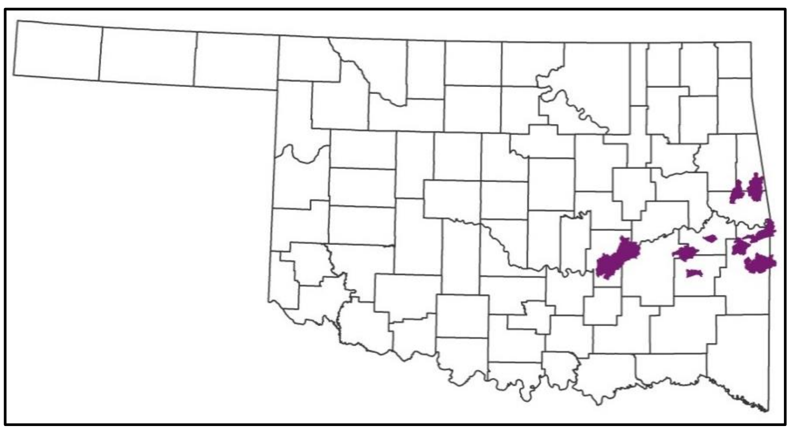
FINAL

2014 BACTERIAL AND TURBIDITY TOTAL MAXIMUM DAILY LOADS FOR OKLAHOMA STREAMS IN THE LOWER ARKANSAS RIVER AREA (OK220100, OK220200, OK220600)

Oklahoma Waterbody Identification Numbers

Poteau River	OK220100010010_00
Poteau River	OK220100010010_40
Brazil Creek	OK220100030010_00
Bandy Creek	OK220100040080_00
Sallisaw Creek	OK220200030010_20
Sans Bois Creek	OK220200040010_10
Sans Bois Creek	OK220200040010_40
Little Lee Creek	OK220200050040_00
Canadian River	OK220600010119_10



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DEPARTMENT OF ENVIRONMENTAL QUALITY

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
ASAE	American Society of Agricultural Engineers
BMP	Best management practices
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfu	colony-forming unit
CPP	Continuing Planning Process
CWA	Clean Water Act
DEQ	Oklahoma Department of Environmental Quality
DMR	Discharge monitoring report
E. coli	Escherichia coli
ENT	Enterococci
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic unit code
IQR	Interquartile range
LA	Load allocation
LDC	Load duration curve
LOC	Line of organic correlation
mg	Million gallons
mgd	Million gallons per day
mg/L	Milligram per liter
mL	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRMSE	Normalized root mean square error
NTU	Nephelometric turbidity unit
OAC	Oklahoma Administrative Code

OLS	Ordinary least square
O.S.	Oklahoma statute
ODAFF	Oklahoma Department of Agriculture, Food and Forestry
OKWBID	Oklahoma Waterbody Identification Number
OPDES	Oklahoma Pollutant Discharge Elimination System
OSWD	Onsite wastewater disposal
OWQS	Oklahoma Water Quality Standards
OWRB	Oklahoma Water Resources Board
PBCR	Primary Body Contact Recreation
PRG	Percent reduction goal
RMSE	Root mean square error
SH	State Highway
SSO	Sanitary sewer overflow
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WWAC	warm water aquatic community
WLA	wasteload allocation
WQM	Water quality monitoring
WQMP	Water Quality Management Plan
WQS	Water quality standard
WWTF	wastewater treatment facility

EXECUTIVE SUMMARY

ES - 1 OVERVIEW

This TMDL report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli)*, Enterococci] and turbidity for certain waterbodies in the Lower Arkansas Rivers Study Area in Oklahoma. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water. Elevated turbidity levels caused by excessive sediment loading and stream bank erosion impact aquatic communities. Data assessment and total maximum daily load (TMDL) calculations are conducted in accordance with requirements of Section 303(d) of the Clean Water Act (CWA), Water Quality Planning and Management Regulations (40 CFR Part 130), U.S. Environmental Protection Agency (EPA) guidance, and Oklahoma Department of Environmental Quality (DEQ) guidance and procedures. DEQ is required to submit all TMDLs to EPA for review. Approved 303(d) listed waterbody-pollutant pairs or surrogates TMDLs will receive notification of the approval or disapproval action. Once the 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 study is to establish pollutant load allocations for indicator bacteria and turbidity in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and instream water quality conditions. 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. MOS can be implicit and/or explicit. The 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 process 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 bacteria or turbidity within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process.

ES - 2 PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

This TMDL report focuses on waterbodies in the Lower Arkansas Rivers Study Area, identified in Table ES-1, that DEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2010 Integrated Report* (aka 2010 Integrated Report) for nonsupport of primary body contact recreation (PBCR), warm water aquatic community (WWAC), or Cool Water Aquatic Community (CWAC).

Elevated levels of bacteria or turbidity above the WQS necessitates the development of a TMDL. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the PBCR or fish and wildlife propagation beneficial uses designated for each waterbody.

Table ES-2 summarizes water quality data collected during primary contact recreation season from the water quality monitoring (WQM) stations between 2004 and 2010 for each bacterial indicator. The data summary in Table ES-2 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. This data collected during the primary contact recreation season includes the data used to support the decision to place specific waterbodies within the Study Area on the DEQ 2010 303(d) list (DEQ 2010). It also includes the new date collected after the data cutoff date for the 2010 303(d) list.

ES-2.1 Chapter 45: Definition of PBCR and Bacterial WQSs

The definition of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Chapter 45 of the Oklahoma WQSs.

(a). *Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.*

(b). *In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.*

(c). *Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefore. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group.*

(1) *Escherichia coli (E. coli): The E. coli geometric mean criterion is 126/100 ml. For swimming advisory and permitting purposes, E. coli shall not exceed a monthly geometric mean of 126/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 235/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 126/100 milliliters compared to the geometric mean of all samples collected over the recreation period.*

Table ES - 1 Excerpt from the 2010 Integrated Report – Oklahoma 303(d) List of Impaired Waters (Category 5)

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK220100010010_00	Poteau River	23.89	2012	1	X		N	X	N
OK220100010010_40	Poteau River	21.35	2012	1				X	N
OK220100030010_00	Brazil Creek	17.83	2021	4	X		N		
OK220100040080_00	Bandy Creek	12.44	2021	4				X	N
OK220200030010_20	Sallisaw Creek	13.30	2021	4	X		N		
OK220200040010_10	Sans Bois Creek	10.76	2021	4	X		N		N*
OK220200040010_40	Sans Bois Creek	27.80	2021	4			N**	X	N
OK220200050040_00	Little Lee Creek	23.66	2021	4	X		N		
OK220600010119_10	Canadian River	39.08	2021	4	X		N	X	N

ENT = Enterococci; N = Not attaining; X = Criterion exceeded; * Due to low DO, not addressed in this report. ** No bacterial indicators cited in the 2010 Integrated Report; no bacterial TMDL developed in this report.
Source: 2010 Integrated Report, DEQ 2010

Table ES - 2 Summary of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2004-2010

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Conc (cfu/100 ml)	Assessment Results
OK220100010010_00	Poteau River	ENT	14	19	Delist: geometric mean meets criterion
OK220100030010_00	Brazil Creek	ENT	10	97	TMDL Required
OK220200030010_20	Sallisaw Creek	ENT	10	221	TMDL Required
OK220200040010_10	Sans Bois Creek	ENT	10	86	TMDL Required
OK220200050040_00	Little Lee Creek	ENT	5	21	Delist: Not enough data available
OK220600010119_10	Canadian River	ENT	19	134	TMDL Required

Enterococci (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL
TMDLs will be developed for waterbodies highlighted in green

(2) Enterococci: The Enterococci geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococci shall not exceed a monthly geometric mean of 33/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 61/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 33/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

ES-2.2 Chapter 46: Implementation of OWQS for PBCR

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2013a). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a). ***Scope.***

The provisions of this Section shall be used to determine whether the subcategory of Primary Body Contact of the beneficial use of Recreation designated in OAC 785:45 for a waterbody is supported during the recreation season from May 1 through September 30 each year. Where data exist for multiple bacterial indicators on the same waterbody or waterbody segment, the determination of use support shall be based upon the use and application of all applicable tests and data.

(b). ***Escherichia coli (E. coli).***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(c). ***Enterococci.***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to Enterococci if

the geometric mean of 33 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

Where concurrent data exist for multiple bacterial indicators on the same waterbody, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2013).

As stipulated in the WQS, only the geometric mean of all samples collected over the recreation period shall be used to assess the impairment status of a stream. Therefore, only the geometric mean criteria is used to develop TMDLs for *E. coli* and Enterococci bacterial indicators.

It is worth noting that the Oklahoma Water Quality Standards (OWQS) prior to July 1, 2011 contains three bacterial indicators (fecal coliform, *E. coli* and Enterococci) and the new OWQS effective on July 1, 2011 contains only *E. coli* and Enterococci. Because the new OWQS no longer have a standard for fecal coliform, fecal coliform TMDLs will not be developed for any stream in this report listed for fecal coliform impairment in the 2010 303(d) list. Bacterial TMDLs will be developed only for *E. coli* and/or Enterococci impaired streams.

ES-2.3 Chapter 45: Criteria for Turbidity

The beneficial use of WWAC or CWAC is one of several subcategories of the Fish and Wildlife Propagation use established to manage the variety of communities of fish and shellfish throughout the state (OWRB 2011). The numeric criteria for turbidity to maintain and protect the use of "Fish and Wildlife Propagation" from Title 785:45-5-12 (f) (7) is as follows:

(A) Turbidity from other than natural sources shall be restricted to not exceed the following numerical limits:

i. Cool Water Aquatic Community/Trout Fisheries: 10 NTUs;

ii. Lakes: 25 NTU; and

iii. Other surface waters: 50 NTUs.

(B) In waters where background turbidity exceeds these values, turbidity from point sources will be restricted to not exceed ambient levels.

(C) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions.

(D) Elevated turbidity levels may be expected during, and for several days after, a runoff event.

ES-2.4 Chapter 46: Implementation of OWQS for Fish and Wildlife Propagation

Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2013a) describes Oklahoma's WQS for Fish and Wildlife Propagation. The excerpt below from Chapter 46: 785:46-15-5, stipulates how water quality data will be assessed to determine support of fish and wildlife propagation as well as how the water quality target for TMDLs will be defined for turbidity.

Assessment of Fish and Wildlife Propagation support

(a). Scope. The provisions of this Section shall be used to determine whether the beneficial use of Fish and Wildlife Propagation or any subcategory thereof designated in OAC 785:45 for a waterbody is supported.

(e). Turbidity. The criteria for turbidity stated in 785:45-5-12(f)(7) shall constitute the screening levels for turbidity. The tests for use support shall follow the default protocol in 785:46-15-4(b).

785:46-15-4. Default protocols

(b). Short term average numerical parameters.

(1) Short term average numerical parameters are based upon exposure periods of less than seven days. Short term average parameters to which this Section applies include, but are not limited to, sample standards and turbidity.

(2) A beneficial use shall be deemed to be fully supported for a given parameter whose criterion is based upon a short term average if 10% or less of the samples for that parameter exceeds the applicable screening level prescribed in this Subchapter.

(3) A beneficial use shall be deemed to be fully supported but threatened if the use is supported currently but the appropriate state environmental agency determines that available data indicate that during the next five years the use may become not supported due to anticipated sources or adverse trends of pollution not prevented or controlled. If data from the preceding two year period indicate a trend away from impairment, the appropriate agency shall remove the threatened status.

(4) A beneficial use shall be deemed to be not supported for a given parameter whose criterion is based upon a short term average if at least 10% of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

Turbidity is a measure of water clarity and is caused by suspended particles in the water column. Because turbidity cannot be expressed as a mass load, total suspended solids (TSS) are used as a surrogate for the TMDLs in this report. Therefore, both turbidity and TSS data are presented.

Table ES-3 summarizes a subset of water quality data collected for turbidity and TSS under base flow conditions, which DEQ considers to be all flows less than the 25th flow exceedance percentile (i.e., the lower 75% of flows). Water quality samples collected under flow conditions greater than the 25th flow exceedance percentile (highest flows) were therefore excluded from the data set used for TMDL analysis.

ES - 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. Bacteria originate from warm-blooded animals and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated sanitary wastewater are required to monitor fecal coliform under the current permits and will be required to monitor *E. coli* when their permits come to renew. These facilities are also required to monitor TSS in accordance with their permits. 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 bacteria or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. Sediment loading of streams can originate from natural erosion processes, including the weathering of soil, rocks, and uncultivated land; geological abrasion; and other natural phenomena. There is insufficient data available to quantify contributions of TSS from these natural processes. TSS or sediment loading can also occur under non-runoff conditions as a result of anthropogenic activities in riparian corridors which cause erosive conditions. Given the lack of data to establish the background conditions for TSS/turbidity, separating background loading from nonpoint sources whether it is from natural or anthropogenic processes is not feasible in this TMDL development. Table ES-6 summarizes the point and nonpoint sources that contribute bacteria or TSS to each respective waterbody.

ES - 4 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDC). LDCs facilitate rapid development of TMDLs, and as a TMDL development tool can provide some information for identifying whether impairments are associated with point or nonpoint sources. The efficiency and simplicity of the LDC method should not be considered as bad descriptors of this powerful tool for displaying the changing water quality over changing flows that provides information as to the sources of the pollutant that is not apparent in the raw data. The LDC has additional valuable uses in the post-TMDL implementation phase of the restoration of the water quality for a waterbody. Plotting future monitoring information on the LDC can show trends of improvement to sources that will identify areas for revision to the watershed restoration plan. The low cost of the LDC method allows accelerated development of TMDL plans on more waterbodies and the evaluation of the implementation of WLAs and BMPs. The technical approach for using LDCs for TMDL development includes the following steps:

Table ES - 3 Summary of Turbidity and TSS Data Excluding High Flow Samples, 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)	Assessment Results
OK220100010010_00	Poteau River	220100010010-001AT	24	6	25%	44.1	TMDL Required
OK220100010010_40	Poteau River	220100010010-001SRF	5	3	60%	74.8	TMDL Required
OK220100040080_00	Bandy Creek	OK220100-04-0020G	NA	NA	NA	NA	Delist: Not enough data
OK220200040010_40	Sans Bois Creek	OK220200-04-0010W	14*	1	7%	29.5	Delist: meets standard
OK220600010119_10	Canadian River	220600010119-001AT	26	9	35%	74.1	TMDL Required

NA: Not applicable.

* Samples from 1999 were added to reach the minimum data requirement for assessment after high flow samples were removed from 2000 and 2001.

Table ES - 4 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK220100010010_00	Poteau River	0.928	4.1%	37	10%
OK220100010010_40	Poteau River	0.928[c]	4.1%[c]	37[c]	10%[c]
OK220600010119_10	Canadian River	0.767	10.8%	35	15%

[a] Calculated using the regression equation and the turbidity standard (50 NTU)

[b] Based on the goodness-of-fit of the turbidity-TSS regression (NRMSE)

[c] There are no paired TSS and turbidity data available for Poteau River segment OK220100010010_40; same statistical result from the downstream segment OK220100010010_00 was used for the TMDL development.

Table ES - 5 Stream and Pollutants for TMDL Development

Waterbody ID	HUC 8 Codes	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	Turbidity
OK220100010010_00	11110105	Poteau River	23.89	2012	1		X
OK220100010010_40	11110105	Poteau River	21.35	2012	1		X
OK220100030010_00	11110105	Brazil Creek	17.83	2021	4	X	
OK220200030010_20	11110104	Sallisaw Creek	13.30	2021	4	X	
OK220200040010_10	11110104	Sans Bois Creek	10.76	2021	4	X	
OK220600010119_10	11090204 11090202	Canadian River	39.08	2021	4	X	X

- Preparing flow duration curves for gaged and ungaged WQM stations.
- Estimating existing loading in the waterbody using ambient bacterial water quality data; and estimating loading in the waterbody using measured TSS water quality data and turbidity-converted data.
- Using LDCs to identify the critical condition that will dictate loading reductions and the overall percent reduction goal (PRG) necessary to attain WQS.

Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the “nonpoint source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the “point source critical condition” would typically occur during low flows, when wastewater treatment facilities (WWTF) effluents would dominate the base flow of the impaired water. However, flow range is only a general indicator of the relative proportion of point/nonpoint contributions. Violations have been noted under low flow conditions in some watersheds that contain no point sources.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by a water quality criterion. The TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

The basic steps to generating an LDC involve:

- Obtaining daily flow data for the site of interest from the U.S. Geological Survey (USGS), or if unavailable, projected from a nearby USGS site.
- Sorting the flow data and calculating flow exceedance percentiles.
- Obtaining the water quality data from the primary contact recreation season (May 1 through September 30); or obtaining available turbidity and TSS water quality data.
- Matching the water quality observations with the flow data from the same date.

Table ES - 6 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal NPDES Facility	Industrial NPDES Facility	MS4	NPDES No Discharge Facility	CAFO/ PFO	Mines	Construction Stormwater Permit	Nonpoint Source
Poteau River	OK220100010010_00								Turbidity
Poteau River	OK220100010010_40								Turbidity
Brazil Creek	OK220100030010_00								Bacteria
Sallisaw Creek	OK220200030010_20								Bacteria
Sans Bois Creek	OK220200040010_10								Bacteria
Canadian River	OK220600010119_10								Bacteria/ Turbidity

Facility present in watershed and potential as contributing pollutant source.

Facility present in watershed, but not recognized as pollutant source.

No facility present in watershed.

- Displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS for each respective bacterial indicator; or displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQ_{goal} for TSS.
- For bacterial TMDLs, displaying and differentiating another curve derived by plotting the geometric mean of all existing bacterial samples continuously along the full spectrum of flow exceedance percentiles which represents the observed load in the stream.
- For turbidity TMDLs, matching the water quality observations with the flow data from the same date and determining the corresponding exceedance percentile. Plotting the flow exceedance percentiles and daily load observations in a load duration plot (See Section 5).

ES-4.1 Bacterial LDC

For bacterial TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQS = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

unit conversion factor = 24,465,525

ES-4.2 TSS LDC

For turbidity (TSS) TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (lb/day) = WQ_{goal} **** flow (cfs) * unit conversion factor***

where:

WQ_{goal} ***= waterbody specific TSS concentration derived from regression analysis results presented in Table 5-1***

unit conversion factor = 5.39377

ES-4.3 LDC Summary

Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. Historical observations of TSS and/or turbidity concentrations are paired with flow data and are plotted on the LDC for a stream. It is noted that the LDCs for bacteria were based on the geometric mean standards or geometric mean of all samples. It is inappropriate to compare single sample bacterial observations to a geometric mean water quality criterion in the LDC; therefore individual bacterial samples are not plotted on the LDCs.

ES - 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 lack of knowledge concerning the relationship between pollutant loading and water quality. This definition can be expressed by the following equation:

$$TMDL = WLA\_{WWTF} + WLA\_{MS4} + LA + MOS$$

ES-5.1 Bacterial PRG

For each waterbody the TMDLs presented in this report are expressed as colony forming units per day across the full range of flow conditions. For information purpose, percent reductions are also provided. The difference between existing loading and the water quality target is used to calculate the loading reductions required. For bacteria, the PRG is calculated by reducing all samples by the same percentage until the geometric mean of the reduced sample values meets the corresponding bacterial geometric mean standard (126 cfu/100 ml for *E. coli* and 33 cfu/100 ml for Enterococci) with 10% of MOS. For turbidity, the PRG is the load reduction that ensures that no more than 10% of the samples under base-flow conditions exceed the TMDL.

Table ES-7 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area.

Table ES - 7 Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate
		ENT
OK220100030010_00	Brazil Creek	61.4%
OK220200030010_20	Sallisaw Creek	86.6%
OK220200040010_10	Sans Bois Creek	65.4%
OK220600010119_10	Canadian River	96.4%

ES-5.2 TSS PRG

Similarly, PRGs for TSS are calculated as the required overall reduction so that no more than 10% of the samples exceed the water quality target for TSS. The PRGs for the waterbodies requiring turbidity TMDLs in this report are summarized in Table ES-8.

Table ES - 8 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK220100010010_00	Poteau River	44.5%
OK220100010010_40	Poteau River	27.5%
OK220600010119_10	Canadian River	68.7%

ES-5.3 MOS

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5^{th} flow interval percentile. The WLA component of each TMDL is the sum of all WLAs within each contributing watershed. The LA can then be calculated as follows:

$$LA = TMDL - MOS - \sum WLA$$

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS and account for seasonal variability. The MOS, which can be implicit or explicit, 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.

For bacterial TMDLs, an explicit MOS was set at 10%.

For turbidity, the TMDLs are calculated for TSS instead of turbidity. Thus, the quality of the regression has a direct impact on confidence of the TMDL calculations. The better the regression is, the more confidence there is in the TMDL targets. As a result, it leads to a smaller MOS. The selection of MOS is based on the normalized root mean square error (NRMSE) for each waterbody (Table ES-4).

ES-5.4 PBCR Season

The bacterial TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1^{st} through September 30^{th}. Similarly, the TSS TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS for turbidity, which applies to seasonal base flow conditions only. Seasonal variation was also accounted for in these TMDLs by using more than five years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

ES - 6 Reasonable Assurance

Reasonable assurance is required by the EPA rules 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 WLA based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurances" that nonpoint (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 standard numerical criteria. This ensures that the impairments of the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

ES - 7 PUBLIC PARTICIPATION

The public had a 45-day opportunity to review the draft TMDL report and submit written comments. One public comment was received, and the response to that public comment can be found in Appendix F. There was no request for a public meeting.

The written comment that was received during the public notice period became a part of the record of this TMDL report. After reviewing the comment, a revision was made to the final TMDL report and to the TMDL 208 Factsheet. The final TMDL was 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 (TMDL) for all waterbodies and pollutants identified by the Regional Administrator as suitable for TMDL calculation. Waterbodies 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 instream 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 assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli)*, Enterococci; all future references to bacteria in this document imply these two fecal pathogen indicator bacterial groups unless specifically stated otherwise.] and turbidity for selected waterbodies in the Lower Arkansas Rivers area in Oklahoma. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water. Elevated turbidity levels caused by excessive sediment loading and stream bank erosion impact aquatic biological communities. 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 Department of Environmental Quality (DEQ) guidance and procedures. DEQ is required to submit all TMDLs to EPA for review. Approved 303(d) listed waterbody-pollutant pairs or surrogates TMDLs will receive notification of the approval or disapproval action. Once the 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 pollutant load allocations for indicator bacteria and turbidity in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and instream water quality conditions. 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). The LA is the fraction of the total pollutant load apportioned to nonpoint sources. 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 process 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 bacteria or turbidity 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.

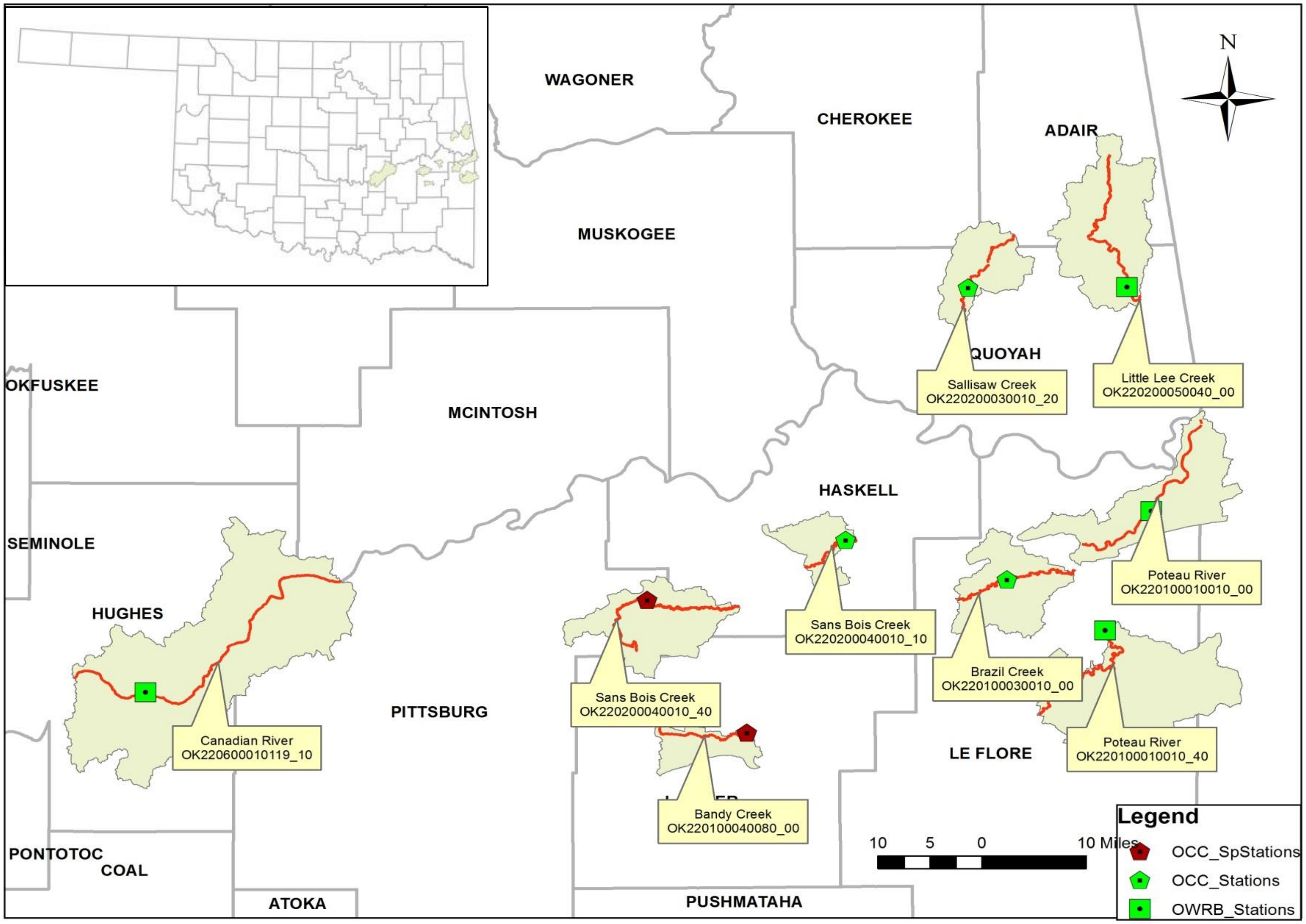
This TMDL report focuses on waterbodies that DEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2010 Integrated Report* (aka 2010 Integrated Report) for nonsupport of primary body contact recreation (PBCR) or Fish and Wildlife Propagation beneficial uses. The waterbodies considered for TMDL development in this report include:

Table 1-1 TMDL Waterbodies

Poteau River	OK220100010010_00
Poteau River	OK220100010010_40
Brazil Creek	OK220100030010_00
Bandy Creek	OK220100040080_00
Sallisaw Creek	OK220200030010_20
Sans Bois Creek	OK220200040010_10
Sans Bois Creek	OK220200040010_40
Little Lee Creek	OK220200050040_00
Canadian River	OK220600010119_10

Figure 1-1 shows these Oklahoma waterbodies and their contributing watersheds. These maps also 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.

