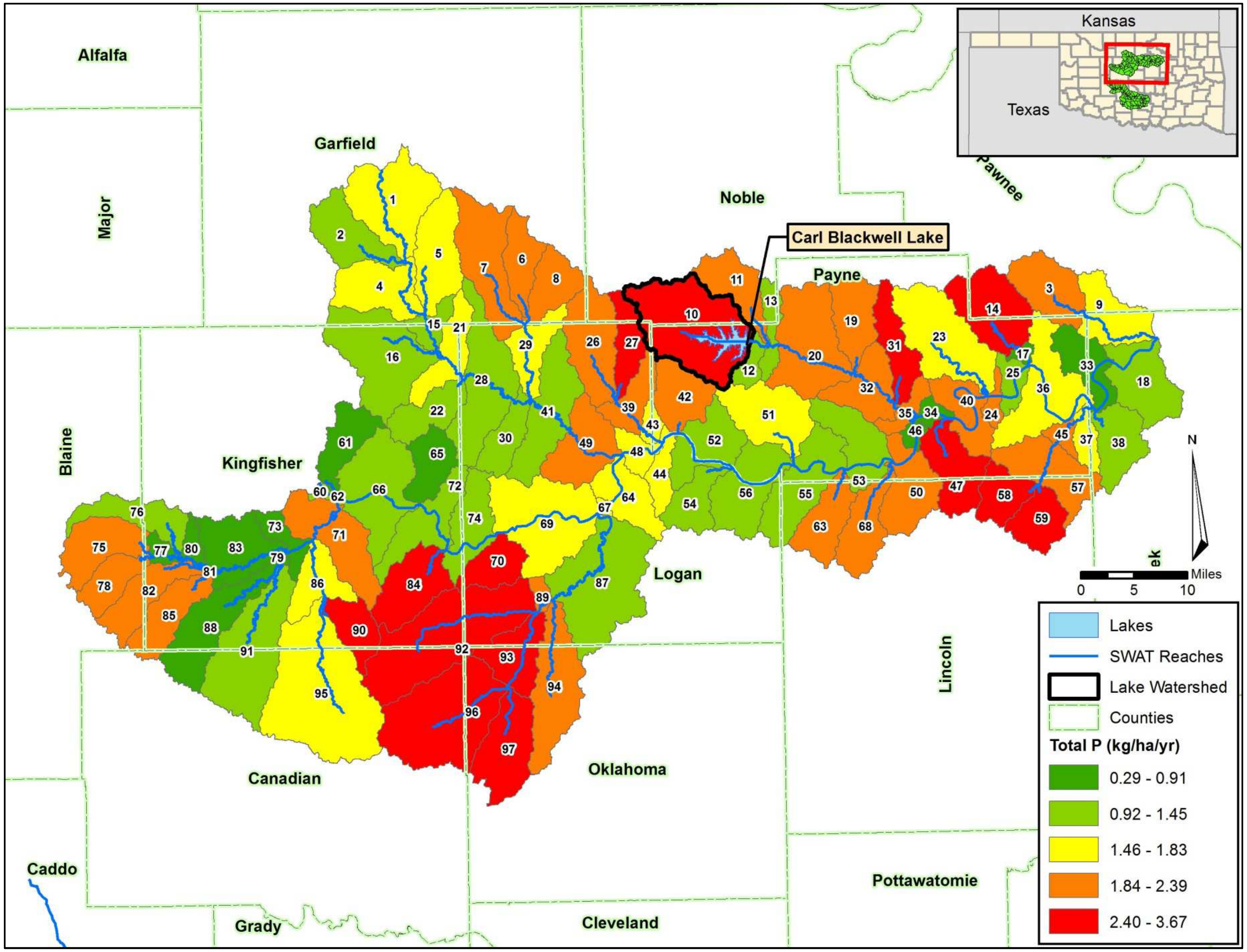


Figure 3-8 Average Total Nitrogen Loading from SWAT Subwatersheds (Carl Blackwell Lake Model)

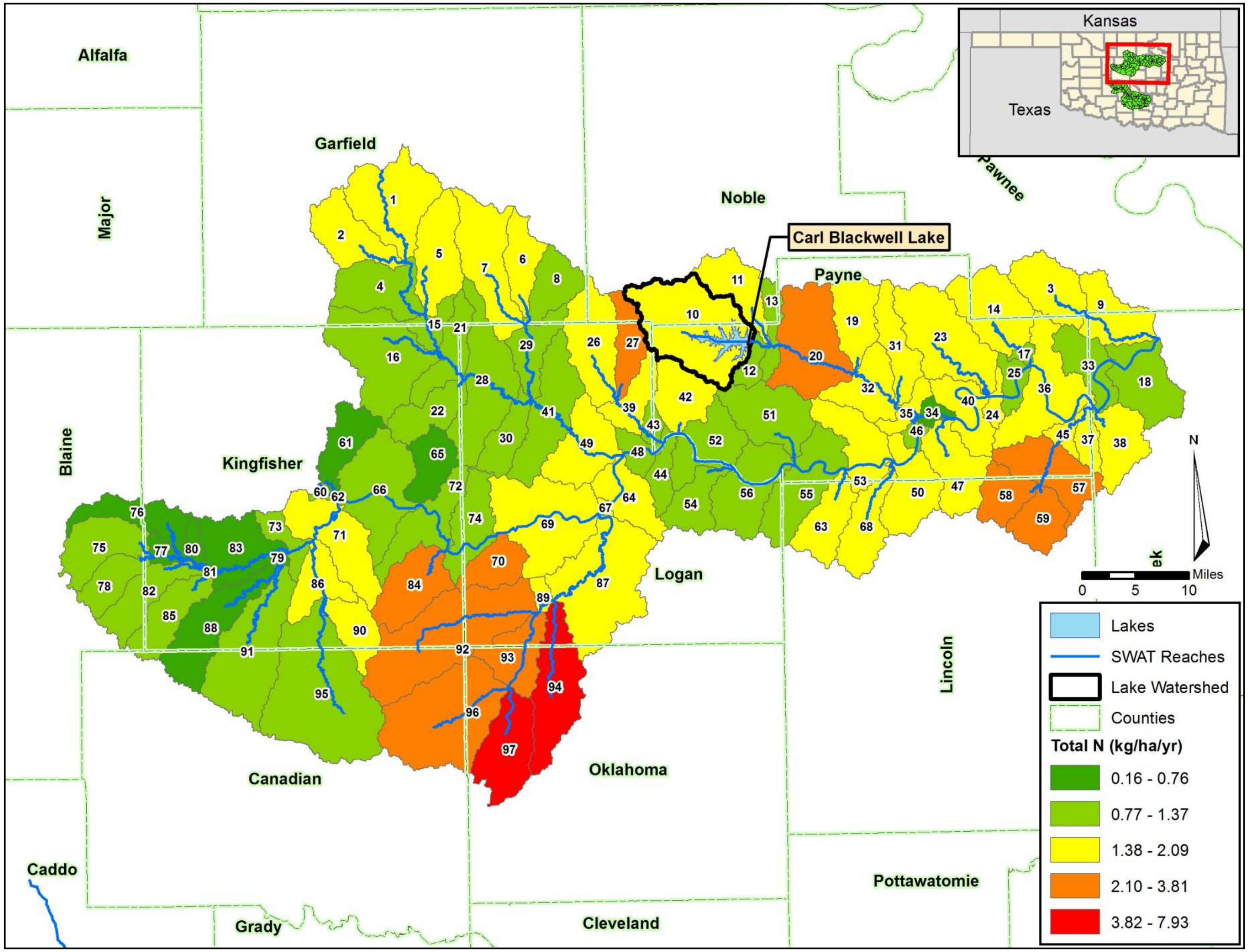


Figure 3-9 Average Total Phosphorus Loading from SWAT Subwatersheds (Lake Humphreys Model)

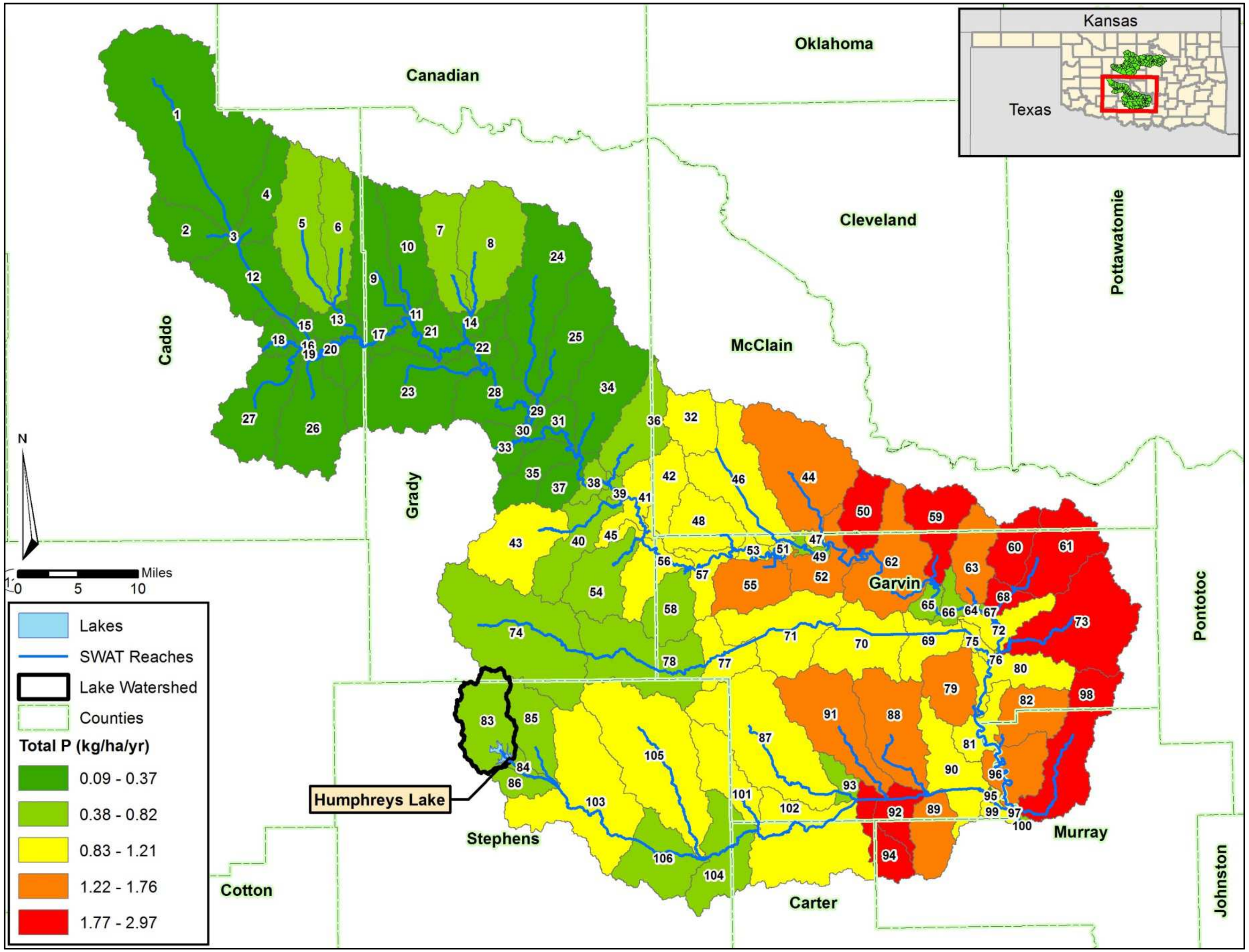
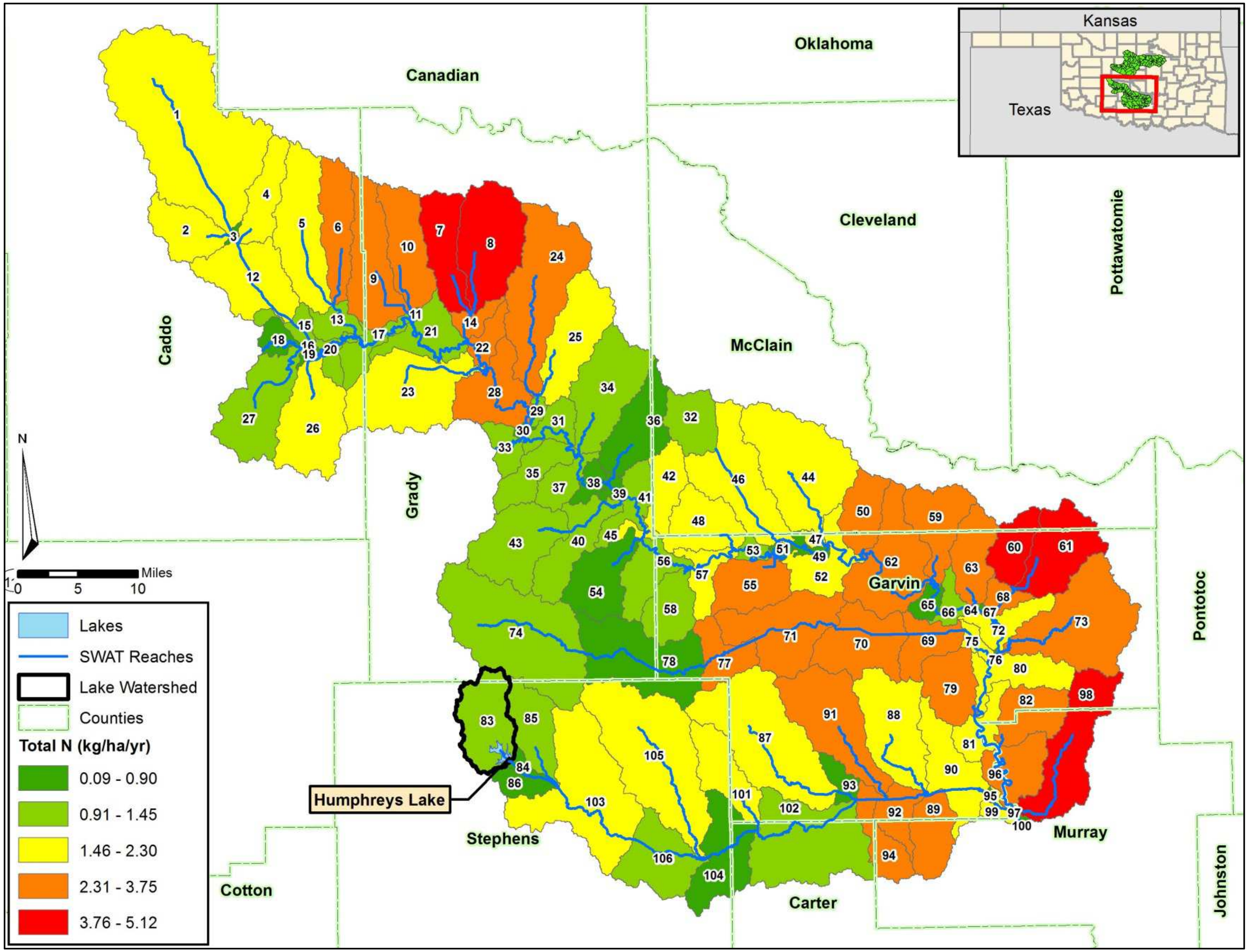


Figure 3-10 Average Total Nitrogen Loading from SWAT Subwatersheds (Lake Humphreys Model)



SECTION 4
TECHNICAL APPROACH AND METHODS

The objective of a TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. To ascertain the effect of management measures on in-lake water quality, it is necessary to establish a linkage between the external loading of nutrients and the waterbody response in terms of lake water quality conditions, as evaluated by chlorophyll-*a* concentrations. This section describes the water quality data analysis methods used to demonstrate the linkage between chlorophyll-*a* levels in Carl Blackwell Lake or Lake Humphreys and the nutrient loadings from their watersheds.

The report *Technical Methods Summary for Watershed and Water Quality Modeling of Sensitive Water Supply Lakes in Oklahoma* (Parsons 2010) provides a thorough description of the water quality modeling analysis. The subsections below summarize the inputs and results of the modeling approach used to establish TMDL calculations.

4.1 BATHTUB Model Description

The water quality linkage analysis was performed using the BATHTUB model (Walker 1986). BATHTUB is a USACE model designed to simulate eutrophication in reservoirs and lakes (USACE 2004). BATHTUB has been cited as an effective tool for reservoir and lake water quality assessment and management, particularly where data are limited. The model incorporates several empirical equations of nutrient settling and algal growth to predict steady-state water column nutrient and chlorophyll-*a* concentrations based on waterbody characteristics, hydraulic characteristics, and external nutrient loadings.

BATHTUB predicts steady-state concentrations of chlorophyll-*a*, total phosphorus, total nitrogen, water transparency, and a conservative substance (e.g., chloride or a dye tracer) in a waterbody under various hydrologic and loading conditions. To do this, the model requires inputs that describe the physical characteristics of each lake (e.g., depth, surface area), tributary flow rates and loadings (which can be estimated by BATHTUB or input from another model), and observed water quality concentrations to use as calibration targets.

4.2 BATHTUB Model Setup and Input Data

The model was run under average, steady-state conditions.

4.2.1 Lake Morphometry

BATHTUB allows the user to segment a lake into a hydraulic network. However, significant lake morphometry data are required to justify the complex assumptions inherent in partitioning a reservoir into multiple hydraulically linked segments. Bathymetric data for Carl Blackwell Lake and Lake Humphreys are available through the Oklahoma Water Resources Board (http://www.owrb.ok.gov/news/publications/lok/lok.php). Since each lake only has one major input and inflows from direct runoff are not expected to affect horizontal mixing, the lakes are considered relatively well-mixed horizontally. Thus, a single segment was deemed applicable for the reservoirs. Based on limited availability of both flow and water quality data, for the purposes of TMDL development, a single segment was determined as sufficient for both lakes. In addition, without monthly or seasonal data to characterize residence time of each lake, an averaging period of one year was used to depict the duration of mass-balance calculations (e.g., a single filling and emptying event in a year).

4.2.2 Meteorology

The BATHTUB model requires both precipitation and evaporation data. Precipitation data, summarized in Section 1.2, were derived from the Oklahoma MESONET system. Monthly water surface evaporation rates for several locations in Oklahoma were estimated by NOAA (http://www.nws.noaa.gov/oh/hrl/dmip/2/evap.html). The MESONET also calculates a daily pan evaporation value for its stations with measured climatological data (http://agweather.mesonet.org/index.php/data/section/soil_water). Using a conversion factor of 0.77, water surface evaporation can be estimated from the MESONET pan evaporation data. Based on these two sets of data, a rate of 76 inches per year was applied for Carl Blackwell Lake and Lake Humphreys.

4.2.3 Inflows and Loads

Key water quality parameters for BATHTUB input include total phosphorus, inorganic ortho-phosphorus, total nitrogen, and inorganic nitrogen. Output from the SWAT model, described in Section 3.2, was the primary source of data inputs to the BATHTUB model. Although SWAT can provide daily output, BATHTUB is a steady-state model and not appropriate for interpreting short-term responses of lakes to nutrients. Therefore, the long-term average annual loads from the SWAT modeled period were applied as inputs to BATHTUB.

BATHTUB also requires an estimate of atmospheric deposition of total and inorganic nitrogen and phosphorus. Atmospheric deposition can contribute a significant amount of nitrogen directly to a lake surface when the ratio of watershed area to lake surface area is low. Total atmospheric deposition of nitrogen was extracted from gridded annual estimates of the National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/). These estimates include wet and dry deposition of all nitrogen species; the estimates for the years 2000 to 2013 were averaged for the grid cells containing each lake (Table 4-1). These atmospheric loads represent approximately 33 and 36 percent, respectively, of the watershed loads of nitrogen to Carl Blackwell Lake and Lake Humphreys. Inorganic nitrogen deposition was estimated for both lakes as the sum of the average nitrate and ammonia nitrogen deposition measured by the National Atmospheric Deposition Program at site OK17 (Kessler Farm Field Laboratory, south of Norman) for the period 2000 to 2013. Reliable estimates of atmospheric loads of phosphorus are not available; the atmosphere is not expected to be a major source of phosphorus.

Table 4-1 Estimate of Atmospheric Loads

Atmospheric Loads	Estimated Areal Average Deposition to Carl Blackwell Lake (mg/m^2-yr)	Estimated Areal Average Deposition to Lake Humphreys (mg/m^2-yr)	Estimated Load to Carl Blackwell Lake (kg/year)	Estimated Load to Lake Humphreys (kg/year)	CV
Total Nitrogen	979	853	13,351	3,046	0.1
Inorganic Nitrogen	390	390	5,320	1,392	0.1

4.2.4 Empirical Equations

BATHTUB consists of a series of empirical equations calibrated and tested for lake application (for a description of the equations, see Model Documentation available online at http://wwwalker.net/bathtub/help/bathtubWebMain.html). These empirical relationships are used to calculate steady-state concentrations of total phosphorus, total nitrogen, chlorophyll-*a*, and water transparency based on the inputs and forcing functions. To predict each output (e.g., total phosphorus concentration), one of several built-in empirical equations must be selected. The BATHTUB model was run using the following options:

- Phosphorus and nitrogen balance: second-order decay rate function
- Chlorophyll-*a*: phosphorus, nitrogen, light, flushing
- Water transparency: Secchi depth vs. chlorophyll-*a* and turbidity

4.3 BATHTUB Model Calibrations and Output

The model was run under average existing conditions, and calibrated to measure in-lake water quality conditions (based on 1999-2013 data) using phosphorus, nitrogen, chlorophyll-a and Secchi disk calibration factors. Table 4-2 includes the calibration factors used for each lake.

Table 4-2 Calibration Factors Used for Lakes

Calibration Factor	Carl Blackwell Lake	Lake Humphreys
Total Phosphorus	9.02	4.47
Total Nitrogen	0.87	0.29
Chlorophyll-*a*	1.78	2.14
Secchi Disk	1	1

The model-predicted concentrations of total nitrogen, total phosphorus, chlorophyll-*a*, and Secchi depth under existing average conditions are compared to average measured concentrations from each lake in Table 4-3.

Table 4-3 Model Predicted and Measured Water Quality Parameter Concentrations

Water Quality Parameter	Carl Blackwell Lake		Lake Humphreys	
	Modeled	Measured	Modeled	Measured
Total Phosphorus (mg/L)	0.04	0.04	0.04	0.04
Total Nitrogen (mg/L)	0.81	0.81	1.04	1.03
Chlorophyll-*a* (µg/L)	14.2	14.2	23.8	23.8
Secchi depth (meters)	0.5	0.46	0.6	0.63

4.4 BATHTUB Model Sensitivity Analysis

Because of uncertainty and variability in input parameter values, BATHTUB modeling can result in output uncertainty. Quantifying this uncertainty is important for assessing the potential water quality of the lakes in this study. Given the large number of parameters in the model, a preliminary sensitivity analysis was performed before the Monte Carlo-based uncertainty analysis to identify the parameters contributing most to the uncertainty of model predictions. The Monte Carlo analyses will provide the probability of compliance with the water quality goal, given reductions in TN, TP, or both. Since TN and TP are then both candidates for TMDL reductions to control chlorophyll-*a* in the reservoirs these species, which can be used as inputs to the BATHTUB model, both must be omitted from the Monte Carlo analyses since their values are set to obtain compliance with the chlorophyll-*a* water quality targets.

The model output of concern is average chlorophyll-*a* concentration. A one-at-a-time sensitivity analysis of the model output was conducted using the minimum and maximum values for each of the parameters selected. Results obtained after completing the steps previously described are summarized in the Characterization Matrices for each lake presented as Figures 4-1 and 4-2 for Carl Blackwell Lake and Lake Humphreys. In these figures, the maximum change in chlorophyll-*a* is on the y-axis, while the percent change in chlorophyll-*a* relative to the change in the input parameter is on the x-axis. The top three or four most sensitive parameters were chosen for further analysis utilizing Monte Carlo techniques described below; these parameters are circled in each of the plots. Parameters chosen for Carl Blackwell Lake are inflow, non-algal turbidity, chlorophyll-*a* calibration factor, and mixed layer depth. The three parameters chosen for Lake Humphreys are inflow, chlorophyll-*a* calibration factor, and mixed layer depth.

Figure 4-1 Characterization Matrix for BATHTUB Parameters for Carl Blackwell Lake

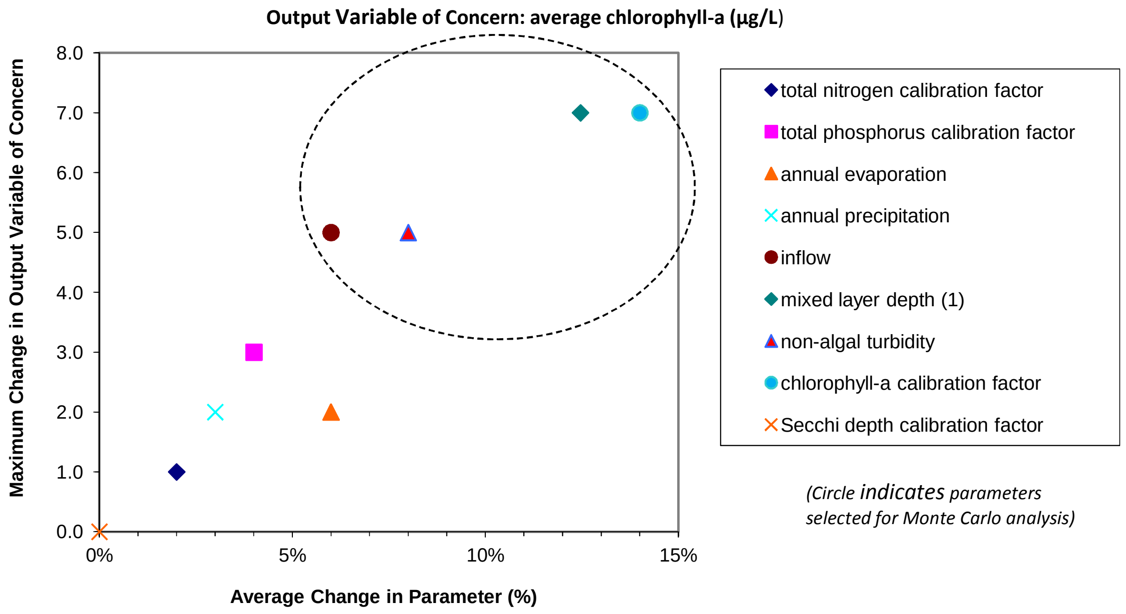
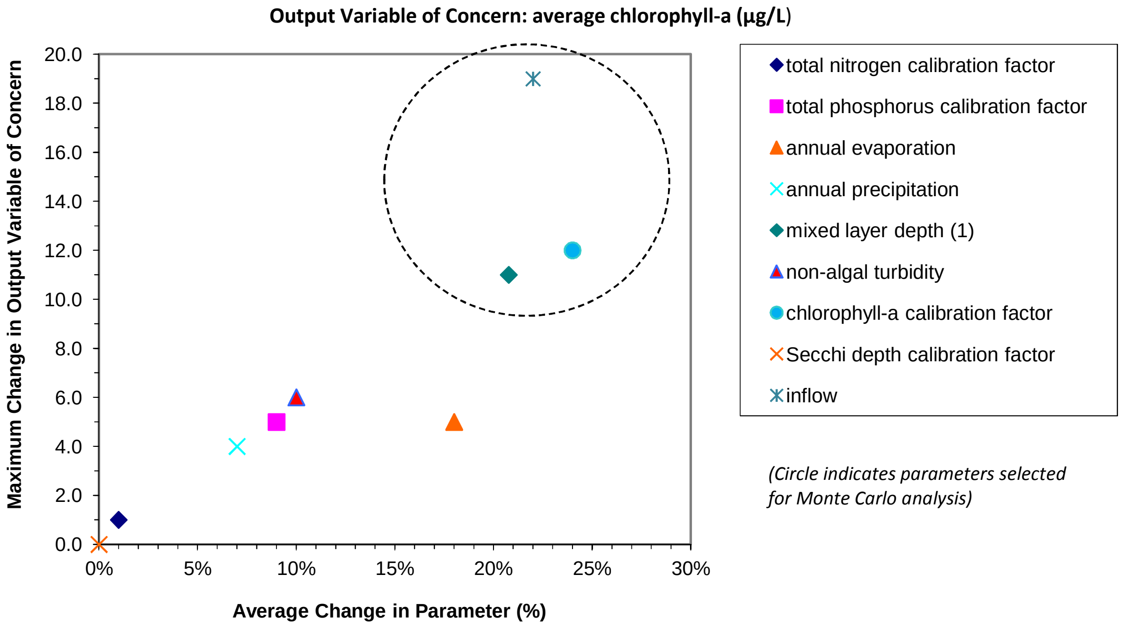


Figure 4-2 Characterization Matrix for BATHTUB Parameters for Lake Humphreys



4.5 BATHTUB Uncertainty Analysis

Based on the results of the sensitivity analysis described above, three or four parameters were selected for the uncertainty analysis. Those correspond to parameters that exhibited a strong influence on chlorophyll-*a* levels. The uncertainty analysis was conducted using Monte Carlo simulations (MCS) incorporating the parameters and distributions summarized in Table 4-4. The simulations were performed with nitrogen and phosphorus watershed loading levels that represent the minimum percent reduction (with nitrogen and phosphorus reduced approximately equally) predicted to meet the water quality standard of 10 µg/L chlorophyll-*a*. A second uncertainty analysis was done with nitrogen and phosphorus watershed loading reduced further to meet a water quality target of 9 µg/L chlorophyll-*a*, to provide a margin of safety to ensure that the water quality standards will be met. A detailed description of the Monte Carlo analysis is provided in *Technical Methods Summary for Watershed and Water Quality Modeling of Sensitive Water Supply Lakes in Oklahoma* (Parsons 2010). Means and standard deviations for the parameters used in the Monte Carlo simulations were calculated directly from the population of values where possible. In this application, however, the parameters of concern generally prove to be model parameters and factors that did not have a known population of potential values. As a result, for these parameters the mean was set to the calibrated value utilized in the calibrated model, and the standard deviation was an estimate of the potential variance of the parameter from the calibrated value. In this case, the mean and standard deviation serve to bound the selection of potential values for the selected Monte Carlo parameter.

Table 4-4 Selected Distribution of Parameters for BATHTUB Uncertainty Analysis

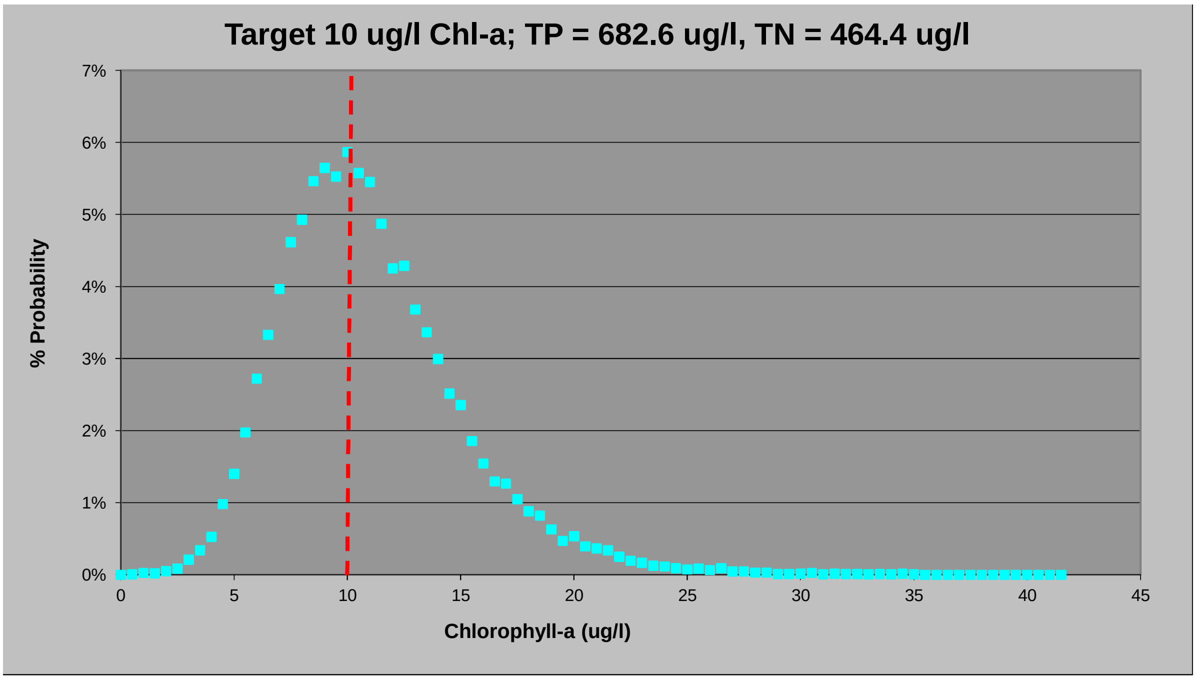
Parameter[†]	Definition	Distribution
a	Non-algal turbidity (1/m)	Normal (Blackwell: mean = 1.81, std. dev. = 0.7)
Kc	Calibration factor for chlorophyll-*a* (unitless)	Normal (Blackwell: mean = 1.78, std. dev. = 0.45; Humphreys: mean = 2.14, std. dev. = 0.45)
zmx	Mixed layer depth (m)	Normal (Blackwell: mean = 4.5, std. dev. = 0.5; Humphreys: mean = 4.5, std. dev. = 0.5)
Q	Inflow (10^6 m^3/year)	Normal (Blackwell: mean = 47.48, std. dev. = 4.8; Humphreys: mean = 8.94, std. dev. = 0.9)

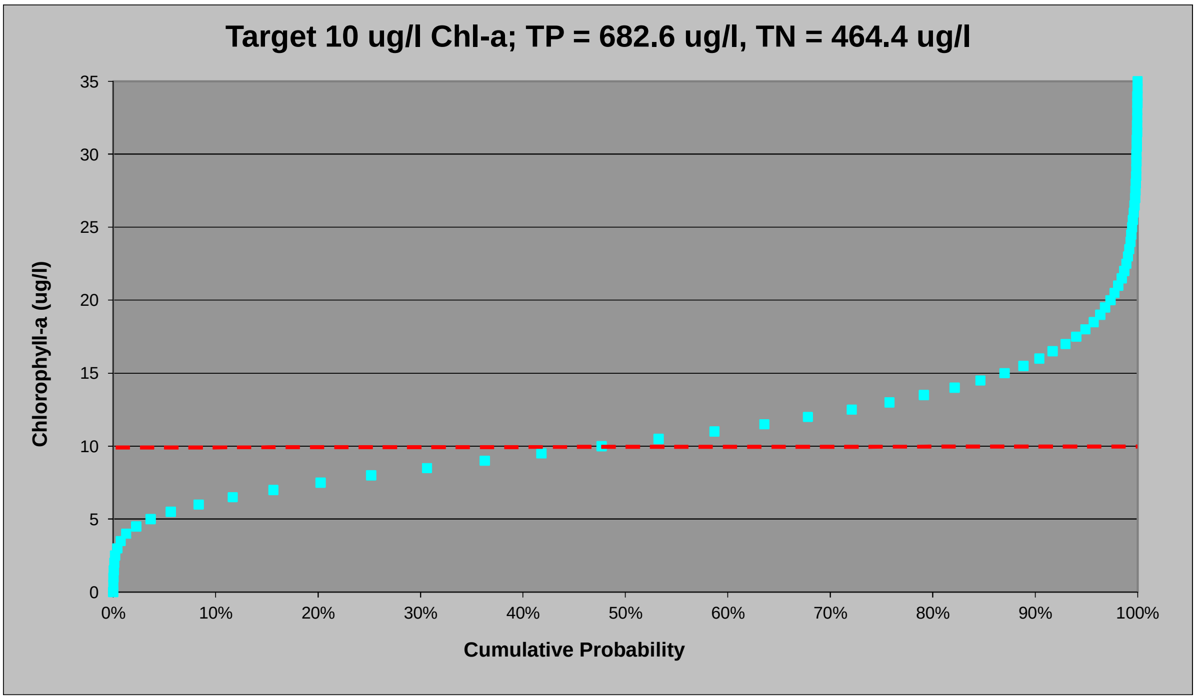
[†] The listed parameters were identified in a one-at-a-time sensitivity analysis to cause the most impact on modeled average chlorophyll-*a* concentrations.
st. dev. = standard deviation

Figure 4-3 shows probability and cumulative probability plots of average chlorophyll-*a* concentration for the 20,000 iterations of the MCS-based uncertainty analysis for Carl Blackwell Lake at loading levels calculated to meet a long-term target concentration of 10 µg/L chlorophyll-*a* level. The results indicate that the probability of exceeding 10 µg/L was greater than 50 percent at these loading levels. Figure 4-4 shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the uncertainty analysis with loading further reduced to incorporate a margin of safety (by using a target of 9 µg/L for chlorophyll-*a*). In this case the expected probability of exceeding 10 µg/L is less than 41 percent. Since the probability of meeting the 10 µg/L WQS is less than 50%, an explicit margin of safety needs to be included. Thus, the water quality target for Carl Blackwell Lake is set at 9 µg/L chlorophyll-*a*.