Figure 1-1 Lower Arkansas River Watersheds Not Supporting Primary Body Contact Recreation or Fish and Wildlife Propagation Use



Elevated levels of pathogen indicator bacteria or turbidity above the WQS numeric criterion result in the requirement that a TMDL be developed. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the PBCR or fish and wildlife propagation use designated for each waterbody. Table 1-2 provides a description of the locations of WQM stations on the 303(d)-listed waterbodies.

Table 1-2 Water Quality Monitoring Stations used for Assessment of Streams

WQM Station	Waterbody Name	Station Location	Waterbody ID
220100010010-001AT	Poteau River	S23 T9N R26EI	OK220100010010_00
220100010010-001SRF	Poteau River	S19 T7N R26EI	OK220100010010_40
OK220100-03-0010G	Brazil Creek	SE/NW/NW S27 T8N R24EI	OK220100030010_00
Multiple Oklahoma Corporation Commission Monitoring Sites	Bandy Creek	S13 T5N R19EI, S17 T5N R20EI, S16 T5N R19EI, S8 T5N R20EI, S15 T5N T19E	OK220100040080_00
OK220200-03-0010G	Sallisaw Creek	NE/NE/NE S26 T13N R23EI	OK220200030010_20
OK220200-04-0010G	Sans Bois Creek	NW/NE/NW S1 T8N R21EI	OK220200040010_10
OK220200-04-0010W	Sans Bois Creek	NW S2 T7N R18EI	OK220200040010_40
220200050040-001AT	Little Lee Creek	S28 R13N R26EI	OK220200050040_00
220600010119-001AT	Canadian River	S22 R6N 10EI	OK220600010119_10

1.2 WATERSHED DESCRIPTION

1.2.1 General

The Lower Arkansas River study area is located in the eastern portion of Oklahoma. The waterbodies and their watersheds addressed in this report are scattered over Hughes, Pittsburg, McIntosh, Latimer, Haskell, Sequoyah, Cherokee, Adair, and Le Flore counties. These counties are part of the Cross Timbers, Arkansas Valley, Ouachita Mountains, Boston Mountains, and Ozark Highlands Level III ecoregions (Woods, A.J, et al 2005). The watersheds in the Study Area are located in the Arkoma Basin, Cherokee Platform and Ozark Uplift geological provinces. Table 1-3, derived from the 2010 U.S. Census, demonstrates that the counties in which these watersheds are located are mostly sparsely populated (U.S. Census Bureau 2010). Table 1-4 lists major towns and cities located in each watershed.

Table 1-3 County Population and Density

County Name	Population (2010 Census)	Population Density (per square mile)
Hughes	14,003	17
Pittsburg	45,837	35
McIntosh	20,252	33
Latimer	11,154	15
Haskell	12,769	22
Sequoyah	42,391	63
Cherokee	46,987	63
Adair	22,683	40
Le Flore	50,384	32

Table 1-4 Major Municipalities by Watershed

Waterbody Name	Waterbody ID	Municipalities
Poteau River	OK220100010010_00	Arkoma, Pocola, Rock Island, Spiro, Poteau, Panama
Poteau River	OK220100010010_40	Heavener, Howe, Wister
Brazil Creek	OK220100030010_00	Bokoshe, Shady Point
Bandy Creek	OK220100040080_00	Wilburton
Sallisaw Creek	OK220200030010_20	Marble City
Sans Bois Creek	OK220200040010_10	
Sans Bois Creek	OK220200040010_40	Quinton
Little Lee Creek	OK220200050040_00	
Canadian River	OK220600010119_10	Lamar, Atwood, Calvin

1.2.2 Climate

Table 1-5 summarizes the average annual precipitation for each Oklahoma waterbody derived from a geospatial layer developed to display annual precipitation using data collected from Oklahoma weather stations between 1971 through 2000. Average annual precipitation values among the watersheds in this portion of Oklahoma range between 43.4 and 50.4 inches (Oklahoma Climatological Survey 2005).

Table 1-5 Average Annual Precipitation by Watershed

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Poteau River	OK220100010010_00	46.3
Poteau River	OK220100010010_40	50.4
Brazil Creek	OK220100030010_00	48.6
Bandy Creek	OK220100040080_00	49.3
Sallisaw Creek	OK220200030010_20	49.0
Sans Bois Creek	OK220200040010_10	47.6
Sans Bois Creek	OK220200040010_40	47.7
Little Lee Creek	OK220200050040_00	49.6
Canadian River	OK220600010119_10	43.3

1.2.3 Land Use

Table 1-6 summarizes the percentages and acreages of the land use categories for the contributing watershed associated with each respective Oklahoma waterbody addressed in the Study Area. The land use/land cover data were derived from the U.S. Geological Survey (USGS) 2006 National Land Cover Dataset (USGS 2013). The percentages provided in Table 1-6 are rounded. The land use categories are displayed in Figure 1-3. The two most dominant land use categories throughout the Lower Arkansas Rivers Study Area are deciduous forest and pasture/hay. The Canadian River (OK220600010119_10) watershed in the Study Area has a significant percentage of land use classified as grassland/herbaceous (rangeland). The watersheds targeted for TMDL development in this Study Area range in size from 20,696 acres (Bandy Creek, OK220100040080_00) to 217,116 acres (Canadian River, OK220600010119_10).

Figure 1-2 Land Use Map

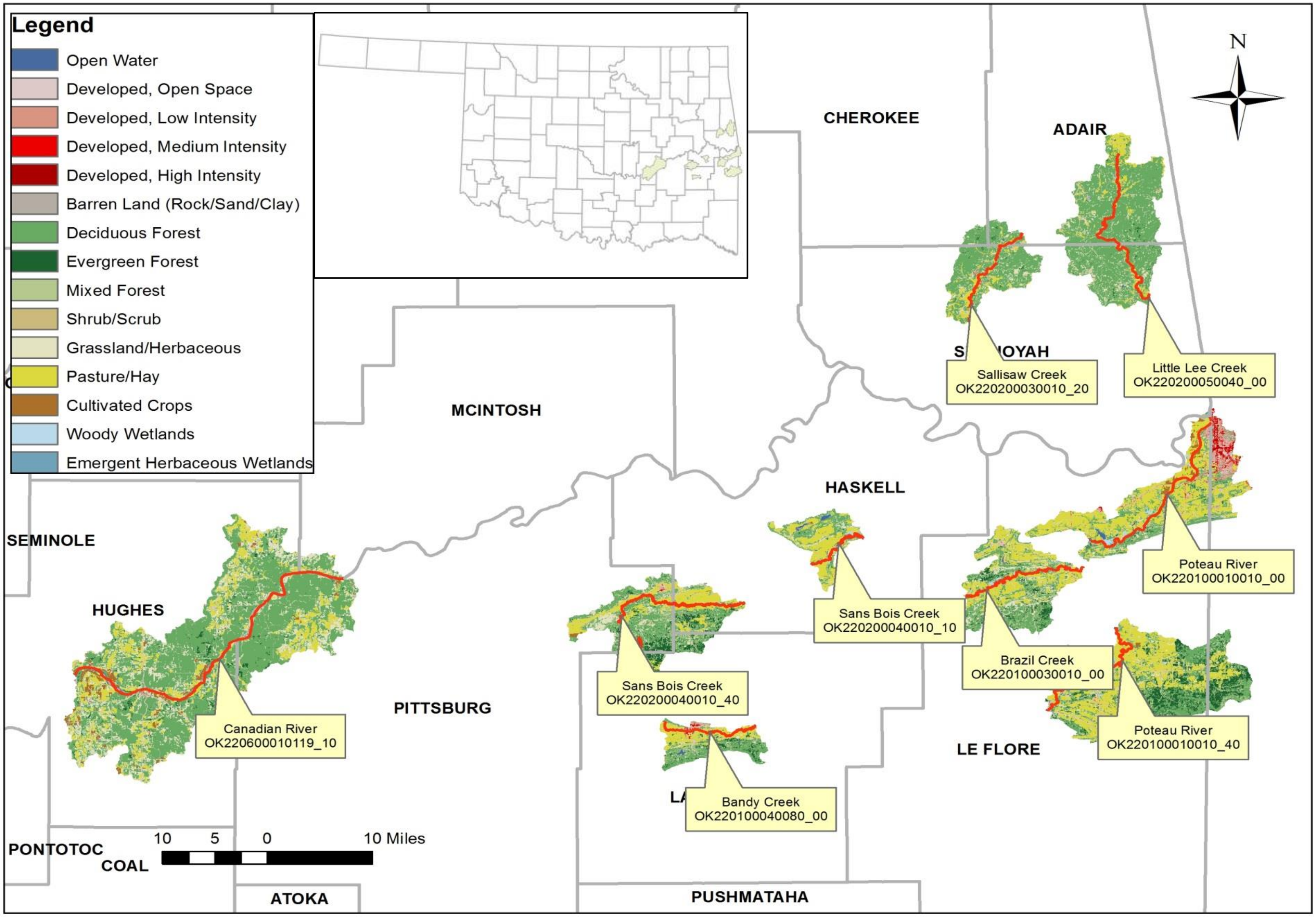


Table 1-6 Land Use Summaries by Watershed

Landuse Category	Watershed								
	Poteau River	Poteau River	Brazil Creek	Bandy Creek	Sallisaw Creek	Sans Bois Creek	Sans Bois Creek	Little Lee Creek	Canadian River
Waterbody ID	OK220100010010_00	OK220100010010_40	OK220100030010_00	OK220100040080_00	OK220200030010_20	OK220200040010_10	OK220200040010_40	OK220200050040_00	OK220600010119_10
Open Water	1,104	470	225	266	79	436	123	81	2,935
Developed, Open Space	4,893	4,351	1,842	922	775	447	1,619	2,095	6,823
Developed, Low Intensity	4,637	363	80	378	69	5	215	47	270
Developed, Medium Intensity	1,859	58	15	144	21	0	34	3	53
Developed, High Intensity	868	11	2	72	12	0	13	0	11
Bare Rock/Sand/Clay	92	36	103	19	102	130	34	85	1,515
Deciduous Forest	16,495	27,684	17,504	7,847	25,243	5,907	22,249	58,688	126,356
Evergreen Forest	779	19,653	3,387	1,611	278	206	7,292	504	3,280
Mixed Forest	2,136	7,922	4,691	1,912	381	855	4,949	441	0
Shrub/Scrub	707	1,128	798	265	615	357	1,010	982	27
Grasslands/Herbaceous	2,974	5,467	5,903	1,028	3,651	2,021	6,039	6,902	41,645
Pasture/Hay	30,543	36,213	14,611	6,164	4,365	10,379	12,562	6,640	28,678
Cultivated Crops	1,507	249	35	8	59	110	219	0	5,292
Woody Wetlands	1,446	753	782	58	235	794	629	148	8
Emergent Herbaceous Wetlands	10	27	11	0	0	62	1	0	223
Total (Acres)	**70,051**	**104,387**	**49,988**	**20,696**	**35,886**	**21,709**	**56,989**	**76,616**	**217,116**
Open Water	1.6	0.5	0.5	1.3	0.2	2.0	0.2	0.1	1.4
Developed, Open Space	7.0	4.2	3.7	4.5	2.2	2.1	2.8	2.7	3.1
Developed, Low Intensity	6.6	0.3	0.2	1.8	0.2	0.0	0.4	0.1	0.1
Developed, Medium Intensity	2.7	0.1	0.0	0.7	0.1	0.0	0.1	0.0	0.0
Developed, High Intensity	1.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Bare Rock/Sand/Clay	0.1	0.0	0.2	0.1	0.3	0.6	0.1	0.1	0.7
Deciduous Forest	23.5	26.5	35.0	37.9	70.3	27.2	39.0	76.6	58.2
Evergreen Forest	1.1	18.8	6.8	7.8	0.8	0.9	12.8	0.7	1.5
Mixed Forest	3.0	7.6	9.4	9.2	1.1	3.9	8.7	0.6	0.0
Shrub/Scrub	1.0	1.1	1.6	1.3	1.7	1.6	1.8	1.3	0.0
Grasslands/Herbaceous	4.2	5.2	11.8	5.0	10.2	9.3	10.6	9.0	19.2
Pasture/Hay	43.6	34.7	29.2	29.8	12.2	47.8	22.0	8.7	13.2
Cultivated Crops	2.2	0.2	0.1	0.0	0.2	0.5	0.4	0.0	2.4
Woody Wetlands	2.1	0.7	1.6	0.3	0.7	3.7	1.1	0.2	0.0
Emergent Herbaceous Wetlands	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1
Total (%):	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	100.0	100.0

1.3 STREAM FLOW CONDITIONS

Stream flow characteristics and data are key information when conducting water quality assessments such as TMDLs. The USGS operates flow gages throughout Oklahoma, from which long-term stream flow records can be obtained. At various WQM stations additional flow measurements are available which were collected at the same time bacteria, total suspended solids (TSS) and turbidity water quality samples were collected. Not all of the waterbodies in this Study Area have historical flow data available. Flow data from the surrounding USGS gage stations and the instantaneous flow measurement data taken with water quality samples have been used to estimate flows for ungaged streams. Flow conditions recorded or projected for the time of water quality sampling are included in Appendix A along with corresponding water chemistry data results. A summary of the method used to project flows for ungaged streams and flow exceedance percentiles from projected flow data are provided in Appendix B.

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 (OWQS) and implementation procedures (OWRB 2011). The Oklahoma Water Resources Board (OWRB) has statutory authority and responsibility concerning establishment of State WQS, 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 2011). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in Appendix C. Table 2-1, an excerpt from the 2010 Integrated Report (DEQ 2012), lists beneficial uses designated for each bacterial and/or turbidity impaired stream segment in the Study Area. The beneficial uses include:

- AES – Aesthetics
- AG – Agriculture Water Supply
- Fish and Wildlife Propagation
  - WWAC – Warm Water Aquatic Community
  - CWAC – Cold Water Aquatic Community
- FISH – Fish Consumption
- PBCR – Primary Body Contact Recreation
- PPWS – Public & Private Water Supply

Table 2-1 Designated Beneficial Uses for Each Stream Segment in the Study Area

Waterbody ID	Waterbody Name	AES	AG	CWAC	WWAC	FISH	PBCR	PPWS
OK220100010010_00	Poteau River	I	F		N	N	N	I
OK220100010010_40	Poteau River	I	F		N	I	F	I
OK220100030010_00	Brazil Creek	I	F		F	X	N	I
OK220100040080_00	Bandy Creek	I	I		N	X	X	
OK220200030010_20	Sallisaw Creek	I	F	F		X	N	I
OK220200040010_10	Sans Bois Creek	I	N		N	X	N	I
OK220200040010_40	Sans Bois Creek	I	F		N	X	N	I
OK220200050040_00	Little Lee Creek	N	F	I		X	N	I
OK220600010119_10	Canadian River	N	N		N	N	N	I

F – Fully supporting; N – Not supporting; I – Insufficient information; X – Not assessed
Source: 2010 Integrated Report, DEQ 2010

The definition of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Chapter 45 of the Oklahoma WQSs.

(a). Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.

(b). In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

(c). Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefore. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group.

(1) Escherichia coli (E. coli): The E. coli geometric mean criterion is 126/100 ml. For swimming advisory and permitting purposes, E. coli shall not exceed a monthly geometric mean of 126/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 235/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 126/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

(2) Enterococci: The Enterococci geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococci shall not exceed a monthly geometric mean of 33/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 61/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 33/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2013a). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a). ***Scope.***

The provisions of this Section shall be used to determine whether the subcategory of Primary Body Contact of the beneficial use of Recreation designated in OAC 785:45 for a waterbody is supported during the recreation season from May 1 through September 30 each year. Where data exist for multiple bacterial indicators on the same waterbody or waterbody segment, the determination of use support shall be based upon the use and application of all applicable tests and data.

(b). ***Escherichia coli (E. coli).***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(c). ***Enterococci.***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

Table 2-2 summarizes the PBCR and WWAC use attainment status and the bacterial and turbidity impairment status for streams in the Study Area. The TMDL priority shown in Table 2-2 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 bacterial and/or turbidity impairments that affect the PBCR and WWAC beneficial uses.

Table 2-2 Excerpt from the 2010 Integrated Report – Oklahoma 303(d) List of Impaired Waters (Category 5)

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK220100010010_00	Poteau River	23.89	2012	1	X		N	X	N
OK220100010010_40	Poteau River	21.35	2012	1				X	N
OK220100030010_00	Brazil Creek	17.83	2021	4	X		N		
OK220100040080_00	Bandy Creek	12.44	2021	4				X	N
OK220200030010_20	Sallisaw Creek	13.30	2021	4	X		N		
OK220200040010_10	Sans Bois Creek	10.76	2021	4	X		N		N*
OK220200040010_40	Sans Bois Creek	27.80	2021	4			N**	X	N
OK220200050040_00	Little Lee Creek	23.66	2021	4	X		N		
OK220600010119_10	Canadian River	39.08	2021	4	X		N	X	N

ENT = Enterococci; N = Not attaining; X = Criterion exceeded;
* Due to low DO, not addressed in this report.
** No bacterial indicators cited in the 2010 Integrated Report; fecal coliform TMDL was developed in 2008.

After the draft 303(d) List is compiled, DEQ assigns a four-level rank to each of the Category 5a waterbodies. This rank helps in determining the priority for TMDL development. The rank is based on criteria developed using the procedure outlined in the 2012 Continuing Planning Process (pp. 139-140). The TMDL prioritization point totals calculated for each watershed were broken down into the following four priority levels:

Priority 1 watersheds - above the 90th percentile (32 watersheds)

Priority 2 watersheds - 70th to 90th percentile (59 watersheds)

Priority 3 watersheds - 40th to 70th percentile (99 watersheds)

Priority 4 watersheds - below the 40th percentile (139 watersheds)

Each waterbody on the 2010 303(d) list has been assigned a potential date of TMDL development based on the priority level for the corresponding HUC 11 watershed.

Priority 1 watersheds are targeted for TMDL development within the next two years.

Compliance with the Oklahoma WQS is based on meeting requirements for both *E. coli* and Enterococci bacterial indicators in addition to the minimum sample requirements for assessment. Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2013).

As stipulated in the WQS, only the geometric mean of all samples collected over the primary recreation period shall be used to assess the impairment status of a stream segment. Therefore, only the geometric mean criteria will be used to develop TMDLs for *E. coli* and Enterococci.

The beneficial use of WWAC or CWAC is one of several subcategories of the Fish and Wildlife Propagation use established to manage the variety of communities of fish and shellfish throughout the state (OWRB 2011). The numeric criteria for turbidity to maintain and protect the use of "Fish and Wildlife Propagation" from Title 785:45-5-12 (f) (7) is as follows:

(A) Turbidity from other than natural sources shall be restricted to not exceed the following numerical limits:

- *i. Cool Water Aquatic Community/Trout Fisheries: 10 NTUs;*
- *ii. Lakes: 25 NTU; and*
- *iii. Other surface waters: 50 NTUs.*

(B) In waters where background turbidity exceeds these values, turbidity from point sources will be restricted to not exceed ambient levels.

(C) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions.

(D) Elevated turbidity levels may be expected during, and for several days after, a runoff event.

Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2013a) describes Oklahoma's WQS for Fish and Wildlife Propagation. The following excerpt (785:46-15-5) stipulates how water quality data will be assessed to determine support of fish and wildlife propagation as well as how the water quality target for TMDLs will be defined for turbidity:

Assessment of Fish and Wildlife Propagation support

(a). Scope. The provisions of this Section shall be used to determine whether the beneficial use of Fish and Wildlife Propagation or any subcategory thereof designated in OAC 785:45 for a waterbody is supported.

(e). Turbidity. The criteria for turbidity stated in 785:45-5-12(f)(7) shall constitute the screening levels for turbidity. The tests for use support shall follow the default protocol in 785:46-15-4(b).

785:46-15-4. Default protocols

(b). Short term average numerical parameters.

(1) Short term average numerical parameters are based upon exposure periods of less than seven days. Short term average parameters to which this Section applies include, but are not limited to, sample standards and turbidity.

(2) A beneficial use shall be deemed to be fully supported for a given parameter whose criterion is based upon a short term average if 10% or less of the samples for that parameter exceeds the applicable screening level prescribed in this Subchapter.

(3) A beneficial use shall be deemed to be fully supported but threatened if the use is supported currently but the appropriate state environmental agency determines that available data indicate that during the next five years the use may become not supported due to anticipated sources or adverse trends of pollution not prevented or controlled. If data from the preceding two year period indicate a trend away from impairment, the appropriate agency shall remove the threatened status.

(4) A beneficial use shall be deemed to be not supported for a given parameter whose criterion is based upon a short term average if at least 10% of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

2.2 Problem Identification

In this subsection water quality data summarizing waterbody impairments caused by elevated levels of bacteria are summarized first followed by the data summarizing impairments caused by elevated levels of turbidity.

2.2.1 Bacterial Data Summary

Table 2-3 summarizes water quality data collected during primary contact recreation season from the WQM stations between 2004 and 2010 for each indicator bacteria. 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 criteria. This data collected during the primary contact recreation season was used to support the decision to place specific waterbodies within the Study Area on the DEQ 2010 303(d) list (DEQ 2010). Water quality data from the primary contact recreation season are provided in Appendix A. For the data collected between 2004 and 2010, evidence of nonsupport of the PBCR use based on Enterococci exceedances was observed in four waterbodies: Brazil Creek (OK220100030010_00), Sallisaw Creek (OK220200030010_20), Sans Bois Creek (OK220200040010_10), and Canadian River (OK220600010119_10). Rows highlighted in green in Table 2-3 require TMDLs. Because the DEQ 2010 303(d) list does not show *E. coli* as the cause of nonsupport of the PBCR use in any of the six waterbodies, *E. coli* data from the WQM stations were not evaluated in this report.

Two waterbodies within the Study Area will be removed from further consideration for bacterial TMDL development in this report. Detailed review of the data collected between 2006 and 2008 for the Poteau River (OK220100010010_00) indicated their geometric mean met the water quality criterion of 33 colonies per 100 ml while data from 2008 for Little Lee Creek (OK 220200050040_00) indicated an insufficient number of samples were available. As a result, no bacterial TMDLs are included in this report for these two waterbodies.

2.2.2 Turbidity Data Summary

Turbidity is a measure of water clarity and is caused by suspended particles in the water column. Because turbidity cannot be expressed as a mass load, total suspended solids (TSS) are used as a surrogate in this TMDL. Therefore, both turbidity and TSS data are presented in this subsection.

Table 2-4 summarizes water quality data collected from the WQM stations between 2001 and 2011 for turbidity. However, as stipulated in Title *785:45-5-12 (f)(7)(C)*, numeric criteria for turbidity only apply under base flow conditions. While the base flow condition is not specifically defined in the OWQS, DEQ considers base flow conditions to be all flows greater than the 25th flow exceedance frequency (i.e., the lower 75% of flows) which is consistent with the USGS Streamflow Conditions Index (USGS 2009). Therefore, Table 2-5 was prepared to represent the subset of these data when samples under high flow conditions were excluded.

Water quality samples collected under flow conditions less than the 25th flow exceedance frequency (highest flows) were therefore excluded from the data set used for TMDL analysis. Five of the six waterbodies listed on the DEQ 2010 303(d) list (DEQ 2010) for nonsupport of the Fish and Wildlife Propagation use were based on turbidity levels observed in the waterbody. The data in Table 2-4 were used to support the decision to place these five on the DEQ 2010 303(d) list. Table 2-6 summarizes TSS data collected from the WQM stations between 1998 and 2000. Table 2-7 presents a subset of these data when samples under high flow conditions were excluded. Water quality data for turbidity and TSS are provided in Appendix A.

Table 2-3 Summary of Assessment of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2004-2010

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Conc (cfu/100 ml)	Assessment Results
OK220100010010_00	Poteau River	ENT	14	19	Delist: geometric mean meets criterion
OK220100030010_00	Brazil Creek	ENT	10	97	TMDL Required
OK220200030010_20	Sallisaw Creek	ENT	10	221	TMDL Required
OK220200040010_10	Sans Bois Creek	ENT	10	86	TMDL Required
OK220200050040_00	Little Lee Creek	ENT	5	21	Delist: Not enough data available
OK220600010119_10	Canadian River	ENT	19	134	TMDL Required

Enterococci (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL

TMDLs will be developed for waterbodies highlighted in green

Table 2-4 Summary of All Turbidity Samples, 2001-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)
OK220100010010_00	Poteau River	220100010010-001AT	32	11	34%	54
OK220100010010_40	Poteau River	220100010010-001SRF	9	7	78%	84
OK220100040080_00	Bandy Creek	OK220100-04-0020G	3	1	33%	52
OK220200040010_40	Sans Bois Creek	OK220200-04-0010W	13	2	15%	36
OK220600010119_10	Canadian River	220600010119-001AT	34	16	47%	172

Table 2-5 Summary of Turbidity Samples Excluding High Flow Samples, 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)	Assessment Results
OK220100010010_00	Poteau River	220100010010-001AT	24	6	25%	44.1	TMDL Required
OK220100010010_40	Poteau River	220100010010-001SRF	5	3	60%	74.8	TMDL Required
OK220100040080_00	Bandy Creek	OK220100-04-0020G	NA	NA	NA	NA	Delist: Not enough data
OK220200040010_40	Sans Bois Creek	OK220200-04-0010W	14*	1	7%	29.5	Delist: meets standard
OK220600010119_10	Canadian River	220600010119-001AT	26	9	35%	74.1	TMDL Required

NA: Not applicable.

* Samples from 1999 were added to reach the minimum data requirement for assessment after high flow samples were removed from 2000 and 2001.

Table 2-6 Summary of All TSS Samples, 1998-2000

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK220100010010_00	Poteau River	220100010010-001AT	20	81
OK220100010010_40	Poteau River	220100010010-001AT*	20	81
OK220600010119_10	Canadian River	220600010119-001AT	21	192

* There are no TSS data available for Poteau River segment OK220100010010_40; TSS samples from the downstream segment OK220100010010_00 were used for the TMDL development.