Figure 4-5 shows probability and cumulative probability plots of average chlorophyll-*a* concentration for the 20,000 iterations of the MCS-based uncertainty analysis for Lake Humphreys at loading levels calculated to meet a long-term target concentration of 10 µg/L chlorophyll-*a* level. As with Lake Carl Blackwell, the results indicate that the probability of exceeding 10 µg/L was greater than 50 percent at these loading levels. Figure 4-6 shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the uncertainty analysis with loading further reduced to incorporate a margin of safety (by using a target of 9 µg/L for chlorophyll-*a*). In this case the expected probability of exceeding 10 µg/L is less than 31 percent. Since the probability of meeting the 10 µg/L WQS is less than 50%, an explicit margin of safety needs to be included. Thus, the water quality target for Lake Humphreys is also set at 9 µg/L chlorophyll-*a*.

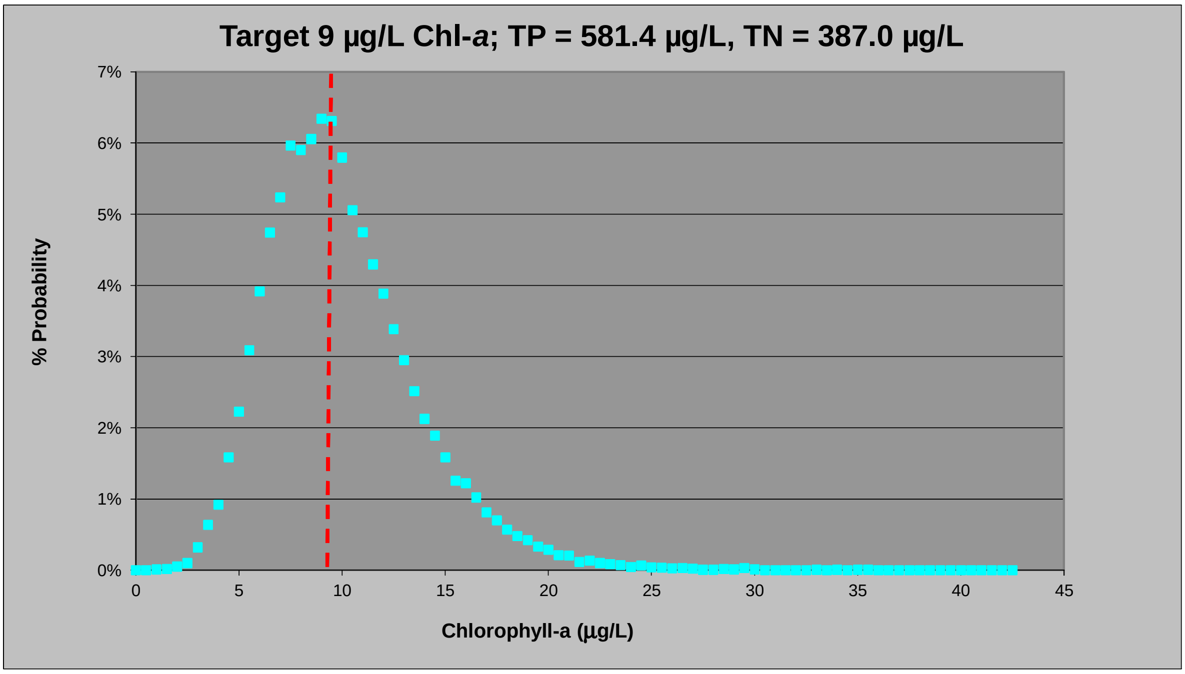
Figure 4-3 Uncertainty Analysis for Carl Blackwell Lake at 10 µg/L Chlorophyll-*a*

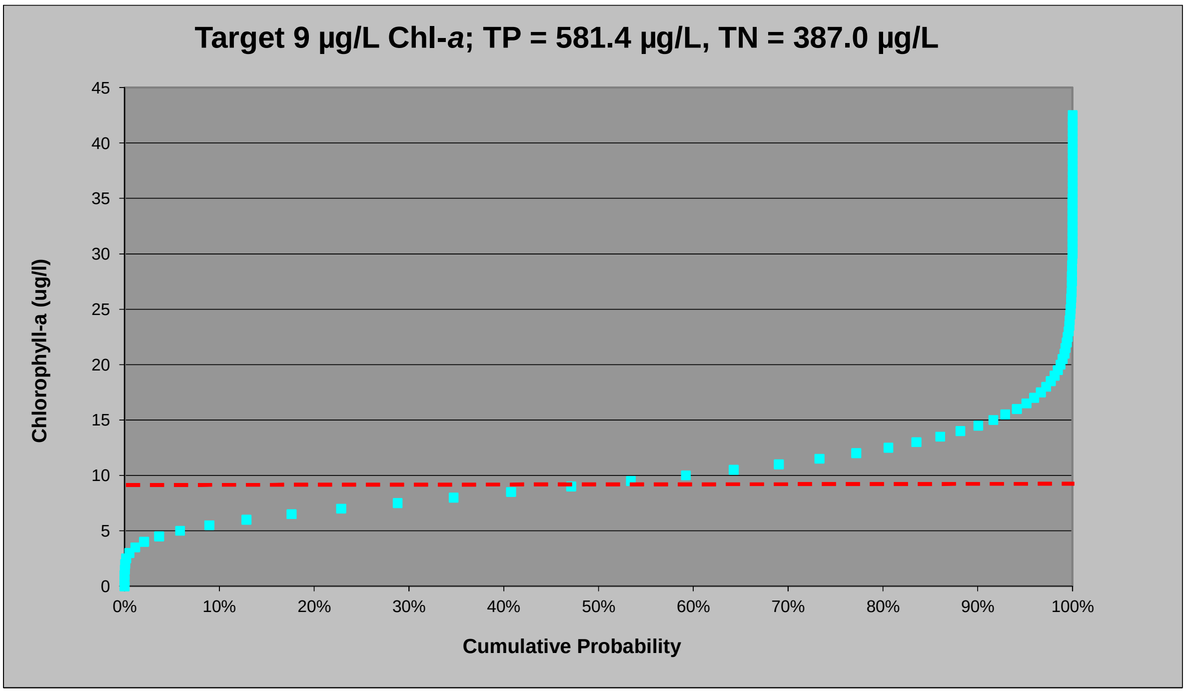




Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

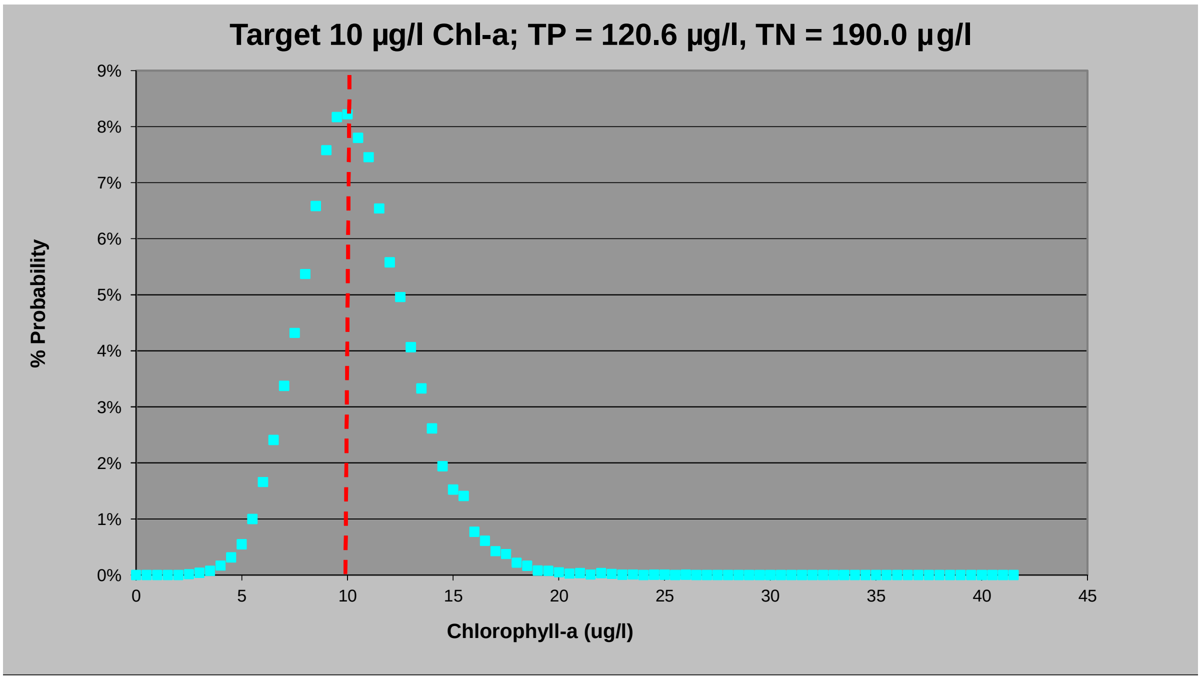
Figure 4-4 Uncertainty Analysis for Carl Blackwell Lake at 9 µg/L Chlorophyll-*a*

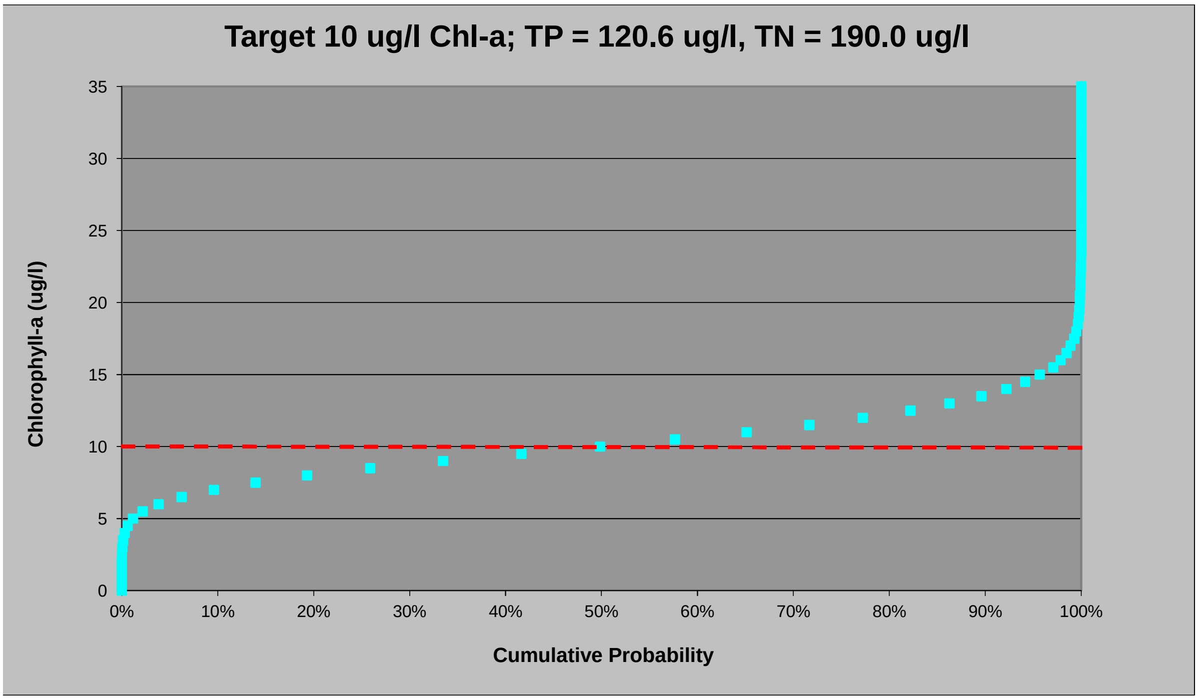




Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

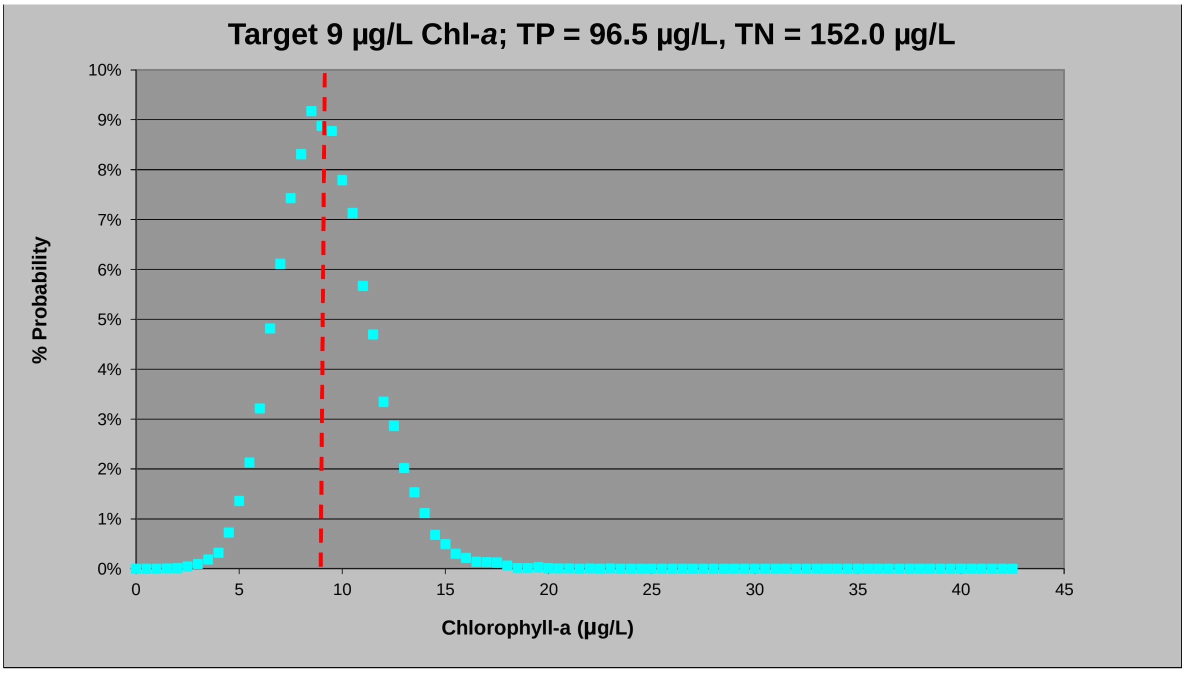
Figure 4-5 Uncertainty Analysis for Lake Humphreys at 10 µg/L Chlorophyll-*a*

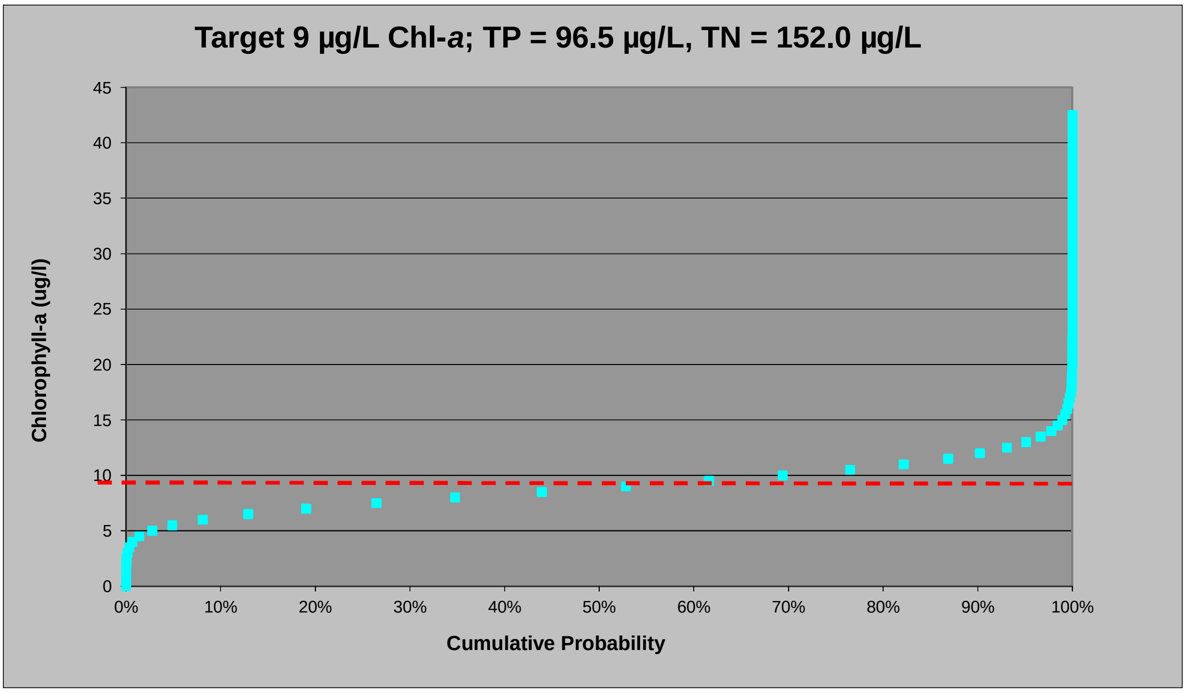




Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

Figure 4-6 Uncertainty Analysis for Lake Humphreys at 9 µg/L Chlorophyll-*a*





Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

4.6 Modeled Load Reduction Scenarios

A summary of the existing loads to Carl Blackwell Lake and Lake Humphreys simulated in BATHTUB is presented in Table 4-5.

Table 4-5 Existing Loads (in kg/yr)

Water Quality Parameter	Carl Blackwell Lake		Lake Humphreys	
	Watershed	Atmospheric	Watershed	Atmospheric
Total Phosphorus	60,000	0[a]	5,400	0[a]
Ortho-phosphorus	9,500	0[a]	700	0[a]
Total Nitrogen	40,900	13,351	8,500	3,046
Inorganic Nitrogen	19,900	5,320	700	1,392

[a] Atmospheric deposition is not expected to be a significant source of phosphorus.

Simulations were performed using the BATHTUB model to evaluate the effect of watershed loading reductions on chlorophyll-*a* levels. Atmospheric loads were maintained at their existing estimated levels. Simulations indicate that the water quality target of 9 µg/L chlorophyll-*a* as a long-term average concentration will be achieved if the total phosphorus and nitrogen loads to Carl Blackwell Lake from the watershed are reduced by 55 percent to 27,000 kg/year of total phosphorus and 18,400 kg/year of total nitrogen. In Lake Humphreys, the simulations indicate that the water quality target of 9 µg/L chlorophyll-*a* will be achieved if the existing loads from the watershed are reduced by 84 percent to 864 kg/year of total phosphorus and 1,360 kg/year of total nitrogen. As discussed above, the uncertainty analysis demonstrated that to ensure at least a 50 percent probability of meeting water quality standards, a water quality target of 9 µg/L chlorophyll-*a* was set for both lakes. Table 4-6 summarizes the percent reduction goals for nutrient loading established for each lake. These maximum loads include an inherent margin of safety through the use of limits on loading of both nitrogen and phosphorus, as well as the use of a water quality target 10% less than the water quality standard.

Table 4-6 Total Phosphorus and Nitrogen Load Reductions to Meet Chlorophyll-*a* In-lake Water Quality Targets

Lake	Chl-*a* In- lake Target (µg/L)	Percent Reduction	Maximum Allowable Load (kg/yr)[a]	
			Total Phosphorus	Total Nitrogen
Carl Blackwell Lake	9	55	27,000	18,400
Lake Humphreys	9	84	864	1,360

[a] Loads do not include atmospheric deposition

Eutrophication is one of the leading causes of pollution in lakes and reservoirs throughout the world (Smith 2003). Therefore, determining which nutrients limit phytoplankton growth is an important step in the development of effective lake and watershed management strategies (Dodds and Priscu 1990; Elser *et al*. 1990; Smith *et al*. 2002). It is often assumed that algal productivity of most freshwater lakes and reservoirs is primarily limited by the availability of the nutrient phosphorus. Therefore, limits on phosphorus loading to lakes are sometimes considered a necessary, and typically sufficient, mechanism to reduce eutrophication. However, more recent studies in reservoirs indicate that both nitrogen and phosphorus play key roles, along with light, mixing conditions, predation by zooplankton, and residence time, in limiting algal growth (Kimmel et al. 1990). In a study of 19 Kansas reservoirs, Dzialowski et al. (2005) utilized bioassays to measure algal growth limitation, and found that phytoplankton growth substantially increased with phosphorus addition (implying that phosphorus alone limited growth) in only 8 percent of the bioassays. Nitrogen was the sole limiting nutrient in 16 percent of the bioassays. In 67 percent of the bioassays, significant algal growth did not occur upon addition of nitrogen or phosphorus singly, but did grow in response to addition of both nitrogen and phosphorus. In these systems, algal growth was considered to be co-limited by availability of phosphorus and nitrogen. Co-limitation by nitrogen and phosphorus was also reported to be the most common condition for two lakes in north Texas (Chrzanowski and Grover 2001). In some cases, growth limitation by phosphorus has been observed to be more common in the spring, followed by a shift to nitrogen limitation in the summer and fall.

Figures 4-7 and 4-8 display summary plots of multiple combinations of TN and TP concentrations and percent reductions that result in 9 µg/L chlorophyll-*a* for Carl Blackwell Lake and 9 µg/L chlorophyll-*a* for Lake Humphreys estimated using BATHTUB. Data points in the plots correspond to the subset of MCS iterations that resulted in the target chlorophyll-*a* levels. While the relative importance of nitrogen and phosphorus in limiting algal productivity in Carl Blackwell Lake and Lake Humphreys is not definitively established, these TMDLs calculate load allocations for both nitrogen and phosphorus as a conservative approach to ensure that water quality targets are met. While the BATHTUB model is capable of simulating chlorophyll-*a* concentrations from both TP and TN concentrations, it is an empirically derived statistical algorithm that does not include the concept of a limiting nutrient. In other words, chlorophyll-*a* concentrations are a continuous function of both TN and TP contributions that can vary from season to season. Since there are infinite combinations of TN and TP concentrations that could result in the desired chlorophyll-*a* concentration and BATHTUB is not capable of discerning between them, a typical starting point for implementation is to begin with equal percent reduction goals for both nutrient parameters. However, depending on the local environmental and socio-economic conditions, different percent reductions for the two nutrients based on the curves in Figures 4-7 and 4-8 could be used during the implementation of each TMDL to achieve the target chlorophyll-*a* level in the lakes.

Figure 4-7 Total N and Total P Combinations Resulting in 9 µg/L Chlorophyll-*a* in Carl Blackwell Lake

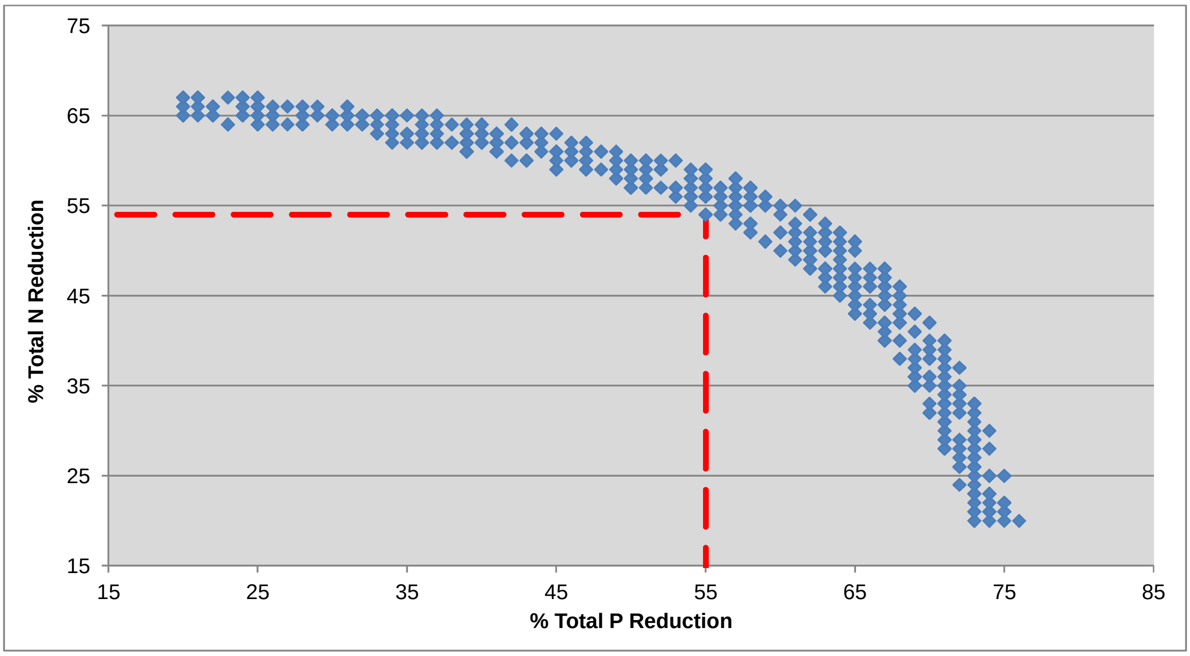
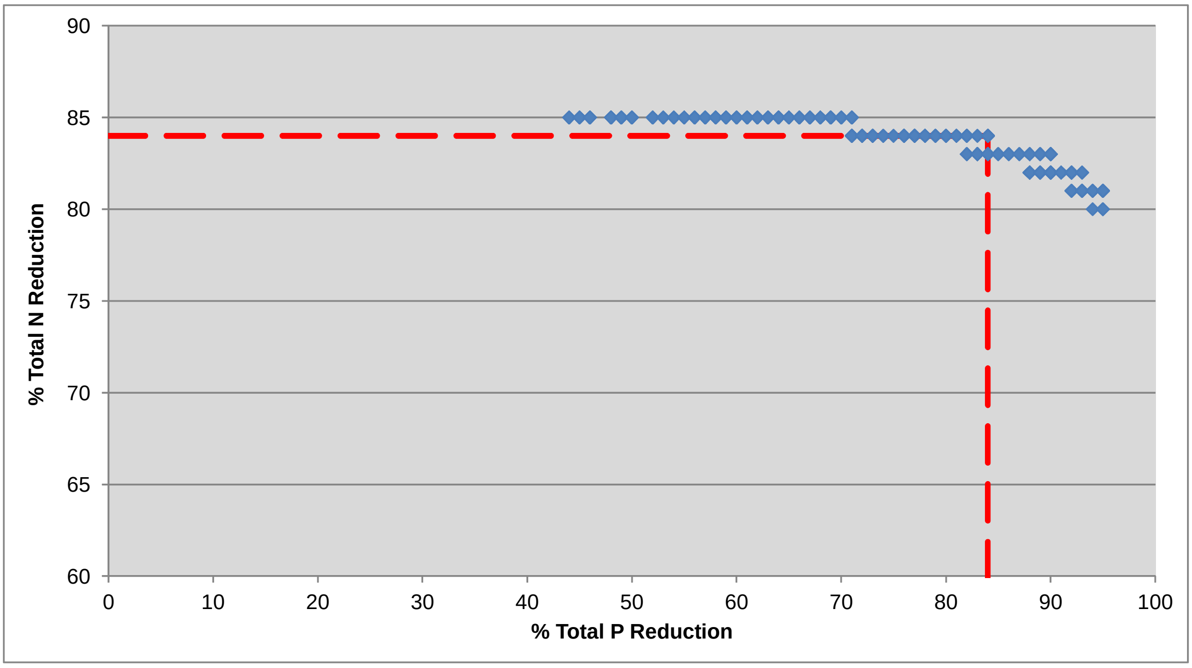


Figure 4-8 Total N and Total P Reduction Combinations Resulting in 9 µg/L Chlorophyll-*a* in Lake Humphreys



SECTION 5
TMDLS AND LOAD ALLOCATIONS

Models were used to calculate TMDLs for each lake as annual average phosphorus and nitrogen loads (kg/yr) that, if achieved, should meet the water quality target established for chlorophyll-*a*. For reporting purpose, the final TMDLs, according to EPA guideline, are expressed for each lake as daily maximum loads (kg/day).

5.1 Wasteload Allocation

There are no point sources discharging nutrient loadings to Carl Blackwell Lake or Lake Humphreys. Furthermore, Oklahoma's implementation of WQS (OAC 785:46-13-4) prohibits new point source discharges to these lakes, except for storm water with approval from DEQ (OWRB 2013a). *New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "SWS."*

Therefore, the wasteload allocation (WLA) for both lakes is zero.

5.2 Load Allocation

The LAs for both lakes are calculated as the difference between the TMDL and the MOS since the WLA is zero:

LA = TMDL – MOS

The total allowable load to Carl Blackwell Lake was conservatively estimated as 27,000 kg/yr of TP and 18,400 kg/yr of TN, necessitating a 55 percent reduction from existing phosphorus and nitrogen loading to achieve the desired water quality target (the 10 µg/L WQS minus a 10% explicit MOS or 9 µg/L).

The LA for watershed nonpoint sources to Lake Humphreys was conservatively estimated as 864 kg/yr of TP and 1,360 kg/yr of TN, necessitating an 84 percent reduction from existing loading to achieve the desired water quality target (the 10 µg/L WQS minus a 10% explicit MOS or 9 µg/L).

5.3 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. The WQS for chlorophyll-*a* specifically applies as a long-term average concentration (OAC 785:45-5-10(7)). Oklahoma procedures to implement WQS (OAC 785:46-7-2) specify that the mean annual average outflow represents the long-term average flow in lakes (OWRB 2013a). Seasonal variation was accounted for in these TMDLs by using more than five years of water quality data collected in each of the four seasons. The variation was accounted for in the watershed model (model period 16 years) and input into the BATHTUB model as an average of all daily values obtained from the watershed model.

5.4 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained. EPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for the lack of knowledge, then the MOS is considered explicit. TMDLs for Carl Blackwell Lake and Lake Humphreys include a 10% explicit MOS.

5.5 TMDL Calculations

A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the uncertainty concerning the relationship between loading limitations and water quality. This definition can be expressed by the following equation:

$$TMDL = \Sigma\, WLA + \Sigma\, LA + MOS$$

Load reduction scenario simulations were run using the BATHTUB model to calculate annual average phosphorus and nitrogen loads (in kg/yr) that, if achieved, should decrease chlorophyll-*a* concentrations to meet the water quality target. Given that transport, assimilation, and dynamics of nutrients vary both temporally and spatially, nutrient loading to both lakes from a practical perspective must be managed on a long-term basis typically as pounds or kilograms per year. However, a recent court decision (*Friends of the Earth, Inc. v. EPA, et al.*, often referred to as the Anacostia decision) states that TMDLs must include a daily load expression. It is important to recognize that the chlorophyll-*a* response to nutrient loading in all three lakes is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load, and algal response. As such it is important to note that expressing this TMDL in daily time steps does not imply a daily response to a daily load is practical from an implementation perspective.

The EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA 1991a) provides a statistical method for identifying a statistical maximum daily limit based on a long-term average and considering variation in a dataset. The method is represented by the following equation:

$$MDL = LTA \times e^{z\sigma - 0.5\sigma^2}$$

where *MDL* = maximum daily load
LTA = long-term average load
z = z statistic of the probability of occurrence (1.645 is used for this value)
$\sigma^2 = \ln(CV^2+1)$
CV = coefficient of variation

The coefficients of variation of daily phosphorus and nitrogen NPS loads, calculated from SWAT model output, were 4.4 and 4.1 for Carl Blackwell Lake and 9.2 and 8.3 for Lake Humphreys. As illustrated in Figures 4-7 and 4-8, there are infinite combinations of TN and TP reductions, as calculated by BATHTUB, that will achieve the chlorophyll-*a* water quality target. As a practical starting point for TMDL implementation an equal reduction goal for both TN and TP loading is recommended. During implementation, it may become evident that some other combination of TN and TP reductions is more cost effective for any given lake.

Using the reductions for both nutrient parameters listed in Table 4-6, the maximum daily load corresponding to the allowable annual average loads are provided in Table 5-1. In Carl Blackwell Lake the 27,000 kg of phosphorus and 18,400 kg of nitrogen per year is translated to a daily maximum load of 74.0 kg/day of phosphorus and 50.4 kg/day of nitrogen. For Lake Humphreys, the allowable average load of 864 kg of phosphorus and 1,360 kg of nitrogen per year is translated to a daily maximum load of 2.4 kg/day of phosphorus and 3.7 kg/day of nitrogen. Reduction of TP and TN loads in lake tributaries to these levels is expected to result in achievement of WQS for chlorophyll-*a* in each lake.

Table 5-1 TMDLs for Chlorophyll-*a* Expressed in Kilograms of Total Phosphorus and Nitrogen Per Day

Waterbody Name	Waterbody ID	Nutrient	TMDL	WLA_{MS4}	LA	MOS
Carl Blackwell Lake	OK620900040280_00	Total Phosphorus	74.0	0	66.6	7.4
		Total Nitrogen	50.4	0	45.4	5.0
Lake Humphreys	OK310810040150_00	Total Phosphorus	2.4	0	2.2	0.2
		Total Nitrogen	3.7	0	3.3	0.4

5.6 TMDL Implementation

DEQ will collaborate with a host of other State agencies and local governments working within the boundaries of State and local regulations to target available funding and technical assistance to support implementation of pollution controls and management measures. Various water quality management programs and funding sources will be utilized so that the pollutant reductions as required by these TMDLs can be achieved and water quality can be restored to maintain designated uses. DEQ's Continuing Planning Process (CPP), required by the CWA §303(e)(3) and 40 CFR 130.5, summarizes Oklahoma's commitments and programs aimed at restoring and protecting water quality throughout the State (DEQ 2012). The CPP can be viewed from DEQ's website at:
http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf.

Table 5-2 provides a partial list of the State partner agencies DEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-2 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	http://www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	http://www.wildlifedepartment.com/wildlifemgmt/endangeredspecies.htm

Oklahoma Department of Agriculture, Food, and Forestry	http://www.ok.gov/~okag/aems
Oklahoma Water Resources Board	http://www.owrb.state.ok.us/quality/index.php

5.6.1 Point Sources

As authorized by Section 402 of the CWA, DEQ has delegation of the NPDES Program in Oklahoma, except for certain jurisdictional areas related to agriculture (retained by State Department of Agriculture, Food, and Forestry), and the oil and gas industry (retained by Oklahoma Corporation Commission), for which EPA has retained permitting authority. The NPDES Program in Oklahoma, in accordance with an agreement between DEQ and EPA relating to administration and enforcement of the delegated NPDES Program, is implemented via the Oklahoma Pollutant Discharge Elimination System (OPDES) Act (Title 252, Chapter 606 (http://www.deq.state.ok.us/rules/611.pdf)). Point source WLAs are outlined in the Oklahoma Water Quality Management Plan (also known as the 208 Plan) under the OPDES program.

5.6.2 Nonpoint Sources

Nonpoint source pollution in Oklahoma is managed by the Oklahoma Conservation Commission. The OCC works with State partners such as Oklahoma Department of Food & Forestry (ODAFF) and federal partners such as EPA and the National Resources Conservation Service of the USDA, to address water quality problems similar to those seen in the Study Area. Primary mechanisms used for management of nonpoint source pollution are incentive-based programs that support the installation of BMPs and public education and outreach. Other programs include regulations and permits for CAFOs. The CAFO Act, as administered by the ODAFF, provides CAFO operators the necessary tools and information to deal with the manure and wastewater animals produce so streams, lakes, ponds, and groundwater sources are not polluted.

The reduction rates in nutrient loading called for in this TMDL report are as high as 84 percent. DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of nutrient loading.

5.6.3 Reasonable Assurance

Reasonable assurance is required by the EPA guidance for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such a case, “reasonable assurance” that the NPS load reductions will actually occur must be demonstrated.

In this report, all point source discharges either already have or will be given discharge limitations less than or equal to the water quality standards numerical criteria. Therefore, reasonable assurance is derived from Oklahoma Pollutant Discharge Elimination System (OPDES). The wasteload allocations for MS4s will be implemented through the OPDES MS4 permits. MS4 permits contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or stormwater pollution prevention plan (SWP3) to implement best management practices (BMPs), public education and outreach, and illicit discharge elimination.

Reasonable assurance that nonpoint sources will meet their allocated amount in the TMDL is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. The OCC is responsible for the state's NPS program as defined in Section 319 of CWA. DEQ will work in conjunction with OCC and other federal, state, and local partners within the respective watersheds to meet the load reduction goals for NPS. All waterbodies are prioritized as part of the Unified Watershed Assessment (UWA) and that ranking will determine the likelihood of an implementation project in a watershed.

SECTION 6
PUBLIC PARTICIPATION

This report is submitted to EPA for technical review. After the technical approval, a public notice will be circulated to the local newspapers and/or other publications in the area affected by the TMDLs in this Study Area. The public will have opportunities to review the TMDL report and make written comments. The public comment period lasts 45 days. Depending on the interest and responses from the public, a public meeting may be held within the watershed affected by the TMDLs in this report. If a public meeting is held, the public will also have opportunities to ask questions and make formal oral comments at the meeting and/or to submit written comments at the public meeting.

All written comments received during the public notice period become a part of the record of these TMDLs. All comments will be considered and the TMDL report will be revised according to the comments, if necessary, prior to the ultimate completion of these TMDLs for submission to EPA for final approval.