Table 2-7 Summary of TSS Samples Excluding High Flow Samples, 1998-2000

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK220100010010_00	Poteau River	220100010010-001AT	16	53
OK220100010010_40	Poteau River	220100010010-001AT*	16	53
OK220600010119_10	Canadian River	220600010119-001AT	16	102

* There are no TSS data available for Poteau River segment OK220100010010_40; TSS samples from the downstream segment OK220100010010_00 were used for the TMDL development.

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 targets for *E. coli* and Enterococci are geometric mean standards of 126 cfu/100ml and 33 cfu/100ml, respectively. The TMDL for bacteria will incorporate an explicit 10% margin of safety.

An individual water quality target established for turbidity must demonstrate compliance with the numeric criteria prescribed in the Oklahoma WQS (OWRB 2011). According to the Oklahoma WQS [785:45-5-12(f)(7)], the turbidity criterion for streams with WWAC beneficial use is 50 NTUs (OWRB 2011). The turbidity of 50 NTUs applies only to seasonal base flow conditions. Turbidity levels are expected to be elevated during, and for several days after, a storm event.

TMDLs for turbidity in streams designated as WWAC must take into account that no more than 10% of the samples may exceed the numeric criterion of 50 NTU. However, as described above, because turbidity cannot be expressed as a mass load, TSS is used as a surrogate for TMDL development. Since there is no numeric criterion in the Oklahoma WQS for TSS, a specific method must be developed to convert the turbidity criterion to TSS based on a relationship between turbidity and TSS. The method for deriving the relationship between turbidity and TSS and for calculating a water body specific water quality goal using TSS is summarized in Section 4 of this report.

The MOS for the TSS TMDLs varies by waterbody and is related to the goodness-of-fit metrics of the turbidity-TSS regressions. The method for defining MOS percentages is described in Section 5 of this report.

SECTION 3 POLLUTANT SOURCE ASSESSMENT

3.1 OVERVIEW

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. Pathogen indicator bacteria originate from the digestive tract of warm-blooded animals, and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are currently required to monitor for fecal coliform and TSS in accordance with their permits. The discharges with bacterial limits will be required to monitor for *E. coli* when their permits come to renew. 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 bacteria or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources.

The potential nonpoint sources for bacteria were compared based on the fecal coliform load produced in each subwatershed. Although fecal coliform is no longer used as a bacterial indicator in the Oklahoma WQS, it is still valid to use fecal coliform concentration or loading estimates to compare the potential contributions of different nonpoint sources because *E. coli* is a subset of fecal coliform. Currently there is insufficient data available in the scientific arena to quantify counts of *E. coli* in feces from warm-blooded animals discussed in Section 3.

The following nonpoint sources were considered in this report:

- Wildlife (deer)
- Non-Permitted Agricultural Activities and Domesticated Animals
- Failing Onsite Wastewater Disposal (OSWD) Systems and Illicit Discharges
- Pets (dogs and cats)

The 2010 Integrated Water Quality Assessment Report (DEQ 2012) listed potential sources of turbidity as clean sediment, grazing in riparian corridors of streams and creeks, highway/road/bridge runoff (non-construction related), non-irrigated crop production, petroleum/natural gas activities, rangeland grazing, as well as other unknown sources. The following discussion describes what is known regarding point and nonpoint sources of bacteria in the impaired watersheds. Where information was available on point and nonpoint sources of indicator bacteria or TSS, data were provided and summarized as part of each category.

3.2 NPDES-PERMITTED FACILITIES

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. Certain municipal facilities are classified as no-discharge. These facilities are required to sign an affidavit of no discharge. NPDES-permitted facilities classified as point sources that may contribute bacterial or TSS loading includes:

- NPDES municipal wastewater treatment facilities (WWTF)
- NPDES Industrial WWTF Discharges
- NPDES municipal separate storm sewer system (MS4) discharges
- NPDES multi-sector general permits
- NPDES construction stormwater discharges
- Municipal no-discharge WWTF
- NPDES Concentrated Animal Feeding Operation (CAFO)

Continuous point source discharges such as WWTFs could result in discharge of elevated concentrations of indicator bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. While the no-discharge facilities do not discharge wastewater directly to a waterbody, it is possible that continuous point source discharges from municipal and industrial WWTFs could result in discharge of elevated concentrations of TSS if a facility is not properly maintained, is of poor design, or flow rates exceed capacity. However, in most cases suspended solids discharged by WWTFs consist primarily of organic solids rather than inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). Discharges of organic suspended solids from WWTFs are addressed by DEQ through its permitting of point sources to maintain WQS for dissolved oxygen and are not considered a potential source of turbidity in this TMDL. Discharges of TSS will be considered to be organic suspended solids if the discharge permit includes a limit for Biochemical Oxygen Demand (BOD) or Carbonaceous Biochemical Oxygen Demand (CBOD). Only WWTF discharges of inorganic suspended solids will be considered and receive WLAs.

While the no-discharge facilities do not discharge wastewater directly to a waterbody, it is possible that the collection systems associated with each facility may be a source of bacterial loading to surface waters. CAFOs are recognized by EPA as potential significant sources of pollution, and may have the potential to cause serious impacts to water quality if not properly managed.

Stormwater runoff from MS4 areas, which is regulated under the EPA NPDES Program, can contain high fecal coliform bacterial concentrations. Stormwater runoff from MS4 areas, facilities under multi-sector general permits, and NPDES construction stormwater discharges, which are regulated under the EPA NPDES Program, can contain TSS. EPA Regulations [40 C.F.R. § 130.2(h)] require that all point sources (such as NPDES-regulated stormwater discharges) must be addressed by the WLA component of a TMDL. However, any stormwater discharge by definition occurs during or immediately following periods of rainfall and elevated flow conditions when Oklahoma Water Quality Standard for turbidity does not apply. OWQS specify that the criteria for turbidity "apply only to seasonal base flow conditions" and go on to say "Elevated turbidity levels may be expected during, and for several days after, a runoff event" [OAC 785:45-5-12(f)(7)]. In other words, the turbidity impairment status is limited to base flow conditions and stormwater discharges from MS4 areas or construction sites do not contribute to the violation of Oklahoma's turbidity standard. Therefore, WLAs for NPDES-regulated stormwater discharges is essentially considered unnecessary in this TMDL report and will not be included in the TMDL calculations.

There is at least one NPDES-permitted facility in six of the nine contributing watersheds. The three watersheds without an NPDES-permitted facility are Sans Bois Creek (OK220200040010_10), Sallisaw Creek (OK220200030010_20), and Little Lee Creek (OK220200050040_00).

3.2.1 Continuous Point Source Dischargers

The locations of the NPDES-permitted facilities that discharge wastewater to surface waters addressed in these TMDLs are listed in Table 3-1 and displayed in Figure 3-1. Municipal WWTFs designated with a Standard Industrial Code number 4952 in Table 3-1 discharges organic TSS with limits for $CBOD_5$. Therefore they are not considered a potential source of turbidity. The facility with permit number OK0038849 also discharges TSS with limits for $CBOD_5$. Consequently, it is not considered a potential source of turbidity as well. DMR data for the remaining four non-4952 active facilities are provided in Appendix D.

3.2.2 Stormwater Permits

3.2.2.1 NPDES Municipal Separate Storm Sewer System

3.2.2.1.1 Phase I MS4

In 1990 the EPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local waterbodies (EPA 2005). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. There are no Phase I MS4 permits in the Study Area.

3.2.2.1.2 Phase II MS4

Phase II of the rule extends coverage of the NPDES stormwater program to certain small MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Phase II requires operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the "maximum extent practicable," protect water quality, and satisfy appropriate water quality requirements of the CWA. Small MS4 stormwater programs must address the following minimum control measures:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post- Construction Runoff Control
- Pollution Prevention/Good Housekeeping

The small MS4 General Permit for communities in Oklahoma became effective on February 8, 2005. DEQ provides information on the current status of the MS4 program on its website, which can be found at: www.deq.state.ok.us/WQDnew/stormwater/ms4/. There are no Phase II MS4 permits in the Study Area.

3.2.2.2 Construction Activities

A general stormwater permit (OKR10) is required by DEQ for any stormwater discharges associated with construction activities that result in land disturbance of equal to or greater than one (1) acre, or less than one (1) acre if they are part of a larger common plan of development or sale that totals at least one (1) acre. The permit also authorizes any stormwater discharges from support activities (e.g. concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, and borrow areas) that are directly related to a construction site that is required to have permit coverage, and is not a commercial operation serving unrelated different sites (DEQ 2007). Stormwater discharges occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply and are not considered potential contributors to turbidity impairment. The permits for construction projects that were active during the time period that samples were taken are summarized in Table 3-6 and shown in Figure 3-2.

3.2.2.3 Multi-Sector General Permits

A multi-sector industrial general permit (OKR05) is also required by DEQ for stormwater discharges from industrial facilities (DEQ 2011). Stormwater discharges from all industrial facilities, except mine dewatering discharges at crushed stone, construction sand and gravel, or industrial sand mining facilities, occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply and therefore are not considered potential contributors of turbidity impairment. Mine dewatering discharges can happen at any time and have the following specific effluent limitations for TSS:

- Daily Maximum: 45 mg/L
- Monthly Average: 25 mg/L

If the TMDL shows that a TSS limit more stringent than 45 mg/L is required, additional TSS limitations and monitoring requirements will be required. These additional requirements will be implemented under the multi-sector general permit. There are two facilities within the Study Area with multi-sector general permits – Blake Construction Incorporated (OKR050184) in the Poteau River (OK220100010010_00) watershed and Robinson Brick Company (OKR050653) in Brazil Creek (OK220100030010_00) watershed. Robinson Brick Company (OKR050653) in Brazil Creek (OK220100030010_00) watershed will not require a wasteload allocation as a contributing source of TSS since the receiving stream is not impaired for TSS. Blake Construction Incorporated (OKR050184) in the Poteau River (OK220100010010_00) watershed, as a Crushed and Broken Stone operation (SIC 1422) will have a wasteload allocation as part of the Poteau River (OK220100010010_00) turbidity TMDL.

3.2.2.4 Rock, Sand and Gravel Quarries

Operators of rock, sand and gravel quarries in Oklahoma are regulated with a general permit (OKG950000) issued by DEQ. The general permit does not allow discharge of wastewater to waterbodies included in Oklahoma's 303(d) List of impaired waterbodies listed for turbidity for which a TMDL has not been performed or the result of the TMDL indicates that discharge limits more stringent than 45 mg/l for TSS are required (DEQ 2009). There are no rock/sand/gravel quarries located in the Study Area.

3.2.3 No-Discharge Facilities and Sanitary Sewer Overflows

For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute indicator bacterial or TSS loading. However, it is possible the wastewater collection systems associated with these no-discharge facilities could be a source of indicator bacterial loading, or that discharges from the wastewater facility may occur during large rainfall events that exceed the systems' storage capacities. There is one municipal no-discharge facility in the Study Area which is listed in Table 3-2. This facility is located in the Sallisaw Creek (OK220200030010_20) watershed. It could be contributing to the elevated levels of instream indicator bacterial loading.

Sanitary sewer overflow (SSO) from wastewater collection systems, although infrequent, can be a major source of indicator bacterial loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of sewer pipes by grease, tree roots, and other debris that clog sewer lines, by sewer line breaks and leaks, cross connections with storm sewers, and inflow and infiltration of groundwater into sanitary sewers. SSOs are permit violations that must be addressed by the responsible NPDES permittee. The reporting of SSOs has been strongly encouraged by EPA, primarily through enforcement and fines. While not all sewer overflows are reported, DEQ has some data on SSOs available. SSOs were reported between 2000 and 2012. During that period 213 overflows were reported ranging from a minimal quantity to over 4.5 million gallons. Table 3-3 summarizes the SSO occurrences by NPDES facilities. Historical data of reported SSOs are provided in Appendix E.

3.2.4 Concentrated Animal Feeding Operations

The Agricultural Environmental Management Services (AEMS) of the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) was created to help develop, coordinate, and oversee environmental policies and programs aimed at protecting the Oklahoma environment from pollutants associated with agricultural animals and their waste. Through regulations established by the Oklahoma Concentrated Animal Feeding Operation (CAFO) Act, Swine Feeding Operation (SFO) Act and Poultry Feeding Operation (PFO) Registration Act, AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the State.

3.2.4.1 CAFO

A CAFO is an animal feeding operation that confines and feeds at least 1,000 animal units for 45 days or more in a 12-month period (ODAFF 2005). The CAFO Act is designed to protect water quality through the use of best management practices (BMP) such as dikes, berms, terraces, ditches, or other similar structures used to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event (ODAFF 2005). CAFOs are considered no-discharge facilities for the purpose of the TMDL calculations in this report.

CAFOs are designated by EPA as significant sources of pollution, and may have the potential to cause serious impacts to water quality if not managed properly (ODAFF 2009a). Potential problems for CAFOs can include animal waste discharges to waters of the state and failure to properly operate wastewater lagoons. CAFOs are not considered a source of TSS loading. The location of each CAFO is shown in Figure 3-2 and is listed in Table 3-4.

Regulated CAFOs within the Study Area operate under state CAFO licenses issued and overseen by ODAFF and NPDES permits by EPA. In order to comply with this TMDL, those CAFO permits in the watershed and their associated management plans must be reviewed. Further actions to reduce bacterial loads and achieve progress toward meeting the specified reduction goals must be implemented. This provision will be forwarded to EPA and ODAFF for follow up.

Table 3-1 NPDES-Permitted CAFOs in Study Area

ODAFF Owner ID	EPA Facility ID	ODAFF ID	ODAFF License Number	Max # of Swine > 55 lbs	Total # of Animal Units at Facility	County	Waterbody ID and Waterbody Name
200717	NA	133	1454	240	240	Hughes	OK220600010119_10 Canadian River
AGN035941	NA	36	1483	1000	1000	Hughes	OK220600010119_10 Canadian River

ODAFF Owner ID	EPA Facility ID	ODAFF ID	ODAFF License Number	Max # of Swine > 55 lbs	Total # of Animal Units at Facility	County	Waterbody ID and Waterbody Name
WQ000184	NA	341	990002	2304	2304	Hughes	OK220600010119_10 Canadian River

3.2.4.2 PFO

Poultry feeding operations not licensed under the Oklahoma Concentrated Animal Feeding Operation Act must register with the State Board of Agriculture. A registered PFO is an animal feeding operation which raises poultry and generates more than 10 tons of poultry waste (litter) per year. PFOs are required to develop an Animal Waste Management Plan (AWMP) or an equivalent document such as a Nutrient Management Plan (NMP). These plans describe how litter will be stored and applied properly in order to protect water quality of streams and lakes located in the watershed. Applicable BMPs shall be included in the Plan.

In order to comply with this TMDL, the registered PFOs in the watershed and their associated management plans must be reviewed. Further actions to reduce bacterial loads and achieve progress toward meeting the specified reduction goals must be implemented. This provision will be forwarded to EPA and ODAFF for follow up.

Per data provided by ODAFF in May 2011, there are 76 PFOs located in the watershed as shown in Table 3-5. These PFOs are small animal feeding operations and are not required to get NPDES permits; they are required only to register with ODAFF. They generate dry litter and do not have any significant impact on the watershed.

Table 3-2 Point Source Discharges in the Study Area

Waterbody ID & Waterbody Name	OPDES Permit No.	Facility	SIC code	Facility Type	Design Flow (mgd)	Ave/Max FC cfu/100mL	Avg/Max TSS mg/L	Expiration Date	Notes
Poteau River OK220100010010_00	OK0034134	Pocola Municipal Auth.	4952	Sewerage system	0.275	200/400	30/45	7/31/2014	Active
	OK0040169	Shady Pt Cogen. Facility	4931	Industrial facility	NA	200/400	NA/45	2/29/2016	Active
	OK0042781	Georges Colliers, Inc. #8	1221	Mining settling ponds	NA	NA	35/70	10/31/2017	Active
Poteau River OK220100010010_40	OKG380011	Heavener Utilities Auth.	4941	Water treatment facility	0.15	NA	20/30	12/31/2017	Active
	OK0038407	Heavener Utilities Auth.	4952	Lagoon system	0.65/ 0.95	200/400	15/22.5 30/45	12/30/2014	Active
	OK0038849	Heavener UA-Ind. Park	2015	Wastewater treatment	3.3	200/400	15/45 15/23 30/45	3/31/2012	Active
	OKG580052	LeFlore Co. RWSD #5	4952	Lagoon system	0.07	NA	90/135	6/30/2016	Active
	OK0040631	Kansas City So. Ry. Co	4011	Railway facility	NA	NA	45	8/31/2015	Active
	OKP003034	OK Foods Heavener	NA	Pretreatment	NA	NA	NA	NA	Inactive
Brazil Creek OK220100030010_00	OK0027731	Bokoshe PWA	4952	Lagoon system	0.09	NA	90/135	7/31/2013	Active
Bandy Creek OK220100040080_00	OK0021881	Wilburton PWA	4952	Sewerage systems	0.75	200/400	15/22.5 30/45	11/30/2015	Active
	OK0033812	Wilburton PWA-South	4952	NA	NA	NA	NA	NA	Inactive
	OK0034550	East OK State College	4952	NA	NA	NA	NA	NA	Inactive
	OKP000028	Franklin Electric Co., Inc.	NA	Pretreatment	NA	NA	NA	NA	Inactive
Sans Bois Creek OK220200040010_40	OK0030694	Town of Quinton	4952	Lagoon system	0.111	NA	90/135	09/30/2016	Active
Canadian River OK220600010119_10	OK0037818	Town of Calvin	4952	Lagoon system	0.028	200/400	90/135	6/30/2017	Active

NA = not available or not applicable.

Table 3-3 NPDES No-Discharge Facilities in the Study Area

Facility	Facility ID	County	Facility Type	Type	Waterbody ID	Waterbody Name
Marble City WWT	S20208	Sequoyah	Total Retention	Municipal	OK220200030010_20	Sallisaw Creek

Table 3-4 Sanitary Sewer Overflow Summary (2000-2012)

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Pocola Municipal Auth.	OK0034134	OK220100010010_00	S20102	50	1/13/2000	8/7/2012	N/A	800,000
Heavener Utilities Auth.	OK0038407	OK220100010010_40	S20119	32	6/1/2004	12/2/2011	NA	6,500
LeFlore Co. RWSD #5	OKG580052	OK220100010010_40	S20114	2	4/8/2002	7/10/2012	NA	34,500
Bokoshe PWA	OK0027731	OK220100030010_00	S20115	2	4/2/2004	4/25/2011	500	500
Wilburton PWA	OK0021881	OK220100040080_00	S20104	116	6/20/2001	4/11/2012	NA	100,000
Town of Quinton	OK0030694	OK220200040010_40	S20202	10	3/17/2000	7/10/2010	NA	4.5 million
Town of Calvin	OK0037818	OK220600010119_10	S20666	1	7/16/2008	7/16/2008	NA	NA

NA = not available

Figure 3-1 Locations of NPDES-Permitted Facilities in the Study Area

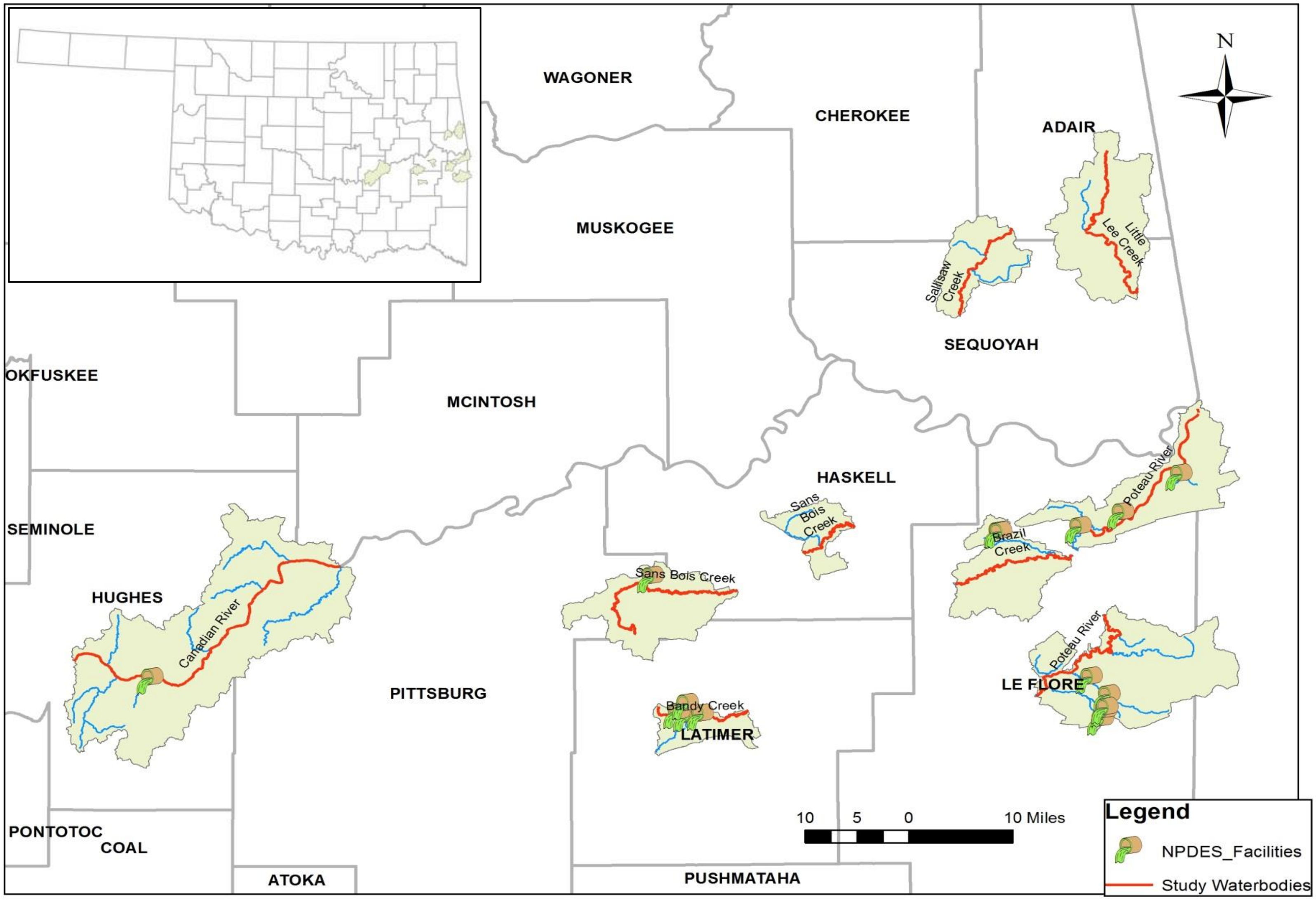


Figure 3-2 Locations of NPDES-Permitted CAFOs, Construction Activities Sites, and Registered PFOs in the Study Area

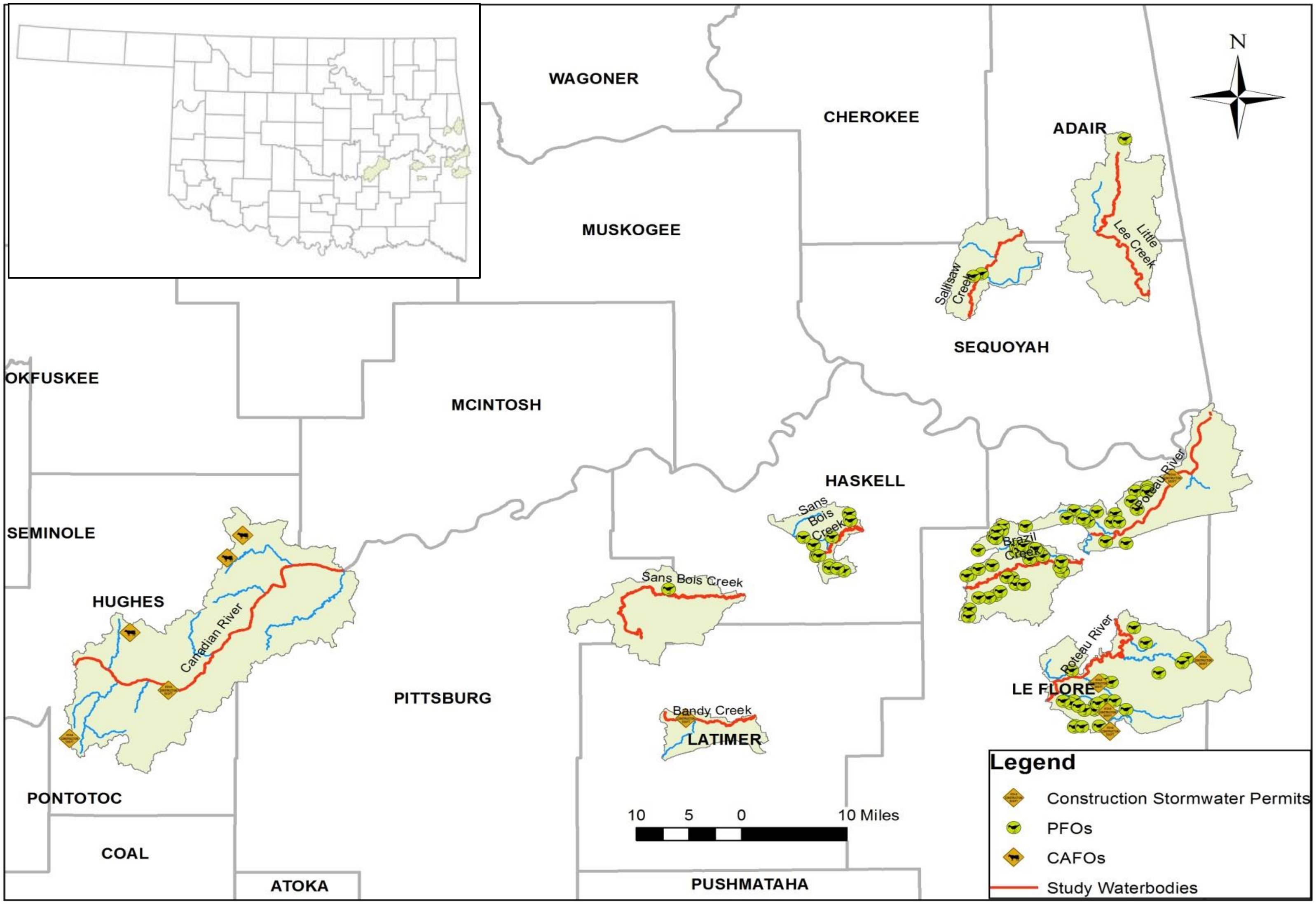


Table 3-5 Registered PFOs in Study Area

Waterbody Name	Waterbody ID	Company Name	Poultry ID	County	Type	Total Birds
Poteau River	OK220100010010_00	OK Farms	308	LeFlore	Broilers	50,000
		Aviagen Inc.	378	LeFlore	Broilers	40,000
		OK Farms	596	LeFlore	Broilers	152,800
		OK Farms	1049	LeFlore	Broilers	48,000
		OK Farms	1060	LeFlore	Broilers	75,000
		OK Farms	1212	LeFlore	Broilers	96,400
		OK Farms	1400	LeFlore	Broilers	75,000
		OK Farms	1424	LeFlore	Broilers	75,000
		OK Farms	1447	LeFlore	Broilers	40,000
		OK Farms	1472	LeFlore	Broilers	79,200
		Aviagen Inc.	1502	LeFlore	Breeders	20,000
		OK Farms	1509	LeFlore	Broilers	102,800
		OK Farms	1516	LeFlore	Broilers	72,300
		OK Farms	1518	LeFlore	Broilers	79,200
		OK Farms	1522	LeFlore	Broilers	96,400
Poteau River	OK220100010010_40	OK Farms	25	LeFlore	NA	NA
		OK Farms	180	LeFlore	Broilers	100,000
		OK Farms	214	LeFlore	Broilers	50,000
		OK Farms	222	LeFlore	Broilers	75,000
		OK Farms	390	LeFlore	Pullets	30,000
		OK Farms	487	LeFlore	Broilers	75,000
		OK Farms	501	LeFlore	Broilers	50,000
		OK Farms	520	LeFlore	Broilers	96,400
		OK Farms	589	LeFlore	Pullets	30,000
		OK Farms	688	LeFlore	Broilers	96,000
		OK Farms	744	LeFlore	Broilers	100,000
		OK Farms	832	LeFlore	Broilers	40,000
		OK Farms	861	LeFlore	Broilers	48,000
		OK Farms	947	LeFlore	Broilers	100,000
		OK Farms	982	LeFlore	Broilers	211,200
		OK Farms	1392	LeFlore	Broilers	100,000
		OK Farms	1529	LeFlore	Broilers	75,000
		OK Farms	1532	LeFlore	Broilers	79,200
		OK Farms	1541	LeFlore	Broilers	75,000
Brazil Creek	OK220100030010_00	OK Farms	2	LeFlore	Broilers	80,000
		OK Farms	71	LeFlore	Broilers	96,400
		OK Farms	104	LeFlore	Broilers	24,000
		OK Farms	125	LeFlore	Broilers	74,000
		OK Farms	127	LeFlore	Broilers	52,000
		OK Farms	134	LeFlore	Broilers	75,000
		OK Farms	135	LeFlore	Broilers	211,200
		OK Farms	175	LeFlore	Broilers	107,800
		OK Farms	397	LeFlore	Broilers	96,000
		OK Farms	398	LeFlore	Broilers	50,000
		OK Farms	399	LeFlore	Broilers	78,000
		OK Farms	400	LeFlore	Broilers	96,400
		OK Farms	412	LeFlore	Broilers	72,300
		OK Farms	902	LeFlore	Broilers	75,000
		OK Farms	943	LeFlore	Broilers	106,000

Waterbody Name	Waterbody ID	Company Name	Poultry ID	County	Type	Total Birds
		OK Farms	957	LeFlore	Broilers	211,200
		OK Farms	965	LeFlore	Broilers	79,200
		OK Farms	1070	LeFlore	Broilers	105,600
		OK Farms	1137	LeFlore	Broilers	48,600
		OK Farms	1208	LeFlore	Broilers	100,000
		OK Farms	1214	LeFlore	Broilers	75,000
		OK Farms	1240	LeFlore	Broilers	72,300
		OK Farms	1365	LeFlore	Broilers	18,000
		OK Farms	1382	LeFlore	Broilers	105,600
		OK Farms	1446	LeFlore	Broilers	96,400
		OK Farms	1468	LeFlore	Broilers	94,500
		NA	1585	LeFlore	NA	NA
		NA	1586	LeFlore	NA	NA
		NA	1590	LeFlore	NA	NA
Sallisaw	OK220200030010_20	Aviagen Inc.	327	Sequoyah	Genetics	9,800
		OK Farms	1452	Sequoyah	Broilers	79,200
Sans Bois Creek	OK220200040010_10	OK Farms	257	Haskell	Broilers	50,000
		OK Farms	279	Haskell	Broilers	48,000
		OK Farms	302	Haskell	Broilers	75,000
		OK Farms	351	Haskell	Broilers	96,400
		OK Farms	406	Haskell	Broilers	100,000
		OK Farms	555	Haskell	Broilers	75,000
		OK Farms	1342	Haskell	Broilers	100,000
		OK Farms	1531	Haskell	Broilers	108,000
Sans Bois Creek	OK220200040010_40	OK Farms	359	Pittsburg	Broilers	75,000
Little Lee Creek	OK220200030010_20	Tyson Foods	282	Adair	Genetics	12,000

3.2.5 Section 404 permits

Section 404 of the CWA establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

Section 404 Permits are administrated by the U.S. Army Corps of Engineers (USACE). EPA reviews and provides comments on each permit application to make sure it adequately protects water quality and complies with applicable guidelines. Both USACE and EPA can take enforcement actions for violations of Section 404.

Discharge of dredged or fill material in waters can be a significant source of turbidity/TSS. The federal CWA requires that a permit be issued for activities which discharge dredged or fill materials into the waters of the United States, including wetlands. The State of Oklahoma will use its Section 401 Certification authority to ensure Section 404 Permits protect Oklahoma WQS.

Table 3-6 Construction Permits Summary

Company Name	County	Permit ID	Date Issued	Waterbody ID	Receiving Water (Permit)	Estimated Acres
Ron's Shale Pit	LeFlore	OKR106391	12/27/2007	OK220100010010_40	Morris Creek	5
ODOT JP #20265(04)	Hughes	OKR107897	NA	OK220600010119_10	Canadian River	30
Allen Mini Switch Station	Hughes	OKR108555	12/18/2007	OK220600010119_10	Big Creek to Canadian River	3
ODOT JP #19684(04)	LeFlore	OKR108633	NA	OK220100010010_40	Sugarloaf Creek	7
Highland Park Addition	LeFlore	OKR108697	1/19/2008	OK220100010010_40	Coal Creek	9
Water Treatment System Impro.	LeFlore	OKR108728	1/19/2008	OK220100010010_40	Coal Creek to Shadwick Creek	3
ODOT JP#11395(04)	LeFlore	OKR108977	5/8/2008	OK220100010010_00	Poteau River	44
Eastern Oklahoma State College	Latimer	OKR109048	5/23/2008	OK220100040080_00	Bandy Creek	4

3.3 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 rural agricultural, forest and range management activities has an influence on the origin and pathways of pollutant sources to surface water. Bacteria originate from warm-blooded animals in rural, suburban, and urban areas. These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state's water quality standards. A study under EPA's National Urban Runoff Project indicated that the average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000/100 mL in stormwater runoff (EPA 1983). Runoff from urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria. Water quality data collected from streams draining many of the non-permitted communities show a high level of fecal coliform bacteria. Various potential nonpoint sources of TSS as indicated in the 2010 Integrated Report include sediments originating from grazing in riparian corridors of streams and creeks, highway/road/bridge runoff, non-irrigated crop production, rangeland grazing and other sources of sediment loading (DEQ 2010). Elevated turbidity measurements can be caused by stream bank erosion processes, stormwater runoff events and other channel disturbances. The following section provides general information on nonpoint sources contributing bacteria or TSS loading within the Study Area.

3.3.1 Wildlife

Fecal coliform bacteria are produced by all warm-blooded animals, including wildlife such as mammals and birds. In developing bacterial TMDLs it is important to identify the potential for bacterial contributions from wildlife by watershed. Wildlife is naturally attracted to riparian corridors of streams and rivers due to habitat and resource availability. With direct access to the stream channel, wildlife can be a concentrated source of bacterial loading to a waterbody. Fecal coliform bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff. Currently there are insufficient data available to estimate populations of wildlife and avian species by watershed. Consequently it is difficult to assess the magnitude of bacterial contributions from wildlife species as a general category.

However, adequate data are available by county to estimate the number of deer by watershed. This report assumes that deer habitat includes forests, croplands, and pastures. Using Oklahoma Department of Wildlife and Conservation (ODWC) county data, the population of deer can be roughly estimated from the actual number of deer harvested and harvest rate estimates. Because harvest success varies from year to year based on weather and other factors, the average harvest from 2005 to 2009 was combined with an estimated annual harvest rate of 20% to predict deer population by county. Using the estimated deer population by county and the percentage of the watershed area within each county, a wild deer population can be calculated for each watershed.

According to a study conducted by the American Society of Agricultural Engineers (ASAE), deer release approximately 5×10^8 fecal coliform units per animal per day (ASAE 1999). Although only a fraction of the total fecal coliform loading produced by the deer population may actually enter a waterbody, the estimated fecal coliform production based on the estimated deer population provided in Table 3-7 in cfu/day provides a relative magnitude of loading in each of the TMDL watersheds impaired for bacteria.

Table 3-7 Estimated Population and Fecal Coliform Production for Deer

Waterbody ID	Waterbody Name	Watershed Area (acres)	Wild Deer Population	Estimated Wild Deer per acre	Fecal Production (x 10^9 cfu/day) of Deer Population
OK220100030010_00	Brazil Creek	49,988	208	0.004	104
OK220200030010_20	Sallisaw Creek	35,886	680	0.019	340
OK220200040010_10	Sans Bois Creek	21,709	327	0.015	164
OK220600010119_10	Canadian River	217,116	1,876	0.009	938

3.3.2 Non-Permitted Agricultural Activities and Domesticated Animals

There are a number of non-permitted agricultural activities that can also be sources of bacterial or TSS loading. Agricultural activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs 2002). Examples of commercially raised farm animal activities that can contribute to bacterial sources include:

- Processed commercially raised farm animal manure is often applied to fields as fertilizer, and can contribute to fecal bacterial loading to waterbodies if washed into streams by runoff.
- Animals grazing in pastures deposit manure containing fecal bacteria onto land surfaces. These bacteria may be washed into waterbodies by runoff.
- Animals often have direct access to waterbodies and can provide a concentrated source of fecal bacterial loading directly into streams or can cause unstable stream banks which can contribute TSS.

Table 3-8 provides estimated numbers of selected livestock by watershed based on the 2007 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2007). The estimated commercially raised farm animal populations in Table 3-8 were derived by using the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and commercially raised farm animals are not evenly distributed across counties or constant with time, these are rough estimates only. Cattle are clearly the most abundant species of commercially raised farm animals in the Study Area and often have direct access to the waterbodies and their tributaries.

Detailed information is not available to describe or quantify the relationship between instream concentrations of bacteria and land application or direct deposition of manure from commercially raised farm animal. Nor is sufficient information available to describe or quantify the contributions of sediment loading caused by commercially raised farm animal responsible for destabilizing stream banks or erosion in pasture fields. The estimated acreage by watershed where manure was applied in 2007 is shown in Table 3-8. These estimates are also based on the county level reports from the 2007 USDA county agricultural census, and thus, represent approximations of the commercially raised farm animal populations in each watershed. Despite the lack of specific data, for the purpose of these TMDLs, land application of commercially raised farm animal manure is considered a potential source of bacterial loading to the watersheds in the Study Area.

According to a livestock study conducted by the ASAE, the daily fecal coliform production rates by livestock species were estimated as follows (ASAE 1999):

- Beef cattle release approximately 1.04E+11 fecal coliform counts per animal per day;
- Dairy cattle release approximately 1.01E+11 per animal per day
- Swine release approximately 1.08E+10 per animal per day
- Chickens release approximately 1.36E+08 per animal per day
- Sheep release approximately 1.20E+10 per animal per day
- Horses release approximately 4.20E+08 per animal per day;
- Turkey release approximately 9.30E+07 per animal per day
- Ducks release approximately 2.43E+09 per animal per day
- Geese release approximately 4.90E+10 per animal per day

Using the estimated animal populations and the fecal coliform production rates from ASAE, an estimate of fecal coliform production from each group of commercially raised farm animal was calculated in each watershed of the Study Area. These estimates are presented in Table 3-9. Note that only a small fraction of these fecal coliform are expected to represent loading into waterbodies, either washed into streams by runoff or by direct deposition from wading animals. Because of their numbers, cattle again appear to represent the most likely commercially raised farm animal source of fecal bacteria.

Table 3-8 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Goats	Sheep	Hogs & Pigs	Ducks & Geese	Acres of Manure Application
OK220100030010_00	Brazil Creek	3,808	8	141	0	38	680	16	1,630
OK220200030010_20	Sallisaw Creek	3,993	271	248	0	38	56	45	535
OK220200040010_10	Sans Bois Creek	3,112	13	84	0	15	781	14	1,023
OK220600010119_10	Canadian River	24,578	44	749	7	204	46,672	46	2,705

Table 3-9 Fecal Coliform Production Estimates for Commercially Raised Farm Animals ($x10^9$ number/day)

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Goats	Sheep	Hogs & Pigs	Ducks & Geese	Total
OK220100030010_00	Brazil Creek	396,032	808	59	0	456	7,344	39	404,738
OK220200030010_20	Sallisaw Creek	415,272	27,371	104	0	456	605	109	443,917
OK220200040010_10	Sans Bois Creek	323,648	1,313	35	0	180	8,435	34	333,645
OK220600010119_10	Canadian River	2,556,109	4,484	315	84	2,448	504,058	112	3,067,609

3.3.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

DEQ is responsible for implementing the regulations of Title 252, Chapter 641 of the Oklahoma Administrative Code, which defines design standards for individual and small public onsite sewage disposal systems (DEQ 2011a). OSWD systems and illicit discharges can be a source of bacterial loading to streams and rivers. Bacterial loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater. Fecal coliform-contaminated groundwater may discharge to creeks through springs and seeps.

To estimate the potential magnitude of OSWDs fecal bacterial loading, the number of OSWD systems was estimated for each watershed. The estimate of OSWD systems was derived by using data from the 1990 U.S. Census which was the last year in which there were Census questions about plumbing facilities (U.S. Department of Commerce, Bureau of the Census 1990). The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census block by the number of acres in each census block. This density was then applied to the number of acres of each census block within a WQM station watershed. Census blocks crossing a watershed boundary required additional calculation to estimate the number of OSWD systems based on the proportion of the census block falling within each watershed. This step involved adding all OSWD systems for each whole or partial census block.

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state's minimum design criteria (Hall 2002). The 1990 American Housing Survey for Oklahoma conducted by the U.S. Census Bureau estimates that, nationwide, 10% of occupied homes with OSWD systems experience malfunctions during the year (U.S. Department of Commerce, Bureau of the Census 1990). A study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12% of the OSWD systems in east Texas and 8% in the Texas Panhandle were chronically malfunctioning. Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger could still cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-10 summarizes estimates of sewered and unsewered households and the average number of septic tanks per square mile for each watershed in the Study Area.

For the purpose of estimating fecal coliform loading in watersheds, an OSWD failure rate of 12% was used in the calculations made to characterize fecal coliform loads in each watershed.

Fecal coliform loads were estimated using the following equation (EPA 2001):

$$\#\frac{counts}{day} = \left(\#Failing\_systems\right) \times \left(\frac{10^6\,counts}{100ml}\right) \times \left(\frac{70gal}{personday}\right) \times \left(\#\frac{person}{household}\right) \times \left(3785.2\frac{ml}{gal}\right)$$

Table 3-10 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks / Mile^2
OK220100030010_00	Brazil Creek	393	484	18	895	6.2
OK220200030010_20	Sallisaw Creek	212	500	22	735	8.9
OK220200040010_10	Sans Bois Creek	159	183	7	349	5.4
OK220600010119_10	Canadian River	268	1,015	51	1,334	3.0

The average of number of people per household was calculated to be from 2.33 to 2.70 for counties in the Study Area (U.S. Census Bureau 2010). Approximately 70 gallons of wastewater were estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per 100 mL of effluent based on reported concentrations from a number of publications (Metcalf and Eddy 1991; Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the watersheds was summarized below in Table 3-11.

Table 3-11 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK220100030010_00	Brazil Creek	49,988	484	58	375
OK220200030010_20	Sallisaw Creek	35,886	500	60	388
OK220200040010_10	Sans Bois Creek	21,709	183	22	142
OK220600010119_10	Canadian River	217,116	1,015	122	787

3.3.4 Domestic Pets

Fecal matter from dogs and cats, which is transported to streams by runoff from urban and suburban areas, can be a potential source of bacterial loading. On average 37.2% of the nation's households own dogs and 32.4% own cats and in these households the average number of dogs is 1.7 and 2.2 cats per household (American Veterinary Medical Association 2007). Using the U.S. Census data at the block level (U.S. Census Bureau 2010), dog and cat populations can be estimated for each watershed. Table 3-12 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-12 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK220100030010_00	Brazil Creek	1,350	1,536
OK220200030010_20	Sallisaw Creek	978	1,113
OK220200040010_10	Sans Bois Creek	290	330
OK220600010119_10	Canadian River	1,563	1,778

Table 3-13 provides an estimate of the fecal coliform production from pets. These estimates are based on estimated fecal coliform production rates of 5.4×10^8 per day for cats and 3.3×10^9 per day for dogs (Schueler 2000).

Table 3-13 Estimated Fecal Coliform Daily Production by Pets ($\times 10^9$ counts/day)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK220100030010_00	Brazil Creek	4,454	829	5,283
OK220200030010_20	Sallisaw Creek	3,227	601	3,828
OK220200040010_10	Sans Bois Creek	958	178	1,137
OK220600010119_10	Canadian River	5,156	960	6,116

3.4 Summary of Sources of Impairment

3.4.1 Bacteria

There are five continuous permitted point sources in the watersheds of Poteau River (OK220100010010_00), Poteau River (OK220100010010_40), Bandy Creek (OK220100040080_00), and Sans Bois Creek (OK220200040010_40) that will not require a waste load allocation because the receiving waterbodies are not impaired for bacteria. Two of the four watersheds requiring a bacterial TMDL [Brazil Creek (OK220100030010_00) and Canadian River (OK220600010119_10)] have one continuous point source discharge each. There are 3 CAFOs in the Canadian River watershed (OK220600010119_10) in the Study Area, and 76 PFOs concentrated mostly in the lower eastern portion of the Study Area in Sans Bois Creek (OK220200040010_10), Brazil Creek (OK220100030010_00), Poteau River (OK220100010010_00), and Poteau River (OK220100010010_40). All the stream segments in Table 3-14 require bacterial TMDLs. That table provides a summary of the estimated percentage of fecal coliform loads in cfu/day from the four major nonpoint source categories (commercially raised farm animals, pets, deer, and septic tanks) that contribute to the elevated bacterial concentrations in each watershed. Because of their numbers and animal unit production of bacteria, livestock are estimated to be the largest contributors of fecal coliform loading to land surfaces. It must be noted that while no data are available to estimate populations and fecal loading of wildlife other than deer, a number of bacterial source tracking studies around the nation suggest that wild birds and mammals represent a major source of the fecal bacteria found in streams.

Table 3-14 Percentage Contribution of Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces

Waterbody ID	Waterbody Name	Commercially Raised Farm Animals	Pets	Deer	Estimated Loads from Septic Tanks
OK220100030010_00	Brazil Creek	98.60	1.29	0.03	0.09
OK220200030010_20	Sallisaw Creek	98.98	0.85	0.08	0.09
OK220200040010_10	Sans Bois Creek	99.57	0.34	0.05	0.04
OK220600010119_10	Canadian River	99.75	0.20	0.03	0.03

The magnitude of loading to a stream may not reflect the magnitude of loading to land surfaces. While no studies have quantified these effects, bacteria may die off or survive at different rates depending on the manure characteristics and a number of other environmental conditions. Also, the structural properties of some manure, such as cow patties, may limit their washoff into streams by runoff. In contrast, malfunctioning septic tank effluent may be present in standing water on the surface, or in shallow groundwater, which may enhance its conveyance to streams.

3.4.2 Turbidity

Of the three watersheds in the Study Area that require turbidity TMDLs, two of them, Poteau River (OK220100010010_00) and Poteau River (OK220100010010_40), have minor industrial permitted sources of TSS that will necessitate a WLA. These three watersheds have other permitted activities such as construction activities that contribute some TSS loading. Therefore, nonsupport of WWAC use in these watersheds is likely caused primarily by nonpoint sources of TSS. Sediment loading of streams can originate from natural erosion processes, including the weathering of soil, rocks, and uncultivated land; geological abrasion; and other natural phenomena. There is insufficient data available to quantify contributions of TSS from these natural processes. TSS or sediment loading can also occur under non-runoff conditions as a result of anthropogenic activities in riparian corridors which cause erosive conditions. Given the lack of data to establish the background conditions for TSS/turbidity, separating background loading from nonpoint sources whether it is from natural or anthropogenic processes is not feasible in this TMDL development.

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. A TMDL is expressed as the sum of three elements as described in the following mathematical equation:

$$TMDL = WLA\_{WWTF} + WLA\_{MS4} + LA + MOS$$

The WLA is the portion of the TMDL allocated to existing and future point sources. The LA is the portion of the TMDL allocated to nonpoint sources, including natural background sources. The MOS is intended to ensure that WQSs will be met.

For *E. coli* or Enterococci bacteria, TMDLs are expressed as colony-forming units per day, and represent the maximum one-day load the stream can assimilate while still attaining the WQS. Percent reduction goals are also calculated to aid to characterizing the possible magnitude of the effort to restore the segment to meeting water quality criterion. Turbidity TMDLs will be derived from TSS calculations and expressed in pounds (lbs) per day which will represent the maximum one-day load the stream can assimilate while still attaining the WQS, as well as a PRG.

4.1 Determining a Surrogate Target for Turbidity

Turbidity is a commonly measured indicator of the suspended solids load in streams. However, turbidity is an optical property of water, which measures scattering of light by suspended solids and colloidal matter. To develop TMDLs, a gravimetric (mass-based) measure of solids loading is required to express loads. There is often a strong relationship between the total suspended solids concentration and turbidity. Therefore, the TSS load, which is expressed as mass per time, is used as a surrogate for turbidity.

To determine the relationship between turbidity and TSS, a linear regression between TSS and turbidity was developed using data collected from 1998 to 2000 at stations within the Study Area. Prior to developing the regression the following steps were taken to refine the dataset:

- Replace TSS samples of "<10" with 9.99.
- Remove data collected under high flow conditions exceeding the base-flow criterion. This means that measurements corresponding to flow exceedance frequency lower than 25th were not used in the regression.
- Check rainfall data on the day when samples were collected and on the previous two days. If there was a significant rainfall event (>= 1.0 inch) in any of these days, the sample will be excluded from regression analysis with one exception. If the significant rainfall happened on the sampling day and the turbidity reading was less than 25 NTUs (half of turbidity standard for streams), the sample will not be excluded from analysis because most likely the rainfall occurred after the sample was taken.
- Log-transform both turbidity and TSS data to minimize effects of their non-linear data distributions.

When ordinary least squares (OLS) regression is applied to ascertain the best relationship between two variables (i.e., X and Y), one variable (Y) is considered "dependent" on the other variable (X), but X must be considered "independent" of the other, and known without measurement error. OLS minimizes the differences, or residuals, between measured Y values and Y values predicted based on the X variable.

For current purposes, a relationship is necessary to predict TSS concentrations from measured turbidity values, but also to translate the TSS-based TMDL back to instream turbidity values. For this purpose, an alternate regression fitting procedure known as the line of organic correlation (LOC) was applied. The LOC has three advantages over OLS (Helsel and Hirsch 2002):

- LOC minimizes fitted residuals in both the X and Y directions
- It provides a unique best-fit line regardless of which parameter is used as the independent variable
- Regression-fitted values have the same variance as the original data

The LOC minimizes the areas of the right triangles formed by horizontal and vertical lines drawn from observations to the fitted line. The slope of the LOC line equals the geometric mean of the Y on X (TSS on turbidity) and X on Y (turbidity on TSS) OLS slopes, and is calculated as:

$$m1 = \sqrt{m \cdot m'} = sign[r] \cdot \frac{s_y}{s_x}$$

$m1$ is the slope of the LOC line

m is the TSS on turbidity OLS slope

m' is the turbidity on TSS OLS slope

r is the TSS-turbidity correlation coefficient

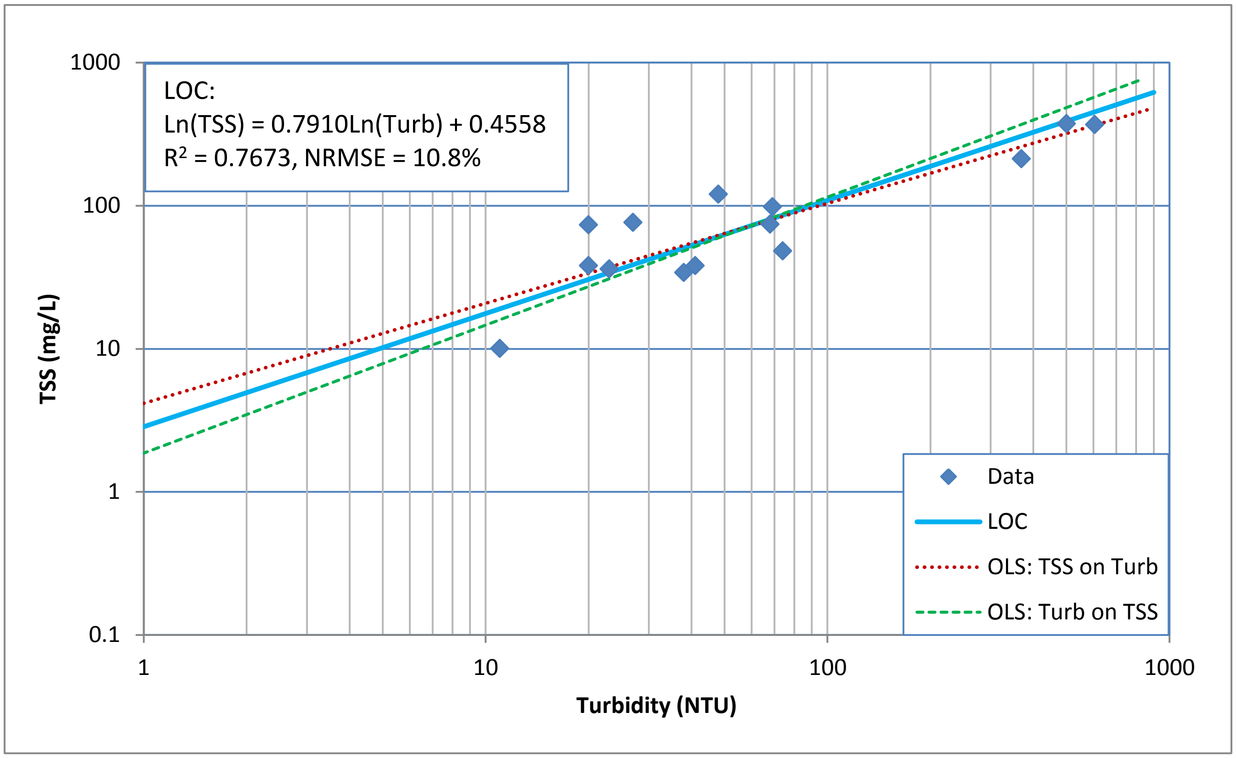
s_y is the standard deviation of the TSS measurements

s_x is the standard deviation of the turbidity measurements

The intercept of the LOC ($b1$) is subsequently found by fitting the line with the LOC slope through the point (mean turbidity, mean TSS). Figure 4-1 shows an example of the correlation between TSS and turbidity, along with the LOC and the OLS lines.