After EPA's final approval, each TMDL will be adopted into the Water Quality Management Plan (WQMP). These TMDLs provide a mathematical solution to meet ambient water quality criterion with a given set of facts. Adoption of these TMDLs into the WQMP provides a mechanism to recalculate acceptable loads when information changes in the future. Updates to the WQMP demonstrate compliance with the water quality criterion. Updates to the WQMP are also useful when the water quality criterion changes and the loading scenario are reviewed to ensure the instream criterion is predicted to be met.

SECTION 7
REFERENCES

Carlson, R.E. 1977. A Trophic State Index for Lakes. *Limnology and Oceanography.* 22:361-369.

Chrzanowski, T.H. and J.P. Grover. 2001. Effects of Mineral Nutrients on the Growth of Bacteria and Phytoplankton in Two Southern Reservoirs. *Limnology and Oceanography* 46(6): 1319-1330.

DEQ 2012. The State of Oklahoma 2012 Continuing Planning Process. http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf.

DEQ 2013. Water Quality in Oklahoma, 2012 Integrated Report. http://www.deq.state.ok.us/wqdnew/305b_303d/index.html

Dodds, W. K. and J.C. Priscu. 1990. A comparison of methods for assessment of nutrient deficiency of phytoplankton in a large oligotrophic lake. *Can. J. Fish. Aquat. Sci.*, 4, 2328–2338.

Driver, N.E., and G.D. Tasker. 1988. Techniques for estimation of storm-runoff loads, volumes, and selected constituent concentrations in urban watersheds in the United States. U.S. Department of the Interior, U.S. Geological Survey: Open File Reports 88-191.

Dzialowski, A.R., S-H Wang, N-C Lim, W.W. Spotts, and D.G. Huggins. 2005. Nutrient Limitation of Phytoplankton Growth in Central Plains Reservoirs, USA. *J. Plankton Res*. 27(60: 587-595.

Elser, J.J., E.R. Marzolf, and C.R. Goldman. 1990. Phosphorus and nitrogen limitation of phytoplankton growth in the freshwaters of North America: a review and critique of experimental enrichment. *Can. J. Fish. Aquat. Sci.*, 47, 1468–1477.

EPA 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, EPA 440/4-91-001

EPA 1991a. Technical Support Document for Water Quality-Based Toxics Control. Office of Water, EPA 505/2-90-001.

EPA 2003. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, TMDL -01-03 - Diane Regas-- July 21, 2003.

Kimmel, B.L., O.T. Lind, and L.J. Paulson. 1990. Reservoir Primary Production. In Reservoir Limnology: Ecological Perspectives. Thornton, K.W., B.L. Kimmel, and F.E. Payne, eds. Wiley- Interscience: New York, NY.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams. 2009. *Soil and Water Assessment Tool Theoretical Documentation: Version 2009*. Grassland, Soil and Water Research Laboratory - Agricultural Research Service and Blackland Research and Extension Center - Texas Agricultural Experiment Station. Available at http://twri.tamu.edu/reports/2011/tr406.pdf.

Oklahoma Mesonet 2012. Oklahoma Mesonet Meteorological Data. http://www.mesonet.org/.

OWRB 2007. Oklahoma Water Resources Board. 2007 Report of the Oklahoma Beneficial Use Monitoring Program: Lakes Report 2006-2007 Draft Report. https://www.owrb.ok.gov/quality/monitoring/bump/pdf_bump/archives/2007BUMPLakesReport.pdf

OWRB 2010. Oklahoma Water Resources Board. Lakes of Oklahoma. http://www.owrb.ok.gov/maps/pmg/owrbdata_SW.html

OWRB 2012. Oklahoma Water Resources Board Water Quality Monitoring Sites. http://www.owrb.ok.gov/maps/pmg/owrbdata_SW.html

OWRB 2012a. Oklahoma Water Resources Board. 2012 Oklahoma Lakes Report. Beneficial Use Monitoring Program. http://www.owrb.ok.gov/quality/monitoring/bump/pdf_bump/Current/Lake_Sites.html.

OWRB 2013. Oklahoma Water Resources Board. Title 785, Chapter 45, *Oklahoma's Water Quality Standards*. July 1, 2013. http://www.owrb.ok.gov/util/rules/pdf_rul/current/Ch45.pdf

OWRB 2013a. Oklahoma Water Resources Board. Title 785, Chapter 46, *Implementation of Oklahoma's Water Quality Standards*. July 1, 2013.

http://www.owrb.ok.gov/util/rules/pdf_rul/current/Ch46.pdf

Parsons 2010. Technical Methods Summary for Watershed and Water Quality Modeling of Sensitive Water Supply Lakes in Oklahoma. November 2010.

Smith, V.H. 2003. Eutrophication of freshwater and coastal marine ecosystems: a global problem. *Environ. Sci. Pollut. Res. Int.*, 10,126–139.

Smith, V.H., J. Sieber-Denlinger, F. deNoyelles. 2002. Managing taste and odor problems in a eutrophic drinking water reservoir. *J. Lake Reserv. Manage.*, 18, 319–323.

Storm, D.E., D. Gade, R. Tejral, M.D. Smolen, P. Kenkel, and M.S. Gregory. 2000. Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma. Final Report. Accessed at http://storm.okstate.edu/reports/vol_1&2_draft_okstate_nonpoint_loading_final_report_rev_4_pdf.zip

USACE 2004. U.S. Army Corps of Engineers 2004. FLUX, PROFILE and BATHTUB: Simplified Procedures for Eutrophication Assessment and Prediction. http://el.erdc.usace.army.mil/elmodels/emiinfo.html.

U.S. Census Bureau 2010. http://2010.census.gov/2010census/data/

USDA 2012. National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Statistics_by_State/Oklahoma/index.asp.

USDA 2014. 2013 Oklahoma Cropland Data Layer. National Agricultural Statistics Service (NASS), Research and Development Division (RDD), Geospatial Information Branch (GIB), Spatial Analysis Research Section (SARS). http://www.nass.usda.gov/research/Cropland/SARS1a.htm. Published January 31, 2014.

Walker, W.W. 1986. Empirical Methods for Predicting Eutrophication in Impoundments; Report 3, Phase III: Applications Manual. Technical Report E-81-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Woods, A.J., J.M. Omernik, D.R. Butler, J.G. Ford, J.E. Henley, B.W. Hoagland, D.S. Arndt, and B.C. Moran. 2005. Ecoregions of Oklahoma (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,250,000).

APPENDIX A

STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix A
State of Oklahoma Antidegradation Policy

785:45-3-1. Purpose; Antidegradation policy statement

(a) Waters of the State constitute a valuable resource and shall be protected, maintained and improved for the benefit of all the citizens.

(b) It is the policy of the State of Oklahoma to protect all waters of the State from degradation of water quality, as provided in OAC 785:45-3-2 and Subchapter 13 of OAC 785:46.

785:45-3-2. Applications of antidegradation policy

(a) Application to outstanding resource waters (ORW). Certain waters of the State constitute an outstanding resource or have exceptional recreational and/or ecological significance. These waters include streams designated "Scenic River" or "ORW" in Appendix A of this Chapter, and waters of the State located within watersheds of Scenic Rivers. Additionally, these may include waters located within National and State parks, forests, wilderness areas, wildlife management areas, and wildlife refuges, and waters which contain species listed pursuant to the federal Endangered Species Act as described in 785:45-5-25(c)(2)(A) and 785:46-13-6(c). No degradation of water quality shall be allowed in these waters.

(b) Application to high quality waters (HQW). It is recognized that certain waters of the State possess existing water quality which exceeds those levels necessary to support propagation of fishes, shellfishes, wildlife, and recreation in and on the water. These high quality waters shall be maintained and protected.

(c) Application to Sensitive Public and Private Water Supplies (SWS). It is recognized that certain public and private water supplies possess conditions that make them more susceptible to pollution events and require additional protection. These sensitive water supplies shall be maintained and protected.

(d) Application to beneficial uses. No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed.

(e) Application to improved waters. As the quality of any waters of the State improve, no degradation of such improved waters shall be allowed.

785:46-13-1. Applicability and scope

(a) The rules in this Subchapter provide a framework for implementing the antidegradation policy stated in OAC 785:45-3-2 for all waters of the State. This policy and framework includes three tiers, or levels, of protection.

(b) The three tiers of protection are as follows:

(1) Tier 1. Attainment or maintenance of an existing or designated beneficial use.

(2) Tier 2. Maintenance or protection of High Quality Waters and Sensitive Public and Private Water Supply waters.

(3) Tier 3. No degradation of water quality allowed in Outstanding Resource Waters.

(c) In addition to the three tiers of protection, this Subchapter provides rules to implement the protection of waters in areas listed in Appendix B of OAC 785:45. Although Appendix B areas are not mentioned in OAC 785:45-3-2, the framework for protection of Appendix B areas is similar to the implementation framework for the antidegradation policy.

(d) In circumstances where more than one beneficial use limitation exists for a waterbody, the most protective limitation shall apply. For example, all antidegradation policy implementation rules applicable to Tier 1 waterbodies shall be applicable also to Tier 2 and Tier 3 waterbodies or areas, and implementation rules applicable to Tier 2 waterbodies shall be applicable also to Tier 3 waterbodies.

(e) Publicly owned treatment works may use design flow, mass loadings or concentration, as appropriate, to calculate compliance with the increased loading requirements of this section if those flows, loadings or concentrations were approved by the Oklahoma Department of Environmental Quality as a portion of Oklahoma's Water Quality Management Plan prior to the application of the ORW, HQW or SWS limitation.

785:46-13-2. Definitions

The following words and terms, when used in this Subchapter, shall have the following meaning, unless the context clearly indicates otherwise:

"Specified pollutants" means

(A) Oxygen demanding substances, measured as Carbonaceous Biochemical Oxygen Demand (CBOD) and/or Biochemical Oxygen Demand (BOD);

(B) Ammonia Nitrogen and/or Total Organic Nitrogen;

(C) Phosphorus;

(D) Total Suspended Solids (TSS); and

(E) Such other substances as may be determined by the Oklahoma Water Resources Board or the permitting authority.

785:46-13-3. Tier 1 protection; attainment or maintenance of an existing or designated beneficial use

(a) General.

(1) Beneficial uses which are existing or designated shall be maintained and protected.

(2) The process of issuing permits for discharges to waters of the State is one of several means employed by governmental agencies and affected persons which are designed to attain or maintain beneficial uses which have been designated for those waters. For example, Subchapters 3, 5, 7, 9 and 11 of this Chapter are rules for the permitting process. As such, the latter Subchapters not only implement numerical and narrative criteria, but also implement Tier 1 of the antidegradation policy.

(b) Thermal pollution. Thermal pollution shall be prohibited in all waters of the State. Temperatures greater than 52 degrees Centigrade shall constitute thermal pollution and shall be prohibited in all waters of the State.

(c) Prohibition against degradation of improved waters. As the quality of any waters of the State improves, no degradation of such improved waters shall be allowed.

785:46-13-4. Tier 2 protection; maintenance and protection of High Quality Waters and Sensitive Water Supplies

(a) General rules for High Quality Waters. New point source discharges of any pollutant after June 11, 1989, and increased load or concentration of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "HQW". Any discharge of any pollutant to a waterbody designated "HQW" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load or concentration of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load or concentration would result in maintaining or improving the level of water quality which exceeds that necessary to support recreation and propagation of fishes, shellfishes, and wildlife in the receiving water.

(b) General rules for Sensitive Public and Private Water Supplies. New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "SWS". Any discharge of any pollutant to a waterbody designated "SWS" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load will result in maintaining or improving the water quality in both the direct receiving water, if designated SWS, and any downstream waterbodies designated SWS.

(c) Stormwater discharges. Regardless of subsections (a) and (b) of this Section, point source discharges of stormwater to waterbodies and watersheds designated "HQW" and "SWS" may be approved by the permitting authority.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "HQW" or "SWS" in Appendix A of OAC 785:45.

785:46-13-5. Tier 3 protection; prohibition against degradation of water quality in outstanding resource waters

(a) General. New point source discharges of any pollutant after June 11, 1989, and increased load of any pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "ORW" and/or "Scenic River", and in any waterbody located within the watershed of any waterbody designated with the limitation "Scenic River". Any discharge of any pollutant to a waterbody designated "ORW" or "Scenic River" which would, if it occurred, lower existing water quality shall be prohibited.

(b) Stormwater discharges. Regardless of 785:46-13-5(a), point source discharges of stormwater from temporary construction activities to waterbodies and watersheds designated "ORW" and/or "Scenic River" may be permitted by the permitting authority. Regardless of 785:46-13-5(a), discharges of stormwater to waterbodies and watersheds designated "ORW" and/or "Scenic River" from point sources existing as of June 25, 1992, whether or not such stormwater discharges were permitted as point sources prior to June 25, 1992, may be permitted by the permitting authority; provided, however, increased load of any pollutant from such stormwater discharge shall be prohibited.

(c) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "ORW" in Appendix A of OAC 785:45, provided, however, that development of conservation plans shall be required in sub-watersheds where discharges or runoff from nonpoint sources are identified as causing or significantly contributing to degradation in a waterbody designated "ORW".

(d) LMFO's. No licensed managed feeding operation (LMFO) established after June 10, 1998 which applies for a new or expanding license from the State Department of Agriculture after March 9, 1998 shall be located...[w]ithin three (3) miles of any designated scenic river area as specified by the Scenic Rivers Act in 82 O.S. Section 1451 and following, or [w]ithin one (1) mile of a waterbody [2:9-210.3(D)] designated in Appendix A of OAC 785:45 as "ORW".

785:46-13-6. Protection for Appendix B areas

(a) General. Appendix B of OAC 785:45 identifies areas in Oklahoma with waters of recreational and/or ecological significance. These areas are divided into Table 1, which includes national and state parks, national forests, wildlife areas, wildlife management areas and wildlife refuges; and Table 2, which includes areas which contain threatened or endangered species listed as such by the federal government pursuant to the federal Endangered Species Act as amended.

(b) Protection for Table 1 areas. New discharges of pollutants after June 11, 1989, or increased loading of pollutants from discharges existing as of June 11, 1989, to waters within the boundaries of areas listed in Table 1 of Appendix B of OAC 785:45 may be approved by the permitting authority under such conditions as ensure that the recreational and ecological significance of these waters will be maintained.

(c) Protection for Table 2 areas. Discharges or other activities associated with those waters within the boundaries listed in Table 2 of Appendix B of OAC 785:45 may be restricted through agreements between appropriate regulatory agencies and the United States Fish and Wildlife Service. Discharges or other activities in such areas shall not substantially disrupt the threatened or endangered species inhabiting the receiving water.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds located within areas listed in Appendix B of OAC 785:45.

APPENDIX B

AMBIENT WATER QUALITY DATA

CHLOROPHYLL-*A* DATA — 2002 TO 2014

PHOSPHORUS AND NITROGEN DATA — 1998 TO 2014

TOTAL SUSPENDED SOLIDS DATA — 1998 TO 1999

Table B-1 Ambient Water Quality Data for Carl Blackwell Lake, 1998-2013

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-01B	09/14/2004	General Environmental Sample	Corrected Chlorophyll-a	20.9	mg/m3
620900040280-01B	12/14/2004	General Environmental Sample	Corrected Chlorophyll-a	21.6	mg/m3
620900040280-01B	03/14/2005	General Environmental Sample	Corrected Chlorophyll-a	5.38	mg/m3
620900040280-01B	06/14/2005	General Environmental Sample	Corrected Chlorophyll-a	7.62	mg/m3
620900040280-01B	10/10/2007	General Environmental Sample	Corrected Chlorophyll-a	18.86	mg/m3
620900040280-01B	01/09/2008	General Environmental Sample	Corrected Chlorophyll-a	3.96	mg/m3
620900040280-01B	04/28/2008	General Environmental Sample	Corrected Chlorophyll-a	3.64	mg/m3
620900040280-01B	07/28/2008	General Environmental Sample	Corrected Chlorophyll-a	28.5	mg/m3
620900040280-01S	09/07/2004	General Environmental Sample	Corrected Chlorophyll-a	11.2	mg/m3
620900040280-01S	09/14/2004	General Environmental Sample	Corrected Chlorophyll-a	18.2	mg/m3
620900040280-01S	12/14/2004	General Environmental Sample	Corrected Chlorophyll-a	21.34	mg/m3
620900040280-01S	03/14/2005	General Environmental Sample	Corrected Chlorophyll-a	4.96	mg/m3
620900040280-01S	06/14/2005	General Environmental Sample	Corrected Chlorophyll-a	7.01	mg/m3
620900040280-01S	01/09/2008	General Environmental Sample	Corrected Chlorophyll-a	3.84	mg/m3
620900040280-01S	04/28/2008	General Environmental Sample	Corrected Chlorophyll-a	2.99	mg/m3
620900040280-01S	07/28/2008	General Environmental Sample	Corrected Chlorophyll-a	30.0	mg/m3
620900040280-01S	11/08/2010	Environmental Churn Duplicate	Corrected Chlorophyll-a	2.98	mg/m3
620900040280-01S	01/18/2011	Environmental Churn Duplicate	Corrected Chlorophyll-a	4.24	mg/m3
620900040280-01S	04/12/2011	Environmental Churn Duplicate	Corrected Chlorophyll-a	2.77	mg/m3
620900040280-01S	07/05/2011	Environmental Churn Duplicate	Corrected Chlorophyll-a	17.6	mg/m3
620900040280-01S	10/10/2012	Environmental Churn Duplicate	Corrected Chlorophyll-a	19.1	mg/m3
620900040280-01S	03/06/2013	Environmental Churn Duplicate	Corrected Chlorophyll-a	12.5	mg/m3
620900040280-01S	04/24/2013	Environmental Churn Duplicate	Corrected Chlorophyll-a	33.5	mg/m3
620900040280-01S	07/01/2013	Environmental Churn Duplicate	Corrected Chlorophyll-a	10.2	mg/m3
620900040280-02	09/14/2004	General Environmental Sample	Corrected Chlorophyll-a	19.5	mg/m3
620900040280-02	12/14/2004	General Environmental Sample	Corrected Chlorophyll-a	12.79	mg/m3
620900040280-02	03/14/2005	General Environmental Sample	Corrected Chlorophyll-a	8.12	mg/m3
620900040280-02	06/14/2005	General Environmental Sample	Corrected Chlorophyll-a	6.04	mg/m3
620900040280-02	10/10/2007	General Environmental Sample	Corrected Chlorophyll-a	28.51	mg/m3
620900040280-02	01/09/2008	General Environmental Sample	Corrected Chlorophyll-a	3.64	mg/m3
620900040280-02	04/28/2008	General Environmental Sample	Corrected Chlorophyll-a	4.02	mg/m3
620900040280-02	07/28/2008	General Environmental Sample	Corrected Chlorophyll-a	28.2	mg/m3
620900040280-02	11/08/2010	General Environmental Sample	Corrected Chlorophyll-a	4.65	mg/m3
620900040280-02	01/18/2011	General Environmental Sample	Corrected Chlorophyll-a	4.91	mg/m3
620900040280-02	04/12/2011	General Environmental Sample	Corrected Chlorophyll-a	5.01	mg/m3
620900040280-02	07/05/2011	General Environmental Sample	Corrected Chlorophyll-a	21.3	mg/m3
620900040280-02	10/10/2012	General Environmental Sample	Corrected Chlorophyll-a	33.4	mg/m3
620900040280-02	03/06/2013	General Environmental Sample	Corrected Chlorophyll-a	10.0	mg/m3
620900040280-02	04/24/2013	General Environmental Sample	Corrected Chlorophyll-a	45.3	mg/m3

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-02	07/01/2013	General Environmental Sample	Corrected Chlorophyll-a	23.5	mg/m3
620900040280-03	09/14/2004	General Environmental Sample	Corrected Chlorophyll-a	28.5	mg/m3
620900040280-03	12/14/2004	General Environmental Sample	Corrected Chlorophyll-a	11.36	mg/m3
620900040280-03	03/14/2005	General Environmental Sample	Corrected Chlorophyll-a	6.54	mg/m3
620900040280-03	06/14/2005	General Environmental Sample	Corrected Chlorophyll-a	6.48	mg/m3
620900040280-03	10/10/2007	General Environmental Sample	Corrected Chlorophyll-a	17.2	mg/m3
620900040280-03	01/09/2008	General Environmental Sample	Corrected Chlorophyll-a	3.48	mg/m3
620900040280-03	04/28/2008	General Environmental Sample	Corrected Chlorophyll-a	5.09	mg/m3
620900040280-03	07/28/2008	General Environmental Sample	Corrected Chlorophyll-a	28.0	mg/m3
620900040280-03	11/08/2010	General Environmental Sample	Corrected Chlorophyll-a	4.10	mg/m3
620900040280-03	01/18/2011	General Environmental Sample	Corrected Chlorophyll-a	4.45	mg/m3
620900040280-03	04/12/2011	General Environmental Sample	Corrected Chlorophyll-a	4.15	mg/m3
620900040280-03	07/05/2011	General Environmental Sample	Corrected Chlorophyll-a	20.4	mg/m3
620900040280-03	10/10/2012	General Environmental Sample	Corrected Chlorophyll-a	28.0	mg/m3
620900040280-03	03/06/2013	General Environmental Sample	Corrected Chlorophyll-a	7.23	mg/m3
620900040280-03	04/24/2013	General Environmental Sample	Corrected Chlorophyll-a	34.0	mg/m3
620900040280-03	07/01/2013	General Environmental Sample	Corrected Chlorophyll-a	16.9	mg/m3
620900040280-04	09/14/2004	General Environmental Sample	Corrected Chlorophyll-a	22.6	mg/m3
620900040280-04	12/14/2004	General Environmental Sample	Corrected Chlorophyll-a	18.97	mg/m3
620900040280-04	03/14/2005	General Environmental Sample	Corrected Chlorophyll-a	3.07	mg/m3
620900040280-04	06/14/2005	General Environmental Sample	Corrected Chlorophyll-a	14.3	mg/m3
620900040280-04	10/10/2007	General Environmental Sample	Corrected Chlorophyll-a	29.59	mg/m3
620900040280-04	01/09/2008	General Environmental Sample	Corrected Chlorophyll-a	3.50	mg/m3
620900040280-04	04/28/2008	General Environmental Sample	Corrected Chlorophyll-a	5.36	mg/m3
620900040280-04	07/28/2008	General Environmental Sample	Corrected Chlorophyll-a	38.9	mg/m3
620900040280-04	11/08/2010	General Environmental Sample	Corrected Chlorophyll-a	6.52	mg/m3
620900040280-04	01/18/2011	General Environmental Sample	Corrected Chlorophyll-a	4.97	mg/m3
620900040280-04	04/12/2011	General Environmental Sample	Corrected Chlorophyll-a	8.77	mg/m3
620900040280-04	07/05/2011	General Environmental Sample	Corrected Chlorophyll-a	9.28	mg/m3
620900040280-04	10/10/2012	General Environmental Sample	Corrected Chlorophyll-a	20.9	mg/m3
620900040280-04	07/01/2013	General Environmental Sample	Corrected Chlorophyll-a	25.1	mg/m3
620900040280-05	09/14/2004	General Environmental Sample	Corrected Chlorophyll-a	19.0	mg/m3
620900040280-05	12/14/2004	General Environmental Sample	Corrected Chlorophyll-a	14.88	mg/m3
620900040280-05	03/14/2005	General Environmental Sample	Corrected Chlorophyll-a	1.9	mg/m3
620900040280-05	06/14/2005	General Environmental Sample	Corrected Chlorophyll-a	13.7	mg/m3
620900040280-05	10/10/2007	General Environmental Sample	Corrected Chlorophyll-a	17.63	mg/m3
620900040280-05	01/09/2008	General Environmental Sample	Corrected Chlorophyll-a	3.59	mg/m3
620900040280-05	04/28/2008	General Environmental Sample	Corrected Chlorophyll-a	3.68	mg/m3
620900040280-05	07/28/2008	General Environmental Sample	Corrected Chlorophyll-a	25.7	mg/m3
620900040280-01B	05/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.15	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-01B	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.59	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Nitrogen, Ammonia	0.36	mg/L
620900040280-01B	01/23/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01B	04/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01B	07/24/2002	General Environmental Sample	Nitrogen, Ammonia	0.76	mg/L
620900040280-01B	09/14/2004	General Environmental Sample	Nitrogen, Ammonia	0.36	mg/L
620900040280-01B	12/14/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	01/23/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	04/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	07/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	09/14/2004	General Environmental Sample	Nitrogen, Ammonia	0.14	mg/L
620900040280-01S	12/14/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	03/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01S	06/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.17	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.19	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Nitrogen, Ammonia	0.16	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	08/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	01/23/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	04/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	07/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	09/14/2004	General Environmental Sample	Nitrogen, Ammonia	0.10	mg/L
620900040280-02	12/14/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	03/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-02	06/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Nitrogen, Ammonia	0.13	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Nitrogen, Ammonia	0.08	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	01/23/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	04/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	07/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	09/14/2004	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
620900040280-03	12/14/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	03/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-03	06/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	11/17/1998	General Environmental Sample	Nitrogen, Ammonia	0.13	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Nitrogen, Ammonia	0.09	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	01/23/2002	General Environmental Sample	Nitrogen, Ammonia	0.08	mg/L
620900040280-04	04/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	07/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	09/14/2004	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
620900040280-04	12/14/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	03/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-04	06/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-05	01/23/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-05	04/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-05	07/24/2002	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-05	09/14/2004	General Environmental Sample	Nitrogen, Ammonia	0.10	mg/L
620900040280-05	12/14/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-05	03/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-05	06/14/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
620900040280-01B	05/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	1.06	mg/L
620900040280-01B	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.42	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.58	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.65	mg/L
620900040280-01B	10/24/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-01B	01/23/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L
620900040280-01B	04/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.38	mg/L
620900040280-01B	07/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	1.38	mg/L
620900040280-01B	09/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	1.02	mg/L
620900040280-01B	12/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
620900040280-01B	07/01/2013	General Environmental Sample	Nitrogen, Kjeldahl	1.71	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	1.09	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.36	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.24	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.37	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.41	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
620900040280-01S	10/24/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.59	mg/L
620900040280-01S	01/23/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.38	mg/L
620900040280-01S	04/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.53	mg/L
620900040280-01S	07/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.52	mg/L
620900040280-01S	09/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.85	mg/L
620900040280-01S	12/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.63	mg/L
620900040280-01S	03/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.34	mg/L
620900040280-01S	06/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.39	mg/L
620900040280-01S	10/10/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.76	mg/L
620900040280-01S	01/09/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
620900040280-01S	04/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.67	mg/L
620900040280-01S	07/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.75	mg/L
620900040280-01S	11/08/2010	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.59	mg/L
620900040280-01S	01/18/2011	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.49	mg/L
620900040280-01S	04/12/2011	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.57	mg/L
620900040280-01S	11/30/2011	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.89	mg/L
620900040280-01S	10/10/2012	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.05	mg/L
620900040280-01S	03/06/2013	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.75	mg/L
620900040280-01S	04/24/2013	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.27	mg/L
620900040280-01S	07/01/2013	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.84	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.42	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.47	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.20	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.33	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.58	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-02	08/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
620900040280-02	10/24/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L
620900040280-02	01/23/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.47	mg/L
620900040280-02	04/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.56	mg/L
620900040280-02	07/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.77	mg/L
620900040280-02	09/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.73	mg/L
620900040280-02	12/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.52	mg/L
620900040280-02	03/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.41	mg/L
620900040280-02	06/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
620900040280-02	10/10/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
620900040280-02	01/09/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.59	mg/L
620900040280-02	04/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.76	mg/L
620900040280-02	07/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L
620900040280-02	11/08/2010	General Environmental Sample	Nitrogen, Kjeldahl	0.52	mg/L
620900040280-02	01/18/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L
620900040280-02	04/12/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.50	mg/L
620900040280-02	11/30/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.84	mg/L
620900040280-02	10/10/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.13	mg/L
620900040280-02	03/06/2013	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
620900040280-02	04/24/2013	General Environmental Sample	Nitrogen, Kjeldahl	1.36	mg/L
620900040280-02	07/01/2013	General Environmental Sample	Nitrogen, Kjeldahl	0.98	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.81	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.55	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.18	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.42	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.58	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.37	mg/L
620900040280-03	10/24/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.42	mg/L
620900040280-03	01/23/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L
620900040280-03	04/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.56	mg/L
620900040280-03	07/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.60	mg/L
620900040280-03	09/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
620900040280-03	12/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L
620900040280-03	03/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.41	mg/L
620900040280-03	06/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.37	mg/L
620900040280-03	10/10/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.76	mg/L
620900040280-03	01/09/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
620900040280-03	04/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.73	mg/L
620900040280-03	07/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-03	11/08/2010	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
620900040280-03	01/18/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.45	mg/L
620900040280-03	04/12/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L
620900040280-03	11/30/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
620900040280-03	10/10/2012	General Environmental Sample	Nitrogen, Kjeldahl	0.98	mg/L
620900040280-03	03/06/2013	General Environmental Sample	Nitrogen, Kjeldahl	0.94	mg/L
620900040280-03	04/24/2013	General Environmental Sample	Nitrogen, Kjeldahl	0.77	mg/L
620900040280-03	07/01/2013	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.73	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.55	mg/L
620900040280-04	11/17/1998	General Environmental Sample	Nitrogen, Kjeldahl	0.29	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.32	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.67	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
620900040280-04	10/24/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
620900040280-04	01/23/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.59	mg/L
620900040280-04	04/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.50	mg/L
620900040280-04	07/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
620900040280-04	09/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.84	mg/L
620900040280-04	12/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
620900040280-04	03/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L
620900040280-04	06/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.45	mg/L
620900040280-04	10/10/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.87	mg/L
620900040280-04	01/09/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.60	mg/L
620900040280-04	04/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.91	mg/L
620900040280-04	07/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	1.08	mg/L
620900040280-04	11/08/2010	General Environmental Sample	Nitrogen, Kjeldahl	0.52	mg/L
620900040280-04	01/18/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
620900040280-04	04/12/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.52	mg/L
620900040280-04	11/30/2011	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
620900040280-04	10/10/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.24	mg/L
620900040280-04	07/01/2013	General Environmental Sample	Nitrogen, Kjeldahl	1.22	mg/L
620900040280-05	10/24/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.45	mg/L
620900040280-05	01/23/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.54	mg/L
620900040280-05	04/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.53	mg/L
620900040280-05	07/24/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.60	mg/L
620900040280-05	09/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.63	mg/L
620900040280-05	12/14/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.53	mg/L
620900040280-05	03/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.38	mg/L
620900040280-05	06/14/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-05	10/10/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.68	mg/L
620900040280-05	01/09/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.70	mg/L
620900040280-05	04/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.68	mg/L
620900040280-05	07/28/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L
620900040280-01B	05/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.15	mg/L
620900040280-01B	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.28	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.28	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.31	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01B	10/24/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01B	01/23/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.17	mg/L
620900040280-01B	04/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.07	mg/L
620900040280-01B	07/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-01B	09/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01B	12/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.07	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.37	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.25	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.32	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.08	mg/L
620900040280-01S	10/24/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01S	01/23/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.16	mg/L
620900040280-01S	04/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-01S	07/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-01S	09/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01S	12/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.11	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.12	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.30	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.27	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.30	mg/L
620900040280-02	08/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-02	10/24/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-02	01/23/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.11	mg/L
620900040280-02	04/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-02	07/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-02	09/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-02	12/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.22	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.28	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.30	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.32	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.06	mg/L
620900040280-03	10/24/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-03	01/23/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.12	mg/L
620900040280-03	04/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-03	07/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-03	09/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-03	12/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.10	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.06	mg/L
620900040280-04	11/17/1998	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-04	10/24/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-04	01/23/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.08	mg/L
620900040280-04	04/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-04	07/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-04	09/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-04	12/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-05	10/24/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-05	01/23/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
620900040280-05	04/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-05	07/24/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
620900040280-05	09/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-05	12/14/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
620900040280-01B	07/01/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-01S	03/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-01S	06/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-01S	10/10/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.22	mg/L
620900040280-01S	01/09/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.27	mg/L
620900040280-01S	04/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.20	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-01S	07/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-01S	11/08/2010	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.54	mg/L
620900040280-01S	01/18/2011	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.48	mg/L
620900040280-01S	04/12/2011	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.40	mg/L
620900040280-01S	11/30/2011	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.23	mg/L
620900040280-01S	10/10/2012	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.17	mg/L
620900040280-01S	03/06/2013	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.10	mg/L
620900040280-01S	04/24/2013	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-01S	07/01/2013	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-02	03/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-02	06/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-02	10/10/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
620900040280-02	01/09/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.27	mg/L
620900040280-02	04/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.21	mg/L
620900040280-02	07/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-02	11/08/2010	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.70	mg/L
620900040280-02	01/18/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.47	mg/L
620900040280-02	04/12/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.39	mg/L
620900040280-02	11/30/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.23	mg/L
620900040280-02	10/10/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-02	03/06/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.12	mg/L
620900040280-02	04/24/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-02	07/01/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-03	03/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-03	06/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-03	10/10/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
620900040280-03	01/09/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.29	mg/L
620900040280-03	04/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.22	mg/L
620900040280-03	07/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-03	11/08/2010	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.50	mg/L
620900040280-03	01/18/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.48	mg/L
620900040280-03	04/12/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.39	mg/L
620900040280-03	11/30/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.23	mg/L
620900040280-03	10/10/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
620900040280-03	03/06/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.10	mg/L
620900040280-03	04/24/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-03	07/01/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-04	03/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-04	06/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-04	10/10/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-04	01/09/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.27	mg/L
620900040280-04	04/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.23	mg/L
620900040280-04	07/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-04	11/08/2010	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.38	mg/L
620900040280-04	01/18/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.46	mg/L
620900040280-04	04/12/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.38	mg/L
620900040280-04	11/30/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.22	mg/L
620900040280-04	10/10/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-04	07/01/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-05	03/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-05	06/14/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-05	10/10/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.20	mg/L
620900040280-05	01/09/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.28	mg/L
620900040280-05	04/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.21	mg/L
620900040280-05	07/28/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
620900040280-01B	05/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	0.20	mg/L
620900040280-01B	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.08	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	10/24/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	01/23/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	04/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	07/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	09/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
620900040280-01B	12/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.10	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	10/24/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	01/23/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	04/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	07/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	09/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01S	12/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.08	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
620900040280-02	08/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	10/24/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
620900040280-02	01/23/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	04/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	07/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	09/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-02	12/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.07	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	10/24/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.14	mg/L
620900040280-03	01/23/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	04/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	07/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	09/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-03	12/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	0.07	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	11/17/1998	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.08	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	10/24/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
620900040280-04	01/23/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	04/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	07/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	09/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-04	12/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-05	10/24/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-05	01/23/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-05	04/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-05	07/24/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-05	09/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-05	12/14/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
620900040280-01B	05/18/1998	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
620900040280-01B	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.046	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Phosphorous, Ortho	0.039	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Phosphorous, Ortho	0.060	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Phosphorous, Ortho	0.107	mg/L
620900040280-01B	10/24/2001	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-01B	01/23/2002	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
620900040280-01B	04/24/2002	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
620900040280-01B	07/24/2002	General Environmental Sample	Phosphorous, Ortho	0.112	mg/L
620900040280-01B	09/14/2004	General Environmental Sample	Phosphorous, Ortho	0.050	mg/L
620900040280-01B	12/14/2004	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Phosphorous, Ortho	0.028	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Phosphorous, Ortho	0.035	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
620900040280-01S	10/24/2001	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
620900040280-01S	01/23/2002	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
620900040280-01S	04/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-01S	07/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-01S	09/14/2004	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-01S	12/14/2004	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
620900040280-01S	03/14/2005	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
620900040280-01S	06/14/2005	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
620900040280-01S	10/10/2007	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-01S	01/09/2008	General Environmental Sample	Phosphorous, Ortho	0.025	mg/L
620900040280-01S	04/28/2008	General Environmental Sample	Phosphorous, Ortho	0.028	mg/L
620900040280-01S	07/28/2008	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-01S	10/10/2012	Environmental Churn Duplicate	Phosphorous, Ortho	0.027	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Phosphorous, Ortho	0.026	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-02	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Phosphorous, Ortho	0.033	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
620900040280-02	08/17/1999	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-02	10/24/2001	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-02	01/23/2002	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
620900040280-02	04/24/2002	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
620900040280-02	07/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-02	09/14/2004	General Environmental Sample	Phosphorous, Ortho	0.021	mg/L
620900040280-02	12/14/2004	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-02	03/14/2005	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
620900040280-02	06/14/2005	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
620900040280-02	10/10/2007	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
620900040280-02	01/09/2008	General Environmental Sample	Phosphorous, Ortho	0.027	mg/L
620900040280-02	04/28/2008	General Environmental Sample	Phosphorous, Ortho	0.030	mg/L
620900040280-02	07/28/2008	General Environmental Sample	Phosphorous, Ortho	0.020	mg/L
620900040280-02	10/10/2012	General Environmental Sample	Phosphorous, Ortho	0.021	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Phosphorous, Ortho	0.025	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Phosphorous, Ortho	0.052	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
620900040280-03	10/24/2001	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-03	01/23/2002	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
620900040280-03	04/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-03	07/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-03	09/14/2004	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
620900040280-03	12/14/2004	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
620900040280-03	03/14/2005	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-03	06/14/2005	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
620900040280-03	10/10/2007	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
620900040280-03	01/09/2008	General Environmental Sample	Phosphorous, Ortho	0.027	mg/L
620900040280-03	04/28/2008	General Environmental Sample	Phosphorous, Ortho	0.026	mg/L
620900040280-03	07/28/2008	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-03	10/10/2012	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-04	11/17/1998	General Environmental Sample	Phosphorous, Ortho	0.037	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Phosphorous, Ortho	0.048	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-04	10/24/2001	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
620900040280-04	01/23/2002	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-04	04/24/2002	General Environmental Sample	Phosphorous, Ortho	0.03	mg/L
620900040280-04	07/24/2002	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
620900040280-04	09/14/2004	General Environmental Sample	Phosphorous, Ortho	0.043	mg/L
620900040280-04	12/14/2004	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
620900040280-04	03/14/2005	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-04	06/14/2005	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
620900040280-04	10/10/2007	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
620900040280-04	01/09/2008	General Environmental Sample	Phosphorous, Ortho	0.026	mg/L
620900040280-04	04/28/2008	General Environmental Sample	Phosphorous, Ortho	0.052	mg/L
620900040280-04	07/28/2008	General Environmental Sample	Phosphorous, Ortho	0.047	mg/L
620900040280-04	10/10/2012	General Environmental Sample	Phosphorous, Ortho	0.033	mg/L
620900040280-05	10/24/2001	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
620900040280-05	01/23/2002	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
620900040280-05	04/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-05	07/24/2002	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
620900040280-05	09/14/2004	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
620900040280-05	12/14/2004	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
620900040280-05	03/14/2005	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-05	06/14/2005	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-05	10/10/2007	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
620900040280-05	01/09/2008	General Environmental Sample	Phosphorous, Ortho	0.027	mg/L
620900040280-05	04/28/2008	General Environmental Sample	Phosphorous, Ortho	0.037	mg/L
620900040280-05	07/28/2008	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
620900040280-01B	05/18/1998	General Environmental Sample	Phosphorous, Total	0.065	mg/L
620900040280-01B	08/18/1998	General Environmental Sample	Phosphorous, Total	0.126	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Phosphorous, Total	0.041	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Phosphorous, Total	0.057	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Phosphorous, Total	0.101	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Phosphorous, Total	0.154	mg/L
620900040280-01B	10/24/2001	General Environmental Sample	Phosphorous, Total	0.037	mg/L
620900040280-01B	01/23/2002	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-01B	04/24/2002	General Environmental Sample	Phosphorous, Total	0.033	mg/L
620900040280-01B	07/24/2002	General Environmental Sample	Phosphorous, Total	0.199	mg/L
620900040280-01B	09/14/2004	General Environmental Sample	Phosphorous, Total	0.077	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-01B	12/14/2004	General Environmental Sample	Phosphorous, Total	0.029	mg/L
620900040280-01B	07/01/2013	General Environmental Sample	Phosphorous, Total	0.159	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Phosphorous, Total	0.061	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Phosphorous, Total	0.012	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Phosphorous, Total	0.040	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Phosphorous, Total	0.058	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Phosphorous, Total	0.049	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Phosphorous, Total	0.029	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Phosphorous, Total	0.035	mg/L
620900040280-01S	10/24/2001	General Environmental Sample	Phosphorous, Total	0.035	mg/L
620900040280-01S	01/23/2002	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-01S	04/24/2002	General Environmental Sample	Phosphorous, Total	0.034	mg/L
620900040280-01S	07/24/2002	General Environmental Sample	Phosphorous, Total	0.025	mg/L
620900040280-01S	09/14/2004	General Environmental Sample	Phosphorous, Total	0.042	mg/L
620900040280-01S	12/14/2004	General Environmental Sample	Phosphorous, Total	0.049	mg/L
620900040280-01S	03/14/2005	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-01S	06/14/2005	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-01S	10/10/2007	General Environmental Sample	Phosphorous, Total	0.029	mg/L
620900040280-01S	01/09/2008	General Environmental Sample	Phosphorous, Total	0.031	mg/L
620900040280-01S	04/28/2008	General Environmental Sample	Phosphorous, Total	0.049	mg/L
620900040280-01S	07/28/2008	General Environmental Sample	Phosphorous, Total	0.032	mg/L
620900040280-01S	11/08/2010	Environmental Churn Duplicate	Phosphorous, Total	0.041	mg/L
620900040280-01S	01/18/2011	Environmental Churn Duplicate	Phosphorous, Total	0.023	mg/L
620900040280-01S	04/12/2011	Environmental Churn Duplicate	Phosphorous, Total	0.033	mg/L
620900040280-01S	11/30/2011	Environmental Churn Duplicate	Phosphorous, Total	0.052	mg/L
620900040280-01S	10/10/2012	Environmental Churn Duplicate	Phosphorous, Total	0.024	mg/L
620900040280-01S	03/06/2013	Environmental Churn Duplicate	Phosphorous, Total	<0.005	mg/L
620900040280-01S	04/24/2013	Environmental Churn Duplicate	Phosphorous, Total	0.007	mg/L
620900040280-01S	07/01/2013	Environmental Churn Duplicate	Phosphorous, Total	0.014	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Phosphorous, Total	0.063	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Phosphorous, Total	0.071	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Phosphorous, Total	0.009	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Phosphorous, Total	0.024	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Phosphorous, Total	0.034	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Phosphorous, Total	0.058	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Phosphorous, Total	0.061	mg/L
620900040280-02	08/17/1999	General Environmental Sample	Phosphorous, Total	0.036	mg/L
620900040280-02	10/24/2001	General Environmental Sample	Phosphorous, Total	0.038	mg/L
620900040280-02	01/23/2002	General Environmental Sample	Phosphorous, Total	0.022	mg/L
620900040280-02	04/24/2002	General Environmental Sample	Phosphorous, Total	0.042	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-02	07/24/2002	General Environmental Sample	Phosphorous, Total	0.030	mg/L
620900040280-02	09/14/2004	General Environmental Sample	Phosphorous, Total	0.046	mg/L
620900040280-02	12/14/2004	General Environmental Sample	Phosphorous, Total	0.032	mg/L
620900040280-02	03/14/2005	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-02	06/14/2005	General Environmental Sample	Phosphorous, Total	0.034	mg/L
620900040280-02	10/10/2007	General Environmental Sample	Phosphorous, Total	0.031	mg/L
620900040280-02	01/09/2008	General Environmental Sample	Phosphorous, Total	0.034	mg/L
620900040280-02	04/28/2008	General Environmental Sample	Phosphorous, Total	0.062	mg/L
620900040280-02	07/28/2008	General Environmental Sample	Phosphorous, Total	0.035	mg/L
620900040280-02	11/08/2010	General Environmental Sample	Phosphorous, Total	0.040	mg/L
620900040280-02	01/18/2011	General Environmental Sample	Phosphorous, Total	0.023	mg/L
620900040280-02	04/12/2011	General Environmental Sample	Phosphorous, Total	0.036	mg/L
620900040280-02	11/30/2011	General Environmental Sample	Phosphorous, Total	0.060	mg/L
620900040280-02	10/10/2012	General Environmental Sample	Phosphorous, Total	0.034	mg/L
620900040280-02	03/06/2013	General Environmental Sample	Phosphorous, Total	<0.005	mg/L
620900040280-02	04/24/2013	General Environmental Sample	Phosphorous, Total	0.010	mg/L
620900040280-02	07/01/2013	General Environmental Sample	Phosphorous, Total	0.025	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Phosphorous, Total	0.015	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Phosphorous, Total	0.018	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Phosphorous, Total	0.020	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Phosphorous, Total	0.060	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Phosphorous, Total	0.030	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Phosphorous, Total	0.087	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Phosphorous, Total	0.031	mg/L
620900040280-03	10/24/2001	General Environmental Sample	Phosphorous, Total	0.032	mg/L
620900040280-03	01/23/2002	General Environmental Sample	Phosphorous, Total	0.024	mg/L
620900040280-03	04/24/2002	General Environmental Sample	Phosphorous, Total	0.035	mg/L
620900040280-03	07/24/2002	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-03	09/14/2004	General Environmental Sample	Phosphorous, Total	0.043	mg/L
620900040280-03	12/14/2004	General Environmental Sample	Phosphorous, Total	0.030	mg/L
620900040280-03	03/14/2005	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-03	06/14/2005	General Environmental Sample	Phosphorous, Total	0.026	mg/L
620900040280-03	10/10/2007	General Environmental Sample	Phosphorous, Total	0.034	mg/L
620900040280-03	01/09/2008	General Environmental Sample	Phosphorous, Total	0.031	mg/L
620900040280-03	04/28/2008	General Environmental Sample	Phosphorous, Total	0.054	mg/L
620900040280-03	07/28/2008	General Environmental Sample	Phosphorous, Total	0.033	mg/L
620900040280-03	11/08/2010	General Environmental Sample	Phosphorous, Total	0.041	mg/L
620900040280-03	01/18/2011	General Environmental Sample	Phosphorous, Total	0.023	mg/L
620900040280-03	04/12/2011	General Environmental Sample	Phosphorous, Total	0.031	mg/L
620900040280-03	11/30/2011	General Environmental Sample	Phosphorous, Total	0.067	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-03	10/10/2012	General Environmental Sample	Phosphorous, Total	0.036	mg/L
620900040280-03	03/06/2013	General Environmental Sample	Phosphorous, Total	<0.005	mg/L
620900040280-03	04/24/2013	General Environmental Sample	Phosphorous, Total	0.041	mg/L
620900040280-03	07/01/2013	General Environmental Sample	Phosphorous, Total	0.014	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Phosphorous, Total	0.084	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Phosphorous, Total	0.025	mg/L
620900040280-04	11/17/1998	General Environmental Sample	Phosphorous, Total	0.039	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Phosphorous, Total	0.019	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Phosphorous, Total	0.082	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Phosphorous, Total	0.046	mg/L
620900040280-04	10/24/2001	General Environmental Sample	Phosphorous, Total	0.069	mg/L
620900040280-04	01/23/2002	General Environmental Sample	Phosphorous, Total	0.023	mg/L
620900040280-04	04/24/2002	General Environmental Sample	Phosphorous, Total	0.054	mg/L
620900040280-04	07/24/2002	General Environmental Sample	Phosphorous, Total	0.039	mg/L
620900040280-04	09/14/2004	General Environmental Sample	Phosphorous, Total	0.062	mg/L
620900040280-04	12/14/2004	General Environmental Sample	Phosphorous, Total	0.053	mg/L
620900040280-04	03/14/2005	General Environmental Sample	Phosphorous, Total	0.027	mg/L
620900040280-04	06/14/2005	General Environmental Sample	Phosphorous, Total	0.040	mg/L
620900040280-04	10/10/2007	General Environmental Sample	Phosphorous, Total	0.025	mg/L
620900040280-04	01/09/2008	General Environmental Sample	Phosphorous, Total	0.036	mg/L
620900040280-04	04/28/2008	General Environmental Sample	Phosphorous, Total	0.070	mg/L
620900040280-04	07/28/2008	General Environmental Sample	Phosphorous, Total	0.061	mg/L
620900040280-04	11/08/2010	General Environmental Sample	Phosphorous, Total	0.041	mg/L
620900040280-04	01/18/2011	General Environmental Sample	Phosphorous, Total	0.023	mg/L
620900040280-04	04/12/2011	General Environmental Sample	Phosphorous, Total	0.039	mg/L
620900040280-04	11/30/2011	General Environmental Sample	Phosphorous, Total	0.064	mg/L
620900040280-04	10/10/2012	General Environmental Sample	Phosphorous, Total	0.051	mg/L
620900040280-04	07/01/2013	General Environmental Sample	Phosphorous, Total	0.040	mg/L
620900040280-05	10/24/2001	General Environmental Sample	Phosphorous, Total	0.039	mg/L
620900040280-05	01/23/2002	General Environmental Sample	Phosphorous, Total	0.024	mg/L
620900040280-05	04/24/2002	General Environmental Sample	Phosphorous, Total	0.038	mg/L
620900040280-05	07/24/2002	General Environmental Sample	Phosphorous, Total	0.025	mg/L
620900040280-05	09/14/2004	General Environmental Sample	Phosphorous, Total	0.040	mg/L
620900040280-05	12/14/2004	General Environmental Sample	Phosphorous, Total	0.039	mg/L
620900040280-05	03/14/2005	General Environmental Sample	Phosphorous, Total	0.024	mg/L
620900040280-05	06/14/2005	General Environmental Sample	Phosphorous, Total	0.036	mg/L
620900040280-05	10/10/2007	General Environmental Sample	Phosphorous, Total	0.027	mg/L
620900040280-05	01/09/2008	General Environmental Sample	Phosphorous, Total	0.031	mg/L
620900040280-05	04/28/2008	General Environmental Sample	Phosphorous, Total	0.052	mg/L
620900040280-05	07/28/2008	General Environmental Sample	Phosphorous, Total	0.027	mg/L