The NRMSE and R-square (r^2) were used as the primary measures of goodness-of-fit. As shown in Figure 4-1, the LOC yields a NRMSE value of 10.8% which means the root mean square error (RMSE) is 10.8% of the average of the measured TSS values. The R-square (R^2) value indicates the fraction of the total variance in TSS or turbidity observations that is explained by the LOC. The regression equation can be used to convert the turbidity standard of 50 NTUs to TSS goals.

Figure 4-1 Linear Regression for TSS-Turbidity for the Canadian River (OK220600010119_10)



It was noted that there were a few outliers that exerted undue influence on the regression relationship. These outliers were identified by applying the Tukey's Boxplot method (Tukey 1977) to the dataset of the distances from observed points to the regression line. The Tukey Method is based on the interquartile range (IQR), the difference between the 75th percentile (Q_3) and 25th percentile (Q_1) of distances between observed points and the LOC. Using the Tukey method, any point with an error greater than Q_3 + 1.5* IQR or less than Q_1 – 1.5*IQR was identified as an outlier and removed from the regression dataset. The above regressions were calculated using the dataset with outliers removed.

The Tukey Method is equivalent to using three times the standard deviation to identify outliers if the residuals (observed - predicted) follow a normal distribution. The probability of sampling results being within three standard deviations of the mean is 99.73% while the probability for the Tukey Method is 99.65%. If three times the standard deviation is used to identify outliers, it is necessary to first confirm that the residuals are indeed normally distributed. This is difficult to do because of the size limitations of the existing turbidity & TSS dataset. Tukey's method does not rely on any assumption about the distribution of the residuals. It can be used regardless of the shape of distribution.

Outliers were removed from the dataset only for calculating the turbidity-TSS relationship, not from the dataset used to develop the TMDL.

The regression between TSS and turbidity and its statistics for each turbidity impaired stream segment is provided in Section 5.1.

4.2 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDC). LDCs facilitate rapid development of TMDLs, and as a TMDL development tool can help identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the three following steps that are described in Subsections 4.3 through 4.5 below:

- Preparing flow duration curves for gaged and ungaged WQM stations.
- Estimating existing loading in the waterbody using ambient bacterial water quality data; and estimating loading in the waterbody using measured TSS water quality data and turbidity-converted data.
- Using LDCs to identify if there is a critical condition.

Historically, in developing WLAs for pollutants from point sources, it was customary to designate a critical low flow condition (*e.g.*, 7Q2) at which the maximum permissible loading was calculated. As water quality management efforts expanded in scope to quantitatively address nonpoint sources of pollution and types of pollutants, it became clear that this single critical low flow condition was inadequate to ensure adequate water quality across a range of flow conditions. Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the “nonpoint source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the “point source critical condition” would typically occur during low flows, when WWTF effluents would dominate the base flow of the impaired water. However, flow range is only a general indicator of the relative proportion of point/nonpoint contributions. It is not used in this report to quantify point source or nonpoint source contributions. Violations that occur during low flows may not be caused exclusively by point sources. Violations during low flows have been noted in some watersheds that contain no point sources.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by a water quality criterion. The TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

4.3 Development of Flow Duration Curves

Flow duration curves (FDC) serve as the foundation of LDCs and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many WQM stations throughout Oklahoma do not have long-term flow data and therefore, flow frequencies must be estimated. Nine of the fourteen waterbodies in the Study Area do not have USGS gage stations. The default approach used to develop flow frequencies necessary to establish flow duration curves considers watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. A detailed explanation of the methods for estimating flow for ungaged streams is provided in Appendix B. The most basic method to estimate flows at an ungaged site involves 1) identifying an upstream or downstream flow gage; 2) calculating the contributing drainage areas of the ungaged sites and the flow gage; and 3) calculating daily flows at the ungaged site by using the flow at the gaged site multiplied by the drainage area ratio.

Flow duration curves are a type of cumulative distribution function. The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. The observed flow values are first ranked from highest to lowest, then, for each observation, the percentage of observations exceeding that flow is calculated. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa (x-axis), which is numbered from 0% to 100%, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100% indicating that flow has equaled or exceeded this value 100% of the time, while the highest measured flow is found at an exceedance frequency of 0%. The median flow occurs at a flow exceedance frequency of 50%. The flow exceedance percentiles for each waterbody addressed in this report are provided in Appendix B.

While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than one year of observations, and encompasses inter-annual and seasonal variation. Ideally, the drought of record and flood of record are included in the observations. For this purpose, the long-term flow gaging stations operated by the USGS are utilized (USGS 2009) to support the Oklahoma TMDL Toolbox.

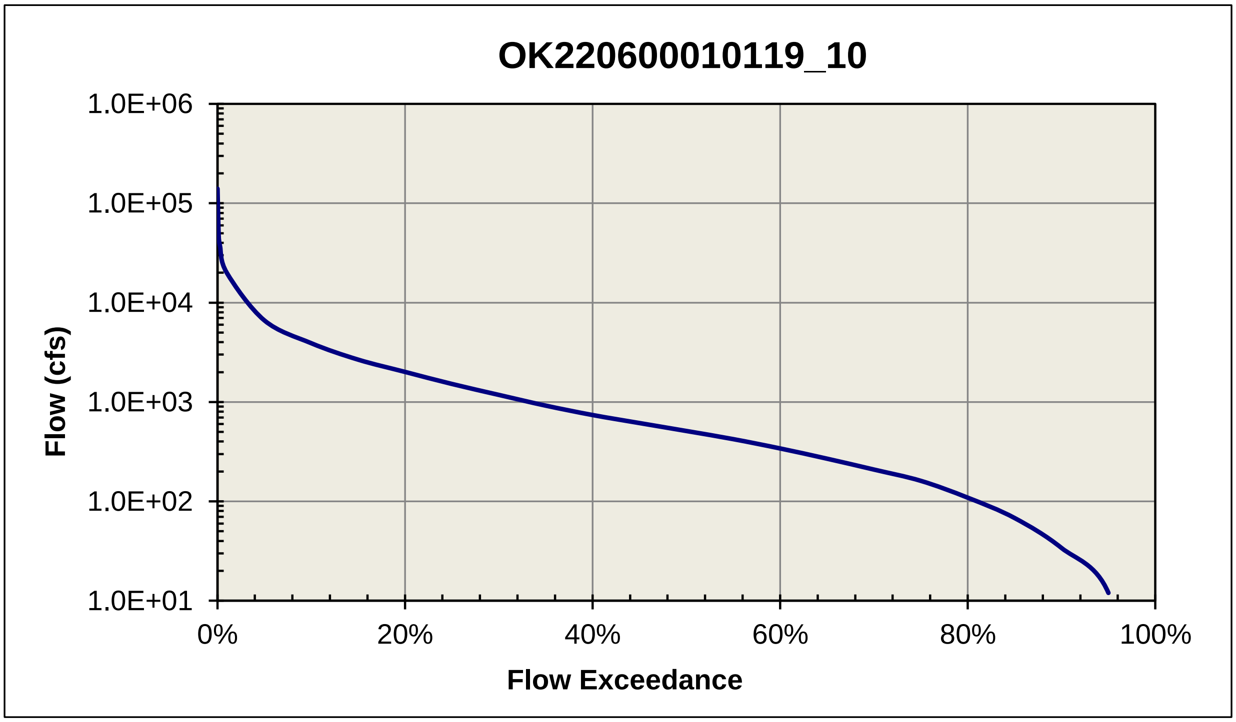
The USGS National Water Information System serves as the primary source of flow measurements for the Oklahoma TMDL Toolbox. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream gages in adjacent states, were retrieved for use in the Oklahoma TMDL Toolbox to generate flow duration curves for gaged and ungaged waterbodies. The application includes a data update module that automatically downloads the most recent USGS data and appends it to the existing flow database.

Some instantaneous flow measurements were available from various agencies. These were not combined with the daily average flows or used in calculating flow percentiles, but were matched turbidity, or TSS grab measurements collected at the same site and time. When available, these instantaneous flow measurements were used in lieu of projected flows to calculate pollutant loads.

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow exceedance frequency value of 0% and downward at a frequency near 100%, often with a relatively constant slope in between. For sites that on occasion exhibit no flow, the curve will intersect the abscissa at a frequency less than 100%. As the number of observations at a site increases, the line of the LDC tends to appear smoother. However, at extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantization. An example of a typical flow duration curve is shown in Figure 4-2.

Flow duration curves for each impaired waterbody in the Study Area are provided in Section 5.2.

Figure 4-2 Flow Duration Curve for the Canadian River (OK220600010119_10)



4.4 ESTIMATING EXISTING LOADING

4.4.1 Bacterial FDC

Existing instream loads can be estimated using FDCs. For bacteria, this is accomplished by:

- Calculating the geometric mean of all water quality observations from the period of record selected for the waterbody.
- Converting the geometric mean concentration value to loads by multiplying the flow duration curve by the geometric mean of the ambient water quality data for each bacterial indicator.

4.4.2 TSS FDC

For TSS, this is accomplished by:

- Matching the water quality observations with the flow data from the same date.
- Converting measured concentration values to loads by multiplying the flow at the time the sample was collected by the water quality parameter concentration (for sampling events with both TSS and turbidity data, the measured TSS value is used; if only turbidity was measured, the value was converted to TSS using the regression equations described); or multiplying the flow by the bacterial indicator concentration to calculate daily loads.

4.5 Development of TMDLs Using Load Duration Curves

The final step in the TMDL calculation process involves a group of additional computations derived from the preparation of LDCs. These computations are necessary to derive a PRG (which is one method of presenting how much pollutant loads must be reduced to meet WQSs in the impaired watershed).

4.5.1 Step 1 - Generate LDCs

LDCs are similar in appearance to flow duration curves; however, for bacteria the ordinate is expressed in terms of a bacterial load in cfu/day, and for TSS the ordinate is expressed in terms of a load in lbs/day. The bacterial curve represents the geometric mean water quality criterion for *E. coli* or Enterococci bacteria expressed in terms of a load through multiplication by the continuum of flows historically observed at the site. Bacterial TMDLs are not easily expressed in mass per day, the following equation calculates a load in the units of cfu per day. The cfu is a total for the day at a specific flow for bacteria, which is the best equivalent to a mass per day of a pollutant such as sulfate. Expressing bacterial TMDLs as cfu per day is consistent with EPA's Protocol for Developing Pathogen TMDLs (EPA 2001).

For turbidity, the curve represents the water quality target for TSS from Table 5-1 expressed in terms of a load obtained through multiplication of the TSS goal by the continuum of flows historically observed at the site. The basic steps to generating an LDC involve:

- Obtaining daily flow data for the site of interest from the USGS
- Sorting the flow data and calculating flow exceedance percentiles
- Obtaining the water quality data from the primary contact recreation season (May 1 through September 30); or obtaining available turbidity and TSS water quality data
- Displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS numerical criterion for each parameter (geometric mean standard for bacterial and TSS goal for turbidity)
- For bacterial TMDLs, displaying another curve derived by plotting the geometric mean of all existing bacteria samples continuously along the full spectrum of flow exceedance percentiles which represents LDC (See Section 5)
- For turbidity TMDLs, matching the water quality observations with the flow data from the same date and determining the corresponding exceedance percentile (See Section 5).

4.5.1.1 Bacterial LDC

For bacterial TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQS = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

unit conversion factor = 24,465,525

4.5.1.2 Turbidity LDC

For turbidity (TSS) TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (lb/day) = WQ_{goal} **** flow (cfs) * unit conversion factor***

Where: WQ_{goal} ***= waterbody specific TSS concentration derived from regression analysis results presented in Table 5-1***

unit conversion factor = 5.39377

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured or estimated flow, in other words, the percent of historical observations that are equal to or exceed the measured or estimated flow. Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. Historical observations of TSS and/or turbidity concentrations are paired with flow data and are plotted on the LDC for a stream. TSS loads representing exceedance of water quality criteria fall above the TMDL line. It is noted that the LDCs for bacteria were based on the geometric mean standards or geometric mean of all samples. It is inappropriate to compare single sample bacterial observations to a geometric mean water quality criterion in the LDC; therefore individual bacterial samples are not plotted on the LDCs.

As noted earlier, runoff has a strong influence on loading of nonpoint pollution. Yet flows do not always correspond directly to runoff; high flows may occur in dry weather (e.g., lake release to provide water downstream) and runoff influence may be observed with low or moderate flows (e.g., persistent high turbidity due to previous storm).

4.5.2 Step 2 - Define MOS

The MOS may be defined explicitly or implicitly. A typical explicit approach would reserve some specific fraction of the TMDL as the MOS. In an implicit approach, conservative assumptions used in developing the TMDL are relied upon to provide an MOS to assure that WQSs are attained. For bacterial TMDLs in this report, an explicit MOS of 10% was selected. The 10% MOS has been used in other approved bacterial TMDLs. For turbidity (TSS) TMDLs an explicit MOS is derived from the NRMSE established by the turbidity/TSS regression analysis conducted for each waterbody. This approach for setting an explicit MOS has been used in other approved turbidity TMDLs.

4.5.3 Step 3 - Calculate WLA

As previously stated, the pollutant load allocation for point sources is defined by the WLA. For bacterial TMDLs a point source can be either a wastewater (continuous) or stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas, and recent EPA guidance includes NPDES-permitted stormwater discharges as point source discharges and, therefore, part of the WLA. For TMDL development purposes when addressing turbidity or TSS, a WLA will be established for wastewater (continuous) discharges in impaired watersheds that do not have a BOD or CBOD permit limit but do have a TSS limit. These point source discharges of inorganic suspended solids will be assigned a TSS WLA as part of turbidity TMDLs to ensure WQS can be maintained. As discussed in Section 3.1, a WLA for TSS is not necessary for MS4s.

The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading will vary with flow condition. WLAs can be expressed in terms of a single load, or as different loads allowable under different flows. WLAs may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources. For turbidity (TSS) TMDLs a load-based approach also meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs "in terms of mass per time, toxicity, or other appropriate measures."

4.5.3.1 WLA for WWTF

For watersheds with permitted point sources discharging the pollutant of concern, NPDES permit limits are used to derive WLAs for evaluation as appropriate for use in the TMDL. The permitted flow rate used for each point source discharge and the water quality concentration defined in a permit are used to estimate the WLA for each wastewater facility. In cases where a permitted flow rate is not available for a WWTF, then the average of monthly flow rates derived from DMRs can be used. WLA values for each NPDES wastewater discharger are then summed to represent the total WLA for a given segment. Using this information bacterial and TSS WLAs can be calculated using the approach as shown in the equations below.

4.5.3.1.1 WLA for Bacteria

WLA = WQS * flow * unit conversion factor (cfu/day)

Where:

WQS = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

flow (mgd) = permitted flow unit conversion factor = 37,854,120

4.5.3.1.2 WLA for TSS

WLA = WQ goal * flow * unit conversion factor (lb/day)

Where:

WQ goal= Waterbody specific water quality goal provided in Table 5-1, or monthly

TSS limit in the current permit, whichever is smaller

flow (mgd) = permitted flow or average monthly flow

unit conversion factor = 8.3445

4.5.4 Step 4 - Calculate LA and WLA for MS4s

Given the lack of data and the variability of storm events and discharges from storm sewer system discharges, it is difficult to establish numeric limits on stormwater discharges that accurately address projected loadings. As a result, EPA regulations and guidance recommend expressing NPDES permit limits for MS4s as BMPs.

LAs can be calculated under different flow conditions. The LA at any particular flow exceedance is calculated as shown in the equation below.

LA = TMDL - WLA_WWTF - WLA_MS4 – MOS

4.5.4.1 Bacterial WLA for MS4s

For bacterial TMDLs, if there are no permitted MS4s in the Study Area, WLA_MS4 is set to zero. When there are permitted MS4s in a watershed, first calculate the sum of LA + WLA_MS4 using the above formula, then separate WLA for MS4s from the sum based on the percentage of a watershed that is under a MS4 jurisdiction. This WLA for MS4s may not be the total load allocated for permitted MS4s unless the whole MS4 area is located within the study watershed boundary. However, in most case the study watershed intersects only a portion of the permitted MS4 coverage areas.

4.5.4.2 Turbidity WLA for MS4s

For turbidity TMDLs, WLAs for permitted stormwater such as MS4s, construction, and multi-sector general permits are not calculated since these discharges occur under high flow conditions when the turbidity criteria do not apply.

4.5.5 Step 5 - Estimate Percent Load Reduction

Percent load reductions are not required items and are provided for informational purposes when making inferences about individual TMDLs or between TMDLs usually in regard to implementation of the TMDL.

The LDC approach recognizes that the assimilative capacity of a waterbody depends on stream flow and that the maximum allowable loading varies with flow condition. Existing loading and load reductions required to meet the TMDL can also be calculated under different flow conditions. The difference between existing loading and the TMDL is used to calculate the loading reductions required. Percent reduction goals are calculated through an iterative process of taking a series of percent reduction values applying each value uniformly to the measured concentrations of samples and verifying if the geometric mean of the reduced values of all samples is less than the geometric mean standards.

4.5.5.1 WLA Load Reduction

The WLA load reduction for bacteria was not calculated as it was assumed that continuous dischargers (NPDES-permitted WWTFs) are adequately regulated under existing permits to achieve WQS at the end-of-pipe and, therefore, no WLA reduction would be required. Currently, bacterial limits are not required for lagoon systems. Lagoon systems located within a sub-watershed of bacterially-impaired stream segment will be required to meet *E. coli* standards at the discharge when the permits are renewed.

MS4s are classified as point sources, but they are nonpoint sources in nature. Therefore, the percent reduction goal calculated for LA will also apply to the MS4 area within the bacterially-impaired sub-watershed. If there are no MS4s located within the Study Area requiring a TMDL, then there is no need to establish a PRG for permitted stormwater.

The WLA load reduction for TSS for dischargers without BOD/CBOD limits can be determined as follows:

- If permitted TSS limit is less than TSS goal for the receiving stream, there will be no reductions

- If permitted TSS limit is greater than TSS goal for the receiving stream, the permit limit will be set at the TSS goal.

4.5.5.2 LA Load Reduction

After existing loading estimates are computed for each pollutant, nonpoint load reduction estimates for each segment are calculated by using the difference between the estimate of existing loading and the allowable loading (TMDL) under all flow conditions. This difference is expressed as the overall PRG for the impaired waterbody. The PRG serves as a guide for the amount of pollutant reduction necessary to meet the TMDL. For *E. coli* and Enterococci, because WQSs are considered to be met if the geometric mean of all future data is maintained below the geometric mean criteria (TMDL). For turbidity, the PRG is the load reduction that ensures that no more than 10% of the samples under flow-base conditions exceed the TMDL.

SECTION 5
TMDL CALCULATIONS

5.1 Surrogate TMDL Target for Turbidity

Using the LOC method described in Section 4.1, correlations between TSS and turbidity were developed for establishing the statistics of the regressions and the resulting TSS goals were provided in Table 5-1. The regression analysis for each impaired waterbody in the Study Area using the LOC method is displayed in Figures 5-1 through 5-2. There were no TSS data available for Poteau River (OK220100010010_40) so the regression for Poteau River (OK220100010010_00) was used.

Table 5-1 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK220100010010_00	Poteau River	0.928	4.1%	37	10%
OK220100010010_40	Poteau River	0.928[c]	4.1%[c]	37[c]	10%[c]
OK220600010119_10	Canadian River	0.767	10.8%	35	15%

[a] Calculated using the regression equation and the turbidity standard (50 NTU)
[b] Based on the goodness-of-fit of the turbidity-TSS regression (NRMSE)
[c] There are no paired TSS and turbidity data available for Poteau River segment OK220100010010_40; same statistical result from the downstream segment OK220100010010_00 was used for the TMDL development.

Figure 5-1 Linear Regression for TSS-Turbidity for the Poteau River (OK220100010010_00)

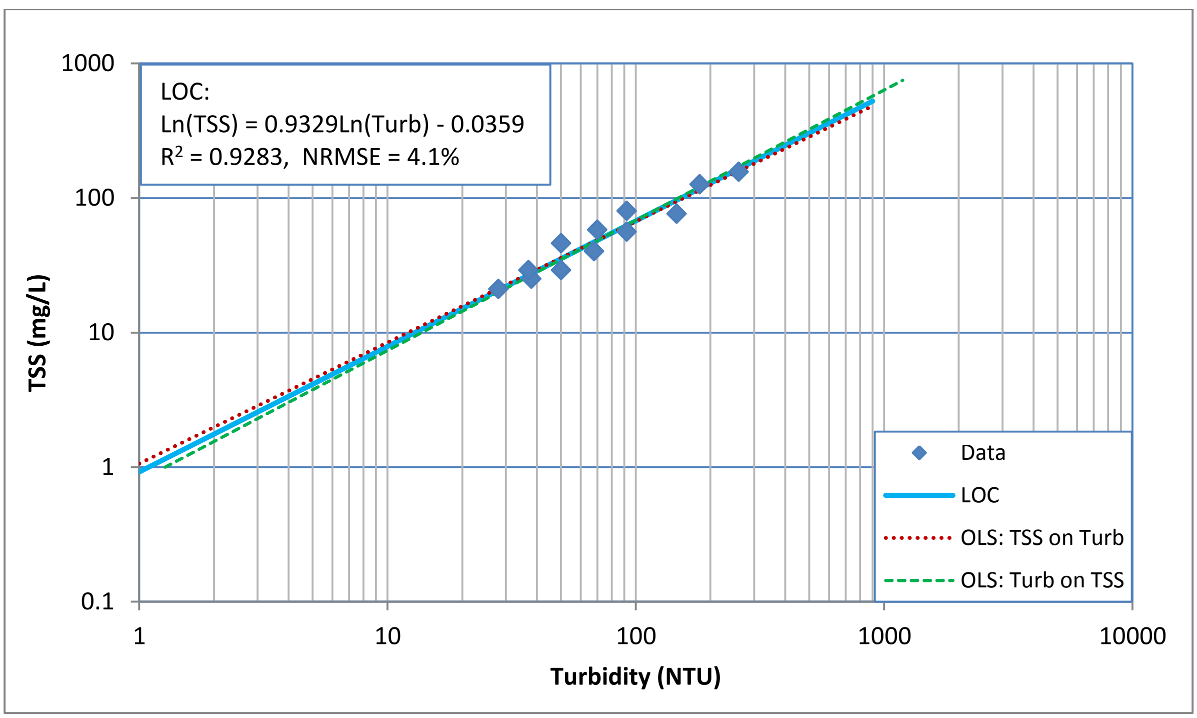
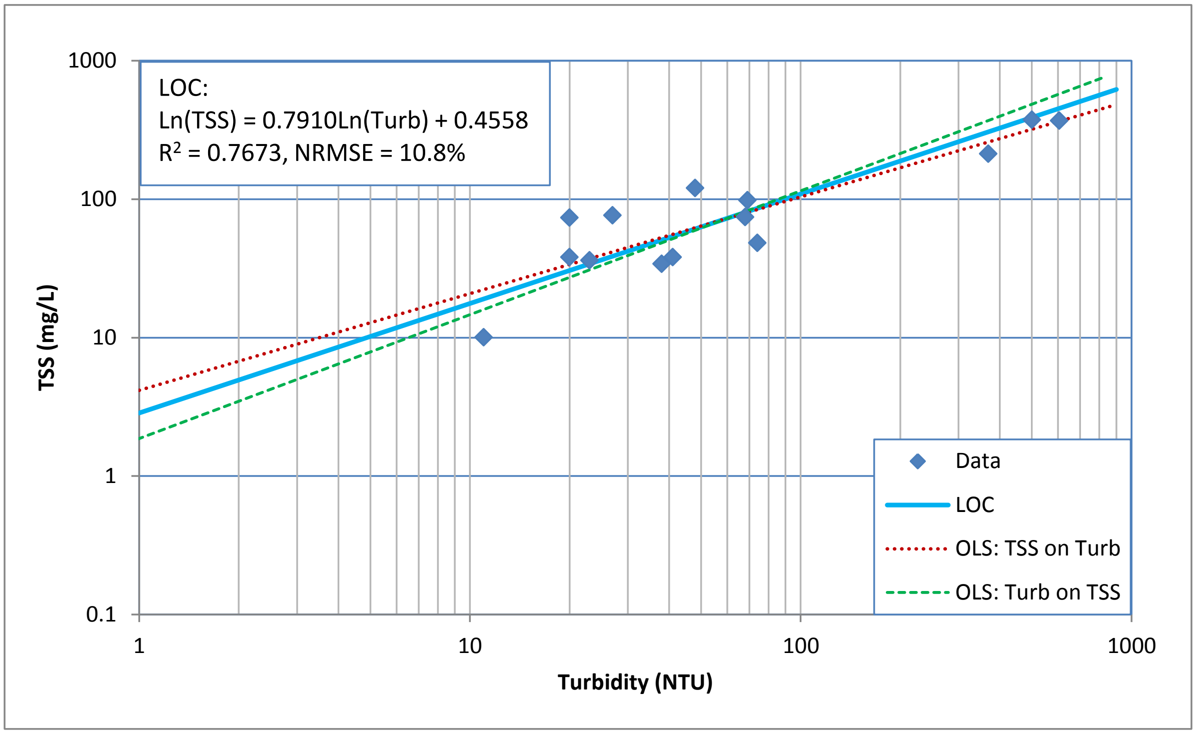


Figure 5-2 Linear Regression for TSS-Turbidity for the Canadian River (OK220600010119_10)



5.2 Flow Duration Curve

Following the same procedures described in Section 4.3, a flow duration curve for each stream segment in this study was developed. These are shown in Figures 5-3 through Figure 5-8.

Flow duration curve for Poteau River (OK220100010010_00) was developed based on the flow data from 1989 to 2011 at USGS gage station 07249413. Flow duration curve for Poteau River (OK220100010010_40) was developed based on USACOE's flow data from 1983 to 2013 at station USACOE-PTA02.

No flow gage exists on Brazil Creek (OK220100030010_00) and Sans Bois Creek (OK220200040010_10). Therefore, flows for these waterbodies were estimated using the watershed area ratio method based on measured flows for the neighboring Fourche Maline River (OK220100040020_00) at USGS gage station 07247500. The flow duration curves were based on measured flows from 1966 to 2012.

No flow gage exists on Sallisaw Creek (OK220200030010_20). Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows for the neighboring Little Lee Creek (OK220200050040_00) at USGS gage station 07249920. The flow duration curve was based on measured flows from 2000 to 2012.

Figure 5-3 Flow Duration Curve for the Poteau River (OK220100010010_00)

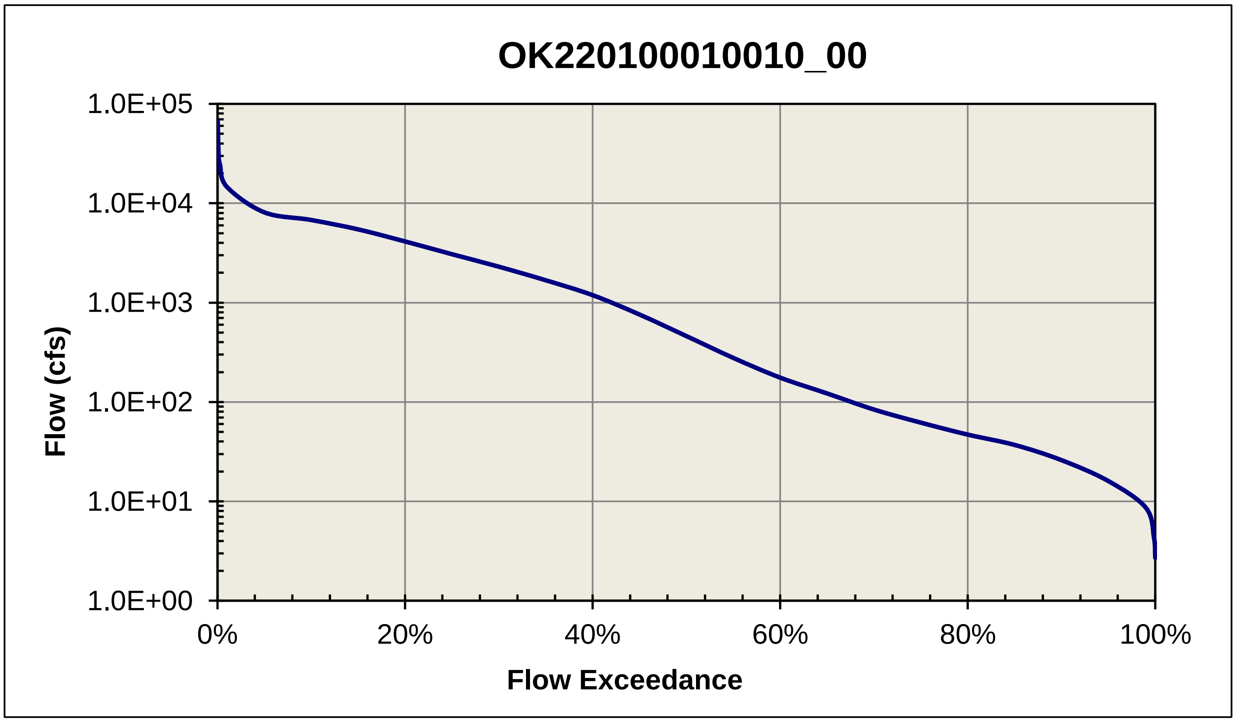


Figure 5-4 Flow Duration Curve for the Poteau River (OK220100010010_40)

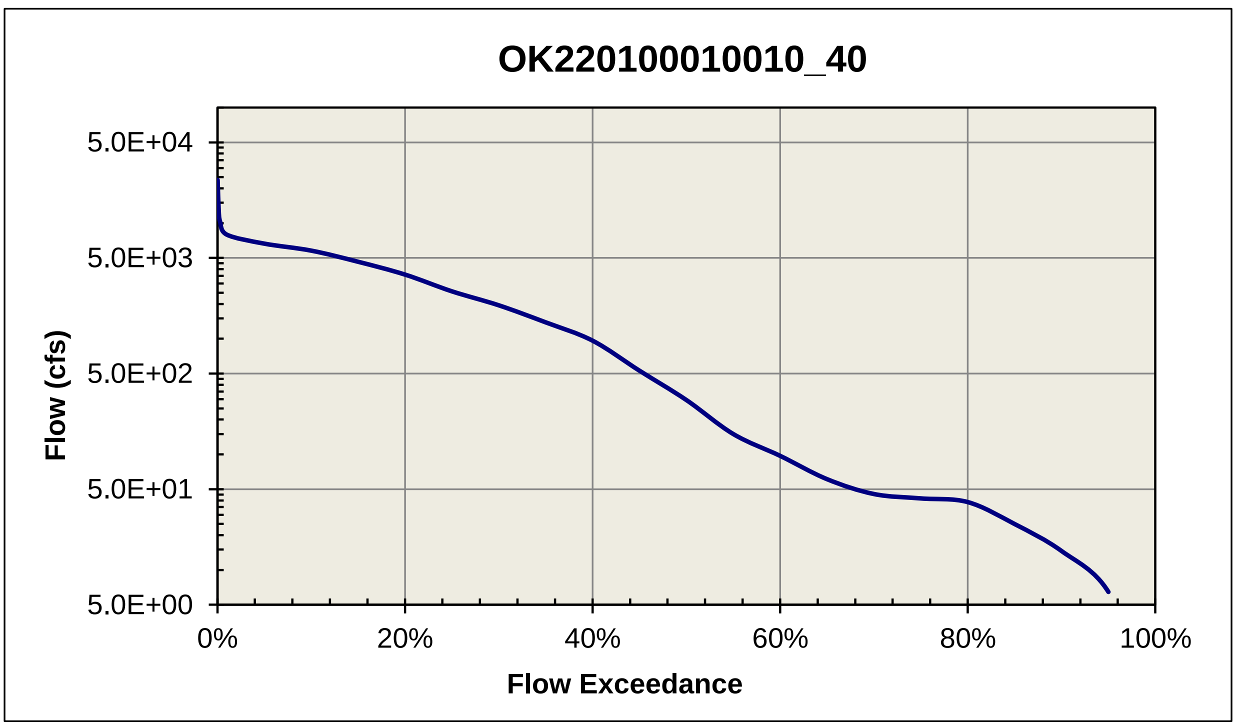


Figure 5-5 Flow Duration Curve for Brazil Creek (OK220100030010_00)

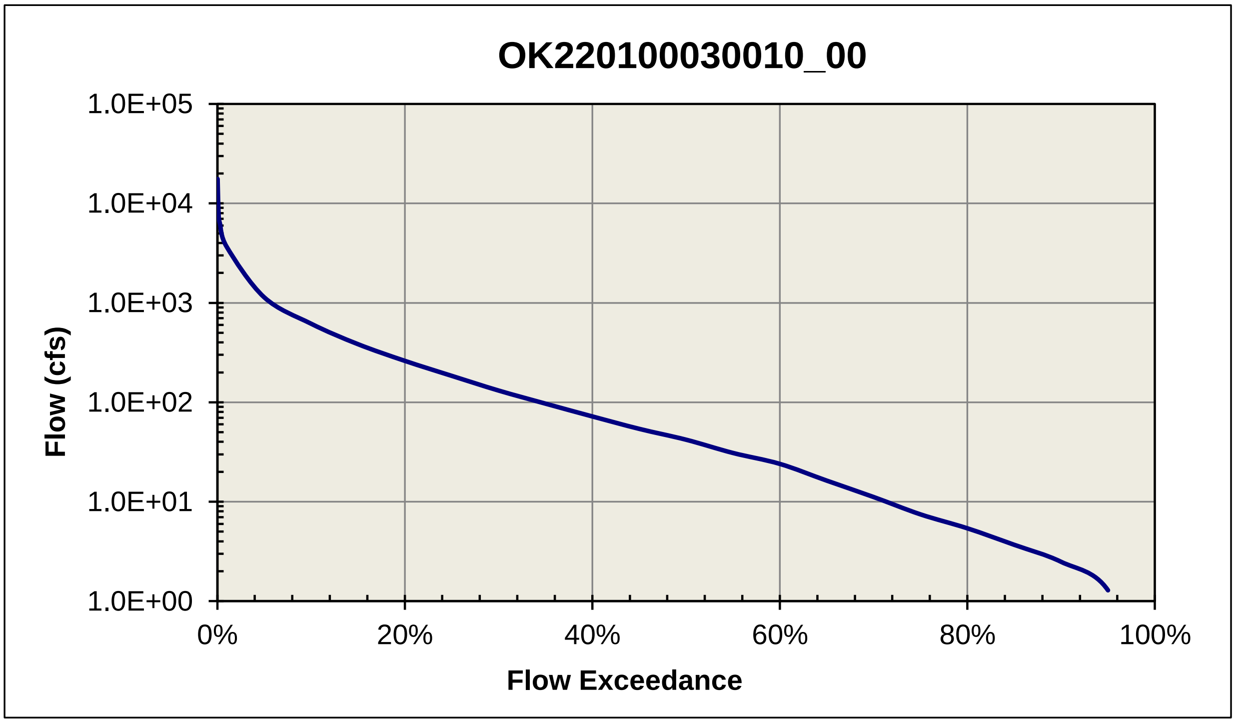


Figure 5-6 Flow Duration Curve for Sallisaw Creek (OK220200030010_20)

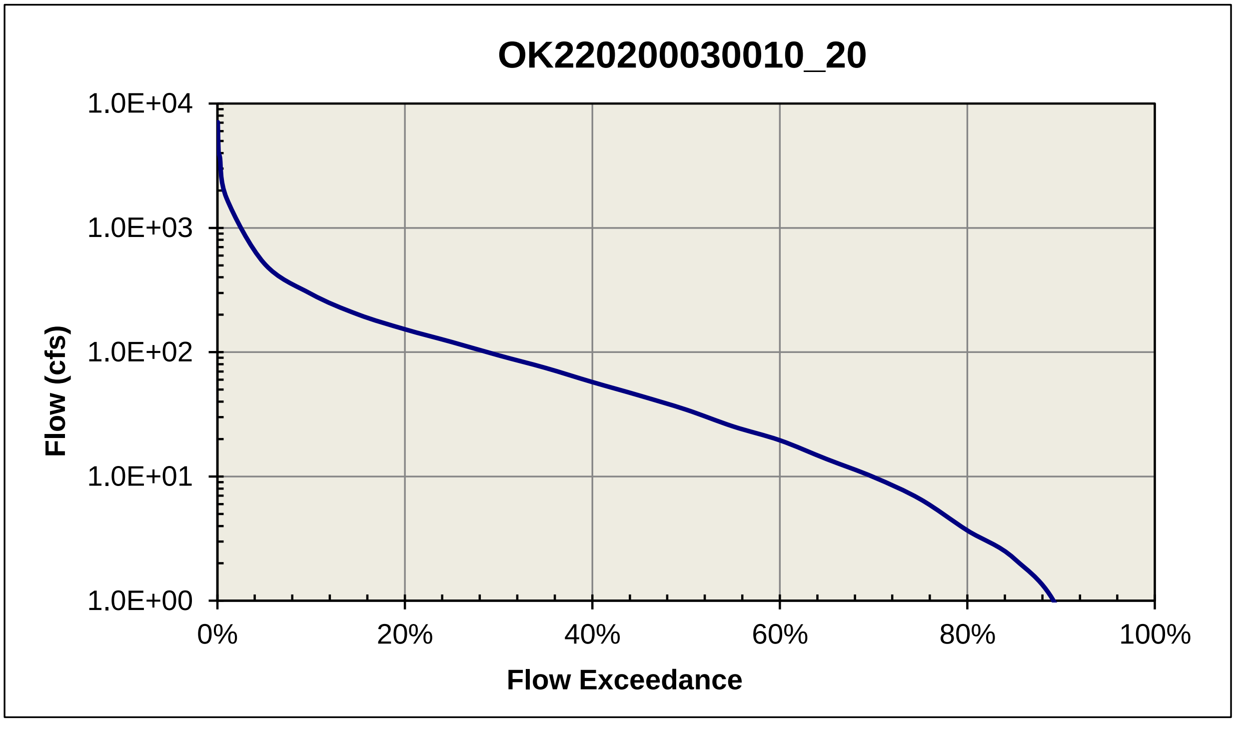


Figure 5-7 Flow Duration Curve for Sans Bois Creek (OK220200040010_10)

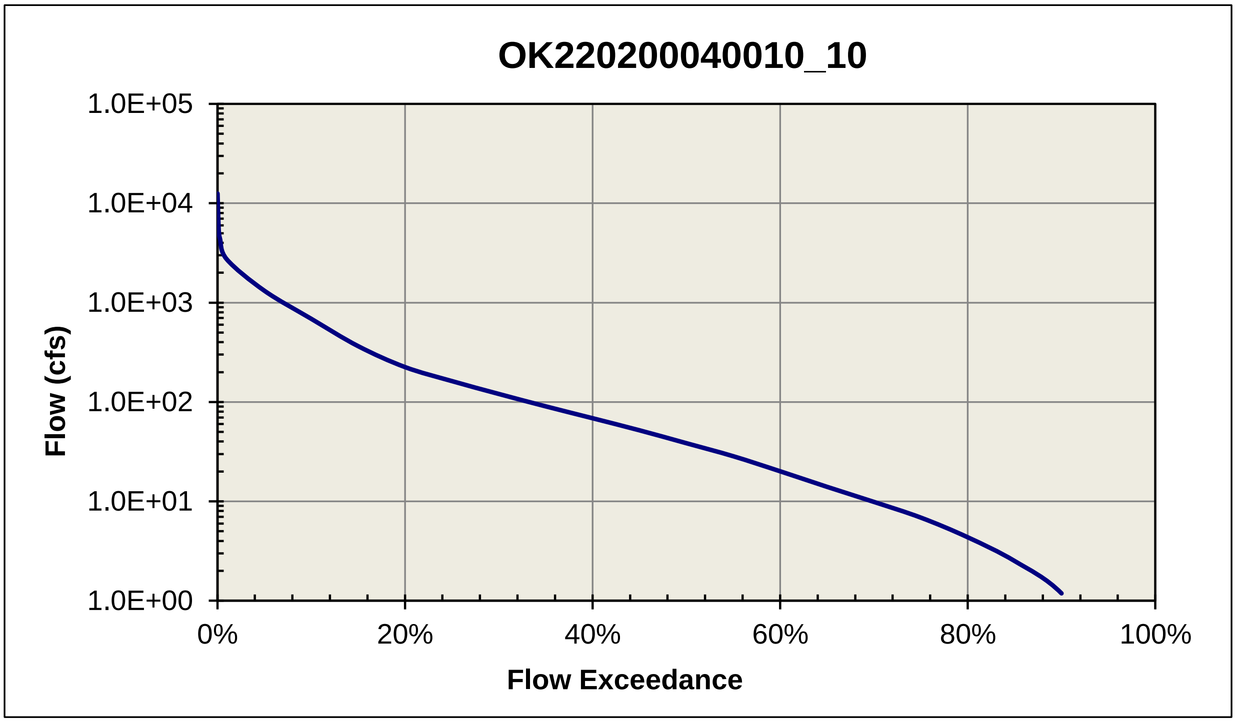
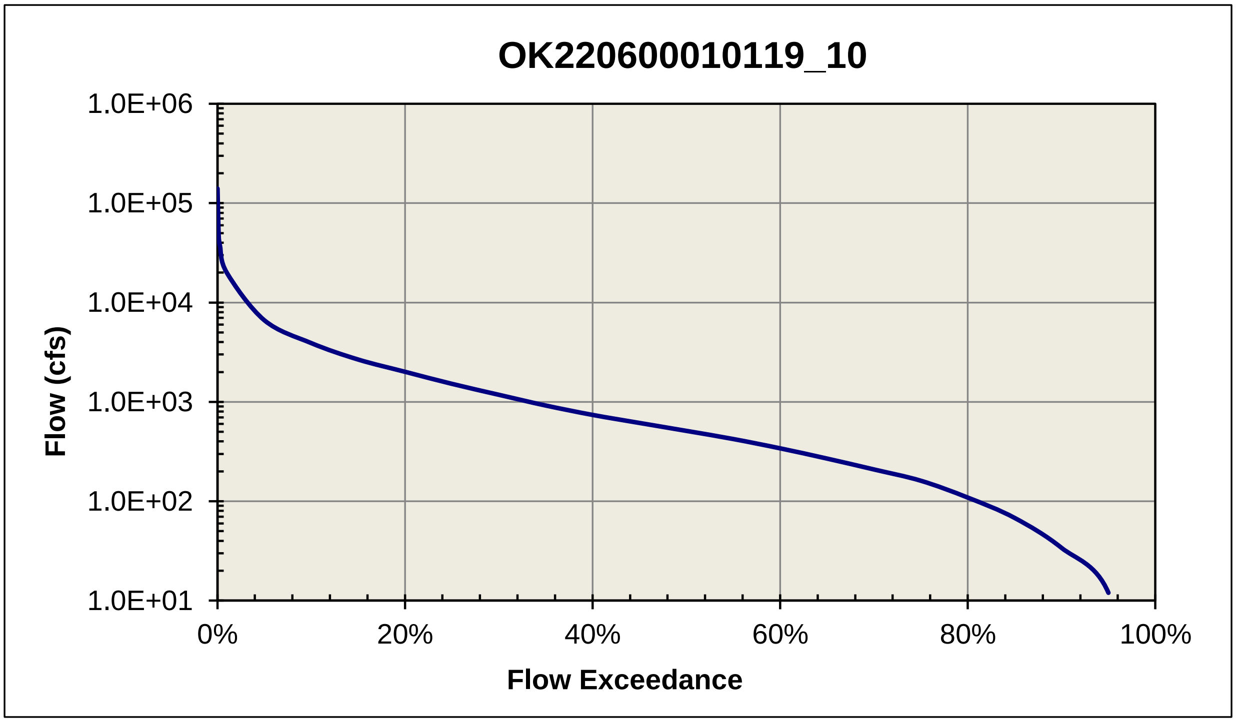


Figure 5-8 Flow Duration Curve for the Canadian River (OK220600010119_10)



5.3 ESTIMATED LOADING AND CRITICAL CONDITIONS

EPA regulations at 40 CFR 130.7(c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and all applicable WQS. To accomplish this, available instream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs.

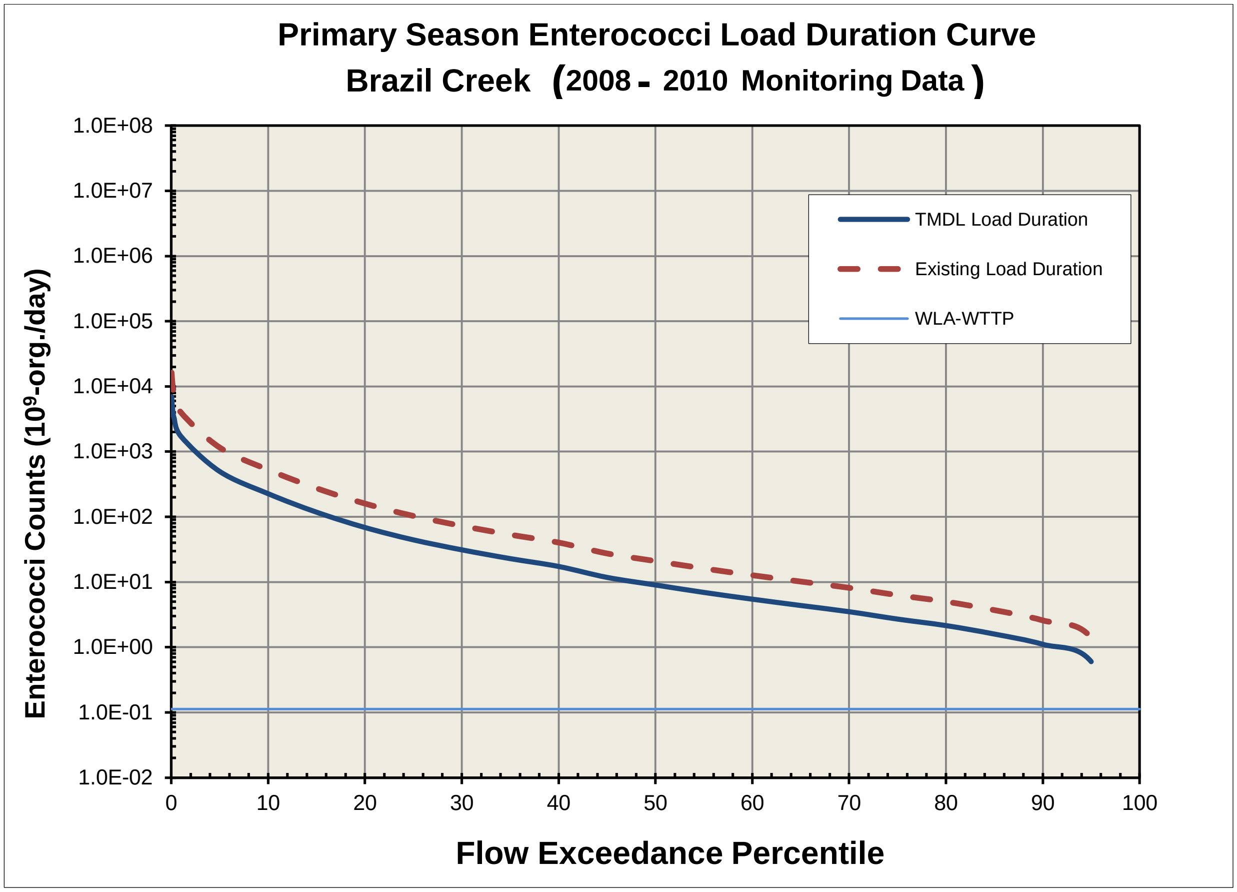
5.3.1 Bacterial LDC

To calculate the allowable bacterial load, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525*) and the geometric mean water quality criterion for each bacterial indicator. This calculation produces the maximum bacterial load in the stream over the range of flow conditions. The allowable bacterial (*E. coli* or Enterococci) loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as a LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a bacterial load.

To estimate existing loading, the geometric mean of all bacterial observations (concentrations) for the primary contact recreation season (May 1st through September 30th) from 2004 to 2010 are paired with the flows measured or estimated in that waterbody. Pollutant loads are then calculated by multiplying the measured bacterial concentration by the flow rate and the unit conversion factor of *24,465,525*. The bacterial LDCs developed for each impaired waterbody are shown in Figures 5-9 through 5-12. Each waterbody had an LDC for Enterococci.

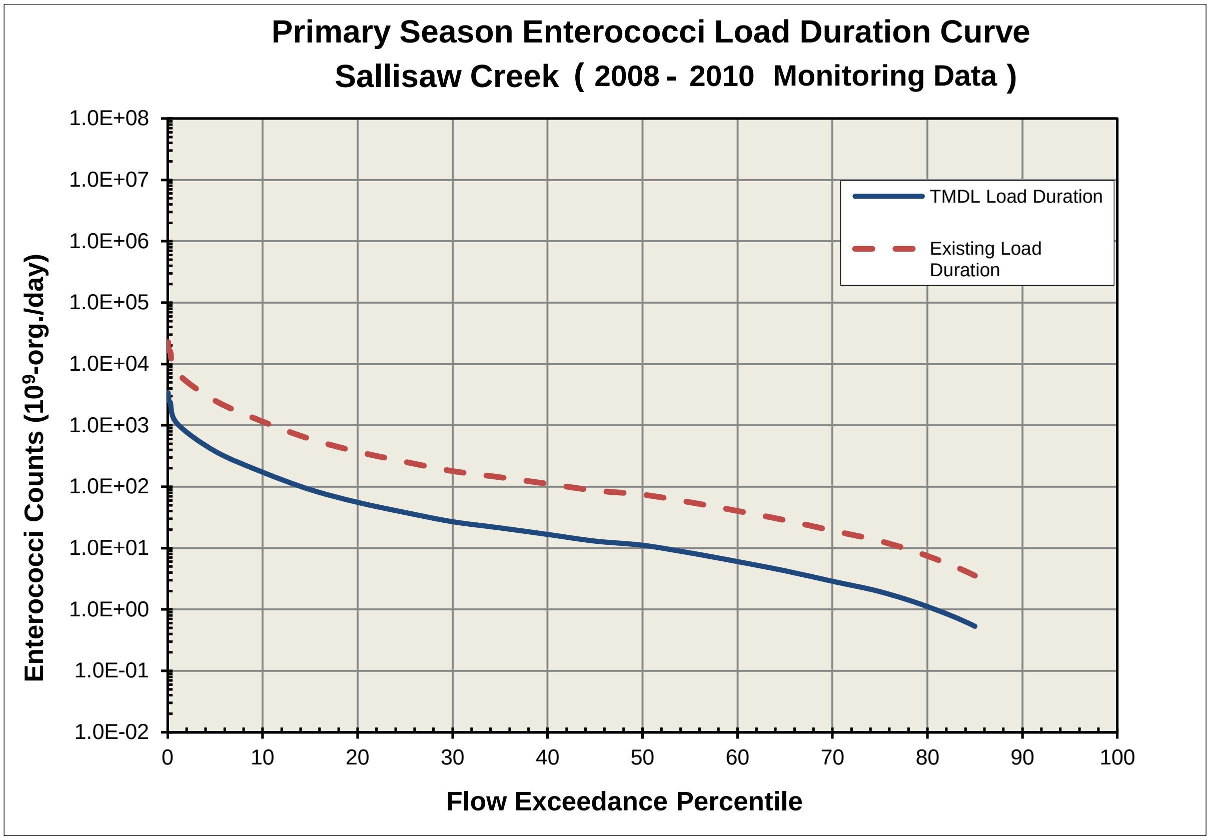
The LDC for Brazil Creek (Figure 5-9) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM station OK220100-03-0010G.