Carl Blackwell Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
620900040280-01B	05/18/1998	General Environmental Sample	Solids, Suspended	44	mg/L
620900040280-01B	08/18/1998	General Environmental Sample	Solids, Suspended	26	mg/L
620900040280-01B	11/17/1998	General Environmental Sample	Solids, Suspended	30	mg/L
620900040280-01B	02/16/1999	General Environmental Sample	Solids, Suspended	4	mg/L
620900040280-01B	05/17/1999	General Environmental Sample	Solids, Suspended	30	mg/L
620900040280-01B	08/17/1999	General Environmental Sample	Solids, Suspended	16	mg/L
620900040280-01S	05/18/1998	General Environmental Sample	Solids, Suspended	12	mg/L
620900040280-01S	08/18/1998	General Environmental Sample	Solids, Suspended	5	mg/L
620900040280-01S	11/17/1998	General Environmental Sample	Solids, Suspended	20	mg/L
620900040280-01S	02/16/1999	General Environmental Sample	Solids, Suspended	20	mg/L
620900040280-01S	05/17/1999	General Environmental Sample	Solids, Suspended	18	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Solids, Suspended	4	mg/L
620900040280-01S	08/17/1999	General Environmental Sample	Solids, Suspended	4	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Solids, Suspended	22	mg/L
620900040280-02	05/18/1998	General Environmental Sample	Solids, Suspended	40	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Solids, Suspended	3	mg/L
620900040280-02	08/18/1998	General Environmental Sample	Solids, Suspended	11	mg/L
620900040280-02	11/17/1998	General Environmental Sample	Solids, Suspended	26	mg/L
620900040280-02	02/16/1999	General Environmental Sample	Solids, Suspended	22	mg/L
620900040280-02	05/17/1999	General Environmental Sample	Solids, Suspended	26	mg/L
620900040280-02	08/17/1999	General Environmental Sample	Solids, Suspended	10	mg/L
620900040280-03	05/18/1998	General Environmental Sample	Solids, Suspended	20	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Solids, Suspended	2	mg/L
620900040280-03	08/18/1998	General Environmental Sample	Solids, Suspended	28	mg/L
620900040280-03	11/17/1998	General Environmental Sample	Solids, Suspended	24	mg/L
620900040280-03	02/16/1999	General Environmental Sample	Solids, Suspended	18	mg/L
620900040280-03	05/17/1999	General Environmental Sample	Solids, Suspended	23	mg/L
620900040280-03	08/17/1999	General Environmental Sample	Solids, Suspended	8	mg/L
620900040280-04	05/18/1998	General Environmental Sample	Solids, Suspended	48	mg/L
620900040280-04	08/18/1998	General Environmental Sample	Solids, Suspended	27	mg/L
620900040280-04	11/17/1998	General Environmental Sample	Solids, Suspended	34	mg/L
620900040280-04	02/16/1999	General Environmental Sample	Solids, Suspended	20	mg/L
620900040280-04	05/17/1999	General Environmental Sample	Solids, Suspended	40	mg/L
620900040280-04	08/17/1999	General Environmental Sample	Solids, Suspended	12	mg/L

Table B-2 Ambient Water Quality Data for Humphreys Lake, 2000-2014

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-01B	11/20/2002	General Environmental Sample	Corrected Chlorophyll-a	7.6	mg/m3
310810040150-01B	03/10/2003	General Environmental Sample	Corrected Chlorophyll-a	9.4	mg/m3
310810040150-01B	05/21/2003	General Environmental Sample	Corrected Chlorophyll-a	15.0	mg/m3
310810040150-01B	09/27/2004	General Environmental Sample	Corrected Chlorophyll-a	38.6	mg/m3
310810040150-01B	12/27/2004	General Environmental Sample	Corrected Chlorophyll-a	16.77	mg/m3
310810040150-01B	03/28/2005	General Environmental Sample	Corrected Chlorophyll-a	5.15	mg/m3
310810040150-01B	11/27/2006	General Environmental Sample	Corrected Chlorophyll-a	12.4	mg/m3
310810040150-01B	02/28/2007	General Environmental Sample	Corrected Chlorophyll-a	15.84	mg/m3
310810040150-01B	05/29/2007	General Environmental Sample	Corrected Chlorophyll-a	16.10	mg/m3
310810040150-01B	08/22/2007	General Environmental Sample	Corrected Chlorophyll-a	33.8	mg/m3
310810040150-01B	10/07/2008	General Environmental Sample	Corrected Chlorophyll-a	34.3	mg/m3
310810040150-01S	11/20/2002	General Environmental Sample	Corrected Chlorophyll-a	8.2	mg/m3
310810040150-01S	03/10/2003	General Environmental Sample	Corrected Chlorophyll-a	9.7	mg/m3
310810040150-01S	05/21/2003	General Environmental Sample	Corrected Chlorophyll-a	12.0	mg/m3
310810040150-01S	09/27/2004	General Environmental Sample	Corrected Chlorophyll-a	30.6	mg/m3
310810040150-01S	12/27/2004	General Environmental Sample	Corrected Chlorophyll-a	20.93	mg/m3
310810040150-01S	03/28/2005	General Environmental Sample	Corrected Chlorophyll-a	6.65	mg/m3
310810040150-01S	06/28/2005	General Environmental Sample	Corrected Chlorophyll-a	2.91	mg/m3
310810040150-01S	11/27/2006	General Environmental Sample	Corrected Chlorophyll-a	11.8	mg/m3
310810040150-01S	05/29/2007	General Environmental Sample	Corrected Chlorophyll-a	15.9	mg/m3
310810040150-01S	08/22/2007	General Environmental Sample	Corrected Chlorophyll-a	31.0	mg/m3
310810040150-01S	10/07/2008	General Environmental Sample	Corrected Chlorophyll-a	33.9	mg/m3
310810040150-01S	01/06/2009	Environmental Churn Duplicate	Corrected Chlorophyll-a	23.3	mg/m3
310810040150-01S	07/06/2009	Environmental Churn Duplicate	Corrected Chlorophyll-a	13.4	mg/m3
310810040150-01S	10/31/2011	Environmental Churn Duplicate	Corrected Chlorophyll-a	64.3	mg/m3
310810040150-01S	02/01/2012	Environmental Churn Duplicate	Corrected Chlorophyll-a	34.2	mg/m3
310810040150-01S	05/01/2012	Environmental Churn Duplicate	Corrected Chlorophyll-a	5.18	mg/m3
310810040150-01S	08/01/2012	Environmental Churn Duplicate	Corrected Chlorophyll-a	30.2	mg/m3
310810040150-01S	10/14/2013	Environmental Churn Duplicate	Corrected Chlorophyll-a	44.6	mg/m3
310810040150-01S	01/15/2014	Environmental Churn Duplicate	Corrected Chlorophyll-a	81.9	mg/m3
310810040150-01S	04/09/2014	Environmental Churn Duplicate	Corrected Chlorophyll-a	29.4	mg/m3
310810040150-01S	07/09/2014	Environmental Churn Duplicate	Corrected Chlorophyll-a	27.2	mg/m3
310810040150-02	11/20/2002	General Environmental Sample	Corrected Chlorophyll-a	8.2	mg/m3
310810040150-02	03/10/2003	General Environmental Sample	Corrected Chlorophyll-a	10.0	mg/m3
310810040150-02	05/21/2003	General Environmental Sample	Corrected Chlorophyll-a	17.8	mg/m3
310810040150-02	09/27/2004	General Environmental Sample	Corrected Chlorophyll-a	38.5	mg/m3
310810040150-02	12/27/2004	General Environmental Sample	Corrected Chlorophyll-a	14.88	mg/m3
310810040150-02	03/28/2005	General Environmental Sample	Corrected Chlorophyll-a	5.29	mg/m3
310810040150-02	06/28/2005	General Environmental Sample	Corrected Chlorophyll-a	13.5	mg/m3

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-02	11/27/2006	General Environmental Sample	Corrected Chlorophyll-a	13.0	mg/m3
310810040150-02	02/28/2007	General Environmental Sample	Corrected Chlorophyll-a	14.8	mg/m3
310810040150-02	05/29/2007	General Environmental Sample	Corrected Chlorophyll-a	23.9	mg/m3
310810040150-02	08/22/2007	General Environmental Sample	Corrected Chlorophyll-a	29.0	mg/m3
310810040150-02	10/07/2008	General Environmental Sample	Corrected Chlorophyll-a	38.6	mg/m3
310810040150-02	01/06/2009	General Environmental Sample	Corrected Chlorophyll-a	21.1	mg/m3
310810040150-02	07/06/2009	General Environmental Sample	Corrected Chlorophyll-a	17.7	mg/m3
310810040150-02	10/31/2011	General Environmental Sample	Corrected Chlorophyll-a	68.6	mg/m3
310810040150-02	02/01/2012	General Environmental Sample	Corrected Chlorophyll-a	24.0	mg/m3
310810040150-02	05/01/2012	General Environmental Sample	Corrected Chlorophyll-a	5.13	mg/m3
310810040150-02	08/01/2012	General Environmental Sample	Corrected Chlorophyll-a	26.9	mg/m3
310810040150-02	10/14/2013	General Environmental Sample	Corrected Chlorophyll-a	57.4	mg/m3
310810040150-02	01/15/2014	General Environmental Sample	Corrected Chlorophyll-a	79.5	mg/m3
310810040150-02	04/09/2014	General Environmental Sample	Corrected Chlorophyll-a	28.9	mg/m3
310810040150-02	07/09/2014	General Environmental Sample	Corrected Chlorophyll-a	34.7	mg/m3
310810040150-03	11/20/2002	General Environmental Sample	Corrected Chlorophyll-a	9.3	mg/m3
310810040150-03	03/10/2003	General Environmental Sample	Corrected Chlorophyll-a	10.2	mg/m3
310810040150-03	05/21/2003	General Environmental Sample	Corrected Chlorophyll-a	27.7	mg/m3
310810040150-03	09/27/2004	General Environmental Sample	Corrected Chlorophyll-a	34.9	mg/m3
310810040150-03	12/27/2004	General Environmental Sample	Corrected Chlorophyll-a	16.21	mg/m3
310810040150-03	03/28/2005	General Environmental Sample	Corrected Chlorophyll-a	5.03	mg/m3
310810040150-03	06/28/2005	General Environmental Sample	Corrected Chlorophyll-a	15.1	mg/m3
310810040150-03	11/27/2006	General Environmental Sample	Corrected Chlorophyll-a	10.9	mg/m3
310810040150-03	02/28/2007	General Environmental Sample	Corrected Chlorophyll-a	14.95	mg/m3
310810040150-03	05/29/2007	General Environmental Sample	Corrected Chlorophyll-a	44.0	mg/m3
310810040150-03	08/22/2007	General Environmental Sample	Corrected Chlorophyll-a	39.6	mg/m3
310810040150-03	10/07/2008	General Environmental Sample	Corrected Chlorophyll-a	42.2	mg/m3
310810040150-03	01/06/2009	General Environmental Sample	Corrected Chlorophyll-a	21.1	mg/m3
310810040150-03	07/06/2009	General Environmental Sample	Corrected Chlorophyll-a	19.3	mg/m3
310810040150-03	10/31/2011	General Environmental Sample	Corrected Chlorophyll-a	59.2	mg/m3
310810040150-03	02/01/2012	General Environmental Sample	Corrected Chlorophyll-a	34.4	mg/m3
310810040150-03	05/01/2012	General Environmental Sample	Corrected Chlorophyll-a	6.37	mg/m3
310810040150-03	08/01/2012	General Environmental Sample	Corrected Chlorophyll-a	26.6	mg/m3
310810040150-03	10/14/2013	General Environmental Sample	Corrected Chlorophyll-a	44.7	mg/m3
310810040150-03	01/15/2014	General Environmental Sample	Corrected Chlorophyll-a	84.7	mg/m3
310810040150-03	04/09/2014	General Environmental Sample	Corrected Chlorophyll-a	26.1	mg/m3
310810040150-03	07/09/2014	General Environmental Sample	Corrected Chlorophyll-a	33.6	mg/m3
310810040150-04	11/20/2002	General Environmental Sample	Corrected Chlorophyll-a	9.1	mg/m3
310810040150-04	03/10/2003	General Environmental Sample	Corrected Chlorophyll-a	9.1	mg/m3
310810040150-04	05/21/2003	General Environmental Sample	Corrected Chlorophyll-a	13.2	mg/m3