Figure 5-9 Load Duration Curve for Enterococci in Brazil Creek (OK220100030010_00)



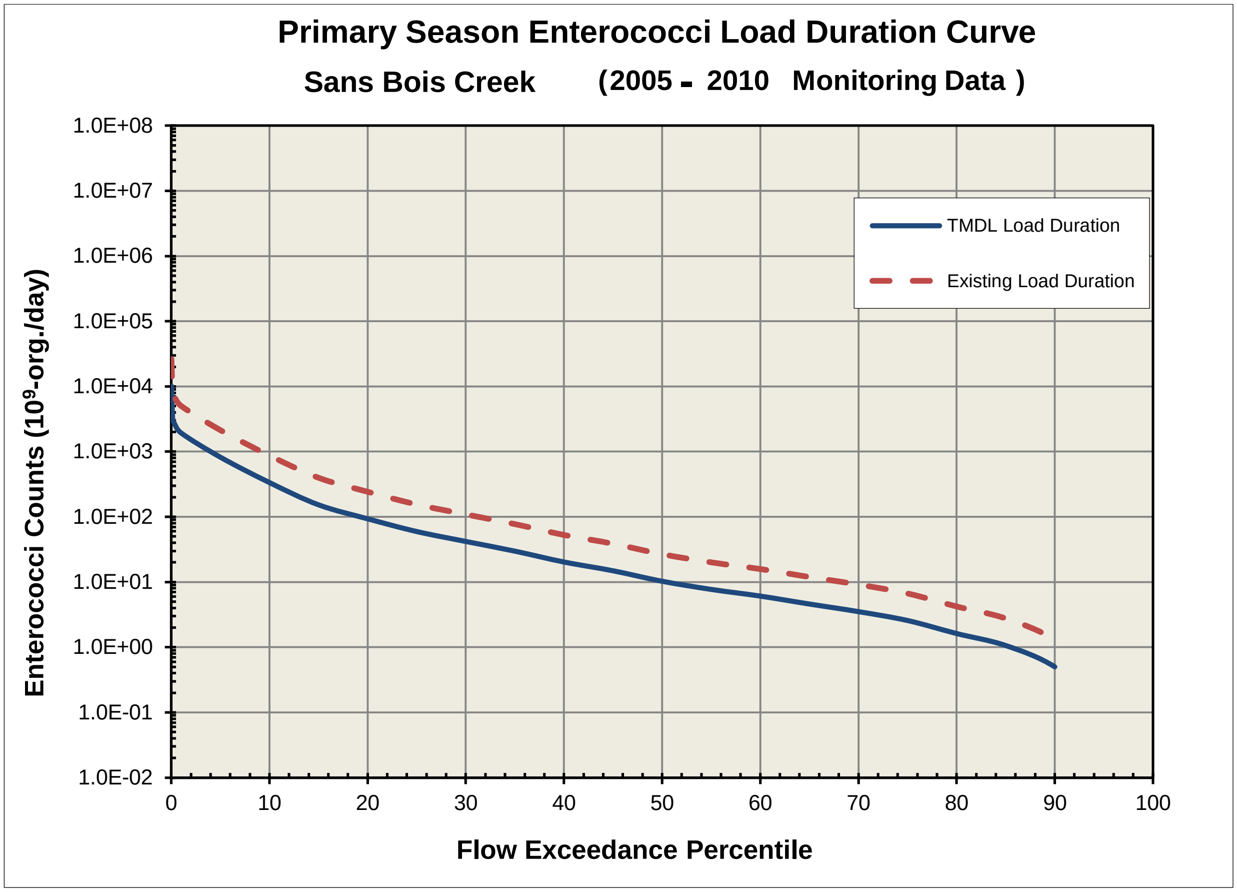
The LDC for Sallisaw Creek (Figure 5-10) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM station OK220200-03-0010G.

Figure 5-10 Load Duration Curve for Enterococci Sallisaw Creek (OK220200030010_20)



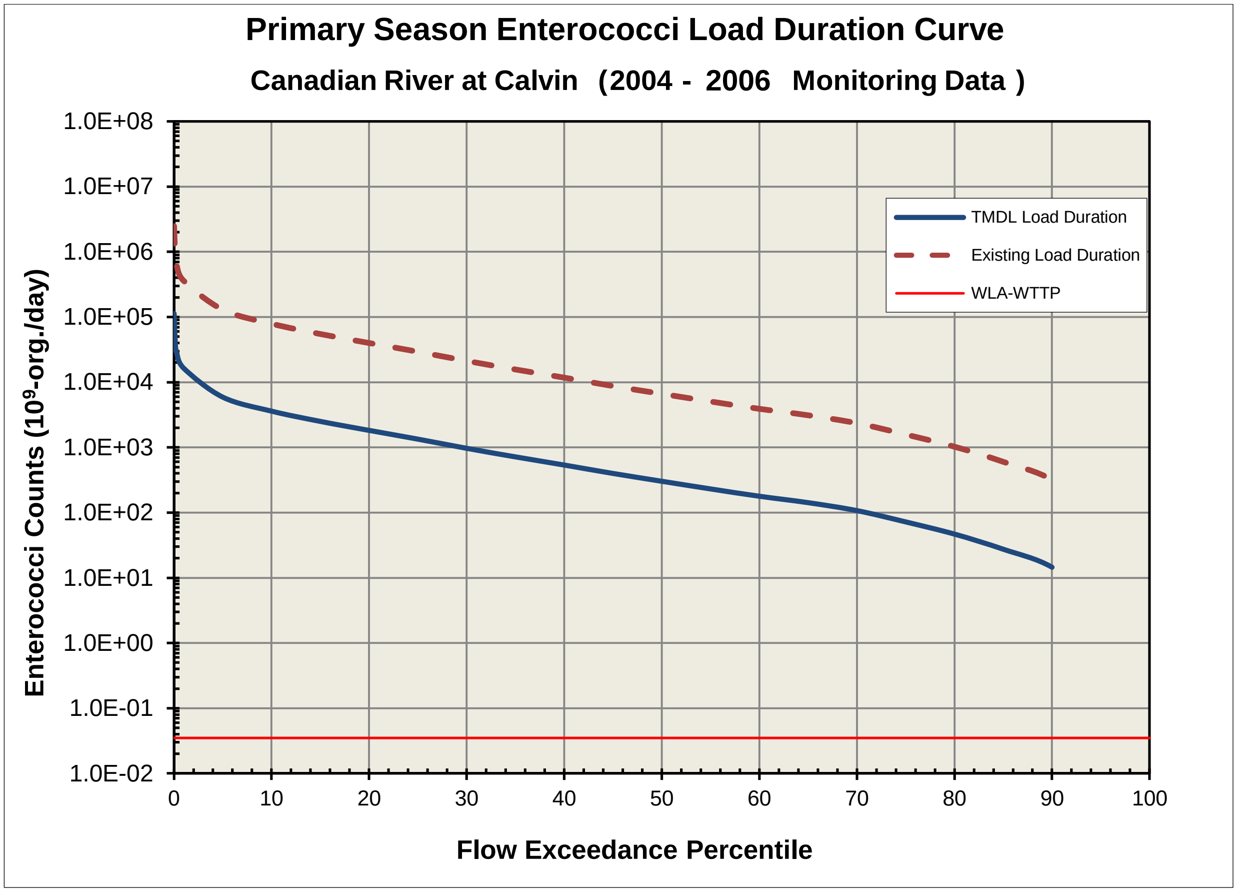
The LDC for Sans Bois Creek (Figure 5-11) is based on Enterococci measurements during primary contact recreation season at WQM stations OK220200-04-0010G.

Figure 5-11 Load Duration Curve for Enterococci in Sans Bois Creek (OK220200040010_10)



The LDC for the Canadian River (Figure 5-12) is based on Enterococci measurements during primary contact recreation season at WQM stations 220600010119-001AT.

Figure 5-12 Load Duration Curve for Enterococci in the Canadian River (OK220600010119_10)



5.3.2 TSS LDC

To calculate the TSS load at the WQ target, the flow rate (cfs) at each flow exceedance percentile is multiplied by a unit conversion factor (*5.39377*) and the TSS goal (mg/L) for each waterbody. This calculation produces the maximum TSS load in the waterbody that will result in attainment of the 50 NTU target for turbidity. The allowable TSS loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as a LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a TSS load in pounds per day.

To estimate existing loading, TSS and turbidity observations from 1998 to 2011 are paired with the flows measured or projected on the same date for the waterbody. For sampling events with both TSS and turbidity data, the measured TSS value is used. Pollutant loads are then calculated by multiplying the TSS concentration by the flow rate and the unit conversion factor. The associated flow exceedance percentile is then matched with the flow from the tables provided in Appendix B. The observed TSS or converted turbidity loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of TSS. Points above the LDC indicate the TSS goal was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample did not exceed the TSS goal.

Figures 5-13 through Figure 5-15 show the TSS LDCs developed for the waterbodies addressed in this TMDL report. Data in the figures indicate that for most waterbodies, TSS levels exceed the water quality target during all flow conditions, indicating water quality impairments due to nonpoint sources or a combination of point and nonpoint sources. Wet weather influenced samples found during low flow conditions can be caused by an isolated rainfall event during dry weather conditions. It is noted that the LDC plots include data under all flow conditions to show the overall condition of the waterbody. However, the turbidity standard only applies to base-flow conditions. Thus, when interpreting the LDC to derive TMDLs for TSS, only the portion of the graph corresponding to flows above the 25th flow exceedance percentile should be used. WLAs for point sources discharges (continuous) of inorganic TSS are shown on a LDC as a horizontal line which represents the sum of all WLAs for TSS in a given watershed.

Figure 5-13 Load Duration Curve for Total Suspended Solids in the Poteau River (OK220100010010_00)

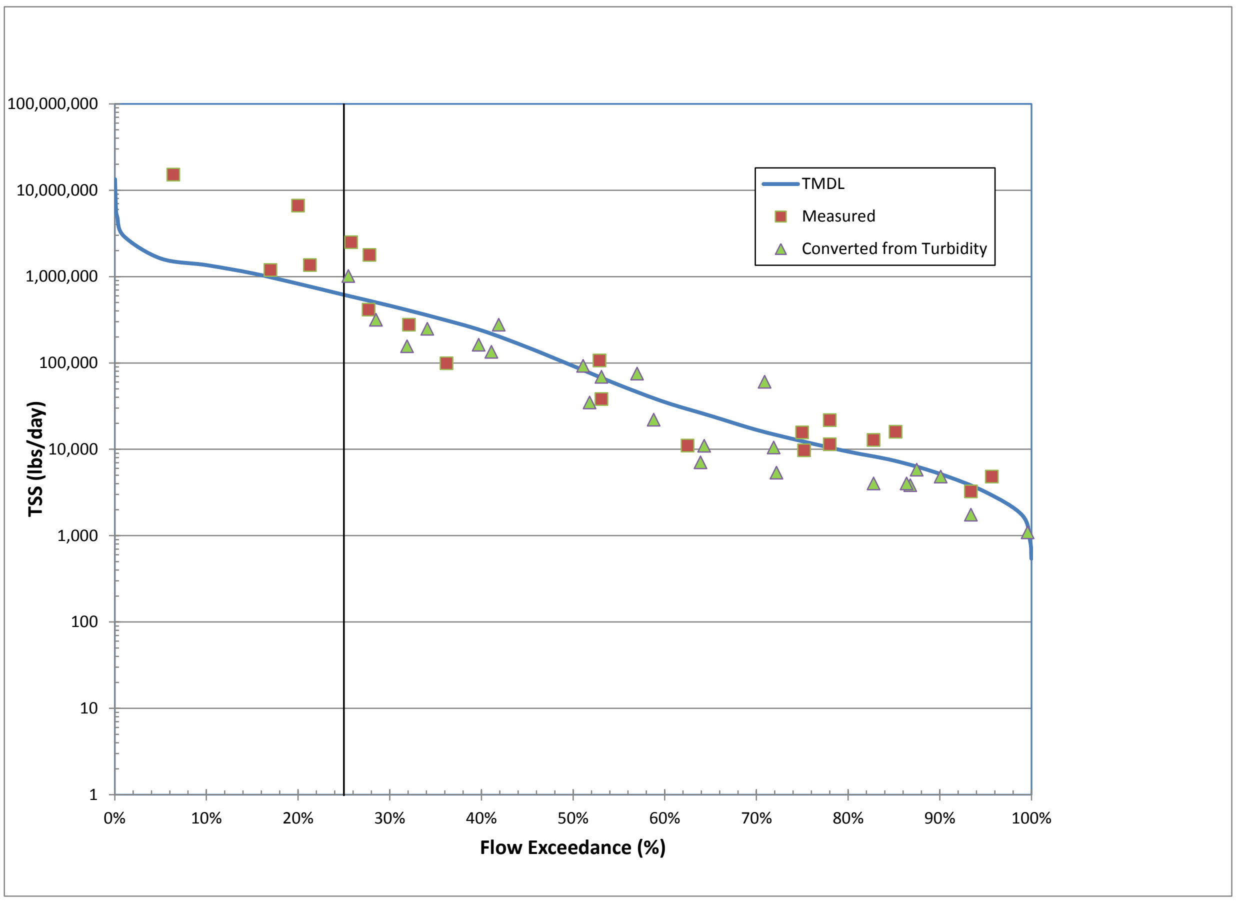
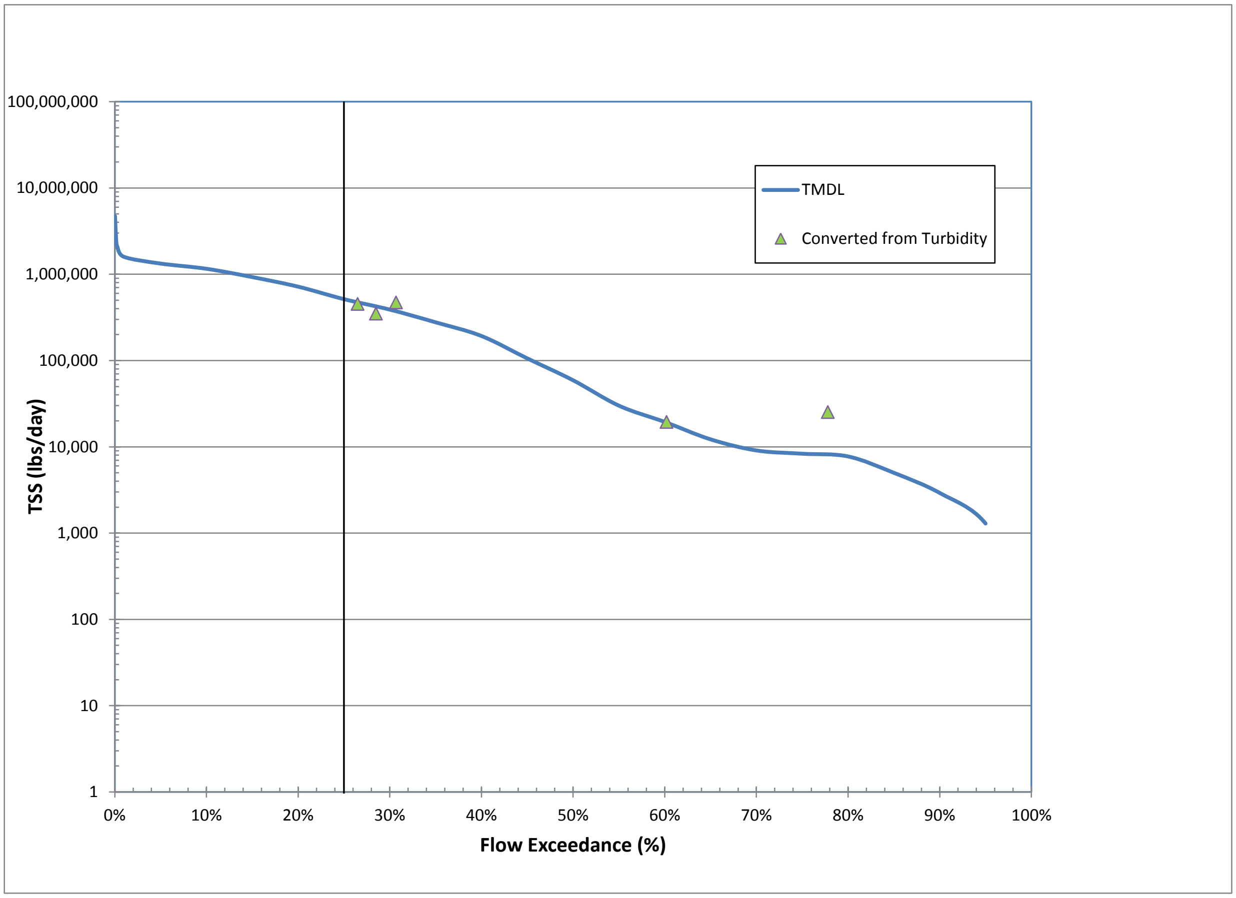
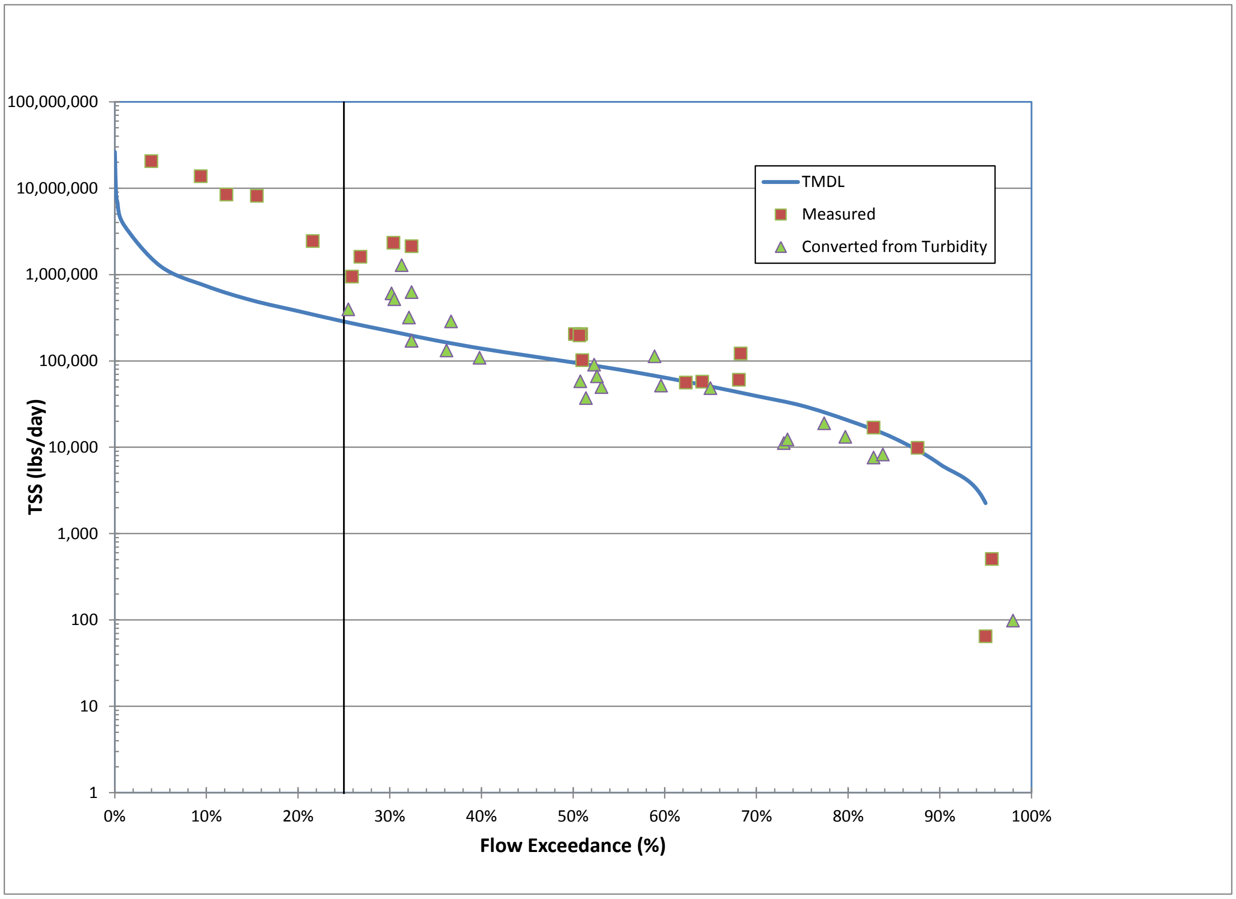


Figure 5-14 Load Duration Curve for Total Suspended Solids in the Poteau River (OK220100010010_40)*



* No measured TSS data available for this segment of the Poteau River.

Figure 5-15 Load Duration Curve for Total Suspended Solids in the Canadian River (OK220600010119_10)



5.3.3 Establishing Percent Reduction Goals

The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading and load reductions required to meet the TMDL can also be calculated under different flow conditions. The difference between existing loading and the TMDL is used to calculate the loading reductions required. PRGs are calculated through an iterative process of taking a series of percent reduction values, applying each value uniformly to the concentrations of samples and verifying if the geometric mean of the reduced values of all samples is less than the WQS geometric mean. Table 5-2 represents the percent reductions necessary to meet the TMDL water quality target for each bacterial indicator in each of the impaired waterbodies in the Study Area. The PRGs range from 61.4% to 96.4%.

Table 5-2 TMDL Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate
		ENT
OK220100030010_00	Brazil Creek	61.4%
OK220200030010_20	Sallisaw Creek	86.6%
OK220200040010_10	Sans Bois Creek	65.4%
OK220600010119_10	Canadian River	96.4%

PRGs for TSS are calculated as the required overall reduction so that no more than 10% of the samples exceed the water quality target for TSS. The PRGs for the seven waterbodies included in this TMDL report are summarized in Table 5-3 and range from 27.5% to 68.7%.

Table 5-3 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK220100010010_00	Poteau River	44.5%
OK220100010010_40	Poteau River	27.5%
OK220600010119_10	Canadian River	68.7%

5.4 Wasteload Allocation

5.4.1 Indicator Bacteria

For bacterial TMDLs, NPDES-permitted facilities are allocated a daily wasteload calculated as their permitted flow rate multiplied by the instream geometric mean water quality criterion. In other words, the facilities are required to meet instream criteria in their discharge. Table 5-4 summarizes the WLA for the NPDES-permitted facilities within the Study Area. The WLA for each facility discharging to a bacterially-impaired waterbody is derived from the following equation:

WLA = WQS * flow * unit conversion factor (cfu/day)

Where:

WQS = 33 and 126 cfu/100 mL for Enterococci and E. coli respectively

flow (mgd) = permitted flow

unit conversion factor = 37,854,120

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding waterbody. When there are no NPDES WWTFs discharging into the contributing watershed of a stream segment, then the WLA is zero. Compliance with the WLA will be achieved by adhering to the fecal coliform or *E. coli* limits and disinfection requirements of NPDES permits. Currently, facilities that discharge treated wastewater are currently required to monitor for fecal coliform. These discharges or any other discharges with a bacterial WLA will be required to monitor for *E. coli* as their permits are renewed.

Table 5-4 indicates which point source dischargers within the Study Area currently have a disinfection requirement in their permit. Certain facilities that utilize lagoons for treatment have not been required to provide disinfection since storage time and exposure to ultraviolet radiation from sunlight should reduce bacterial levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacterial limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacterial load from existing discharges will be considered consistent with the TMDL provided that the NPDES permit requires instream criteria to be met.

Permitted stormwater discharges are considered point sources; however, there are no areas designated as MS4s within the watersheds of the Study Area impaired for contact recreation, so there aren't any WLAs for MS4s.

Table 5-4 Bacterial Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID	Stream Name	Name	NPDES Permit No.	Dis-infection?	Design Flow (mg/d)	Wasteload Allocation ($x10^8$ cfu/day)
						ENT
OK220100030010_00	Brazil Creek	**Bokoshe PWA**	OK0027731	No	0.09	1.12
OK220600010119_10	Canadian River	**Town of Calvin**	OK0037818	Yes	0.028	0.35

5.4.2 Total Suspended Solids

NPDES-permitted facilities discharging inorganic TSS are allocated a daily wasteload calculated by using the average of self-reported monthly flow multiplied by the water quality target. In other words, the facilities are required to meet instream criteria in their discharge. If the current monthly TSS limits of a facility are greater than instream TSS criteria, the new limits equal to instream criteria will be applied to the facility as their permit is renewed. Table 5-5 summarizes the WLA for the NPDES-permitted facilities within the Study Area. The WLA for each facility is derived as follows:

WLA_WWTF = WQ goal * flow * unit conversion factor (lb/day)

Where:

WQ goal = Waterbody specific water quality goal provided in Table 5-1, or monthly TSS limit in the current permit, whichever is smaller

flow (mgd) = average monthly flow

unit conversion factor = 8.3445

Table 5-5 Total Suspended Solids Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID	Stream Name	Name	NPDES Permit No.	Average Monthly Flow (mgd)	In-stream TSS criteria	Wasteload Allocation (lb/day)
OK220100010010_00	Poteau River	**Shady Pt Cogen. Facility**	OK0040169	1.12	37 mg/L	346.5
OK220100010010_00	Poteau River	**Georges Colliers, Inc. #8**	OK0042781	0.07	37 mg/L	21.7
OK220100010010_00	Poteau River	**Blake Construction Incorp.**	OKR050184	0.01*	37 mg/L	3.1
OK220100010010_40	Poteau River	**Kansas City So. Ry. Co**	OK0040631	0.004	37 mg/L	1.2

* Flow was assumed equal to 0.01 MGD for allocation purposes.

By definition, any stormwater discharge occurs during periods of rainfall and elevated flow conditions. Oklahoma's Water Quality Standards specify that the criteria for turbidity "apply only to seasonal base flow conditions" and go on to say "Elevated turbidity levels may be expected during, and for several days after, a runoff event" [OAC 785:45-5-12(f)(7)]. To accommodate the potential for future growth in the watersheds of turbidity impaired stream segments, 1% of TSS loading is reserved as part of the WLA.