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-04	09/27/2004	General Environmental Sample	Corrected Chlorophyll-a	33.9	mg/m3
310810040150-04	12/27/2004	General Environmental Sample	Corrected Chlorophyll-a	16.14	mg/m3
310810040150-04	03/28/2005	General Environmental Sample	Corrected Chlorophyll-a	1.0	mg/m3
310810040150-04	06/28/2005	General Environmental Sample	Corrected Chlorophyll-a	10.7	mg/m3
310810040150-04	11/27/2006	General Environmental Sample	Corrected Chlorophyll-a	11.4	mg/m3
310810040150-04	02/28/2007	General Environmental Sample	Corrected Chlorophyll-a	15.88	mg/m3
310810040150-04	05/29/2007	General Environmental Sample	Corrected Chlorophyll-a	7.33	mg/m3
310810040150-04	08/22/2007	General Environmental Sample	Corrected Chlorophyll-a	22.6	mg/m3
310810040150-05	11/20/2002	General Environmental Sample	Corrected Chlorophyll-a	9.3	mg/m3
310810040150-05	03/10/2003	General Environmental Sample	Corrected Chlorophyll-a	10.8	mg/m3
310810040150-05	05/21/2003	General Environmental Sample	Corrected Chlorophyll-a	33.2	mg/m3
310810040150-05	09/27/2004	General Environmental Sample	Corrected Chlorophyll-a	32.9	mg/m3
310810040150-05	12/27/2004	General Environmental Sample	Corrected Chlorophyll-a	17.78	mg/m3
310810040150-05	03/28/2005	General Environmental Sample	Corrected Chlorophyll-a	4.83	mg/m3
310810040150-05	06/28/2005	General Environmental Sample	Corrected Chlorophyll-a	11.6	mg/m3
310810040150-05	11/27/2006	General Environmental Sample	Corrected Chlorophyll-a	10.9	mg/m3
310810040150-05	02/28/2007	General Environmental Sample	Corrected Chlorophyll-a	16.19	mg/m3
310810040150-05	05/29/2007	General Environmental Sample	Corrected Chlorophyll-a	38.7	mg/m3
310810040150-05	08/22/2007	General Environmental Sample	Corrected Chlorophyll-a	41.0	mg/m3
310810040150-01B	11/06/2000	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-01B	01/29/2001	General Environmental Sample	Nitrogen, Ammonia	0.23	mg/L
310810040150-01B	04/23/2001	General Environmental Sample	Nitrogen, Ammonia	0.48	mg/L
310810040150-01B	11/20/2002	General Environmental Sample	Nitrogen, Ammonia	0.14	mg/L
310810040150-01B	03/10/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01B	05/21/2003	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-01B	08/20/2003	General Environmental Sample	Nitrogen, Ammonia	1.17	mg/L
310810040150-01B	09/27/2004	General Environmental Sample	Nitrogen, Ammonia	0.56	mg/L
310810040150-01B	12/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01S	11/06/2000	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-01S	01/29/2001	General Environmental Sample	Nitrogen, Ammonia	0.21	mg/L
310810040150-01S	04/23/2001	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-01S	11/20/2002	General Environmental Sample	Nitrogen, Ammonia	0.15	mg/L
310810040150-01S	03/10/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01S	05/21/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01S	08/20/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01S	09/27/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
310810040150-01S	12/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01S	03/29/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-01S	06/27/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-02	11/06/2000	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-02	01/29/2001	General Environmental Sample	Nitrogen, Ammonia	0.20	mg/L
310810040150-02	04/23/2001	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-02	11/20/2002	General Environmental Sample	Nitrogen, Ammonia	0.10	mg/L
310810040150-02	03/10/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-02	05/21/2003	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-02	08/20/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-02	09/27/2004	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
310810040150-02	12/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-02	03/29/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-02	06/27/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-03	11/06/2000	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
310810040150-03	01/29/2001	General Environmental Sample	Nitrogen, Ammonia	0.15	mg/L
310810040150-03	04/23/2001	General Environmental Sample	Nitrogen, Ammonia	0.09	mg/L
310810040150-03	11/20/2002	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
310810040150-03	03/10/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-03	05/21/2003	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
310810040150-03	08/20/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-03	09/27/2004	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
310810040150-03	12/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-03	03/29/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-03	06/27/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-04	05/21/2003	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
310810040150-04	08/20/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-04	09/27/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
310810040150-04	12/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-04	03/29/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-04	06/27/2005	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
310810040150-05	05/21/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-05	08/20/2003	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-05	09/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-05	12/27/2004	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-05	03/29/2005	General Environmental Sample	Nitrogen, Ammonia	<0.050	mg/L
310810040150-05	06/27/2005	General Environmental Sample	Nitrogen, Ammonia	0.08	mg/L
310810040150-01B	11/06/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
310810040150-01B	01/29/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.70	mg/L
310810040150-01B	04/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	1.11	mg/L
310810040150-01B	07/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	2.25	mg/L
310810040150-01B	11/20/2002	General Environmental Sample	Nitrogen, Kjeldahl	1.26	mg/L
310810040150-01B	03/10/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.15	mg/L
310810040150-01B	05/21/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.68	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-01B	08/20/2003	General Environmental Sample	Nitrogen, Kjeldahl	2.61	mg/L
310810040150-01B	09/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	1.44	mg/L
310810040150-01B	12/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.62	mg/L
310810040150-01B	02/28/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.90	mg/L
310810040150-01S	11/06/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
310810040150-01S	01/29/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
310810040150-01S	04/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.76	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.50	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.52	mg/L
310810040150-01S	11/20/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
310810040150-01S	03/10/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.28	mg/L
310810040150-01S	05/21/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.65	mg/L
310810040150-01S	08/20/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.01	mg/L
310810040150-01S	09/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	1.02	mg/L
310810040150-01S	12/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.59	mg/L
310810040150-01S	03/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L
310810040150-01S	06/27/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.72	mg/L
310810040150-01S	11/27/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
310810040150-01S	05/29/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
310810040150-01S	08/22/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
310810040150-01S	10/07/2008	General Environmental Sample	Nitrogen, Kjeldahl	1.07	mg/L
310810040150-01S	01/06/2009	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.79	mg/L
310810040150-01S	04/07/2009	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.74	mg/L
310810040150-01S	10/31/2011	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.56	mg/L
310810040150-01S	02/01/2012	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.33	mg/L
310810040150-01S	05/01/2012	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.18	mg/L
310810040150-01S	08/01/2012	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.52	mg/L
310810040150-01S	10/14/2013	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.62	mg/L
310810040150-01S	01/15/2014	Environmental Churn Duplicate	Nitrogen, Kjeldahl	2.09	mg/L
310810040150-01S	04/09/2014	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.49	mg/L
310810040150-01S	07/09/2014	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.34	mg/L
310810040150-02	11/06/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
310810040150-02	01/29/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
310810040150-02	04/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	1.28	mg/L
310810040150-02	07/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.58	mg/L
310810040150-02	11/20/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.68	mg/L
310810040150-02	03/10/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
310810040150-02	05/21/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.75	mg/L
310810040150-02	08/20/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
310810040150-02	09/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	1.00	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-02	12/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.63	mg/L
310810040150-02	03/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.55	mg/L
310810040150-02	06/27/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
310810040150-02	11/27/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.77	mg/L
310810040150-02	02/28/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
310810040150-02	05/29/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.75	mg/L
310810040150-02	08/22/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.91	mg/L
310810040150-02	10/07/2008	General Environmental Sample	Nitrogen, Kjeldahl	1.05	mg/L
310810040150-02	01/06/2009	General Environmental Sample	Nitrogen, Kjeldahl	0.72	mg/L
310810040150-02	04/07/2009	General Environmental Sample	Nitrogen, Kjeldahl	0.73	mg/L
310810040150-02	10/31/2011	General Environmental Sample	Nitrogen, Kjeldahl	1.50	mg/L
310810040150-02	02/01/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.32	mg/L
310810040150-02	05/01/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.18	mg/L
310810040150-02	08/01/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.53	mg/L
310810040150-02	10/14/2013	General Environmental Sample	Nitrogen, Kjeldahl	1.63	mg/L
310810040150-02	01/15/2014	General Environmental Sample	Nitrogen, Kjeldahl	1.53	mg/L
310810040150-02	04/09/2014	General Environmental Sample	Nitrogen, Kjeldahl	1.37	mg/L
310810040150-02	07/09/2014	General Environmental Sample	Nitrogen, Kjeldahl	1.35	mg/L
310810040150-03	11/06/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
310810040150-03	01/29/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
310810040150-03	04/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	1.25	mg/L
310810040150-03	07/23/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.63	mg/L
310810040150-03	11/20/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.70	mg/L
310810040150-03	03/10/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.35	mg/L
310810040150-03	05/21/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.75	mg/L
310810040150-03	08/20/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.81	mg/L
310810040150-03	09/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	1.11	mg/L
310810040150-03	12/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.53	mg/L
310810040150-03	03/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.47	mg/L
310810040150-03	06/27/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.64	mg/L
310810040150-03	11/27/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.77	mg/L
310810040150-03	02/28/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
310810040150-03	05/29/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.99	mg/L
310810040150-03	08/22/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
310810040150-03	10/07/2008	General Environmental Sample	Nitrogen, Kjeldahl	1.02	mg/L
310810040150-03	01/06/2009	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L
310810040150-03	04/07/2009	General Environmental Sample	Nitrogen, Kjeldahl	0.73	mg/L
310810040150-03	10/31/2011	General Environmental Sample	Nitrogen, Kjeldahl	1.10	mg/L
310810040150-03	02/01/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.44	mg/L
310810040150-03	05/01/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.23	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-03	08/01/2012	General Environmental Sample	Nitrogen, Kjeldahl	1.57	mg/L
310810040150-03	10/14/2013	General Environmental Sample	Nitrogen, Kjeldahl	1.56	mg/L
310810040150-03	01/15/2014	General Environmental Sample	Nitrogen, Kjeldahl	1.25	mg/L
310810040150-03	04/09/2014	General Environmental Sample	Nitrogen, Kjeldahl	1.60	mg/L
310810040150-03	07/09/2014	General Environmental Sample	Nitrogen, Kjeldahl	1.49	mg/L
310810040150-04	05/21/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.80	mg/L
310810040150-04	08/20/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
310810040150-04	09/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.91	mg/L
310810040150-04	12/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
310810040150-04	03/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.55	mg/L
310810040150-04	06/27/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.85	mg/L
310810040150-04	11/27/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.76	mg/L
310810040150-04	02/28/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
310810040150-04	05/29/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L
310810040150-04	08/22/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
310810040150-05	05/21/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.96	mg/L
310810040150-05	08/20/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
310810040150-05	09/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
310810040150-05	12/27/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.55	mg/L
310810040150-05	03/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.69	mg/L
310810040150-05	06/27/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.68	mg/L
310810040150-05	11/27/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.78	mg/L
310810040150-05	02/28/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
310810040150-05	05/29/2007	General Environmental Sample	Nitrogen, Kjeldahl	1.19	mg/L
310810040150-05	08/22/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
310810040150-01B	11/06/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.20	mg/L
310810040150-01B	01/29/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
310810040150-01B	04/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.22	mg/L
310810040150-01B	07/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-01B	11/20/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.28	mg/L
310810040150-01B	03/10/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.23	mg/L
310810040150-01B	05/21/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.09	mg/L
310810040150-01B	08/20/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-01B	09/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-01B	12/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.15	mg/L
310810040150-01S	11/06/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.20	mg/L
310810040150-01S	01/29/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.30	mg/L
310810040150-01S	04/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.28	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-01S	11/20/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
310810040150-01S	03/10/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.23	mg/L
310810040150-01S	05/21/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.09	mg/L
310810040150-01S	08/20/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-01S	09/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-01S	12/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.15	mg/L
310810040150-02	11/06/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.17	mg/L
310810040150-02	01/29/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.30	mg/L
310810040150-02	04/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.28	mg/L
310810040150-02	07/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-02	11/20/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
310810040150-02	03/10/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.23	mg/L
310810040150-02	05/21/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.11	mg/L
310810040150-02	08/20/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-02	09/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-02	12/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
310810040150-03	11/06/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.12	mg/L
310810040150-03	01/29/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.30	mg/L
310810040150-03	04/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	0.27	mg/L
310810040150-03	07/23/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-03	11/20/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.29	mg/L
310810040150-03	03/10/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.22	mg/L
310810040150-03	05/21/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.09	mg/L
310810040150-03	08/20/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-03	09/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-03	12/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.13	mg/L
310810040150-04	05/21/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.10	mg/L
310810040150-04	08/20/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-04	09/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-04	12/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.15	mg/L
310810040150-05	05/21/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.09	mg/L
310810040150-05	08/20/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-05	09/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.050	mg/L
310810040150-05	12/27/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.13	mg/L
310810040150-01B	02/28/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.30	mg/L
310810040150-01S	03/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.06	mg/L
310810040150-01S	06/27/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	11/27/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
310810040150-01S	05/29/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	08/22/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-01S	10/07/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	01/06/2009	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.09	mg/L
310810040150-01S	04/07/2009	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.12	mg/L
310810040150-01S	10/31/2011	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	02/01/2012	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	05/01/2012	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	08/01/2012	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	10/14/2013	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	01/15/2014	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	04/09/2014	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01S	07/09/2014	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	03/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
310810040150-02	06/27/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	11/27/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
310810040150-02	02/28/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.30	mg/L
310810040150-02	05/29/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	08/22/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	10/07/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	01/06/2009	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.08	mg/L
310810040150-02	04/07/2009	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.12	mg/L
310810040150-02	10/31/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	02/01/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	05/01/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	08/01/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	10/14/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	01/15/2014	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	04/09/2014	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-02	07/09/2014	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	03/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
310810040150-03	06/27/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	11/27/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.13	mg/L
310810040150-03	02/28/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.30	mg/L
310810040150-03	05/29/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	08/22/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	10/07/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	01/06/2009	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.08	mg/L
310810040150-03	04/07/2009	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
310810040150-03	10/31/2011	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	02/01/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	05/01/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-03	08/01/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	10/14/2013	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	01/15/2014	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	04/09/2014	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-03	07/09/2014	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-04	03/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
310810040150-04	06/27/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-04	11/27/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
310810040150-04	02/28/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.30	mg/L
310810040150-04	05/29/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-04	08/22/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-05	03/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.06	mg/L
310810040150-05	06/27/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-05	11/27/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.13	mg/L
310810040150-05	02/28/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.30	mg/L
310810040150-05	05/29/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-05	08/22/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.050	mg/L
310810040150-01B	11/06/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	01/29/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	04/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	07/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
310810040150-01B	11/20/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
310810040150-01B	03/10/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	05/21/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	08/20/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	09/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	12/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	11/06/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	01/29/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	04/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
310810040150-01S	11/20/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
310810040150-01S	03/10/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	05/21/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	08/20/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	09/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01S	12/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	11/06/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	01/29/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-02	04/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	07/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
310810040150-02	11/20/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
310810040150-02	03/10/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	05/21/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	08/20/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	09/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-02	12/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	11/06/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	01/29/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	04/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	07/23/2001	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
310810040150-03	11/20/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
310810040150-03	03/10/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	05/21/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	08/20/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	09/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-03	12/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-04	05/21/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-04	08/20/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-04	09/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-04	12/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-05	05/21/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-05	08/20/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-05	09/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-05	12/27/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.050	mg/L
310810040150-01B	11/06/2000	General Environmental Sample	Phosphorous, Ortho	0.028	mg/L
310810040150-01B	01/29/2001	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
310810040150-01B	04/23/2001	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
310810040150-01B	07/23/2001	General Environmental Sample	Phosphorous, Ortho	0.413	mg/L
310810040150-01B	11/20/2002	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
310810040150-01B	03/10/2003	General Environmental Sample	Phosphorous, Ortho	0.005	mg/L
310810040150-01B	05/21/2003	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
310810040150-01B	08/20/2003	General Environmental Sample	Phosphorous, Ortho	0.270	mg/L
310810040150-01B	09/27/2004	General Environmental Sample	Phosphorous, Ortho	0.034	mg/L
310810040150-01B	12/27/2004	General Environmental Sample	Phosphorous, Ortho	0.005	mg/L
310810040150-01B	02/28/2007	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
310810040150-01S	11/06/2000	General Environmental Sample	Phosphorous, Ortho	0.026	mg/L
310810040150-01S	01/29/2001	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-01S	04/23/2001	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-01S	07/23/2001	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
310810040150-01S	11/20/2002	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
310810040150-01S	03/10/2003	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-01S	05/21/2003	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
310810040150-01S	08/20/2003	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
310810040150-01S	09/27/2004	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
310810040150-01S	12/27/2004	General Environmental Sample	Phosphorous, Ortho	0.005	mg/L
310810040150-01S	03/29/2005	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
310810040150-01S	06/27/2005	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
310810040150-01S	11/27/2006	General Environmental Sample	Phosphorous, Ortho	0.006	mg/L
310810040150-01S	05/29/2007	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
310810040150-01S	08/22/2007	General Environmental Sample	Phosphorous, Ortho	0.021	mg/L
310810040150-01S	07/06/2009	Environmental Churn Duplicate	Phosphorous, Ortho	0.040	mg/L
310810040150-02	11/06/2000	General Environmental Sample	Phosphorous, Ortho	0.035	mg/L
310810040150-02	01/29/2001	General Environmental Sample	Phosphorous, Ortho	0.027	mg/L
310810040150-02	04/23/2001	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
310810040150-02	07/23/2001	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
310810040150-02	11/20/2002	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
310810040150-02	03/10/2003	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-02	05/21/2003	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
310810040150-02	08/20/2003	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
310810040150-02	09/27/2004	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
310810040150-02	12/27/2004	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-02	03/29/2005	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
310810040150-02	06/27/2005	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
310810040150-02	11/27/2006	General Environmental Sample	Phosphorous, Ortho	0.006	mg/L
310810040150-02	02/28/2007	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
310810040150-02	05/29/2007	General Environmental Sample	Phosphorous, Ortho	0.030	mg/L
310810040150-02	08/22/2007	General Environmental Sample	Phosphorous, Ortho	0.024	mg/L
310810040150-03	11/06/2000	General Environmental Sample	Phosphorous, Ortho	0.050	mg/L
310810040150-03	01/29/2001	General Environmental Sample	Phosphorous, Ortho	0.027	mg/L
310810040150-03	04/23/2001	General Environmental Sample	Phosphorous, Ortho	0.020	mg/L
310810040150-03	07/23/2001	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
310810040150-03	11/20/2002	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
310810040150-03	03/10/2003	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-03	05/21/2003	General Environmental Sample	Phosphorous, Ortho	0.020	mg/L
310810040150-03	08/20/2003	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
310810040150-03	09/27/2004	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
310810040150-03	12/27/2004	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-03	03/29/2005	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
310810040150-03	06/27/2005	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
310810040150-03	11/27/2006	General Environmental Sample	Phosphorous, Ortho	0.006	mg/L
310810040150-03	02/28/2007	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
310810040150-03	05/29/2007	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
310810040150-03	08/22/2007	General Environmental Sample	Phosphorous, Ortho	0.021	mg/L
310810040150-04	05/21/2003	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
310810040150-04	08/20/2003	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
310810040150-04	09/27/2004	General Environmental Sample	Phosphorous, Ortho	0.010	mg/L
310810040150-04	12/27/2004	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-04	03/29/2005	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
310810040150-04	06/27/2005	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
310810040150-04	11/27/2006	General Environmental Sample	Phosphorous, Ortho	0.006	mg/L
310810040150-04	02/28/2007	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
310810040150-04	05/29/2007	General Environmental Sample	Phosphorous, Ortho	0.026	mg/L
310810040150-04	08/22/2007	General Environmental Sample	Phosphorous, Ortho	0.025	mg/L
310810040150-05	05/21/2003	General Environmental Sample	Phosphorous, Ortho	0.025	mg/L
310810040150-05	08/20/2003	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
310810040150-05	09/27/2004	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
310810040150-05	12/27/2004	General Environmental Sample	Phosphorous, Ortho	<0.005	mg/L
310810040150-05	03/29/2005	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
310810040150-05	06/27/2005	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
310810040150-05	11/27/2006	General Environmental Sample	Phosphorous, Ortho	0.005	mg/L
310810040150-05	02/28/2007	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
310810040150-05	05/29/2007	General Environmental Sample	Phosphorous, Ortho	0.032	mg/L
310810040150-05	08/22/2007	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
310810040150-01B	11/06/2000	General Environmental Sample	Phosphorous, Total	0.105	mg/L
310810040150-01B	01/29/2001	General Environmental Sample	Phosphorous, Total	0.055	mg/L
310810040150-01B	04/23/2001	General Environmental Sample	Phosphorous, Total	0.059	mg/L
310810040150-01B	07/23/2001	General Environmental Sample	Phosphorous, Total	0.499	mg/L
310810040150-01B	11/20/2002	General Environmental Sample	Phosphorous, Total	0.032	mg/L
310810040150-01B	03/10/2003	General Environmental Sample	Phosphorous, Total	0.035	mg/L
310810040150-01B	05/21/2003	General Environmental Sample	Phosphorous, Total	0.046	mg/L
310810040150-01B	08/20/2003	General Environmental Sample	Phosphorous, Total	0.297	mg/L
310810040150-01B	09/27/2004	General Environmental Sample	Phosphorous, Total	0.097	mg/L
310810040150-01B	12/27/2004	General Environmental Sample	Phosphorous, Total	0.037	mg/L
310810040150-01B	02/28/2007	General Environmental Sample	Phosphorous, Total	0.027	mg/L
310810040150-01S	11/06/2000	General Environmental Sample	Phosphorous, Total	0.104	mg/L
310810040150-01S	01/29/2001	General Environmental Sample	Phosphorous, Total	0.058	mg/L
310810040150-01S	04/23/2001	General Environmental Sample	Phosphorous, Total	0.039	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-01S	07/23/2001	General Environmental Sample	Phosphorous, Total	0.020	mg/L
310810040150-01S	07/23/2001	General Environmental Sample	Phosphorous, Total	0.023	mg/L
310810040150-01S	11/20/2002	General Environmental Sample	Phosphorous, Total	0.032	mg/L
310810040150-01S	03/10/2003	General Environmental Sample	Phosphorous, Total	0.026	mg/L
310810040150-01S	05/21/2003	General Environmental Sample	Phosphorous, Total	0.039	mg/L
310810040150-01S	08/20/2003	General Environmental Sample	Phosphorous, Total	0.033	mg/L
310810040150-01S	09/27/2004	General Environmental Sample	Phosphorous, Total	0.056	mg/L
310810040150-01S	12/27/2004	General Environmental Sample	Phosphorous, Total	0.035	mg/L
310810040150-01S	03/29/2005	General Environmental Sample	Phosphorous, Total	0.040	mg/L
310810040150-01S	06/27/2005	General Environmental Sample	Phosphorous, Total	0.028	mg/L
310810040150-01S	11/27/2006	General Environmental Sample	Phosphorous, Total	0.040	mg/L
310810040150-01S	05/29/2007	General Environmental Sample	Phosphorous, Total	0.031	mg/L
310810040150-01S	08/22/2007	General Environmental Sample	Phosphorous, Total	0.091	mg/L
310810040150-01S	10/07/2008	General Environmental Sample	Phosphorous, Total	0.044	mg/L
310810040150-01S	01/06/2009	Environmental Churn Duplicate	Phosphorous, Total	0.025	mg/L
310810040150-01S	04/07/2009	Environmental Churn Duplicate	Phosphorous, Total	0.042	mg/L
310810040150-01S	10/31/2011	Environmental Churn Duplicate	Phosphorous, Total	0.056	mg/L
310810040150-01S	02/01/2012	Environmental Churn Duplicate	Phosphorous, Total	0.026	mg/L
310810040150-01S	05/01/2012	Environmental Churn Duplicate	Phosphorous, Total	<0.005	mg/L
310810040150-01S	08/01/2012	Environmental Churn Duplicate	Phosphorous, Total	0.016	mg/L
310810040150-01S	10/14/2013	Environmental Churn Duplicate	Phosphorous, Total	0.050	mg/L
310810040150-01S	01/15/2014	Environmental Churn Duplicate	Phosphorous, Total	0.053	mg/L
310810040150-01S	04/09/2014	Environmental Churn Duplicate	Phosphorous, Total	0.026	mg/L
310810040150-01S	07/09/2014	Environmental Churn Duplicate	Phosphorous, Total	0.043	mg/L
310810040150-02	11/06/2000	General Environmental Sample	Phosphorous, Total	0.112	mg/L
310810040150-02	01/29/2001	General Environmental Sample	Phosphorous, Total	0.057	mg/L
310810040150-02	04/23/2001	General Environmental Sample	Phosphorous, Total	0.048	mg/L
310810040150-02	07/23/2001	General Environmental Sample	Phosphorous, Total	0.035	mg/L
310810040150-02	11/20/2002	General Environmental Sample	Phosphorous, Total	0.029	mg/L
310810040150-02	03/10/2003	General Environmental Sample	Phosphorous, Total	0.026	mg/L
310810040150-02	05/21/2003	General Environmental Sample	Phosphorous, Total	0.051	mg/L
310810040150-02	08/20/2003	General Environmental Sample	Phosphorous, Total	0.055	mg/L
310810040150-02	09/27/2004	General Environmental Sample	Phosphorous, Total	0.062	mg/L
310810040150-02	12/27/2004	General Environmental Sample	Phosphorous, Total	0.034	mg/L
310810040150-02	03/29/2005	General Environmental Sample	Phosphorous, Total	0.033	mg/L
310810040150-02	06/27/2005	General Environmental Sample	Phosphorous, Total	0.040	mg/L
310810040150-02	11/27/2006	General Environmental Sample	Phosphorous, Total	0.040	mg/L
310810040150-02	02/28/2007	General Environmental Sample	Phosphorous, Total	0.030	mg/L
310810040150-02	05/29/2007	General Environmental Sample	Phosphorous, Total	0.043	mg/L
310810040150-02	08/22/2007	General Environmental Sample	Phosphorous, Total	0.073	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-02	10/07/2008	General Environmental Sample	Phosphorous, Total	0.054	mg/L
310810040150-02	01/06/2009	General Environmental Sample	Phosphorous, Total	0.022	mg/L
310810040150-02	04/07/2009	General Environmental Sample	Phosphorous, Total	0.043	mg/L
310810040150-02	10/31/2011	General Environmental Sample	Phosphorous, Total	0.061	mg/L
310810040150-02	02/01/2012	General Environmental Sample	Phosphorous, Total	0.025	mg/L
310810040150-02	05/01/2012	General Environmental Sample	Phosphorous, Total	0.006	mg/L
310810040150-02	08/01/2012	General Environmental Sample	Phosphorous, Total	0.017	mg/L
310810040150-02	10/14/2013	General Environmental Sample	Phosphorous, Total	0.052	mg/L
310810040150-02	01/15/2014	General Environmental Sample	Phosphorous, Total	0.066	mg/L
310810040150-02	04/09/2014	General Environmental Sample	Phosphorous, Total	0.046	mg/L
310810040150-02	07/09/2014	General Environmental Sample	Phosphorous, Total	0.043	mg/L
310810040150-03	11/06/2000	General Environmental Sample	Phosphorous, Total	0.153	mg/L
310810040150-03	01/29/2001	General Environmental Sample	Phosphorous, Total	0.050	mg/L
310810040150-03	04/23/2001	General Environmental Sample	Phosphorous, Total	0.061	mg/L
310810040150-03	07/23/2001	General Environmental Sample	Phosphorous, Total	0.039	mg/L
310810040150-03	11/20/2002	General Environmental Sample	Phosphorous, Total	0.026	mg/L
310810040150-03	03/10/2003	General Environmental Sample	Phosphorous, Total	0.030	mg/L
310810040150-03	05/21/2003	General Environmental Sample	Phosphorous, Total	0.053	mg/L
310810040150-03	08/20/2003	General Environmental Sample	Phosphorous, Total	0.052	mg/L
310810040150-03	09/27/2004	General Environmental Sample	Phosphorous, Total	0.067	mg/L
310810040150-03	12/27/2004	General Environmental Sample	Phosphorous, Total	0.037	mg/L
310810040150-03	03/29/2005	General Environmental Sample	Phosphorous, Total	0.031	mg/L
310810040150-03	06/27/2005	General Environmental Sample	Phosphorous, Total	0.038	mg/L
310810040150-03	11/27/2006	General Environmental Sample	Phosphorous, Total	0.039	mg/L
310810040150-03	02/28/2007	General Environmental Sample	Phosphorous, Total	0.028	mg/L
310810040150-03	05/29/2007	General Environmental Sample	Phosphorous, Total	0.060	mg/L
310810040150-03	08/22/2007	General Environmental Sample	Phosphorous, Total	0.081	mg/L
310810040150-03	10/07/2008	General Environmental Sample	Phosphorous, Total	0.078	mg/L
310810040150-03	01/06/2009	General Environmental Sample	Phosphorous, Total	0.025	mg/L
310810040150-03	04/07/2009	General Environmental Sample	Phosphorous, Total	0.045	mg/L
310810040150-03	10/31/2011	General Environmental Sample	Phosphorous, Total	0.061	mg/L
310810040150-03	02/01/2012	General Environmental Sample	Phosphorous, Total	0.022	mg/L
310810040150-03	05/01/2012	General Environmental Sample	Phosphorous, Total	0.014	mg/L
310810040150-03	08/01/2012	General Environmental Sample	Phosphorous, Total	0.024	mg/L
310810040150-03	10/14/2013	General Environmental Sample	Phosphorous, Total	0.057	mg/L
310810040150-03	01/15/2014	General Environmental Sample	Phosphorous, Total	0.035	mg/L
310810040150-03	04/09/2014	General Environmental Sample	Phosphorous, Total	0.046	mg/L
310810040150-03	07/09/2014	General Environmental Sample	Phosphorous, Total	0.053	mg/L
310810040150-04	05/21/2003	General Environmental Sample	Phosphorous, Total	0.036	mg/L
310810040150-04	08/20/2003	General Environmental Sample	Phosphorous, Total	0.041	mg/L

Humphreys Lake WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
310810040150-04	09/27/2004	General Environmental Sample	Phosphorous, Total	0.060	mg/L
310810040150-04	12/27/2004	General Environmental Sample	Phosphorous, Total	0.035	mg/L
310810040150-04	03/29/2005	General Environmental Sample	Phosphorous, Total	0.033	mg/L
310810040150-04	06/27/2005	General Environmental Sample	Phosphorous, Total	0.032	mg/L
310810040150-04	11/27/2006	General Environmental Sample	Phosphorous, Total	0.038	mg/L
310810040150-04	02/28/2007	General Environmental Sample	Phosphorous, Total	0.028	mg/L
310810040150-04	05/29/2007	General Environmental Sample	Phosphorous, Total	0.026	mg/L
310810040150-04	08/22/2007	General Environmental Sample	Phosphorous, Total	0.072	mg/L
310810040150-05	05/21/2003	General Environmental Sample	Phosphorous, Total	0.090	mg/L
310810040150-05	08/20/2003	General Environmental Sample	Phosphorous, Total	0.052	mg/L
310810040150-05	09/27/2004	General Environmental Sample	Phosphorous, Total	0.058	mg/L
310810040150-05	12/27/2004	General Environmental Sample	Phosphorous, Total	0.034	mg/L
310810040150-05	03/29/2005	General Environmental Sample	Phosphorous, Total	0.033	mg/L
310810040150-05	06/27/2005	General Environmental Sample	Phosphorous, Total	0.033	mg/L
310810040150-05	11/27/2006	General Environmental Sample	Phosphorous, Total	0.047	mg/L
310810040150-05	02/28/2007	General Environmental Sample	Phosphorous, Total	0.031	mg/L
310810040150-05	05/29/2007	General Environmental Sample	Phosphorous, Total	0.055	mg/L
310810040150-05	08/22/2007	General Environmental Sample	Phosphorous, Total	0.088	mg/L

APPENDIX C

SWAT MODEL INPUT AND CALIBRATION

CARL BLACKWELL LAKE

Appendix C
SWAT Model Input and Calibration – Carl Blackwell Lake

Given the lack of flow gage and water quality data available to quantify loadings directly from the tributaries of Carl Blackwell Lake and Lake Humphreys, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2011). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. The major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management.

C-1. Model Inputs

All the GIS layers were processed using the ArcSWAT 2012.10.2.16 interface for SWAT2012 (Winchell et al. 2013). The interface was also used to change input parameters to achieve calibration and to export the model results to a Microsoft Access database.

C-1.1 Elevation Data

The 2002/2004 30-meter United States Geographical Survey (USGS) National Elevation Dataset (NED) was used for watershed delineation. The NED was also used to calculate the slopes and determine the stream network incorporated into SWAT. Slopes were divided into three categories: 0-1, 1-5, and > 5%.

C-1.2 Soil Data

Soil data used for this model were derived using the Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) soils database incorporated in ArcSWAT.

C-1.3 Land Use Data

Land use and land cover data were derived from NASS 2013 Cropland Data Layer (CDL) (http://www.nass.usda.gov/research/Cropland/SARS1a.htm) (USDA 2014). Three main crops were included in the model: corn, winter wheat and rye.

Table C-1 Distribution of Land Cover in the Modeled Watershed

Description	SWAT Code	Area (acres)	Percent of Total Watershed Area
Corn	AGRR	62,649	3.3
Winter Wheat	WWHT	421,318	21.9
Rye	RYE	64,121	3.3
Open Water	WATR	23,659	1.2
Residential-Low Density	URLD	106,069	5.5
Residential-Medium Density	URMD	27,315	1.4
Residential-High Density	URHD	14,932	0.8
Industrial	UIDU	4,821	0.3
Southwestern US (Arid) Range	SWRN	552	<0.1
Forest-Deciduous	FRSD	267,890	13.9
Forest-Evergreen	FRSE	15,875	0.8
Forest-Mixed	FRST	9	<0.1
Range-Brush	RNGB	1	<0.1
Range-Grasses	RNGE	916,180	47.6
Wetlands-Forested	WETF	201	0.0

C-1.4 Meteorology

The meteorological data for the simulation period of 1994 to 2013 was derived from eleven Oklahoma Mesonet stations (Breckinridge, El Reno, Guthrie, Kingfisher, Lake Carl Blackwell, Marena, Marshall, Oilton, Pawnee, Perkins, and Stillwater). Weather station locations are shown in Figure C-1. Daily time-series of precipitation, temperature, solar radiation, wind speed, and relative humidity were imported into the SWAT model along with the station coordinates and SWAT subsequently assigned the precipitation to the various subwatersheds using the nearest station (Neitsch et al., 2011).

C-1.5 Subwatershed Delineation

The modeled area was split into 97 sub-watersheds (Figure C-2) based on the National Elevation Dataset (http://ned.usgs.gov) and the National Hydrography Dataset (http://nhd.usgs.gov) of the USGS. The watersheds of Carl Blackwell Lake is outlined in black in Figure C-2. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

Figure C-1 Weather Station Locations

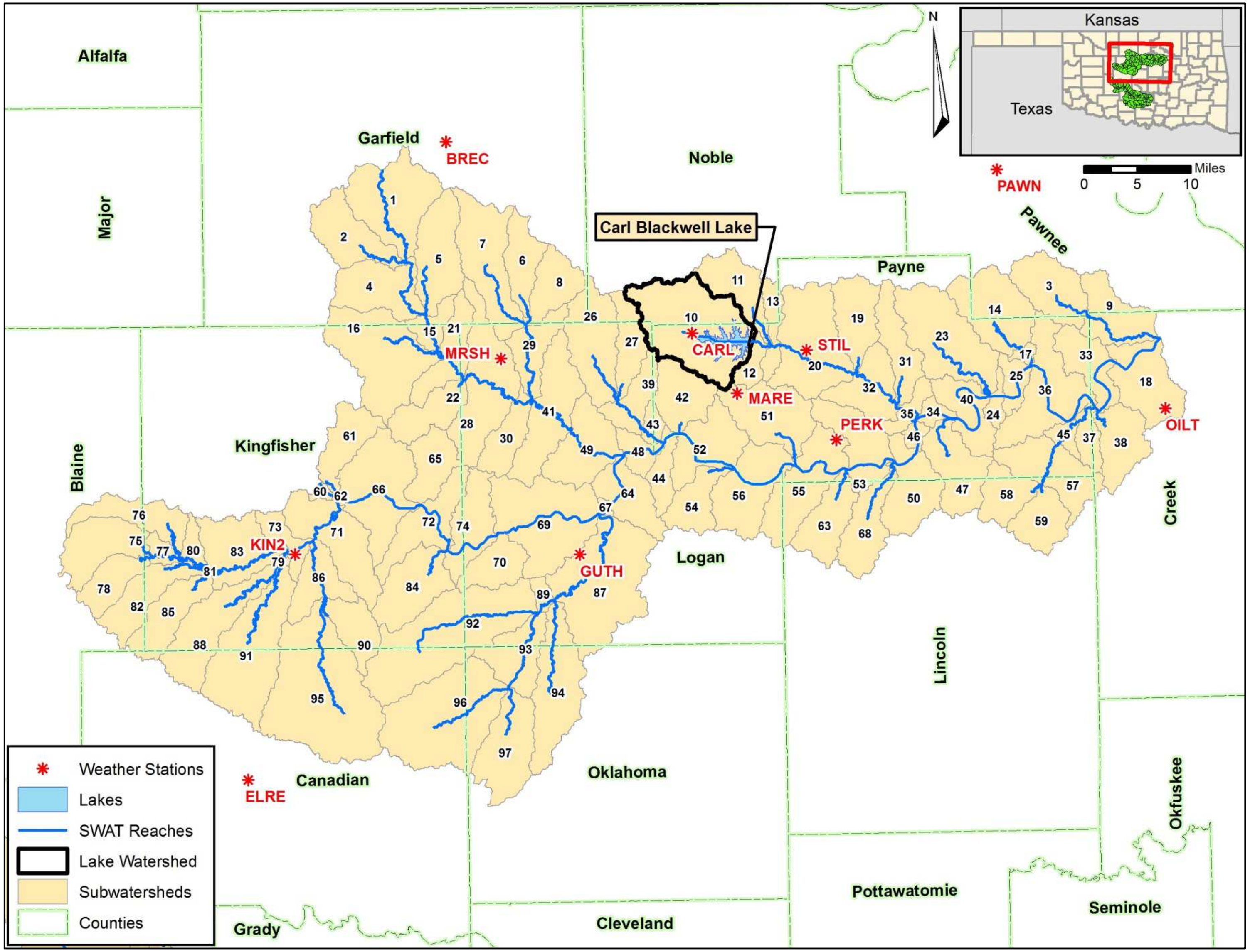
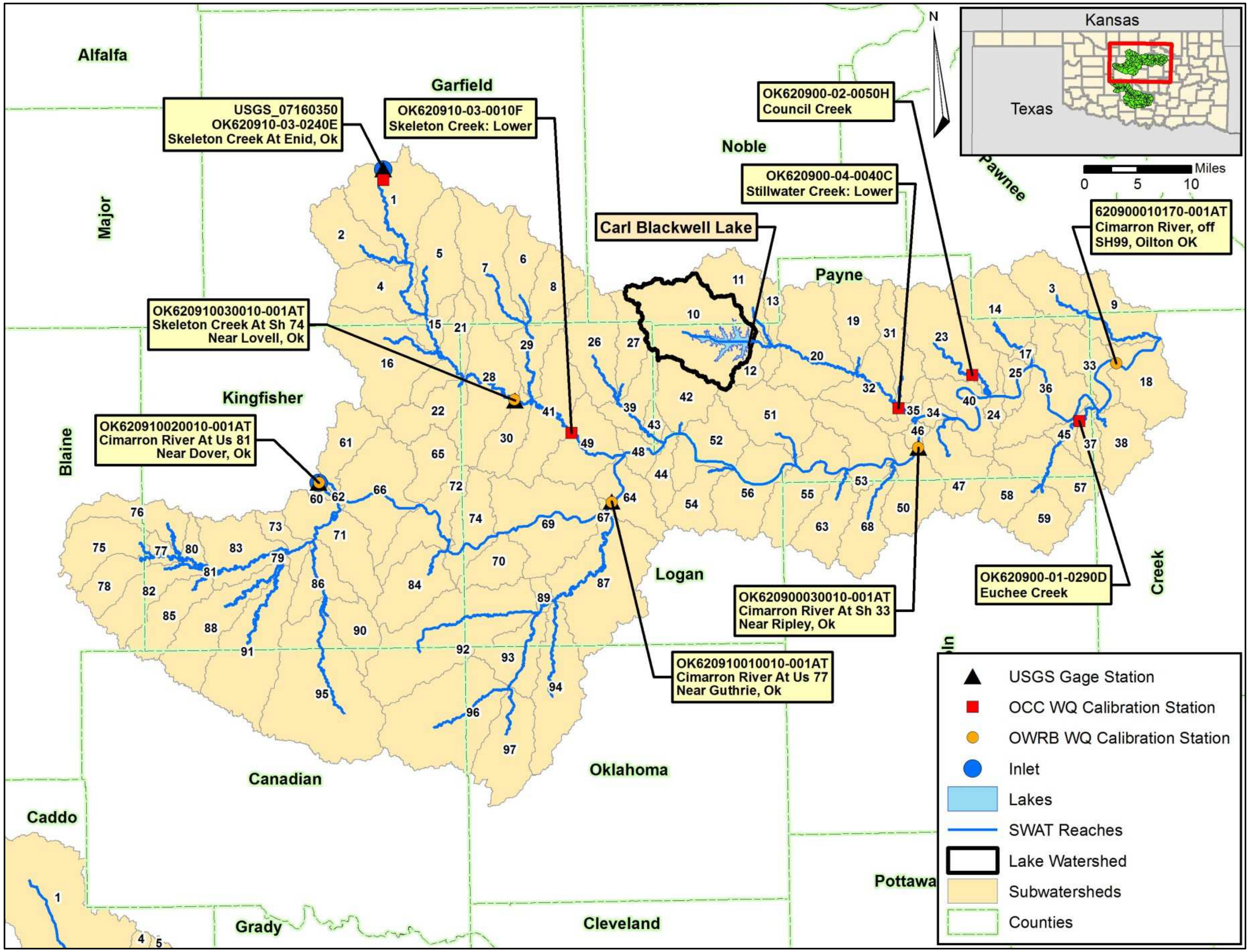


Figure C-2 Model Segmentation and Calibration Stations



C-1.6 Point Sources

SWAT also allows the user to input data from point sources [mainly municipal and industrial wastewater treatment facilities (WWTF)]. Several WWTF outfalls are located in the model area, as shown in Figure C-3, but none directly in the watershed discharging to the lake. To develop datasets for pollutant loads from the point sources, the modeling team gathered data from Discharge Monitoring Reports (DMR) for the various outfalls (Table C-2).

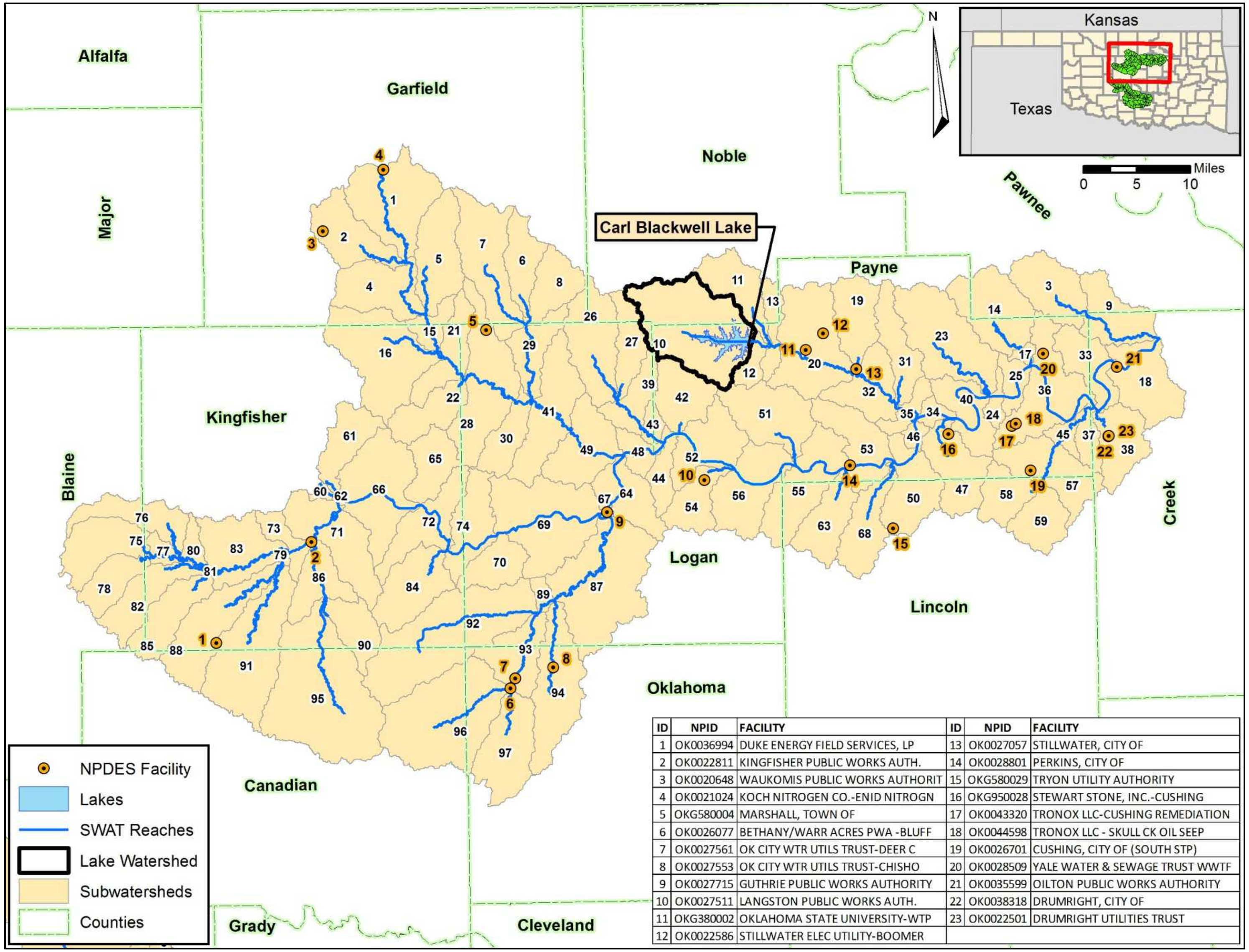
Table C-2 Summary of DMR Data for Point Sources in Model Area

Facility Name	NPDES	Model Subwatershed	Average of Reported Monthly Average Values	
			Flow (MGD)	TSS (mg/L)
Koch Nitrogen Co.-Enid Nitrogen	OK0021024	1	1.12	17.9
Waukomis Public Works Authority	OK0020648	2	0.003	26.6
Oilton Public Works Authority	OK0035599	18	0.03	7.7
City of Stillwater	OK0027057	19	5.16	6.7
Stillwater Electric Utility-Boomer	OK0022586	20	3.34	NA
Oklahoma State University-WTP	OKG380002	20	0.03	8.1
Town of Marshall	OKG580004	28	0.0001	1.1
Yale Water & Sewage Trust WWTF	OK0028509	36	0.13	14.8
Tronox LLC-Cushing Remediation	OK0043320	36	0.05	0.0
Tronox LLC - Skull Ck Oil Seep	OK0044598	36	0.003	1.5
Drumright Utilities Trust	OK0022501	38	0.53	9.0
City of Drumright	OK0038318	38	0.03	1.2
Stewart Stone, Inc.-Cushing	OKG950028	47	0.01	23.7
Tryon Utility Authority	OKG580029	50	0.01	3.7
City of Perkins	OK0028801	53	1.62	47.4
Langston Public Works Authority	OK0027511	54	2.24	47.9
City of Cushing (South STP)	OK0026701	57	1.02	8.6
Guthrie Public Works Authority	OK0027715	67	0.79	11.2
Kingfisher Public Works Authority	OK0022811	73	0.61	7.7
Duke Energy Field Services, LP	OK0036994	88	0.02	14.4
Oklahoma City WTR Utils Trust-Deer Ck	OK0027561	93	10.50	5.4
Oklahoma City WTR Utils Trust-Chisho	OK0027553	94	5.01	6.6
Bethany/Warr Acres PWA -Bluff	OK0026077	97	2.95	2.5

This table is for reference only. Input time-series for the various point sources were prepared using monthly data. Some discharges are non-continuous; average is for months when a discharge was reported.

NA = not reported DMR data available

Figure C-3 Locations of NPDES Point Sources



ID	NPID	FACILITY	ID	NPID	FACILITY
1	OK0036994	DUKE ENERGY FIELD SERVICES, LP	13	OK0027057	STILLWATER, CITY OF
2	OK0022811	KINGFISHER PUBLIC WORKS AUTH.	14	OK0028801	PERKINS, CITY OF
3	OK0020648	WAUKOMIS PUBLIC WORKS AUTHORIT	15	OKG580029	TRYON UTILITY AUTHORITY
4	OK0021024	KOCH NITROGEN CO.-ENID NITROGN	16	OKG950028	STEWART STONE, INC.-CUSHING
5	OKG580004	MARSHALL, TOWN OF	17	OK0043320	TRONOX LLC-CUSHING REMEDIATION
6	OK0026077	BETHANY/WARR ACRES PWA -BLUFF	18	OK0044598	TRONOX LLC - SKULL CK OIL SEEP
7	OK0027561	OK CITY WTR UTILS TRUST-DEER C	19	OK0026701	CUSHING, CITY OF (SOUTH STP)
8	OK0027553	OK CITY WTR UTILS TRUST-CHISHO	20	OK0028509	YALE WATER & SEWAGE TRUST WWTF
9	OK0027715	GUTHRIE PUBLIC WORKS AUTHORITY	21	OK0035599	OILTON PUBLIC WORKS AUTHORITY
10	OK0027511	LANGSTON PUBLIC WORKS AUTH.	22	OK0038318	DRUMRIGHT, CITY OF
11	OKG380002	OKLAHOMA STATE UNIVERSITY-WTP	23	OK0022501	DRUMRIGHT UTILITIES TRUST
12	OK0022586	STILLWATER ELEC UTILITY-BOOMER			

Point source flows were input in monthly increments as reported in the DMRs. For months without data, the average of the period of record for a given facility was assumed. Subsequently, the flows from all the outfalls were added on a subwatershed basis and input to the model as a single point per subwatershed.

C-1.7 Concentrated Animal Feeding Operations

There are four concentrated animal feeding operation (CAFO) facilities located in the modeled watershed. CAFOs were not included in the SWAT model given the insignificant contributions from the CAFO facilities located in the model domain.

C-1.8 Management

SWAT defines management as a series of individual operations for each land cover. No modifications were made to the default management input files for urban, forest, and wetland land covers.

Cultivated Crop

The operations for corn, winter wheat, and rye are listed below:

Corn

3/15 Harvest and kill wheat

3/16 Fertilize 5 lb/acre of P_2O_5

3/16 Fertilize 120 lb/acre of 46-00-00 (yields 55 lb/acre of N)

3/25 Disk plow with two passes

3/26 Springtooth harrow

3/27 Plant corn

3/28 Irrigation begins based on plant water demand

9/16 Harvest and kill corn

9/25 Fertilize 60 lb/acre of 46-00-00 (yields 28 lb/acre of N)

9/26 Disk plow with two passes

9/26 Springtooth harrow

10/1 Plant wheat

Winter Wheat

2/15 Fertilize 110 lb/acre of 46-00-00 (yields 50 lb/acre of N)

6/1 Harvest wheat

6/30 Disk plow with two passes

7/1 Springtooth harrow

8/10 Fertilize 150 lb/acre of 18-46-00 (yields 30 lb/acre P_2O_5 and 27 lb/acre of N)

8/10 Fertilize 52 lb/acre of 46-00-00 (yields 23 lb/acre of N)

10/1 Plant wheat

12/1 Grazing 1/3 au/acre for 90 days

Rye

6/10 Harvest rye

6/30 Disk plow with two passes

7/1 Springtooth harrow

8/10 Fertilize 12 lb/acre of P_2O_5

8/10 Fertilize 60 lb/acre of 46-00-00

9/20 Plant rye

11/15 Grazing 1/3 au/acre for 90 days

Pasture

The stocking rate used for pastures in the SWAT model was calculated using the actual number of cattle in the basin. County level NASS estimates for the period 1997-2013 were combined with land cover data to estimate the number of cattle within the model area (USDA 2013). It was assumed that cattle were evenly distributed across all pastures in the ten counties encompassing the basin. The estimated number of cattle and calves in the model area is 263,375 head (Table C-3).

The operation schedule for pastures is summarized below:

3/1 Grazing 0.2 au/acre for 300 days

Table C-3 Cattle Estimates for SWAT Watershed

County	Average number of cattle (head)[a]	Area of range land cover in county (acre)[b]	Density (head/acre rangeland)[c]	Area of range land cover in SWAT (acre)	Estimated # cattle in watershed (head)[d]
Blaine	96,777	247,627	0.39	25,329	9,899
Canadian	97,178	247,876	0.39	76,229	29,885
Creek	40,721	233,799	0.17	28,446	4,955
Garfield	92,408	214,918	0.43	61,443	26,418
Kingfisher	109,539	189,491	0.58	125,393	72,485
Lincoln	65,417	360,060	0.18	70,698	12,845
Logan	53,855	247,959	0.22	204,969	44,518
Noble	54,221	240,988	0.22	30,977	6,970
Oklahoma	20,154	147,188	0.14	30,498	4,176
Pawnee	38,272	200,561	0.19	23,061	4,401
Payne	51,502	264,137	0.19	240,147	46,824
Total					**263,375**

[a] Average of 1997-2013 NASS estimates at the county level; [b] Derived using ArcGIS to intersect the land cover raster with the county shapefile; [c] Number of cattle in county divided by the area of rangeland for that county (assumes cattle are evenly distributed); [d] Density times the area of rangeland of a given county that is within the modeled watershed

C-1.9 Soil Nutrients

Mehlich III Soil Test Phosphorus (STP) for cropland and pasture were derived from Oklahoma State University Department of Plant and Soil Science county level averages for the period 1994 to 2001 (obtained from Storm et al. 2000). A summary of the soil concentrations by county is provided in Table C-4.

Table C-4 Average Mehlich III Phosphorus Soil Test Results by County

County	Average County Mehlich III STP (lb/acre)		
	Pasture	Corn	Wheat
Blaine	81	53	88
Canadian	90	93	87
Creek	40	47	101
Garfield	88	299	81
Kingfisher	74	-	73
Lincoln	41	-	51
Logan	59	-	82
Noble	80	-	85
Oklahoma	62	50	58
Pawnee	59	-	96
Payne	59	83	78

Source: The STP concentrations were obtained from “Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma – Final Report” by Daniel Storm et al.

Soil nitrogen levels were estimated by the SWAT model based on the organic carbon data included in the soils database.

C-2. Calibration

C-2.1 Hydrologic Calibration

The lake was simulated as a reservoir in SWAT. The SWAT hydrologic calibration was primarily performed based on flow data available at the USGS gages located on Skeleton Creek at SH74 near Lovell, OK (USGS Station 07160500), Cimarron River near Guthrie, OK (USGS Station 07160000), and Cimarron River near Ripley, OK (USGS Station 07161450) (Figure C-2). Table C-5 summarizes the parameters changed during calibration along with their calibrated value. The parameters were changed on a watershed level (overall change across the 97 subwatersheds), except when noted in the table.

Table C-5 List of Adjusted Parameters for Hydrologic Calibration of SWAT Model

Parameter	Units	Description	Location in SWAT Input	Default Value	Subwatershed	Calibrated Value
GW_DELAY	day	Groundwater delay time	**.gw	31	All	100
GW_REVAP	-	Groundwater revap coefficient	**.gw	0.02	Sub-basins 1, 2, 4, 5, 15, 16, 21, 22, and 28	0.02
					All others	0.04
SOL_AWC	mm H_2O/mm soil	Available water capacity of soil layer	**.sol	Varies	All	x 1.25
SURLAG	day	Surface runoff lag coefficient	**.bsn	4	All	1

The primary calibration targets included annual water balances. But modeled monthly flows and the resulting flow duration curves were also compared to measured values. Figures C-4 and C-5 display time series of observed vs. predicted annual and monthly flows in Skeleton Creek at SH74 (sub-basin 28), Cimarron River near Guthrie (sub-basin 67), and Cimarron River near Ripley (sub-basin 50). Table C-6 summarizes the statistics computed to evaluate model performance for annual flows. Overall, the model reproduces the annual flows within the 15 percent target for most years, with overall errors below the target for all three locations (-5% for Skeleton Creek, -1% for Cimarron River near Guthrie, and -3% for Cimarron River near Ripley). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.879 and 0.833 for Skeleton Creek at SH74, 0.932 and 0.933 for Cimarron River near Guthrie, and 0.904 and 0.905 for Cimarron River near Ripley. The high resulting coefficients indicate very good model performance for annual flows.

Figure C-6 compares the modeled and observed daily flow duration curves for sub-watersheds 28, 67 and 50. A flow duration curve depicts the percentage of the time that a given flow is not exceeded. The model simulation agrees well with the observed flow duration curves across all flow conditions, except for very low flows.

Figure C-4 Observed and Modeled Annual Flows

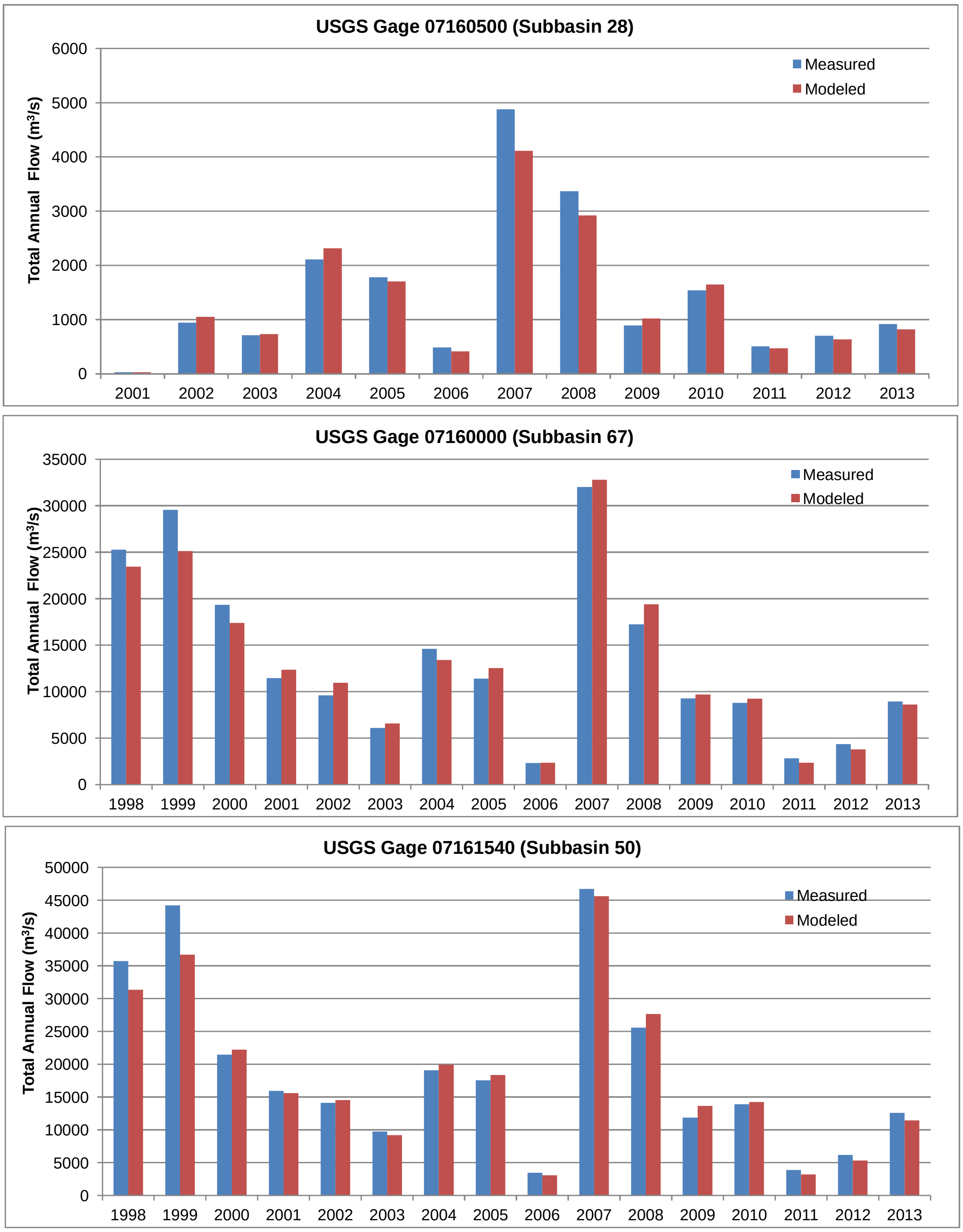
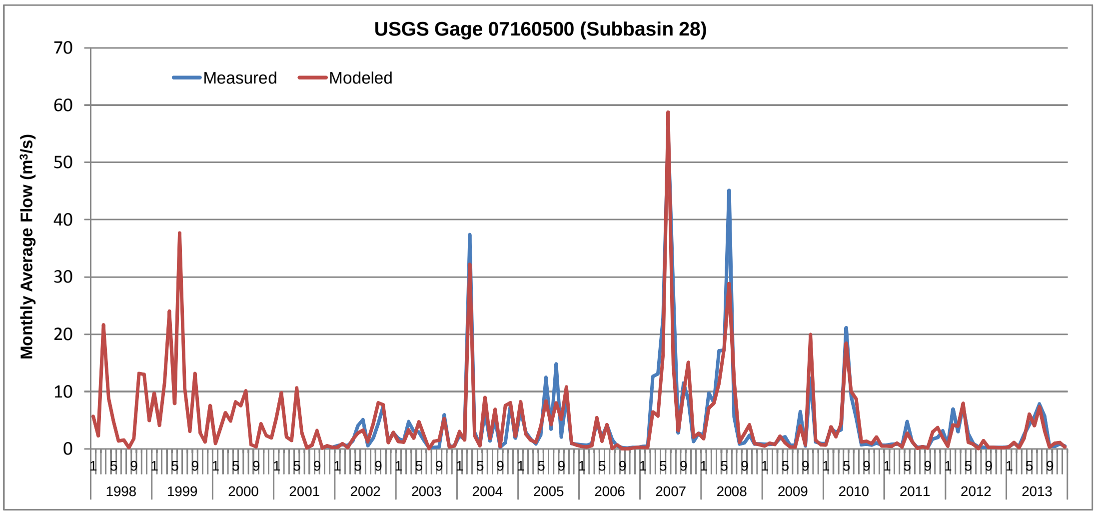
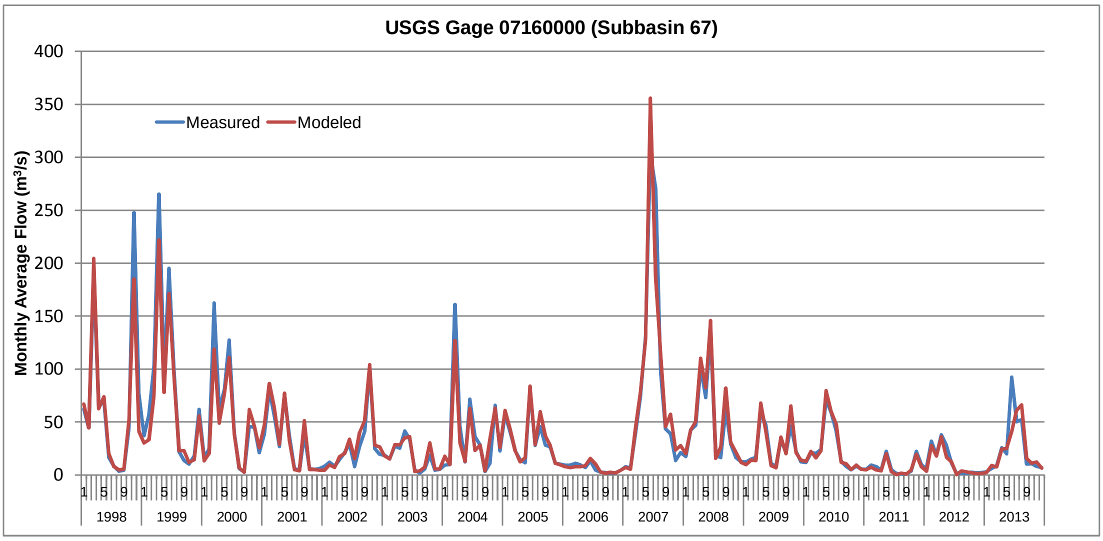


Figure C-5 Observed and Modeled Average Monthly Flows





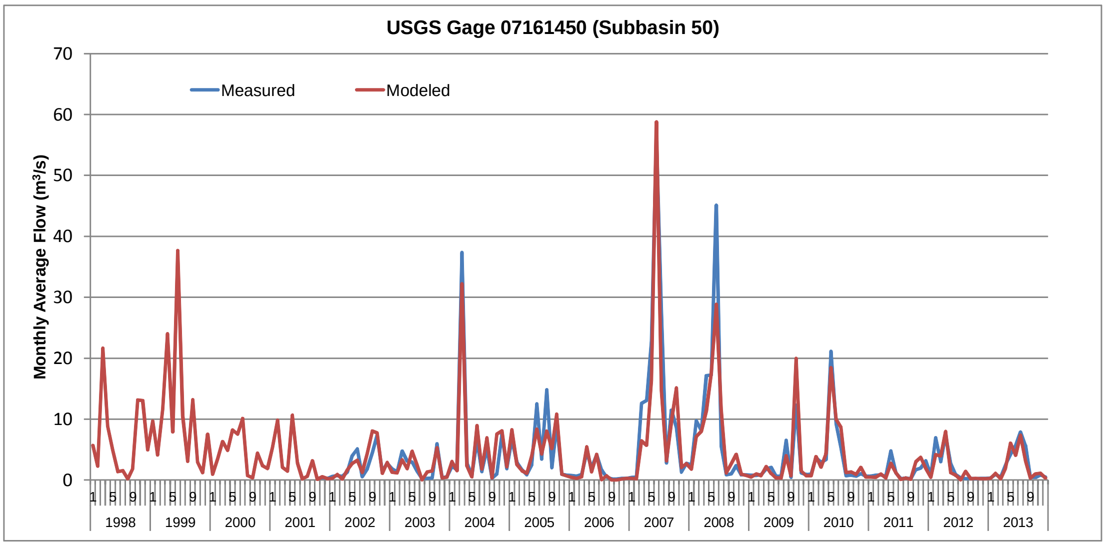


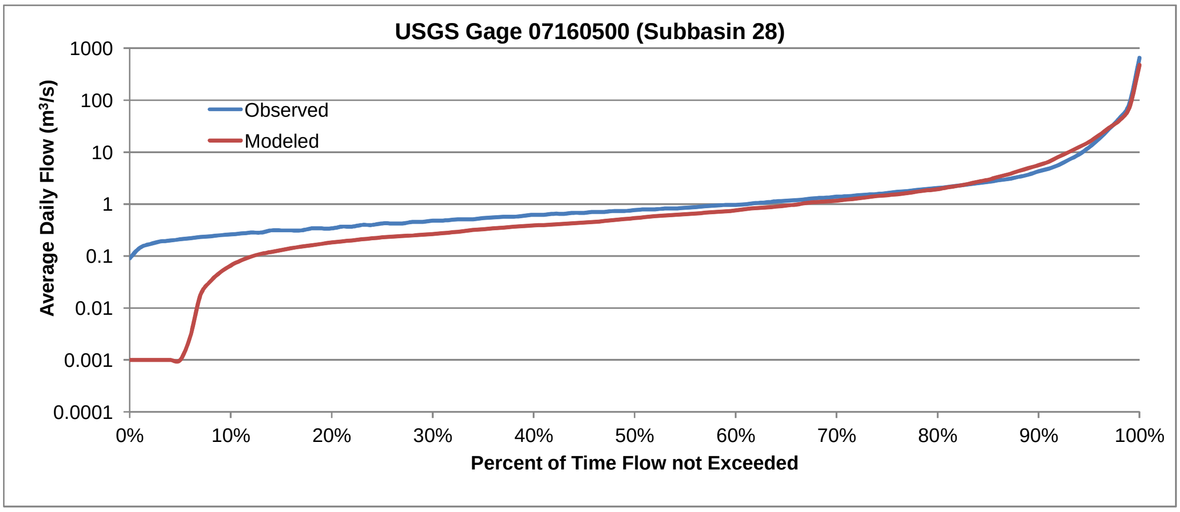
Table C-6 Summary of Model Performance for Water Quantity

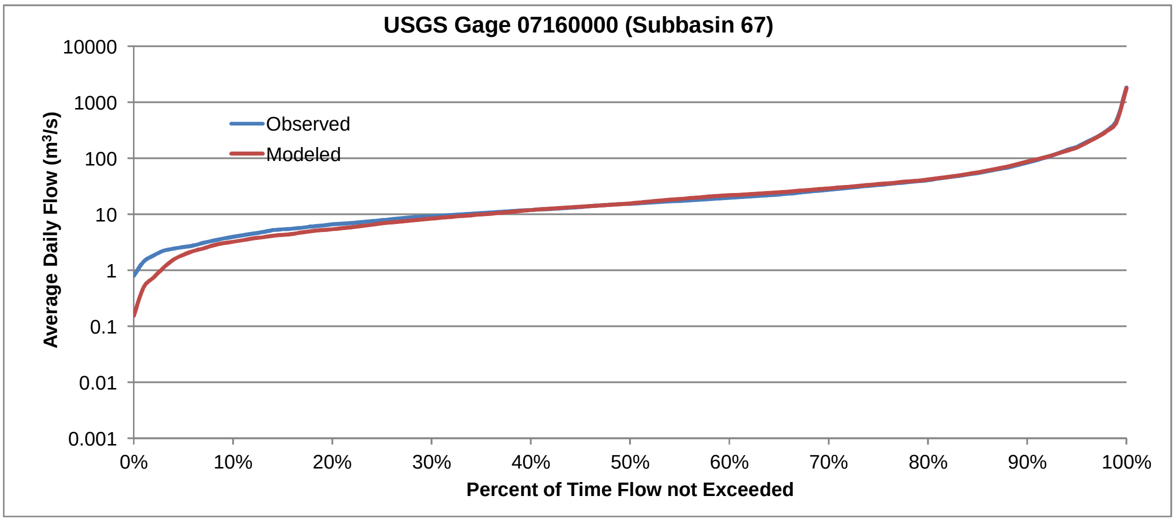
Year	USGS 07160500 (Subwatershed 28)				USGS 07160000 (Subwatershed 67)				USGS 07161450 (Subwatershed 50)			
	Total Annual Flow (m^3/s)		Model Error (%)	NSE/r^2 [(a,b)]	Total Annual Flow (m^3/s)		Model Error (%)	NSE/r^2 [(a,b)]	Total Annual Flow (m^3/s)		Model Error (%)	NSE /r^2 [(a,b)]
	Observed	Modeled			Observed	Modeled			Observed	Modeled		
1998				0.879/0.883	25,243	23,424	-7	0.932/0.933	35,704	31,351	-12	0.904/0.905
1999					29,548	25,111	-15		44,228	36,703	-17	
2000					19,353	17,386	-10		21,445	22,212	4	
2001	29	28	-2		11,462	12,348	8		15,932	15,605	-2	
2002	941	1,048	11		9,596	10,928	14		14,119	14,516	3	
2003	710	729	3		6,109	6,591	8		9,766	9,176	-6	
2004	2,112	2,316	10		14,609	13,404	-8		19,082	19,954	5	
2005	1,781	1,705	-4		11,392	12,534	10		17,574	18,366	5	
2006	485	411	-15		2,317	2,356	2		3,470	3,089	-11	
2007	4,880	4,112	-16		32,014	32,782	2		46,708	45,602	-2	
2008	3,369	2,918	-13		17,255	19,373	12		25,589	27,667	8	
2009	894	1,019	14		9,273	9,674	4		11,856	13,624	15	
2010	1,537	1,648	7		8,781	9,232	5		13,907	14,271	3	
2011	506	471	-7		2,810	2,350	-16		3,887	3,196	-18	
2012	703	635	-10		4,364	3,783	-13		6,168	5,314	-14	
2013	917	822	-10		8,934	8,590	-4		12,562	11,438	-9	
Overall	**18,864**	**17,862**	**-5**		**213,069**	**209,864**	**-1**		**301,995**	**292,084**	**-3**	

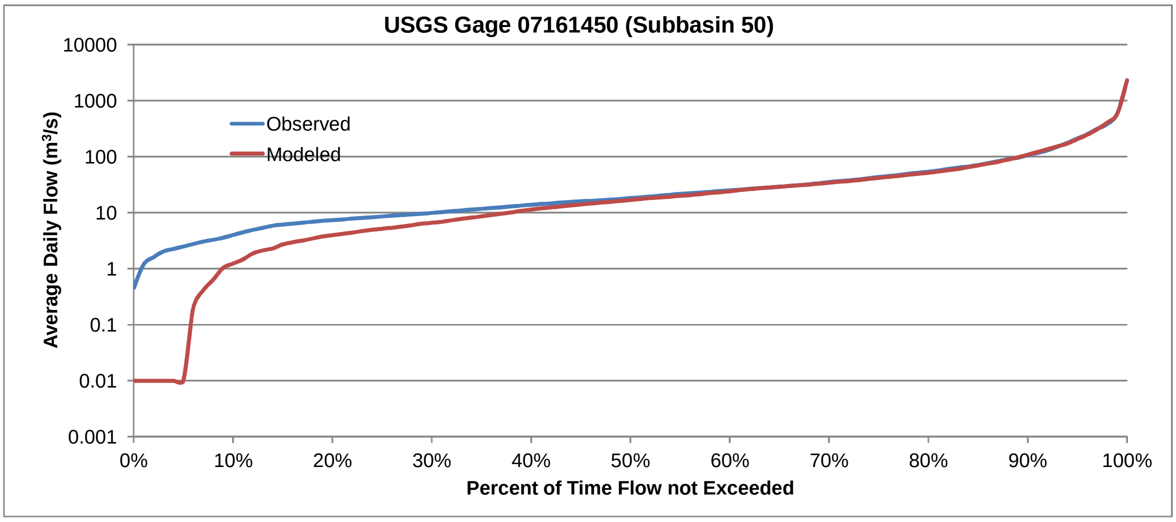
[a] Calculated using average monthly flows

[b] Nash-Sutcliffe Efficiency Coefficient = $1 - \frac{\sum(obs - mod)^2}{\sum(obs - obs_{avg})^2}$

Figure C-6 Observed and Modeled Daily Flow Duration Curves







C-2.2 Water Quality Calibration

There are no water quality monitoring stations in the tributary to Carl Blackwell Lake. The SWAT model was calibrated at six stream water quality monitoring stations in the modeled domain (Figure C-2): Skeleton Creek: Lower (OWRB monitoring site 620910030010-001AT), Cimarron River near Ripley, OK (OWRB monitoring site 620900030010-001AT –no TSS data-), Cimarron River near Guthrie, OK (OWRB monitoring site 620910010010-001AT), Council Creek (OCC monitoring site OK620900-02-0050H), Stillwater Creek: Lower (OCC monitoring site OK620900-04-0040C) and Euchee Creek (OCC monitoring site OK620900-01-0290D). The goal of the water quality calibration was to match average modeled concentrations to average measured concentrations within a 25% error. SWAT model calibration input files can be provided by DEQ upon request.

Figure C-7 shows a comparison of observed and modeled TSS concentrations for the four calibration stations. The model predicts the average of the measured TSS concentrations at the various locations within the 25% target error.

Figure C-7 Observed and Modeled Average TSS Concentrations

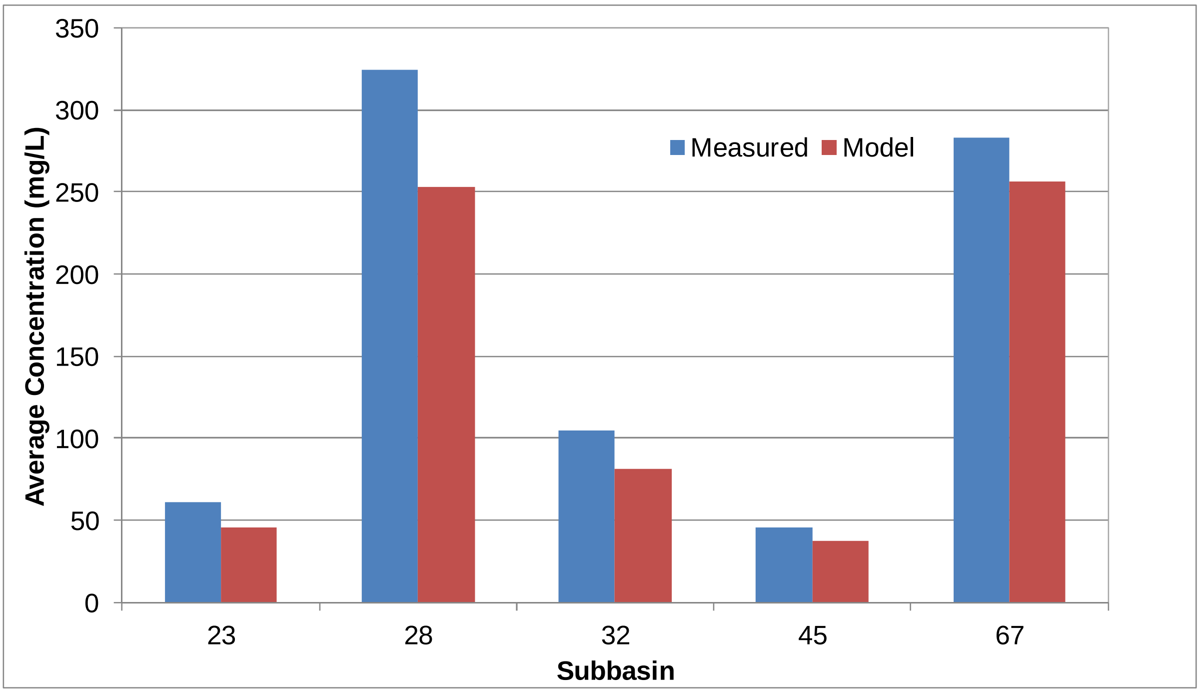


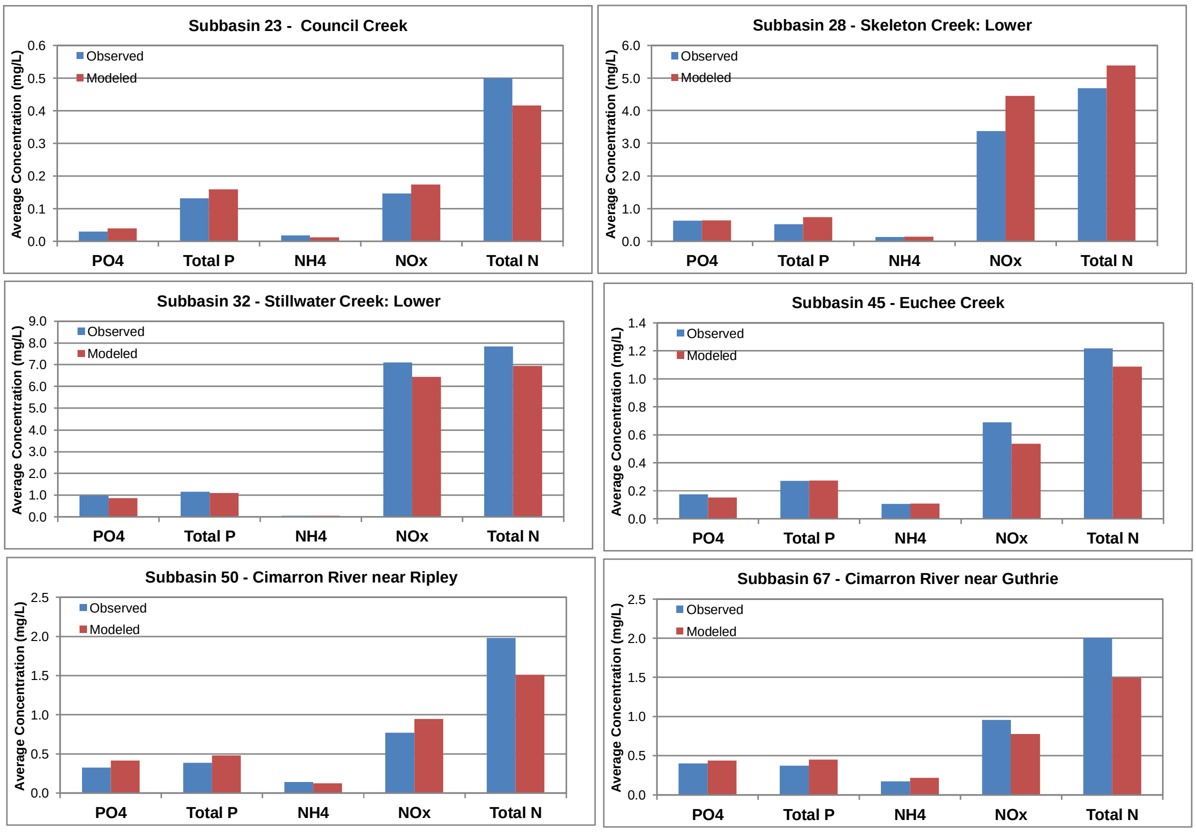
Table C-7 summarizes the model error for the various nutrients. As can be seen, in most cases, the SWAT model reproduced the average nutrient concentrations within 25% of the measured averages (Figure C-8). In some instances, the model does not replicate speciation for a given period, but nevertheless the total phosphorus and nitrogen predicted averages are within the 25% target. For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. The monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

Table C-7 Summary of Model Error for Nutrient Predictions (mg/L)

Sub-basin	Description	Parameter				
		PO_4	Total P	NH_4	NO_x	Total N
23	Observed (mg/L)	0.03	0.13	0.02	0.15	0.50
	Modeled (mg/L)	0.04	0.16	0.01	0.17	0.42
	Error (%)	*31*	*22*	*-35*	*18*	*-17*
28	Observed (mg/L)	0.63	0.52	0.13	3.37	4.68
	Modeled (mg/L)	0.63	0.74	0.14	4.45	5.39
	Error (%)	*1*	*41*	*6*	*32*	*15*
32	Observed (mg/L)	0.99	1.16	0.05	7.10	7.84
	Modeled (mg/L)	0.87	1.11	0.06	6.44	6.94
	Error (%)	*-12*	*-5*	*9*	*-9*	*-11*
45	Observed (mg/L)	0.17	0.27	0.11	0.69	1.22
	Modeled (mg/L)	0.15	0.27	0.11	0.54	1.09
	Error (%)	*-13*	*0*	*3*	*-22*	*-11*
50	Observed (mg/L)	0.32	0.39	0.14	0.77	1.98
	Modeled (mg/L)	0.42	0.48	0.13	0.95	1.51
	Error (%)	*29*	*25*	*-11*	*23*	*-24*
67	Observed (mg/L)	0.40	0.37	0.17	0.96	2.00
	Modeled (mg/L)	0.44	0.45	0.22	0.78	1.49
	Error (%)	*9*	*21*	*26*	*-19*	*-25*

Non-detects were assumed equal to ½ DL

Figure C-8 Observed and Modeled Average Nutrient Concentrations



PO4 = mineral phosphate phosphorus; Total P = total phosphorus; NH4 = ammonia nitrogen; NOx = nitrate+nitrite nitrogen; Total N = total nitrogen

C-3. Model Results

Figures C-9 and C-10 show the average annual load of nutrients from runoff for each of the 97 sub-watersheds in the model domain. Total phosphorus loads ranged from 0.3 to 3.7 kg/ha/year. Total nitrogen loads varied between 0.2 and 7.9 kg/ha/yr.

A summary of average daily values for the sub-watershed draining to Carl Blackwell Lake is included in Table C-8. Under current conditions, Carl Blackwell Lake is estimated to receive a total annual load of 60,000 kg of phosphorus and 40,900 kg of nitrogen, on average, from nonpoint sources in its watershed. These values serve as the input data to the BATHTUB model to simulate average conditions for flow and nutrient loading to the lake.

Table C-8 Average Flows and Nutrient Loads Discharging to Carl Blackwell Lake

Parameter	Carl Blackwell Lake
Watershed Size (square miles)	77
Flow (m^3/day)	1.30E+05
Organic Phosphorus (kg/year)	50,500
Mineral Ortho-Phosphorus (kg/year)	9,500
Total Phosphorus (kg/year)	**60,000**
Organic Nitrogen (kg/year)	21,000
Ammonia Nitrogen (kg/year)	400
Nitrate+Nitrite Nitrogen (kg/year)	19,500
Total Nitrogen (kg/year)	**40,900**

Figure C-9 Average Total Phosphorus Loading from SWAT Subwatersheds

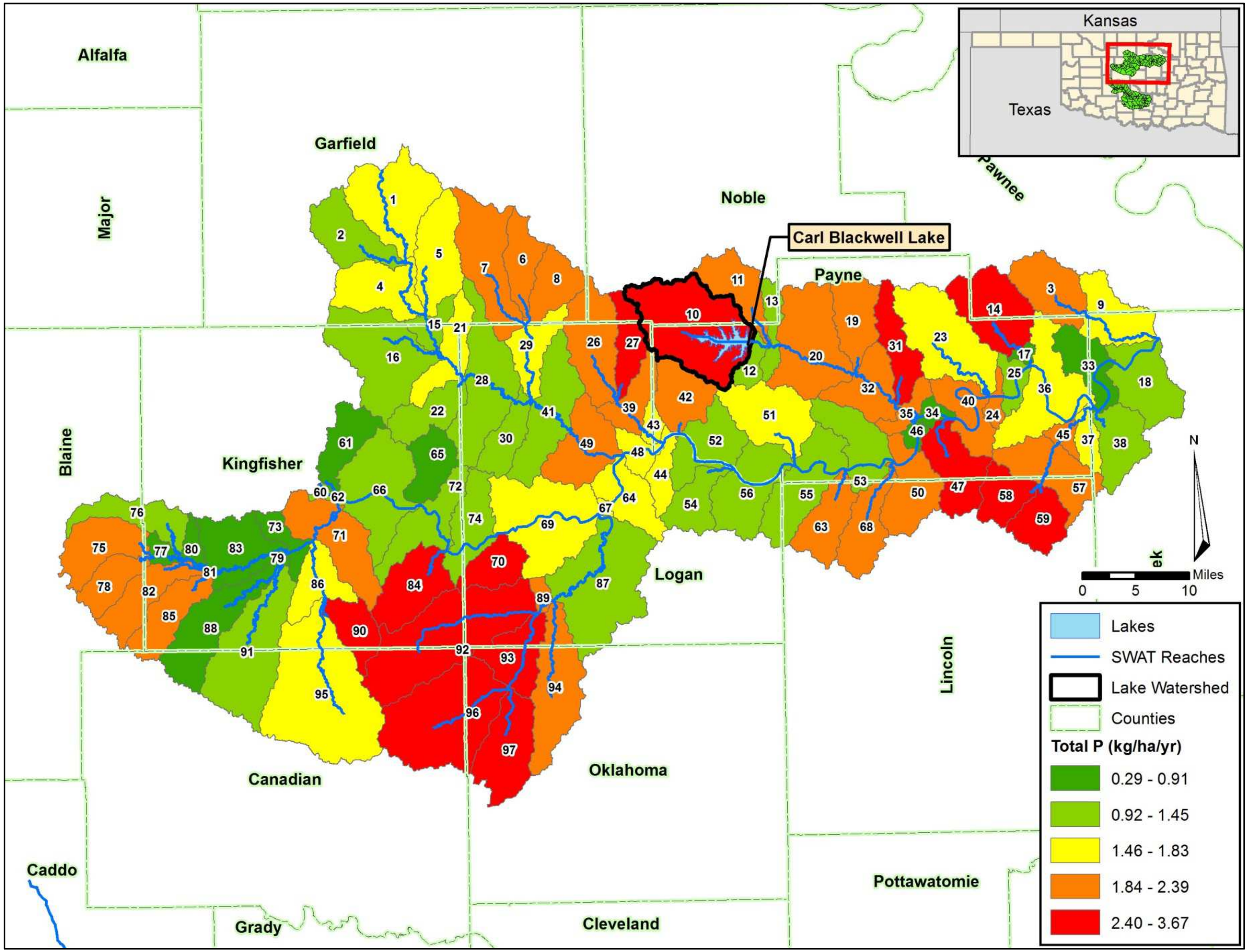
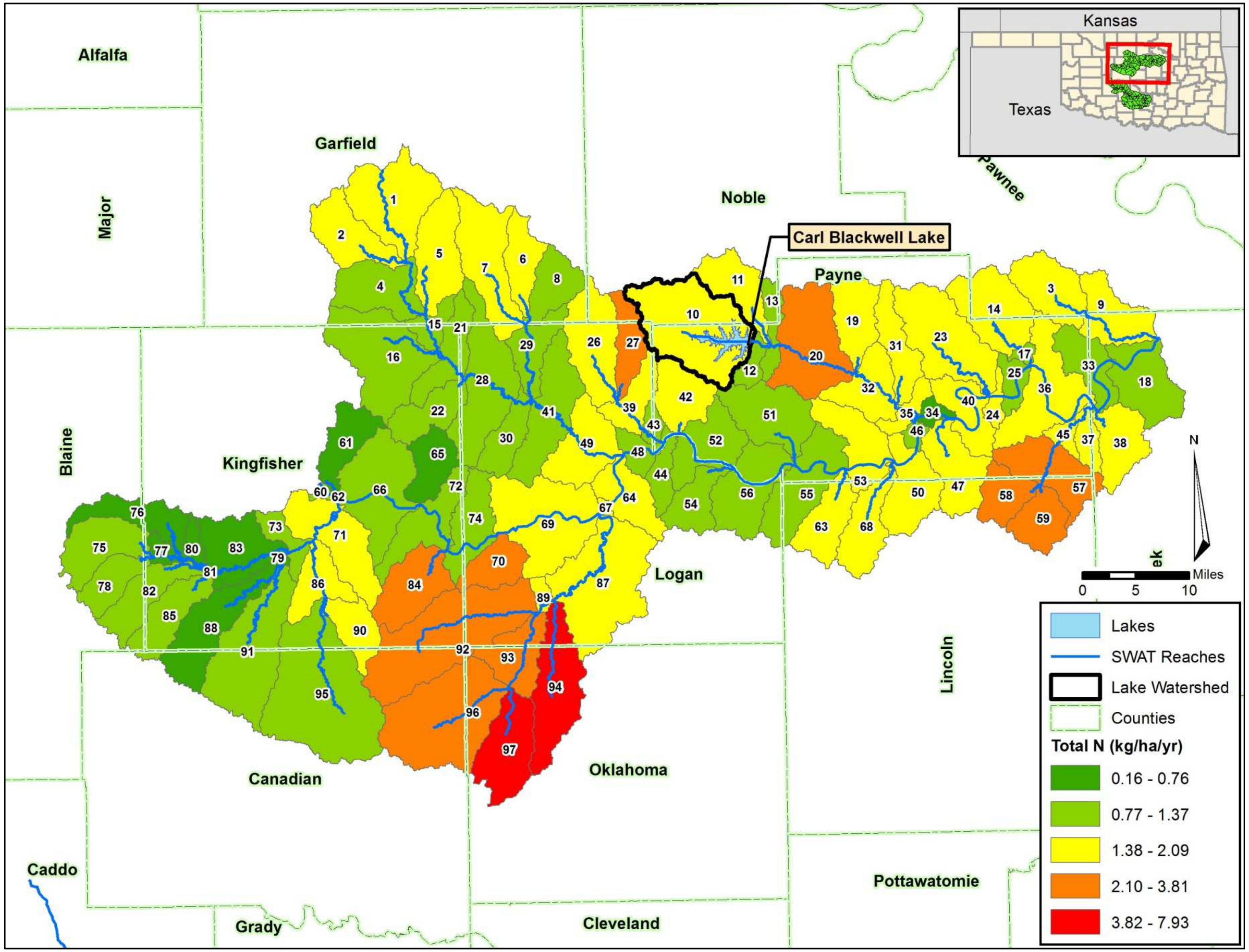


Figure C-10 Average Total Nitrogen Loading from SWAT Subwatersheds



References

Haan, C.T., B.J. Barfield, and J.C. Hayes. 1994. Design Hydrology and Sedimentation for Small Catchments. Academic Press INC.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams, 2009. *Soil and Water Assessment Tool Theoretical Documentation: Version 2009*. Grassland, Soil and Water Research Laboratory - Agricultural Research Service and Blackland Research and Extension Center - Texas Agricultural Experiment Station. Available at http://twri.tamu.edu/reports/2011/tr406.pdf.

Storm, D.E., D. Gade, R. Tejral, M.D. Smolen, P. Kenkel, and M.S. Gregory. 2000. Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma. Oklahoma State University, Departments of Biosystems and Agricultural Engineering and Department of Agricultural Economics, University of Tennessee. Prepared for the Oklahoma Conservation Commission and the U.S. Environmental Protection Agency. August 24, 2000.

USDA 2012. National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Statistics_by_State/Oklahoma/index.asp.

USDA 2014. 2013 Oklahoma Cropland Data Layer. National Agricultural Statistics Service (NASS), Research and Development Division (RDD), Geospatial Information Branch (GIB), Spatial Analysis Research Section (SARS). http://www.nass.usda.gov/research/Cropland/SARS1a.htm. Published January 31, 2014.

Winchell, M., R. Srinivasan, M. Di Luzio, and J. Arnold. 2013. ArcSWAT Interface for SWAT 2012 – User’s Guide. Blackland Research and Extension Center - Texas AgriLife Research and Grassland, Soil and Water Research Laboratory – USDA Agricultural Research Service.

APPENDIX D

SWAT MODEL INPUT AND CALIBRATION

LAKE HUMPHREYS

Appendix D
SWAT Model Input and Calibration – Lake Humphreys

Given the lack of flow gage data available to quantify loadings directly from the tributary to Lake Humphreys, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2011). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. The major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management.

D-1. Model Inputs

All the GIS layers were processed using the ArcSWAT 2012.10.2.16 interface for SWAT2012 (Winchell et al. 2013). The interface was also used to change input parameters to achieve calibration and to export the model results to a Microsoft Access database.

D-1.1 Elevation Data

The 2002/2004 30-meter United States Geographical Survey (USGS) National Elevation Dataset (NED) was used for watershed delineation. The NED was also used to calculate the slopes and determine the stream network incorporated into SWAT. Slopes were divided into three categories: 0-1, 1-5, and > 5%.

D-1.2 Soil Data

Soil data used for this model were derived using the Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) soils database incorporated in ArcSWAT.

D-1.3 Land Use Data

Land use and land cover data were derived from NASS 2013 Cropland Data Layer (CDL) (http://www.nass.usda.gov/research/Cropland/SARS1a.htm) (USDA 2014). Three main crops were included in the model: corn, winter wheat, and alfalfa.

Table D-1 Distribution of Land Cover in the Modeled Watershed

Description	SWAT Code	Area (acres)	Percent of Total Watershed Area
Corn	AGRR	36,380	2.2
Winter Wheat	WWHT	146,254	8.6
Alfalfa	ALFA	33,743	2.0
Open Water	WATR	15,287	0.9
Residential-Low Density	URLD	72,108	4.3
Residential-Medium Density	URMD	11,120	0.7
Residential-High Density	URHD	3,084	0.2
Industrial	UIDU	1,368	0.1
Southwestern US (Arid) Range	SWRN	121	<0.1
Forest-Deciduous	FRSD	266,451	15.8
Forest-Evergreen	FRSE	29,635	1.8
Range-Brush	RNGB	3	<0.1
Range-Grasses	RNGE	1,075,885	63.6
Wetlands-Forested	WETF	15	<0.1

D-1.4 Meteorology

The meteorological data for the simulation period of 1994 to 2013 was derived from twelve Oklahoma Mesonet stations (Acme, Apache, Byars, Chickasha, Fort Cobb, Hinton, Ketchum Ranch, Minco, Ninnekah, Pauls Valley, Sulphur, and Washington). Weather station locations are shown in Figure D-1. Daily time-series of precipitation, temperature, solar radiation, wind speed, and relative humidity were imported into the SWAT model along with the station coordinates and SWAT subsequently assigned the precipitation to the various subwatersheds using the nearest station (Neitsch et al., 2011).

D-1.5 Subwatershed Delineation

The modeled area was split into 106 sub-watersheds (Figure D-2) based on the National Elevation Dataset (http://ned.usgs.gov) and the National Hydrography Dataset (http://nhd.usgs.gov) of the USGS. The watershed of Holdenville Lake is outlined in black in Figure D-2. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

D-1.6 Point Sources

SWAT also allows the user to input data from point sources [mainly municipal and industrial wastewater treatment facilities (WWTF)]. Several WWTF outfalls are located in the model area, as shown in Figure D-3, but none directly in the watershed discharging to the lake. To develop datasets for pollutant loads from the point sources, the modeling team gathered data from Discharge Monitoring Reports (DMR) for the various outfalls (Table D-2).

Figure D-1 Weather Station Locations

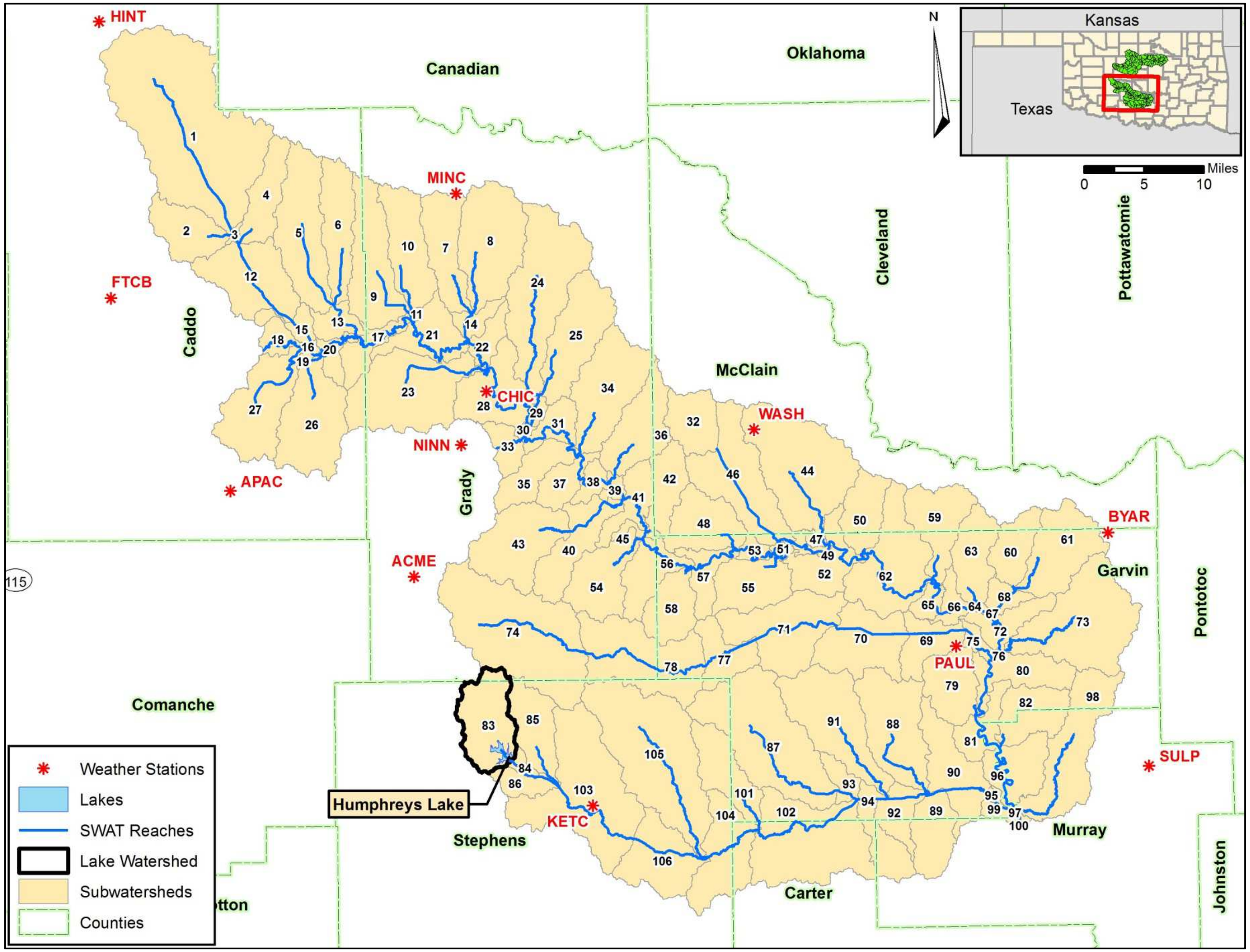


Figure D-2 Model Segmentation and Calibration Stations

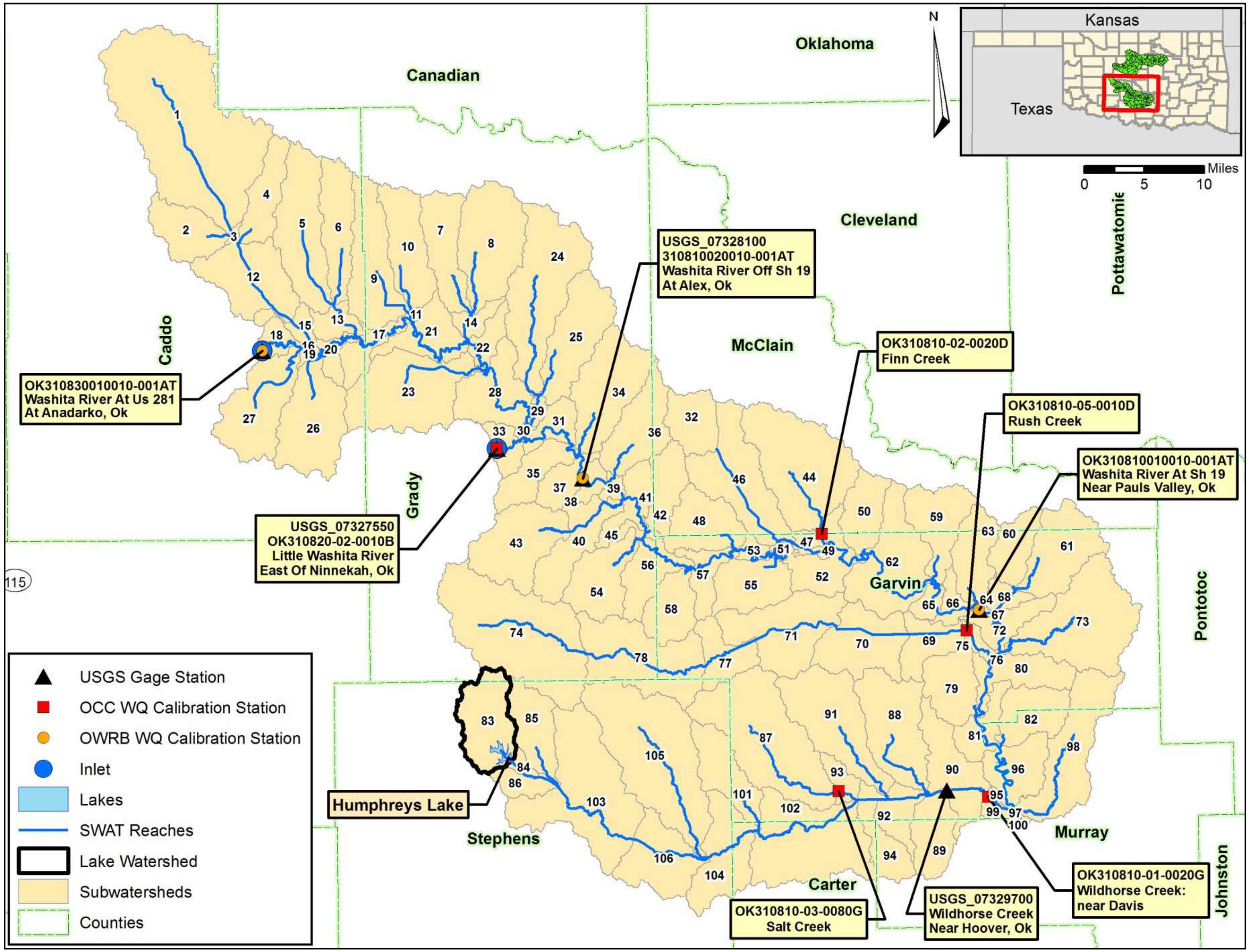
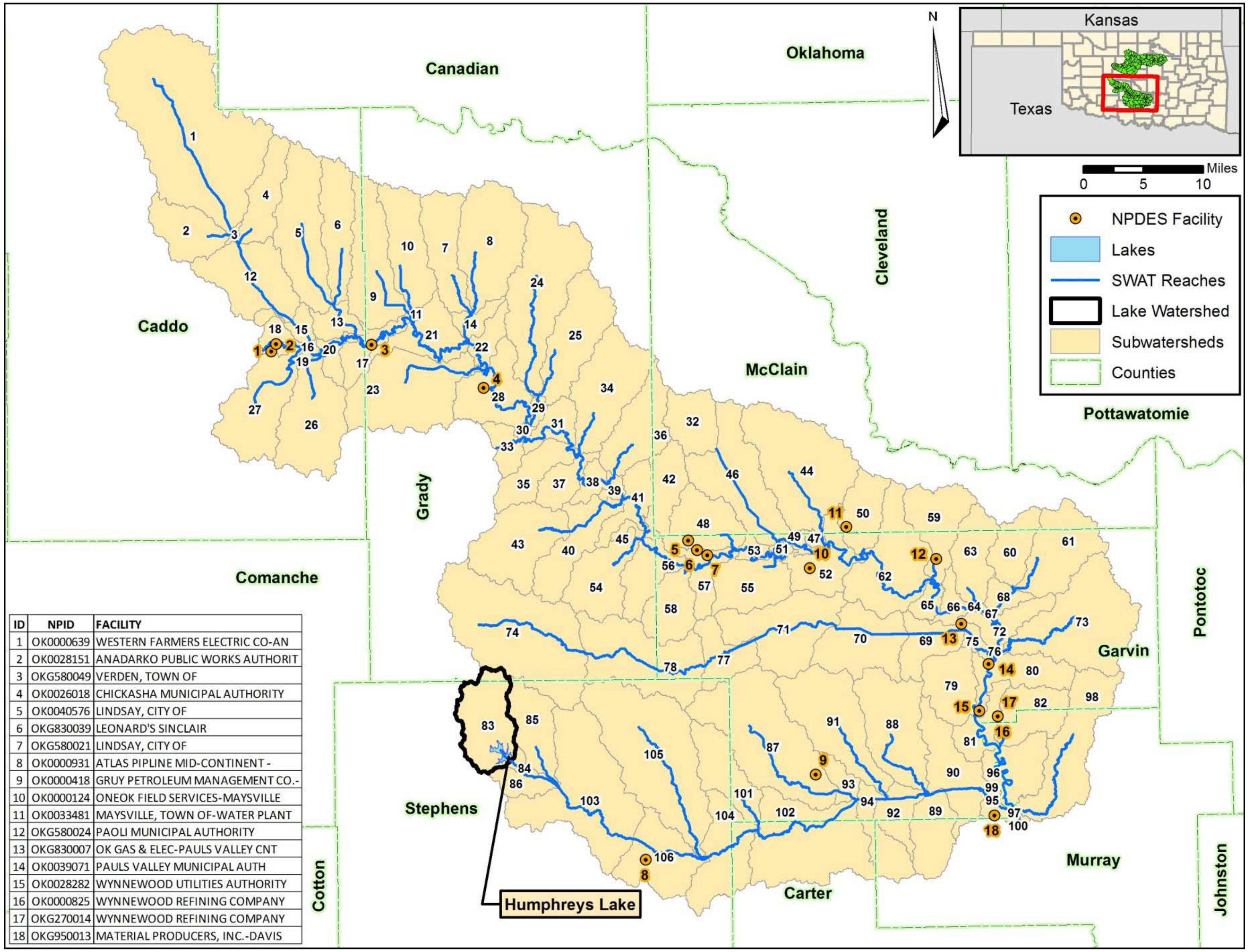


Figure D-3 Locations of NPDES Point Sources



ID	NPID	FACILITY
1	OK0000639	WESTERN FARMERS ELECTRIC CO-AN
2	OK0028151	ANADARKO PUBLIC WORKS AUTHORIT
3	OKG580049	VERDEN, TOWN OF
4	OK0026018	CHICKASHA MUNICIPAL AUTHORITY
5	OK0040576	LINDSAY, CITY OF
6	OKG830039	LEONARD'S SINCLAIR
7	OKG580021	LINDSAY, CITY OF
8	OK0000931	ATLAS PIPLINE MID-CONTINENT -
9	OK0000418	GRUY PETROLEUM MANAGEMENT CO.-
10	OK0000124	ONEOK FIELD SERVICES-MAYSVILLE
11	OK0033481	MAYSVILLE, TOWN OF-WATER PLANT
12	OKG580024	PAOLI MUNICIPAL AUTHORITY
13	OKG830007	OK GAS & ELEC-PAULS VALLEY CNT
14	OK0039071	PAULS VALLEY MUNICIPAL AUTH
15	OK0028282	WYNNEWOOD UTILITIES AUTHORITY
16	OK0000825	WYNNEWOOD REFINING COMPANY
17	OKG270014	WYNNEWOOD REFINING COMPANY
18	OKG950013	MATERIAL PRODUCERS, INC.-DAVIS

Table D-2 Summary of DMR Data for Point Sources in Model Area

Facility Name	NPDES	Model Subwatershed	Average of Reported Monthly Average Values	
			Flow (MGD)	TSS (mg/L)
Town of Verden	OKG580049	17	0.02	25.0
Western Farmers Electric Co-Anadarko	OK0000639	18	0.43	12.9
Anadarko Public Works Authority	OK0028151	18	0.34	10.9
Chickasha Municipal Authority	OK0026018	28	1.88	5.6
City of Lindsay	OK0040576	48	5.30	2.6
Town of Maysville, Water Plant	OK0033481	50	0.00	13.4
Oneok Field Services-Maysville	OK0000124	52	0.02	8.6
City of Lindsay	OKG580021	57	0.17	53.5
Leonard's Sinclair	OKG830039	57	0.01	2.6
Paoli Municipal Authority	OKG580024	59	0.02	5.7
OG&E -Pauls Valley Center	OKG830007	75	0.00	NA
Pauls Valley Municipal Authority	OK0039071	80	0.45	58.4
Wynnewood Utilities Authority	OK0028282	80	0.33	5.4
Wynnewood Refining Company	OK0000825	81	1.13	14.5
Wynnewood Refining Company	OKG270014	82	0.02	5.7
Material Producers, Inc.-Davis	OKG950013	89	0.06	3.6
Atlas Pipeline Mid-Continent	OK0000931	106	0.004	NA

This table is for reference only. Input time-series for the various point sources were prepared using monthly data. Some discharges are non-continuous; average is for months when a discharge was reported.

NA = not reported DMR data available

Point source flows were input in monthly increments as reported in the DMRs. For months without data, the average of the period of record for a given facility was assumed. Subsequently, the flows from all the outfalls were added on a subwatershed basis and input to the model as a single point per subwatershed.

D-1.7 Concentrated Animal Feeding Operations

There are four concentrated animal feeding operation (CAFO) facilities located in the modeled watershed. CAFOs were not included in the SWAT model given the insignificant contributions from the CAFO facilities located in the model domain.

D-1.8 Management

SWAT defines management as a series of individual operations for each land cover. No modifications were made to the default management input files for urban, forest, and wetland land covers.

Cultivated Crop

The operations for corn, winter wheat, and soybeans are listed below:

<u>Corn</u>

3/15 Harvest and kill wheat

3/16 Fertilize 5 lb/acre of P_2O_5

3/16 Fertilize 120 lb/acre of 46-00-00 (yields 55 lb/acre of N)

3/25 Disk plow with two passes

3/26 Springtooth harrow

3/27 Plant corn

3/28 Irrigation begins based on plant water demand

9/16 Harvest and kill corn

9/25 Fertilize 60 lb/acre of 46-00-00 (yields 28 lb/acre of N)

9/26 Disk plow with two passes

9/26 Springtooth harrow

10/1 Plant wheat

<u>Winter Wheat</u>

2/15 Fertilize 110 lb/acre of 46-00-00 (yields 50 lb/acre of N)

6/1 Harvest wheat

6/30 Disk plow with two passes

7/1 Springtooth harrow

8/10 Fertilize 150 lb/acre of 18-46-00 (yields 30 lb/acre P_2O_5 and 27 lb/acre of N)

8/10 Fertilize 52 lb/acre of 46-00-00 (yields 23 lb/acre of N)

10/1 Plant wheat

12/1 Grazing 1/3 au/acre for 90 days

<u>Alfalfa</u>

4/1 Plant alfalfa

5/15 Harvest alfalfa

8/29 Fertilize 17 lb/acre of P_2O_5

9/1 Plant alfalfa

10/15 Harvest alfalfa

Pasture

The stocking rate used for pastures in the SWAT model was calculated using the actual number of cattle in the basin. County level NASS estimates for the period 1997-2013 were combined with land cover data to estimate the number of cattle within the model area (USDA 2013). It was assumed that cattle were evenly distributed across all pastures in the ten counties encompassing the basin. The estimated number of cattle and calves in the model area is 256,355 head (Table D-3).

Table D-3 Cattle Estimates for SWAT Watershed

County	Average number of cattle (head)[a]	Area of range land cover in county (acre)[b]	Density (head/acre rangeland)[c]	Area of range land cover in SWAT (acre)	Estimated # cattle in watershed (head)[d]
Caddo	130,111	420,480	0.31	167,990	51,982
Carter	53,453	329,890	0.16	27,077	4,387
Garvin	73,717	335,214	0.22	313,906	69,031
Grady	117,350	447,667	0.26	293,321	76,890
McClain	54,819	231,916	0.24	94,806	22,410
Murray	28,680	168,575	0.17	45,703	7,776
Stephens	68,228	380,243	0.18	133,081	23,879
Total					**256,355**

[a] Average of 1997-2013 NASS estimates at the county level
[b] Derived using ArcGIS to intersect the land cover raster with the county shapefile
[c] Number of cattle in county divided by the area of rangeland for that county (assumes cattle are evenly distributed)
[d] Density times the area of rangeland of a given county that is within the modeled watershed

The operation schedule for pastures is summarized below:

3/1 Grazing 0.2 au/acre for 300 days

D-1.9 Soil Nutrients

Mehlich III Soil Test Phosphorus (STP) for cropland and pasture were derived from Oklahoma State University Department of Plant and Soil Science county level averages for the period 1994 to 2001 (obtained from Storm et al. 2000). A summary of the soil concentrations by county is provided in Table D-4.

Table D-4 Average Mehlich III Phosphorus Soil Test Results by County

County	Average County Mehlich III STP (lb/acre)		
	Pasture	Corn	Winter Wheat
Caddo	74	92	81
Carter	71		148
Garvin	54	50	86
Grady	66	73	71
McClain	66	42	71
Murray	259		
Stephens	125	46	79

Source: The STP concentrations were obtained from "Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma – Final Report" by Daniel Storm et al.

Soil nitrogen levels were estimated by the SWAT model based on the organic carbon data included in the soils database.

D-1.10 Simulation Period and Variables of Concern

A 20 year period (1994 - 2013) was simulated in the SWAT model. However, the first four years were considered a "spin-up" period for stabilizing model initial conditions, and the model output consisted of only the latter 16 years (1998 - 2013). The variables simulated in SWAT included flow, organic phosphorus, mineral ortho-phosphorus, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and total suspended solids.

D-2. Calibration

D-2.1 Hydrologic Calibration

The lake was simulated as a reservoir in SWAT. The SWAT hydrologic calibration was performed based on flow data available at the USGS gages located on Washita River at Alex, OK (USGS Station 07328100), Washita River near Pauls Valley, OK (USGS Station 07328500), and Wildhorse Creek near Hoover, OK (USGS Station 07329700) (Figure D-2). Table D-5 summarizes the parameters changed during calibration along with their calibrated value. The parameters were changed on a watershed level (overall change across the 106 subwatersheds), except when noted in the table.

Table D-5 List of Adjusted Parameters for Hydrologic Calibration of SWAT Model

Parameter	Units	Description	Location in SWAT Input	Default Value	Sub-basin	Calibrated Value
GW_DELAY	day	Groundwater delay time	**.gw	31	Sub-basins 83, 85-94, 101-106	70
					All others	31
GW_REVAP	--	Groundwater revap coefficient	**.gw	0.02	All	0.025
SOL_AWC	mm H_2O/mm soil	Available water capacity of soil layer	**.sol	Varies	All	x 1.25
ESCO	--	Evaporation coefficient	**.hru	0.95	All	0.8

The primary calibration targets included annual water balances, but modeled monthly flows and the resulting flow duration curves were also compared to measured values. Figures D-4 and D-5 display time series of observed vs. predicted annual and monthly flows in Washita River at Alex (sub-basin 37), Washita River near Pauls Valley (sub-basin 64), and Wildhorse Creek near Hoover (sub-basin 89). Table D-6 summarizes the statistics computed to evaluate model performance for annual flows. Overall, the model reproduces the annual flows within the 15% target for most years, with overall errors below the target for Washita River near Pauls Valley and Wildhorse Creek (-2% and -1%, respectively), and above the target (7%) for Washita River at Alex. Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.924 and 0.954 for Washita River at Alex, 0.942 and 0.941 for Washita River near Pauls Valley, and 0.749 and 0.739 for Wildhorse Creek. The high resulting coefficients indicate very good model performance for annual flows.

Figure D-6 compares the modeled and observed daily flow duration curves for sub-watersheds 37, 64, and 89. The model simulation agrees well with the observed flow duration curves for most flow conditions, except for very low flows.

Figure D-4 Observed and Modeled Annual Flows

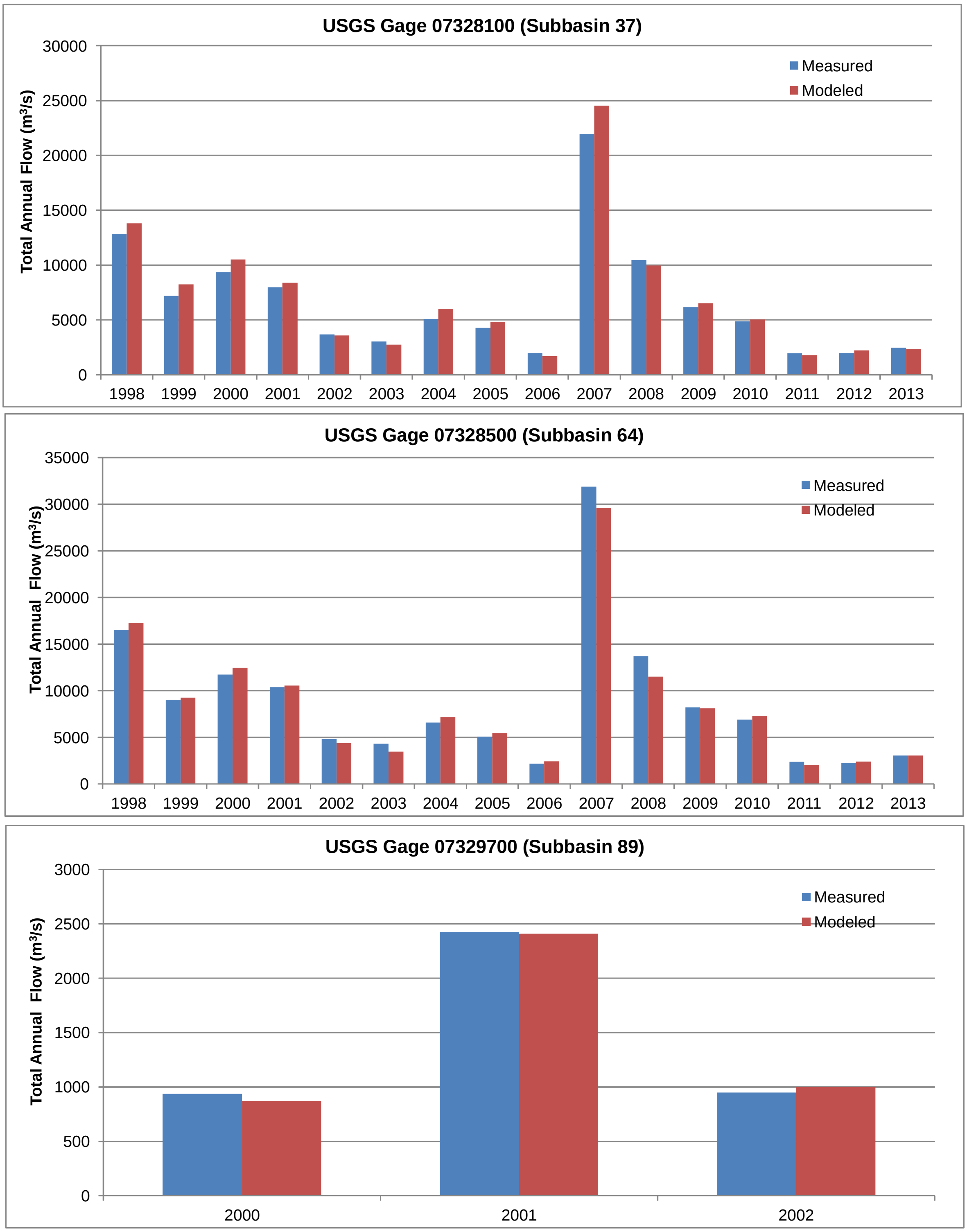


Figure D-5 Observed and Modeled Average Monthly Flows

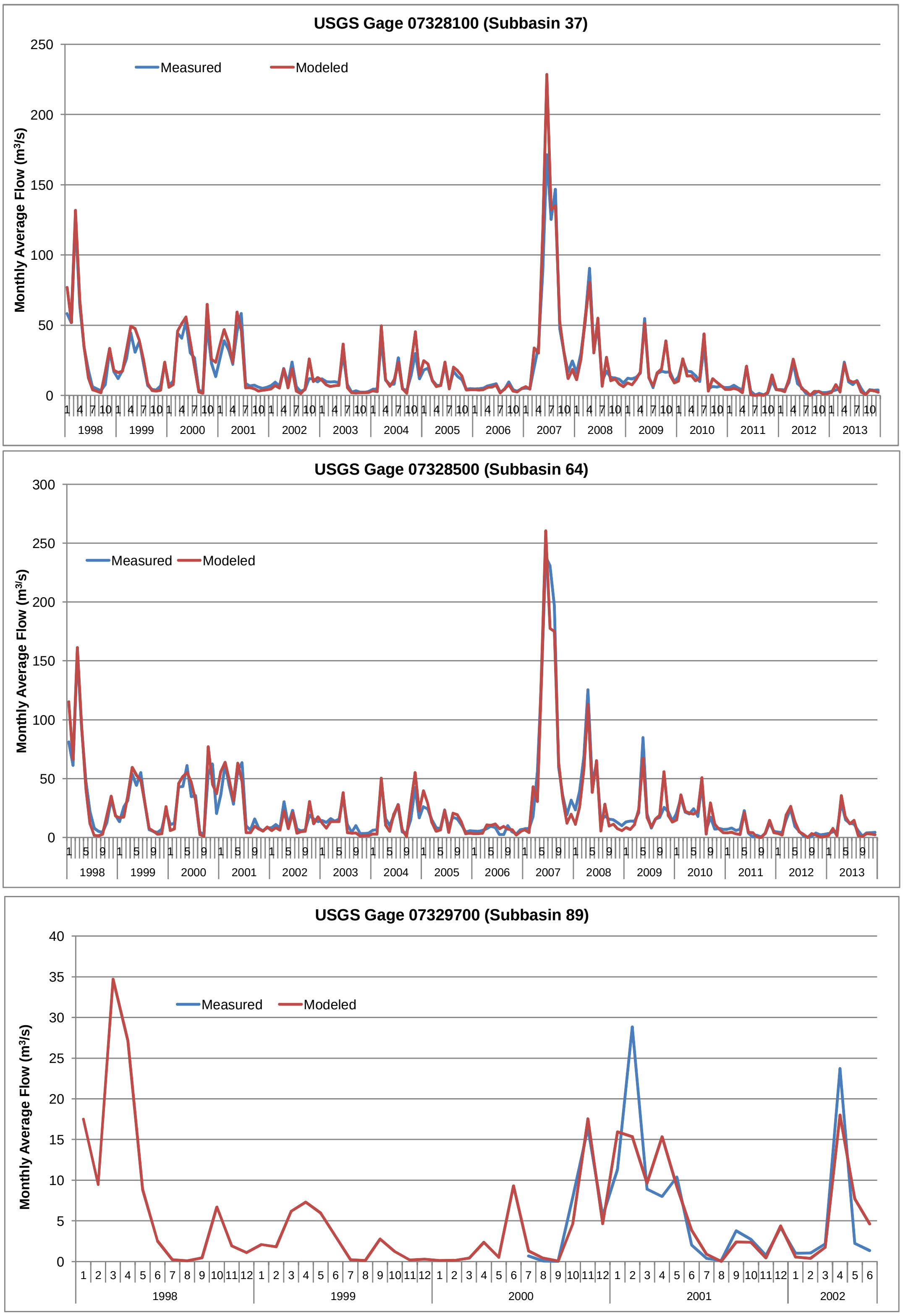


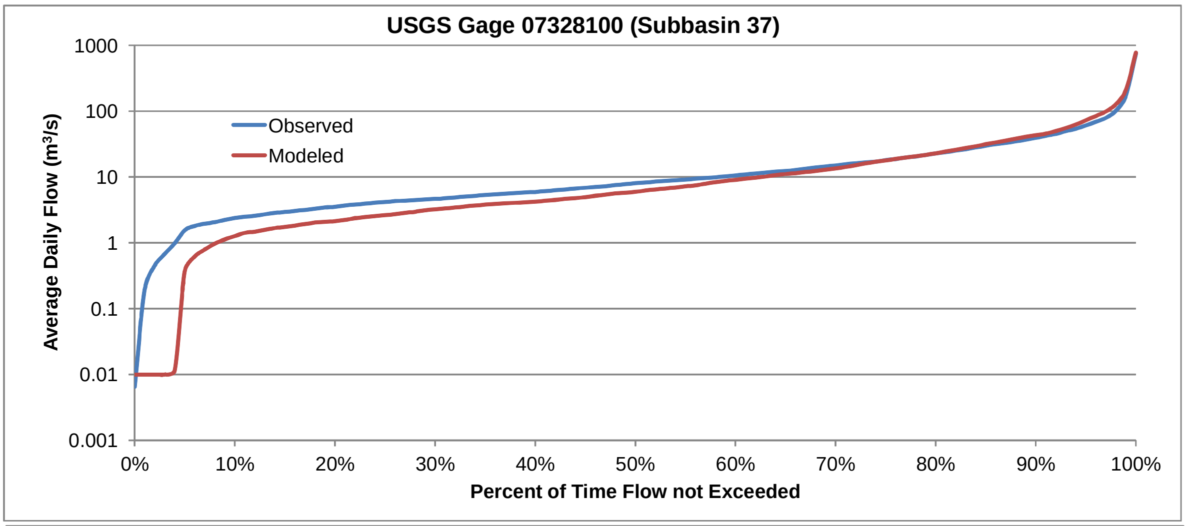
Table D-6 Summary of Model Performance for Water Quantity

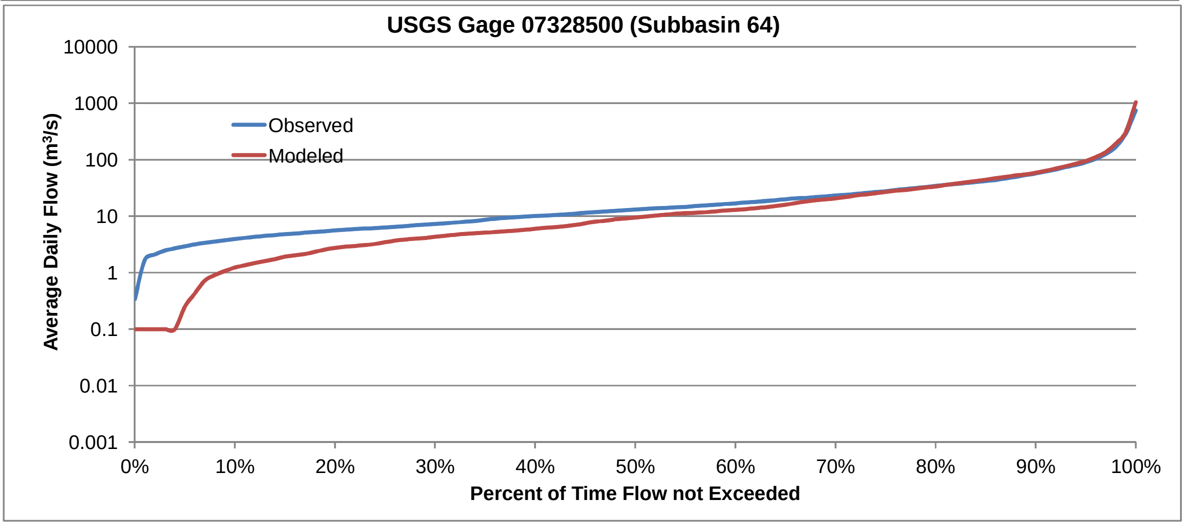
Year	USGS 07328100 (Subwatershed 37)				USGS 07328500 (Subwatershed 64)				USGS 07329700 (Subwatershed 89)			
	Total Annual Flow (m^3/s)		Model Error		Total Annual Flow (m^3/s)		Model Error		Total Annual Flow (m^3/s)		Model Error	NSE /r^2 (a,b)
	Observed	Modeled	(%)	NSE/r^2 (a,b)	Observed	Modeled	(%)	NSE/r^2 (a,b)	Observed	Modeled	(%)	
1998	12,847	13,788	7		16,531	17,249	4					
1999	7,197	8,232	14		9,037	9,262	2					
2000	9,322	10,521	13		11,746	12,465	6		937	873	-7	
2001	7,959	8,370	5		10,373	10,564	2		2,423	2,407	-1	
2002	3,671	3,572	-3		4,812	4,405	-8		950	999	5	
2003	3,029	2,744	-9		4,305	3,455	-20					
2004	5,092	6,019	18		6,591	7,166	9					
2005	4,272	4,811	13		5,066	5,435	7					
2006	1,980	1,689	-15	**0.924/0.954**	2,162	2,438	13	**0.942/0.941**				**0.749/0.739**
2007	21,939	24,532	12		31,868	29,578	-7					
2008	10,452	9,959	-5		13,694	11,509	-16					
2009	6,160	6,511	6		8,212	8,102	-1					
2010	4,873	5,047	4		6,897	7,297	6					
2011	1,943	1,780	-8		2,368	2,029	-14					
2012	1,973	2,214	12		2,274	2,404	6					
2013	2,445	2,344	-4		3,058	3,057	0					
Overall	**105,154**	**112,134**	**7**		**138,993**	**136,416**	**-2**		**4,310**	**4,279**	**-1**	

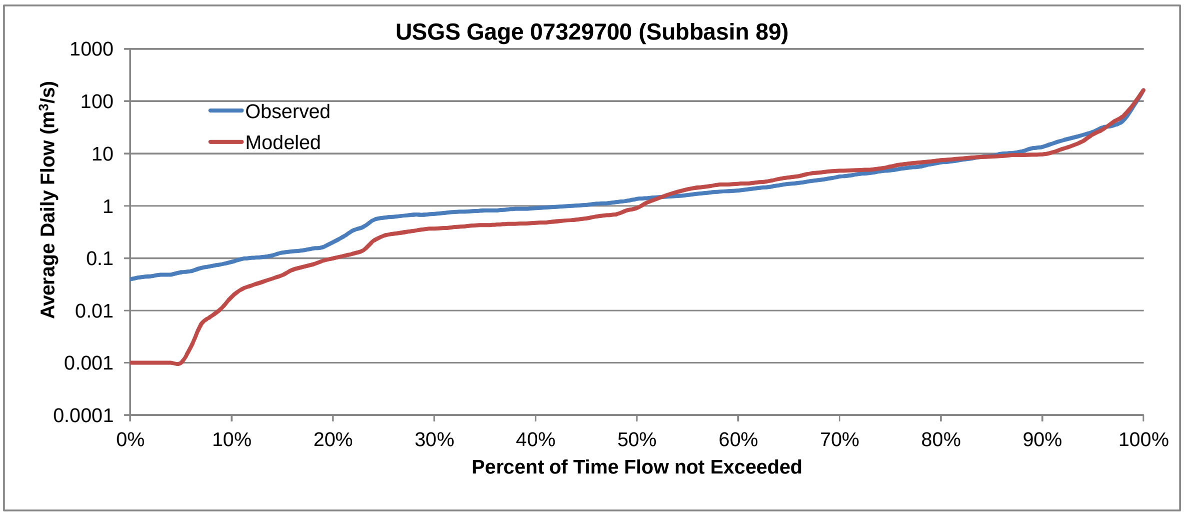
[a] Calculated using average monthly flows

[b] Nash-Sutcliffe Efficiency Coefficient = $1 - \frac{\sum(obs - mod)^2}{\sum(obs - obs_{avg})^2}$

Figure D-6 Observed and Modeled Daily Flow Duration Curves







D-2.2 Water Quality Calibration

There are no water quality monitoring stations in the tributary to Lake Humphreys. The SWAT model was calibrated at six stream water quality monitoring stations in the modeled domain (Figure D-2): Washita River at Alex (OWRB monitoring site 310810020010-001AT--no TSS data-), Washita River near Pauls Valley (OWRB monitoring site 310810010010-001AT), Finn Creek (OCC monitoring site OK310810-02-0020D), Rush Creek (OCC monitoring site OK310810-05-0010D), Salt Creek (OCC monitoring site OK310810-03-0080G), and Wildhorse Creek (OCC monitoring site OK310810-01-0020G). The goal of the water quality calibration was to match average modeled concentrations to average measured concentrations within a 25% error. SWAT model calibration input files can be provided by DEQ upon request.

Figure D-7 shows a comparison of observed and modeled TSS concentrations for the five calibration stations with available TSS data. The model predicts the average of the measured TSS concentrations at the various locations within the 25% target error.

Figure D-7 Observed and Modeled Average TSS Concentrations

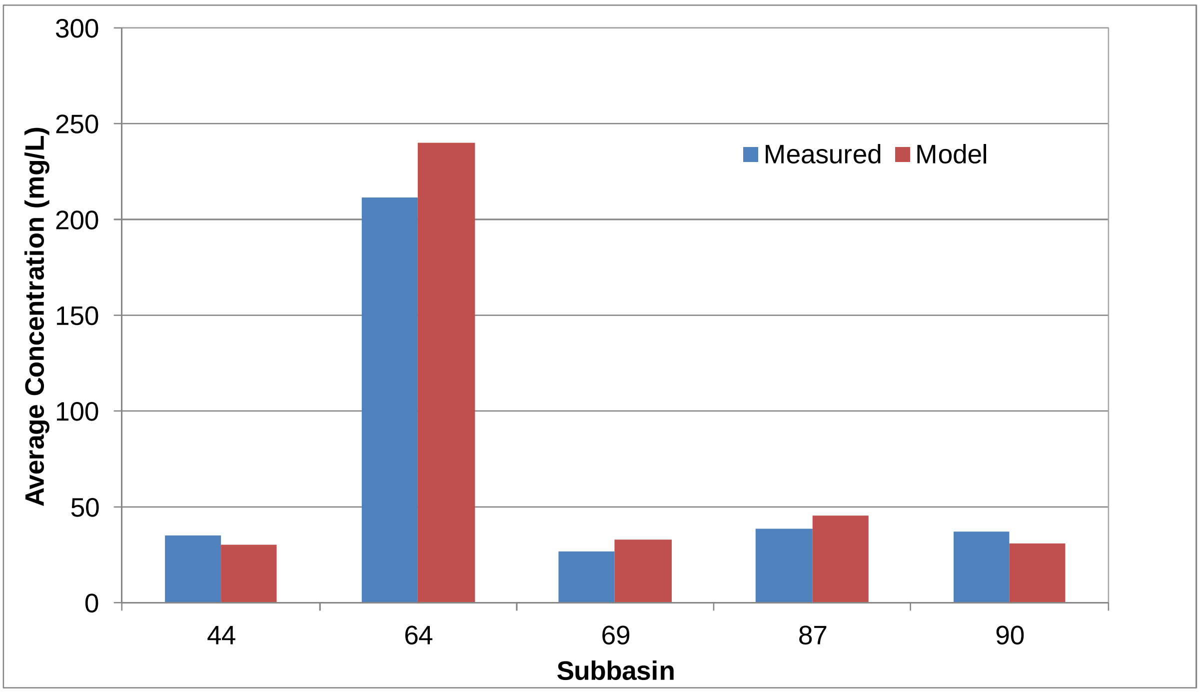


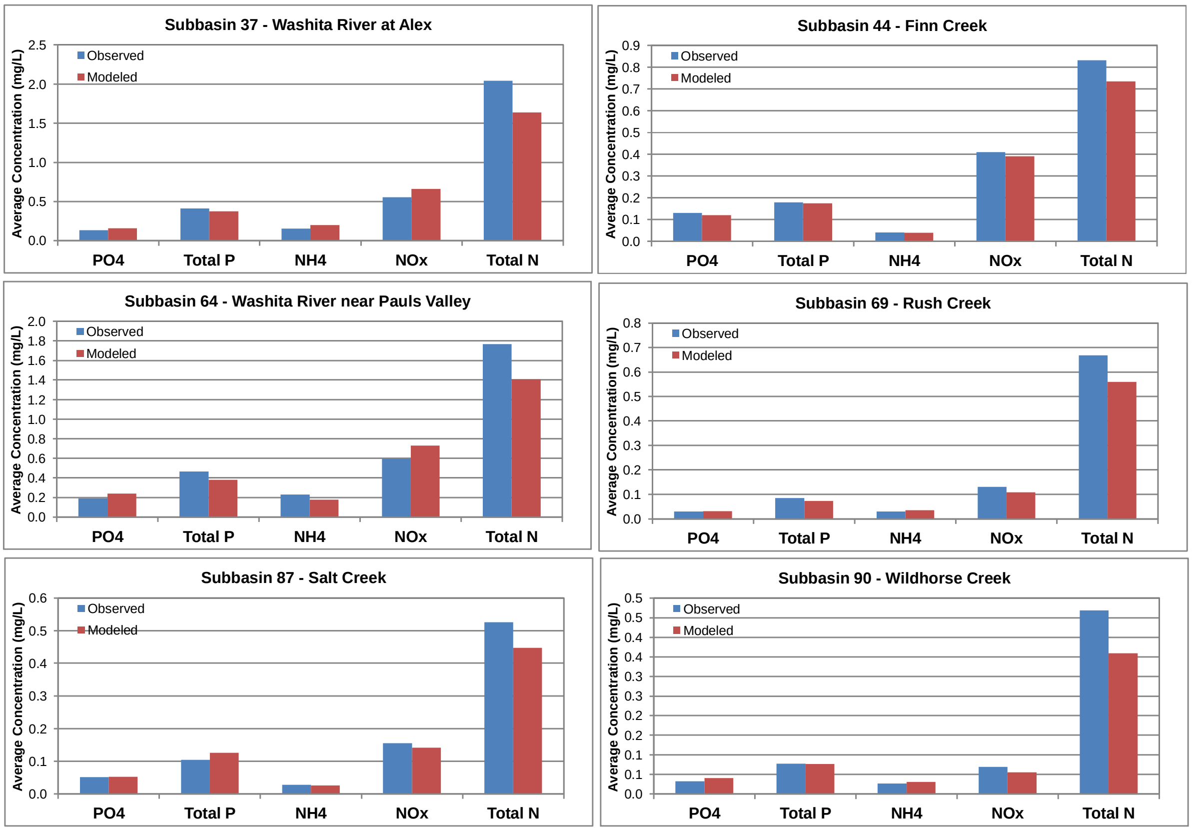
Table D-7 summarizes the model error for the various nutrients. As can be seen, in most cases, the SWAT model reproduced the average nutrient concentrations within 25% of the measured averages (Figure D-8). In some instances, the model does not replicate speciation for a given period, but nevertheless the total phosphorus and nitrogen predicted averages are within or close to the 25% target. For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. The monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

Table D-7 Summary of Model Error for Nutrient Predictions (mg/L)

Sub-basin	Description	Parameter				
		PO_4	Total P	NH_4	NO_x	Total N
37	Observed (mg/L)	0.13	0.41	0.15	0.56	2.04
	Modeled (mg/L)	0.16	0.37	0.20	0.66	1.64
	Error (%)	*20*	*-9*	*31*	*18*	*-20*
44	Observed (mg/L)	0.13	0.18	0.04	0.41	0.83
	Modeled (mg/L)	0.12	0.17	0.04	0.39	0.73
	Error (%)	*-8*	*-3*	*-1*	*-5*	*-12*
64	Observed (mg/L)	0.19	0.46	0.23	0.60	1.76
	Modeled (mg/L)	0.24	0.38	0.18	0.73	1.41
	Error (%)	*25*	*-18*	*-23*	*23*	*-20*
69	Observed (mg/L)	0.03	0.08	0.03	0.13	0.67
	Modeled (mg/L)	0.03	0.07	0.03	0.11	0.56
	Error (%)	*4*	*-14*	*16*	*-17*	*-16*
87	Observed (mg/L)	0.05	0.10	0.03	0.15	0.53
	Modeled (mg/L)	0.05	0.13	0.03	0.14	0.45
	Error (%)	*3*	*20*	*-8*	*-9*	*-15*
90	Observed (mg/L)	0.03	0.08	0.03	0.07	0.47
	Modeled (mg/L)	0.04	0.08	0.03	0.06	0.36
	Error (%)	*25*	*-1*	*16*	*-21*	*-23*

Non-detects were assumed equal to ½ DL

Figure D-8 Observed and Modeled Average Nutrient Concentrations



PO4 = mineral phosphate phosphorus; Total P = total phosphorus; NH4 = ammonia nitrogen; NOx = nitrate+nitrite nitrogen; Total N = total nitrogen

D-3. Model Results

Figures D-9 and D-10 show the average annual load of nutrients from runoff for each of the 82 sub-watersheds in the model domain. Total phosphorus loads ranged from 0.09 to 2.97 kg/ha/year. Total nitrogen loads varied between 0.09 and 5.12 kg/ha/yr.

A summary of average daily values for the sub-watershed draining to Lake Humphreys is included in Table C-9. Under current conditions, Lake Humphreys is estimated to receive a total annual load of 5,400 kg of phosphorus and 8,500 kg of nitrogen, on average, from nonpoint sources in its watershed.

Table D-9 Average Flows and Nutrient Loads Discharging to Holdenville Lake

Parameter	Lake Humphreys
Watershed Size (square miles)	32
Flow (m^3/day)	2.45E+04
Organic Phosphorus (kg/year)	4,600
Mineral Ortho-Phosphorus (kg/year)	700
Total Phosphorus (kg/year)	**5,400**
Organic Nitrogen (kg/year)	7,800
Ammonia Nitrogen (kg/year)	100
Nitrate+Nitrite Nitrogen (kg/year)	600
Total Nitrogen (kg/year)	**8,500**

Figure D-9 Average Total Phosphorus Loading from SWAT Subwatersheds

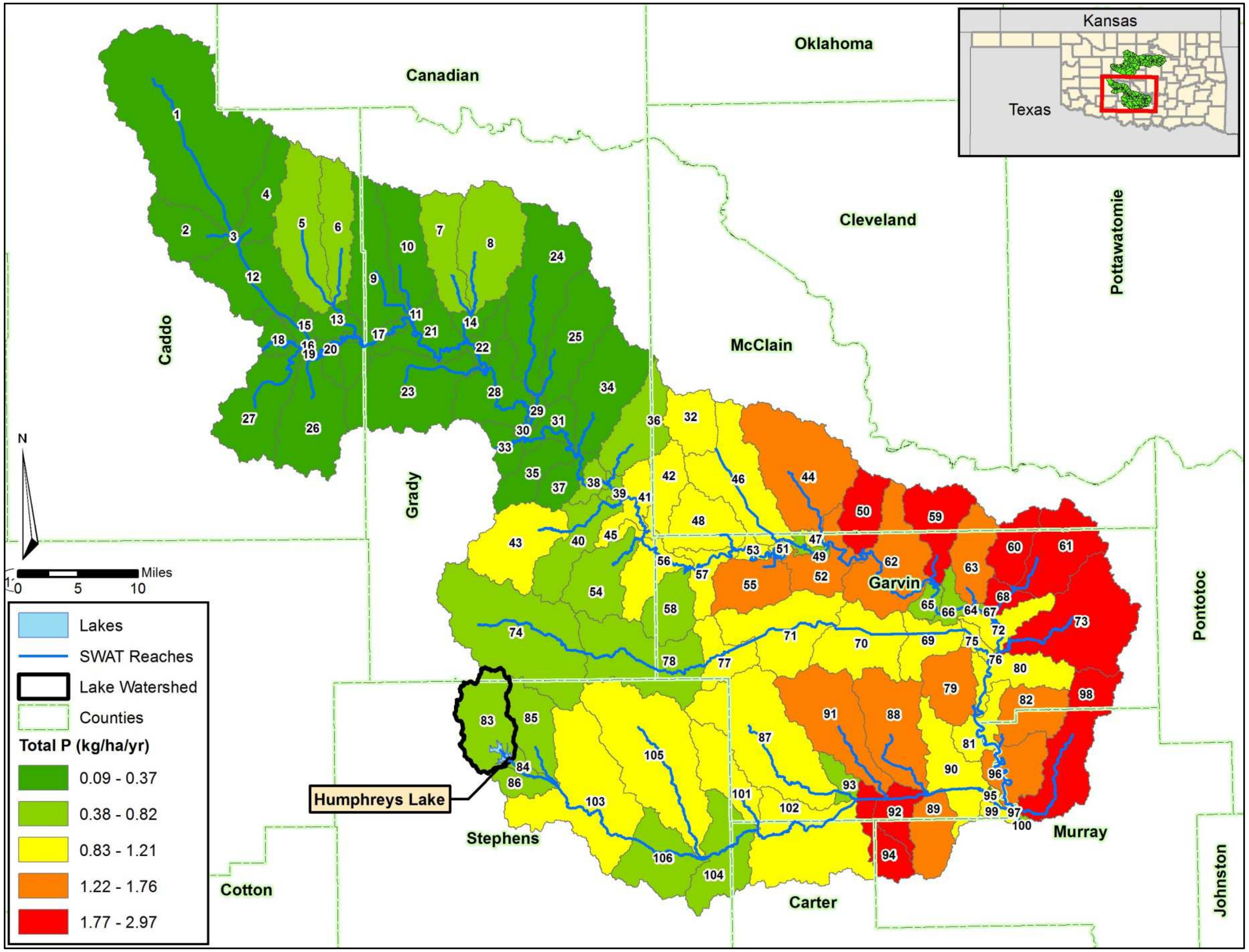
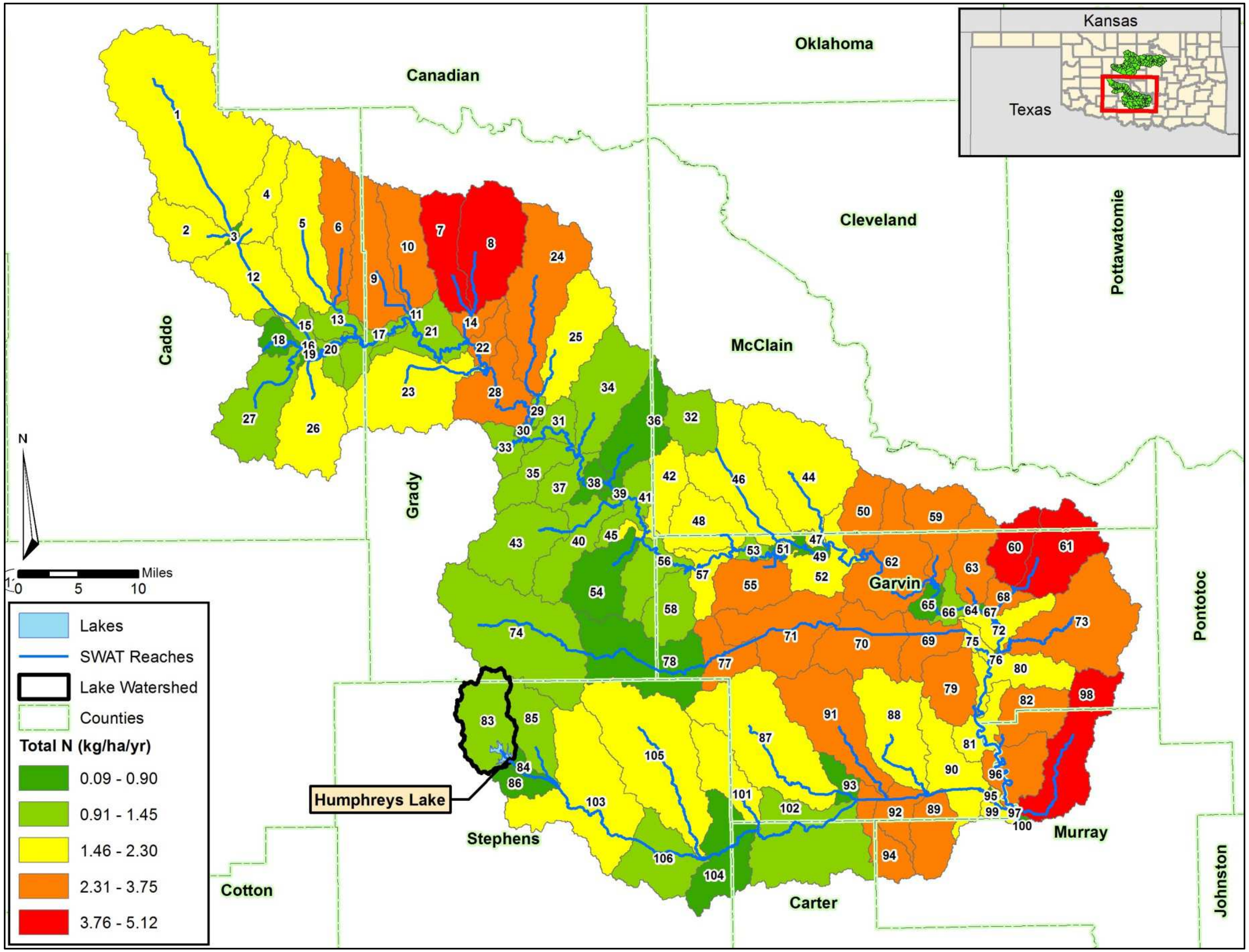


Figure D-10 Average Total Nitrogen Loading from SWAT Subwatersheds



References

Haan, C.T., B.J. Barfield, and J.C. Hayes. 1994. Design Hydrology and Sedimentation for Small Catchments. Academic Press INC.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams, 2009. *Soil and Water Assessment Tool Theoretical Documentation: Version 2009*. Grassland, Soil and Water Research Laboratory - Agricultural Research Service and Blackland Research and Extension Center - Texas Agricultural Experiment Station. Available at http://twri.tamu.edu/reports/2011/tr406.pdf.

Storm, D.E., D. Gade, R. Tejral, M.D. Smolen, P. Kenkel, and M.S. Gregory. 2000. Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma. Oklahoma State University, Departments of Biosystems and Agricultural Engineering and Department of Agricultural Economics, University of Tennessee. Prepared for the Oklahoma Conservation Commission and the U.S. Environmental Protection Agency. August 24, 2000.

USDA 2012. National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Statistics_by_State/Oklahoma/index.asp.

USDA 2014. 2013 Oklahoma Cropland Data Layer. National Agricultural Statistics Service (NASS), Research and Development Division (RDD), Geospatial Information Branch (GIB), Spatial Analysis Research Section (SARS). http://www.nass.usda.gov/research/Cropland/SARS1a.htm. Published January 31, 2014.

Winchell, M., R. Srinivasan, M. Di Luzio, and J. Arnold. 2013. ArcSWAT Interface for SWAT 2012 – User's Guide. Blackland Research and Extension Center - Texas AgriLife Research and Grassland, Soil and Water Research Laboratory – USDA Agricultural Research Service.

APPENDIX E

RESONSE TO PUBLIC COMMENTS

Comments received by email from Todd Fagin (Oklahoma Natural Heritage Inventory/Oklahoma Biological Survey)

We have reviewed occurrence information on federal and state threatened, endangered or candidate species, as well as non-regulatory rare species and ecological systems of importance currently in the Oklahoma Natural Heritage Inventory database for the following location you provided:

Portions of T19N-R1W and T19N-R1E, Payne County and Sec. 32-T20N-R20E, Noble County (Lake Carl Blackwell) and Sec. 1 and 2-T1N-R7W and Sec. 34, 35, and 36-T2N-R7W (Lake Humphreys), Stephens County

We found no occurrences of relevant species within the vicinity of the project location as described.

However, absence from our database does not preclude such species from occurring in the area.

Response:

Thank you for your comments.

Comments received by email from Ed Long

I am most pleased you are taking a proactive stance in preventing further deterioration of the water quality of Lake Carl Blackwell and to prevent further damage to this natural asset. Also I would estimate fertilizer applied on the agriculture land could have contributed to the problem.

These same things are affecting the water in Lake Carl Blackwell and please get it corrected.

Response:

Thank you for your comments.

Comments from Oklahoma State University Facilities Management by email from James W Rosner, PE, CEM

1. According to the ODEQ draft proposed modification to Carl Blackwell's Water Quality management Plan, the source of TN and TP levels were determined to be exclusively based on upstream non-point sources. Since the upstream drainage area is privately owned, how much influence can the Oklahoma State University (OSU), the lake owner have on non-point sources of nitrogen and phosphorus levels in the lake which affect the chlorophyll-a and turbidity levels?

   Response:

   As the lake owner, it is in the best interest of OSU to encourage responsible land management and educate landowners in the watershed of the potential health and economic impacts on the lake.

2. What are the repercussions to OSU, as the lake owner, if we are not able to influence landowners to manage their lands in such a way that will reduce the TN and TP levels?

   Response:

   As noted in response #1, OSU can best serve in an educational role. However, OSU cannot and will not be held responsible for outcomes outside of its direct control.

3. Section 5.6.3 of the draft report states:

   Reasonable assurance that nonpoint sources will meet their allocated amount in the TMDL is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. The OCC is responsible for the state's NPS program as defined in Section 319 of CWA. DEQ will work in conjunction with OCC and other federal, state, and local partners within the respective watersheds to meet the load reduction goals for NPS.

   How does OSU, as the lake owner, fit into this? Will there be any requirements on OSU to help meet the proposed standards?

   Response:

   The Oklahoma Conservation Commission (OCC) administers the State's nonpoint source program and, therefore, will contact the stakeholder(s) responsible for the lake or the vicinities around the lake prior to the implementation of any management strategies to improve aimed at improving the lake's water quality.

4. How would these nutrient recommendations legally impact domestic water treatment and production?

   Response:

   The nutrient recommendations in the report are aimed at increasing raw water quality in the lake and, thus, making treatment easier and less expensive. There are no apparent legal impacts of these recommendations.

5. If nutrient levels are not met in the future, will there be implications on domestic water treatment and production?

   Response:

   Elevated levels of chlorophyll-a in lakes reflect excessive algae growth, which can have deleterious effects on the quality and treatment costs of drinking water. Excessive algae growth can also negatively affect the aquatic biological communities of lakes. Increases in nutrients affect and limit recreational use and cause taste and odor issues.

6. Where on the lake were the samples taken that were used for this draft TMDL?

   Response:

   Table 2-2 of the draft report includes longitudes, latitudes and site descriptions of the water quality monitoring stations used in this report.

7. Was the testing done by OWRB or another entity, and if yes- what is the name of the other entity?

   Response:

Water quality samples collected by OWRB are analyzed by the DEQ laboratory services.

8. If we have independent laboratory testing that now suggests different results, will we be removed from the public notice?

   Response:

   Any independent laboratory chosen will have to be DEQ accredited and any data collected to assess water quality will need to be collected pursuant to a Quality Assurance Project Plan (QAPP) approved by DEQ and EPA.

   For the lake to be removed from the Oklahoma impaired waterbodies list (303d)the rules in the Implementation Procedures for Oklahoma's Water Quality Standards stipulates that (785:46-15-3(c)) the most recent 10 years of water quality data are used as the basis for evaluating the beneficial use support for lakes (OWRB 2013a).

   The minimum data required is also stipulated in Implementation Procedures for Oklahoma's Water Quality Standards (785:46-15-3(d)) ….., a minimum of 20 samples shall be required on lakes of more than 250 surface acres to assess beneficial use support due to water quality parameters including but not limited to DO, pH and temperature. A minimum of 20 samples shall likewise be required on such lakes for other routine water quality constituents including but not limited to coliform bacteria, chlorophyll a, and dissolved solids. A minimum of 10 samples shall be required on lakes or arms of 250 surface acres of less. Samples may be aggregated to meet the minimum requirements of this paragraph.

9. Can ODEQ provide testing protocols so that OSU can do the same testing for representative results?

   Response:

   For information regarding DEQ's laboratory testing protocols, please contact David Caldwell at 1-866-412-3057 or 405-702-1000.

10. What groups report findings on lake water testing to ODEQ?

    Response:

    OWRB is the primary entity that collects and assesses lake water quality in the State. The City of Tulsa and the Army Corps of Engineers are two other entities that collect samples from specific lakes.

    The water quality data used in the assessment of the two lakes contained in this report were collected by OWRB.

11. At the time of the samples were taken we were experiencing a drought situation and now that the lake is full does this not change the results?

    Response:

    Table 2-3 shows the range of data used in this report. The data available for this report ranged from 1998 to 2013 which encompassed both drought and wet periods. However, data from the most recent 10 years were used as stipulated in the Implementation Procedures for Oklahoma's Water Quality Standards (785:46-15-3(c)).

12. Does ODEQ have a recommended next step or procedure if the lab results are the same now?

    Response:

    If laboratory results confirm impairments, stakeholders will have to make a decision on which management strategies to employ to help improve water quality.

    DEQ will recommend that OSU contact the water quality section of the Oklahoma Conservation Commission for advice and/or assistance

13. What is the anticipated timeline to meet the reduction?

    Response:

    There is no timeline to meet the reductions outlined in the report; however, it is in the best interest of the stakeholders and or the City to devise means and/or methods to meet the reductions.

14. What methods or suggestions are needed to fix the issue?

    Response:

    Methods and/or suggestions regarding how the reductions in the lake can be met have to be discussed among the stakeholders within the watershed.

    OCC can help with programs such as educating landowners about the effectiveness of best management practices (BMPs) and assisting them through cost-share programs to voluntarily install appropriate BMPs on their property.

15. What lake impairment is being caused by nitrogen and phosphorus levels, or is the impairment due to chlorophyll-a levels?

    Response:

    Lake Carl Blackwell is impaired for chlorophyll-a. Elevated chlorophyll-a levels typically indicate excessive loading of the primary growth-limiting algal nutrients such as nitrogen and phosphorus to the waterbody, a process known as eutrophication.