5.4.3 Section 404 permits

No TSS WLAs were set aside for Section 404 Permits. The State will use its Section 401 Certification authority to ensure Section 404 Permits protect Oklahoma WQS and comply with TSS TMDLs in this report. Section 401 Certification will be conditioned to meet one of the following two conditions to be certified by the state:

- Include TSS limits in the permit and establish a monitoring requirement to ensure compliance with turbidity standards and TSS TMDLs; or
- Submit to DEQ a BMP turbidity reduction plan which should include all practicable turbidity control techniques. The turbidity reduction plan must be approved first before a Section 401 Certification can be issued.

Compliance with the Section 401 Certification condition will be considered compliance with this TMDL.

5.5 Load Allocation

As discussed in Section 3, nonpoint source bacterial loading to each waterbody emanate from a number of different sources. The data analysis and the LDCs indicate that exceedances for each waterbody are the result of a variety of nonpoint source loading. The LAs for each bacterial indicator in waterbodies not supporting the PBCR use are calculated as the difference between the TMDL, MOS, and WLA, as follows:

LA = TMDL – WLA_WWTF – WLA_MS4 – MOS

This equation is used to calculate the LA for TSS however the LA is further reduced by allocating 1% of the TMDL as part of the WLA:

LA = TMDL – WLA_WWTF – WLA_MS4 – WLA_growth – MOS

5.6 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. The bacterial TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1st through September 30th. Similarly, the turbidity TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS for turbidity, which applies to seasonal base flow conditions only. Seasonal variation was also accounted for in these TMDLs by using five years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.7 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. For bacterial TMDLs, an explicit MOS was set at 10%.

For turbidity, the TMDLs are calculated for TSS instead of turbidity. Thus, the quality of the regression has a direct impact on confidence of the TMDL calculations. The better the regression is, the more confidence there is in the TMDL targets. As a result, it leads to a smaller MOS. The selection of MOS is based on the NRMSE for each waterbody. The explicit MOS ranged from 10% to 15%. Table 5-1 shows the MOS for each waterbody.

5.8 TMDL Calculations

The TMDLs for the 303(d)-listed waterbodies covered in this report were derived using LDCs. 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 lack of knowledge concerning the relationship between pollutant loading and water quality.

This definition can be expressed by the following equation:

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

The TMDL represents a continuum of desired load over all flow conditions, rather than fixed at a single value, because loading capacity varies as a function of the flow present in the stream. The higher the flow is, the more wasteload the stream can handle without violating WQS. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges or increased load from existing discharges will be considered consistent with the TMDL provided the NPDES permit requires instream criteria to be met.

The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5th flow interval percentile. Tables 5-6 and 5-7 summarize the TMDL, WLA, LA and MOS loadings at the 50% flow percentile. Tables 5-8 through 5-11 summarize the allocations for indicator bacteria. The bacterial TMDLs calculated in these tables apply to the recreation season (May 1 through September 30) only. Tables 5-12 to 5-14 present the allocations for total suspended solids.

Table 5-6 Summaries of Bacterial TMDLs

Stream Name	Waterbody ID	Pollutant	TMDL (cfu/day)	$WLA_{\_WWTF}$ (cfu/day)	$WLA_{\_MS4}$ (cfu/day)	LA (cfu/day)	MOS (cfu/day)
Brazil Creek	OK220100030010_00	ENT	9.01E+09	1.12E+08	0.00E+00	7.99E+09	9.01E+08
Sallisaw Creek	OK220200030010_20	ENT	1.11E+10	0.00E+00	0.00E+00	1.00E+10	1.11E+09
Sans Bois Creek	OK220200040010_10	ENT	1.03E+10	0.00E+00	0.00E+00	9.25E+09	1.03E+09
Canadian River	OK220600010119_10	ENT	3.03E+11	3.50E+07	0.00E+00	2.72E+11	3.03E+10

Table 5-7 Summaries of TSS TMDLs

Stream Name	Waterbody ID	Pollutant	TMDL (lbs/day)	WLA (lbs/day)	$WLA_{\_MS4}$ (cfu/day)	$WLA_{\_Growth}$ (lbs/day)	LA (lbs/day)	MOS (lbs/day)
Poteau River	OK220100010010_00	TSS	92,138	371.3	0.0	921.4	81,631	9,214
Poteau River	OK220100010010_40	TSS	59,041	1.2	0.0	590.4	52,546	5,904
Canadian River	OK220600010119_10	TSS	95,849	0.0	0.0	958.5	80,513	14,377

Table 5-8 Enterococci TMDL Calculations for Brazil Creek (OK220100030010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	8,667.9	7.00E+12	1.12E+08	0.00E+00	6.30E+12	7.00E+11
5	614.6	4.96E+11	1.12E+08	0.00E+00	4.46E+11	4.96E+10
10	280.5	2.26E+11	1.12E+08	0.00E+00	2.04E+11	2.26E+10
15	145.9	1.18E+11	1.12E+08	0.00E+00	1.06E+11	1.18E+10
20	85.0	6.86E+10	1.12E+08	0.00E+00	6.16E+10	6.86E+09
25	54.9	4.43E+10	1.12E+08	0.00E+00	3.98E+10	4.43E+09
30	38.6	3.12E+10	1.12E+08	0.00E+00	2.79E+10	3.12E+09
35	28.3	2.29E+10	1.12E+08	0.00E+00	2.05E+10	2.29E+09
40	21.5	1.73E+10	1.12E+08	0.00E+00	1.55E+10	1.73E+09
45	14.6	1.18E+10	1.12E+08	0.00E+00	1.05E+10	1.18E+09
50	11.2	9.01E+09	1.12E+08	0.00E+00	7.99E+09	9.01E+08
55	8.6	6.93E+09	1.12E+08	0.00E+00	6.12E+09	6.93E+08
60	6.8	5.46E+09	1.12E+08	0.00E+00	4.80E+09	5.46E+08
65	5.4	4.36E+09	1.12E+08	0.00E+00	3.82E+09	4.36E+08
70	4.3	3.51E+09	1.12E+08	0.00E+00	3.04E+09	3.51E+08
75	3.3	2.70E+09	1.12E+08	0.00E+00	2.32E+09	2.70E+08
80	2.66	2.15E+09	1.12E+08	0.00E+00	1.82E+09	2.15E+08
85	1.97	1.59E+09	1.12E+08	0.00E+00	1.32E+09	1.59E+08
90	1.37	1.11E+09	1.12E+08	0.00E+00	8.85E+08	1.11E+08
95	0.74	6.01E+08	1.12E+08	0.00E+00	4.29E+08	6.01E+07
100	0.14	1.12E+00	1.12E+08	0.00E+00	0.00E+00	0.00E+00

Table 5-9 Enterococci TMDL Calculations for Sallisaw Creek (OK220200030010_20)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4,208.1	3.40E+12	0.00E+00	0.00E+00	3.06E+12	3.40E+11
5	468.2	3.78E+11	0.00E+00	0.00E+00	3.40E+11	3.78E+10
10	213.9	1.73E+11	0.00E+00	0.00E+00	1.55E+11	1.73E+10
15	111.2	8.98E+10	0.00E+00	0.00E+00	8.08E+10	8.98E+09
20	69.0	5.57E+10	0.00E+00	0.00E+00	5.01E+10	5.57E+09
25	47.1	3.81E+10	0.00E+00	0.00E+00	3.42E+10	3.81E+09
30	33.3	2.69E+10	0.00E+00	0.00E+00	2.42E+10	2.69E+09
35	26.4	2.13E+10	0.00E+00	0.00E+00	1.92E+10	2.13E+09
40	20.7	1.67E+10	0.00E+00	0.00E+00	1.50E+10	1.67E+09
45	16.1	1.30E+10	0.00E+00	0.00E+00	1.17E+10	1.30E+09
50	13.8	1.11E+10	0.00E+00	0.00E+00	1.00E+10	1.11E+09
55	10.3	8.35E+09	0.00E+00	0.00E+00	7.52E+09	8.35E+08
60	7.5	6.03E+09	0.00E+00	0.00E+00	5.43E+09	6.03E+08
65	5.3	4.27E+09	0.00E+00	0.00E+00	3.84E+09	4.27E+08
70	3.6	2.88E+09	0.00E+00	0.00E+00	2.59E+09	2.88E+08
75	2.4	1.95E+09	0.00E+00	0.00E+00	1.75E+09	1.95E+08
80	1.38	1.11E+09	0.00E+00	0.00E+00	1.00E+09	1.11E+08
85	0.66	5.31E+08	0.00E+00	0.00E+00	4.78E+08	5.31E+07
90	0.23	1.86E+08	0.00E+00	0.00E+00	1.67E+08	1.86E+07
95	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5-10 Enterococci TMDL Calculations for Sans Bois Creek (OK220200040010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	12,526.8	1.01E+13	0.00E+00	0.00E+00	9.10E+12	1.01E+12
5	1,017.9	8.22E+11	0.00E+00	0.00E+00	7.40E+11	8.22E+10
10	415.3	3.35E+11	0.00E+00	0.00E+00	3.02E+11	3.35E+10
15	189.2	1.53E+11	0.00E+00	0.00E+00	1.37E+11	1.53E+10
20	115.6	9.33E+10	0.00E+00	0.00E+00	8.40E+10	9.33E+09
25	73.7	5.95E+10	0.00E+00	0.00E+00	5.35E+10	5.95E+09
30	51.9	4.19E+10	0.00E+00	0.00E+00	3.77E+10	4.19E+09
35	36.8	2.97E+10	0.00E+00	0.00E+00	2.68E+10	2.97E+09
40	25.1	2.03E+10	0.00E+00	0.00E+00	1.83E+10	2.03E+09
45	18.4	1.49E+10	0.00E+00	0.00E+00	1.34E+10	1.49E+09
50	12.7	1.03E+10	0.00E+00	0.00E+00	9.25E+09	1.03E+09
55	9.5	7.71E+09	0.00E+00	0.00E+00	6.94E+09	7.71E+08
60	7.5	6.08E+09	0.00E+00	0.00E+00	5.48E+09	6.08E+08
65	5.7	4.60E+09	0.00E+00	0.00E+00	4.14E+09	4.60E+08
70	4.4	3.52E+09	0.00E+00	0.00E+00	3.16E+09	3.52E+08
75	3.2	2.57E+09	0.00E+00	0.00E+00	2.31E+09	2.57E+08
80	2.01	1.62E+09	0.00E+00	0.00E+00	1.46E+09	1.62E+08
85	1.32	1.06E+09	0.00E+00	0.00E+00	9.56E+08	1.06E+08
90	0.62	5.00E+08	0.00E+00	0.00E+00	4.50E+08	5.00E+07
95	0.15	1.22E+08	0.00E+00	0.00E+00	1.10E+08	1.22E+07
100	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5-11 Enterococci TMDL Calculations for the Canadian River (OK220600010119_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	140,000.0	1.13E+14	3.50E+07	0.00E+00	1.02E+14	1.13E+13
5	7,314.5	5.90E+12	3.50E+07	0.00E+00	5.31E+12	5.90E+11
10	4,460.0	3.60E+12	3.50E+07	0.00E+00	3.24E+12	3.60E+11
15	3,104.5	2.51E+12	3.50E+07	0.00E+00	2.26E+12	2.51E+11
20	2,260.0	1.82E+12	3.50E+07	0.00E+00	1.64E+12	1.82E+11
25	1,660.0	1.34E+12	3.50E+07	0.00E+00	1.21E+12	1.34E+11
30	1,200.0	9.69E+11	3.50E+07	0.00E+00	8.72E+11	9.69E+10
35	887.0	7.16E+11	3.50E+07	0.00E+00	6.44E+11	7.16E+10
40	665.0	5.37E+11	3.50E+07	0.00E+00	4.83E+11	5.37E+10
45	494.0	3.99E+11	3.50E+07	0.00E+00	3.59E+11	3.99E+10
50	375.0	3.03E+11	3.50E+07	0.00E+00	2.72E+11	3.03E+10
55	286.0	2.31E+11	3.50E+07	0.00E+00	2.08E+11	2.31E+10
60	221.0	1.78E+11	3.50E+07	0.00E+00	1.61E+11	1.78E+10
65	176.0	1.42E+11	3.50E+07	0.00E+00	1.28E+11	1.42E+10
70	133.0	1.07E+11	3.50E+07	0.00E+00	9.66E+10	1.07E+10
75	89.3	7.20E+10	3.50E+07	0.00E+00	6.48E+10	7.20E+09
80	58.00	4.68E+10	3.50E+07	0.00E+00	4.21E+10	4.68E+09
85	34.00	2.74E+10	3.50E+07	0.00E+00	2.47E+10	2.74E+09
90	18.00	1.45E+10	3.50E+07	0.00E+00	1.30E+10	1.45E+09
95	4.79	3.86E+09	3.50E+07	0.00E+00	3.44E+09	3.86E+08
100	0.04	3.50E+07	3.50E+07	0.00E+00	0.00E+00	0.00E+00

Table 5-12 Total Suspended Solids TMDL Calculations for the Poteau River (OK220100010010_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
0	67,000.0	N/A	0.0	0.0	N/A	N/A	N/A
5	8,100.0	N/A	0.0	0.0	N/A	N/A	N/A
10	6,785.0	N/A	0.0	0.0	N/A	N/A	N/A
15	5,460.0	N/A	0.0	0.0	N/A	N/A	N/A
20	4,130.0	N/A	0.0	0.0	N/A	N/A	N/A
25	3,072.5	614,084.7	371.3	0.0	6,140.8	546,164.1	61,408.5
30	2,300.0	459,689.1	371.3	0.0	4,596.9	408,752.0	45,968.9
35	1,680.0	335,772.9	371.3	0.0	3,357.7	298,466.6	33,577.3
40	1,190.0	237,839.1	371.3	0.0	2,378.4	211,305.6	23,783.9
45	759.5	151,797.3	371.3	0.0	1,518.0	134,728.4	15,179.7
50	461.0	92,137.7	371.3	0.0	921.4	81,631.3	9,213.8
55	278.0	55,562.4	371.3	0.0	555.6	49,079.3	5,556.2
60	176.0	35,176.2	371.3	0.0	351.8	30,935.6	3,517.6
65	122.0	24,383.5	371.3	0.0	243.8	21,330.1	2,438.4
70	84.0	16,788.6	371.3	0.0	167.9	14,570.6	1,678.9
75	62.0	12,391.6	371.3	0.0	123.9	10,657.3	1,239.2
80	47.0	9,393.6	371.3	0.0	93.9	7,989.1	939.4
85	37.0	7,395.0	371.3	0.0	73.9	6,210.3	739.5
90	26.0	5,196.5	371.3	0.0	52.0	4,253.6	519.6
95	16.0	3,197.8	371.3	0.0	32.0	2,474.8	319.8
100	1.9	371.3	371.3	0.0	0.0	0.0	0.0

NA = Not Applicable

Table 5-13 Total Suspended Solids TMDL Calculations for the Poteau River (OK220100010010_40)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
0	23,642.5	N/A	0.0	0.0	N/A	N/A	N/A
5	6,650.7	N/A	0.0	0.0	N/A	N/A	N/A
10	5,788.2	N/A	0.0	0.0	N/A	N/A	N/A
15	4,635.2	N/A	0.0	0.0	N/A	N/A	N/A
20	3,591.0	N/A	0.0	0.0	N/A	N/A	N/A
25	2,573.4	514,324.0	1.2	0.0	5,143.2	457,747.1	51,432.4
30	1,947.4	389,218.3	1.2	0.0	3,892.2	346,403.0	38,921.8
35	1,387.1	277,241.3	1.2	0.0	2,772.4	246,743.5	27,724.1
40	963.0	192,471.8	1.2	0.0	1,924.7	171,298.7	19,247.2
45	529.6	105,847.4	1.2	0.0	1,058.5	94,203.0	10,584.7
50	295.4	59,041.4	1.2	0.0	590.4	52,545.6	5,904.1
55	150.0	29,979.7	1.2	0.0	299.8	26,680.7	2,998.0
60	97.1	19,411.0	1.2	0.0	194.1	17,274.5	1,941.1
65	61.0	12,199.8	1.2	0.0	122.0	10,856.6	1,220.0
70	45.4	9,075.2	1.2	0.0	90.8	8,075.7	907.5
75	41.6	8,316.2	1.2	0.0	83.2	7,400.2	831.6
80	38.7	7,729.2	1.2	0.0	77.3	6,877.7	772.9
85	25.0	4,992.4	1.2	0.0	49.9	4,442.0	499.2
90	14.6	2,918.8	1.2	0.0	29.2	2,596.5	291.9
95	6.5	1,290.8	1.2	0.0	12.9	1,147.6	129.1
100	0.1	1.2	1.2	0.0	0.0	0.0	0.0

NA = Not Applicable

Table 5-14 Total Suspended Solids TMDL Calculations for the Canadian River (OK220600010119_10)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
0	140,000.0	N/A	0.0	0.0	N/A	N/A	N/A
5	6,640.0	N/A	0.0	0.0	N/A	N/A	N/A
10	3,910.0	N/A	0.0	0.0	N/A	N/A	N/A
15	2,670.0	N/A	0.0	0.0	N/A	N/A	N/A
20	2,010.0	N/A	0.0	0.0	N/A	N/A	N/A
25	1,520.0	285,107.5	0.0	0.0	2,851.1	239,490.3	42,766.1
30	1,180.0	221,333.5	0.0	0.0	2,213.3	185,920.1	33,200.0
35	920.0	172,565.1	0.0	0.0	1,725.7	144,954.7	25,884.8
40	740.0	138,802.3	0.0	0.0	1,388.0	116,594.0	20,820.4
45	614.0	115,168.4	0.0	0.0	1,151.7	96,741.5	17,275.3
50	511.0	95,848.6	0.0	0.0	958.5	80,512.9	14,377.3
55	423.0	79,342.4	0.0	0.0	793.4	66,647.6	11,901.4
60	341.0	63,961.6	0.0	0.0	639.6	53,727.8	9,594.2
65	269.0	50,456.5	0.0	0.0	504.6	42,383.5	7,568.5
70	209.0	39,202.3	0.0	0.0	392.0	32,929.9	5,880.3
75	161.0	30,198.9	0.0	0.0	302.0	25,367.1	4,529.8
80	109.0	20,445.2	0.0	0.0	204.5	17,174.0	3,066.8
85	68.0	12,754.8	0.0	0.0	127.5	10,714.0	1,913.2
90	34.0	6,377.4	0.0	0.0	63.8	5,357.0	956.6
95	12.0	2,250.8	0.0	0.0	22.5	1,890.7	337.6
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0

NA = Not Applicable

5.9 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 at DEQ's website: http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf.

Table 5-15 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 5-15 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	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.ok.gov/quality/index.php

5.9.1 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 & gas industry (retained by the Oklahoma Corporation Commission) for which the 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/606.pdf)]. Point source WLAs are outlined in the Oklahoma Water Quality Management Plan (aka the 208 Plan) under the OPDES program.

5.9.2 Nonpoint Sources

Nonpoint source pollution in Oklahoma is managed by the Oklahoma Conservation Commission. The Oklahoma Conservation Commission works with state partners such as ODAFF and federal partners such as the EPA and the National Resources Conservation Service of the USDA, to address water quality problems similar to those seen in the Study Area. The 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 called for in this TMDL report are as high as 96.4%. DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of both bacterial and TSS loading. The high reduction rates are not uncommon for pathogen- or TSS-impaired waters. Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of a waterbody should be reviewed. For example, the Kansas Department of Environmental Quality has proposed to exclude certain high flow conditions during which pathogen standards will not apply, although that exclusion was not approved by the EPA. Additionally, EPA has been conducting new epidemiology studies and may develop new recommendations for pathogen criteria in the near future.

Revisions to the current pathogen provisions of Oklahoma's WQSs should be considered. There are three basic approaches to such revisions that may apply.

- Removing the PBCR use: This revision would require documentation in a Use Attainability Analysis that the use is not an existing use and cannot be attained. It is unlikely that this approach would be successful since there is evidence that people do swim in this segment of the river, thus constituting an existing use. Existing uses cannot be removed.
- Modifying application of the existing criteria: This approach would include considerations such as an exemption under certain high flow conditions, an allowance for wildlife or "natural conditions," a sub-category of the use or other special provision for urban areas, or other special provisions for storm flows. Since large bacterial violations occur over all flow ranges, it is likely that large reductions would still be necessary. However, this approach may have merit and should be considered.
- Revising the existing numeric criteria: Oklahoma's current pathogen criteria, revised in 2011, are based on EPA guidelines (See the *2012 Draft Recreational Water Quality Criteria*, December 2011; Implementation Guidance for Ambient Water Quality Criteria for Bacteria, May 2002 Draft; and Ambient Water Quality Criteria for Bacteria-1986, January 1986). However, those guidelines have received much criticism and EPA studies that could result in revisions to their recommendations are ongoing. The numeric criteria values should also be evaluated using a risk-based method such as that found in EPA guidance.

Unless or until the WQSs are revised and approved by EPA, federal rules require that the TMDLs in this report must be based on attainment of the current standards. If revisions to the pathogen standards are approved in the future, reductions specified in these TMDLs will be re-evaluated.

5.10 Reasonable Assurances

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 discharging discharge limitations less than or equal to the water quality standards numerical criteria. This ensures that the impairments of the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

SECTION 6
PUBLIC PARTICIPATION

The draft TMDL report was preliminary reviewed by EPA prior to the public notice. The public notice was then sent to local newspapers, to stakeholders in the area affected by the TMDLs in the Lower Arkansas River Study Area, and to stakeholders who have requested copies of all TMDL public notices. The public notice was also posted at the DEQ website: http://www.deq.state.ok.us/wqdnew/index.htm.

The public comment period lasted 45 days and was open from January 30, 2014 to March 17, 2014. During that time, the public had the opportunity to review the draft TMDL report and make written comments. One comment was received. The response to that comment is in Appendix F. The comment and response are part of the record of this TMDL report. There were no requests for a public meeting.

After EPA's final approval, each TMDL was adopted into Oklahoma's Water Quality Management Plan (WQMP). These TMDLs provide a mathematical solution to meet ambient water quality criterion with a given set of facts. The 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. The updates to the WQMP are also useful when the water quality criterion changes and the loading scenario is reviewed to ensure that the instream criterion is predicted to be met.

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APPENDIX A: AMBIENT WATER QUALITY DATA

TABLE A - 1 Bacterial Data: 2004 to 2010

Waterbody Name	WQM Station	Date	EC[1]	ENT[1,2]
Poteau River	220100010010-001AT	5/23/2006		30
Poteau River	220100010010-001AT	6/27/2006		41
Poteau River	220100010010-001AT	7/10/2006		30
Poteau River	220100010010-001AT	7/26/2006		< 10
Poteau River	220100010010-001AT	8/1/2006		< 10
Poteau River	220100010010-001AT	8/16/2006		31
Poteau River	220100010010-001AT	8/23/2006		< 10
Poteau River	220100010010-001AT	8/29/2006		< 10
Poteau River	220100010010-001AT	9/6/2006		< 10
Poteau River	220100010010-001AT	9/18/2006		318
Poteau River	220100010010-001AT	5/19/2008		30
Poteau River	220100010010-001AT	6/11/2008		< 10
Poteau River	220100010010-001AT	7/2/2008		< 10
Poteau River	220100010010-001AT	7/23/2008		< 10
Brazil Creek	OK220100-03-0010G	6/10/2008		160
Brazil Creek	OK220100-03-0010G	7/14/2008		30
Brazil Creek	OK220100-03-0010G	8/18/2008		180
Brazil Creek	OK220100-03-0010G	9/15/2008		1080
Brazil Creek	OK220100-03-0010G	5/4/2009		1600
Brazil Creek	OK220100-03-0010G	6/8/2009		10
Brazil Creek	OK220100-03-0010G	7/13/2009		< 10
Brazil Creek	OK220100-03-0010G	8/17/2009		20
Brazil Creek	OK220100-03-0010G	9/21/2009		20
Brazil Creek	OK220100-03-0010G	5/17/2010		240
Sallisaw Creek	OK220200-03-0010G	6/10/2008		200
Sallisaw Creek	OK220200-03-0010G	7/15/2008		135
Sallisaw Creek	OK220200-03-0010G	8/18/2008		200
Sallisaw Creek	OK220200-03-0010G	9/23/2008		55
Sallisaw Creek	OK220200-03-0010G	5/5/2009		860
Sallisaw Creek	OK220200-03-0010G	6/9/2009		10
Sallisaw Creek	OK220200-03-0010G	7/14/2009		165
Sallisaw Creek	OK220200-03-0010G	8/18/2009		80
Sallisaw Creek	OK220200-03-0010G	9/22/2009		1000
Sallisaw Creek	OK220200-03-0010G	5/11/2010		8050
Sans Bois Creek	OK220200-04-0010G	5/25/2005		1000
Sans Bois Creek	OK220200-04-0010G	6/10/2008		980
Sans Bois Creek	OK220200-04-0010G	7/14/2008		10
Sans Bois Creek	OK220200-04-0010G	8/18/2008		100
Sans Bois Creek	OK220200-04-0010G	5/4/2009		500
Sans Bois Creek	OK220200-04-0010G	6/8/2009		20

Waterbody Name	WQM Station	Date	EC[1]	ENT[1,2]
Sans Bois Creek	OK220200-04-0010G	7/13/2009		< 10
Sans Bois Creek	OK220200-04-0010G	8/17/2009		20
Sans Bois Creek	OK220200-04-0010G	9/21/2009		20
Sans Bois Creek	OK220200-04-0010G	5/17/2010		1100
Little Lee Creek	220200050040-001AT	5/27/2008		405
Little Lee Creek	220200050040-001AT	6/18/2008		10
Little Lee Creek	220200050040-001AT	7/7/2008		10
Little Lee Creek	220200050040-001AT	7/28/2008		10
Little Lee Creek	220200050040-001AT	8/18/2008		10
Canadian River	220600010119-001AT	5/3/2004		662
Canadian River	220600010119-001AT	5/17/2004		282
Canadian River	220600010119-001AT	6/16/2004		257
Canadian River	220600010119-001AT	6/21/2004		1390
Canadian River	220600010119-001AT	7/6/2004		2370
Canadian River	220600010119-001AT	7/26/2004		135
Canadian River	220600010119-001AT	8/9/2004		103
Canadian River	220600010119-001AT	8/31/2004		175
Canadian River	220600010119-001AT	9/13/2004		78
Canadian River	220600010119-001AT	9/27/2004		27
Canadian River	220600010119-001AT	5/1/2006		2650
Canadian River	220600010119-001AT	5/30/2006		16

[1] EC = *E. coli*; according to the DEQ 2010 303(d) List none of the studied waterbodies is impaired for EC; data not presented here.

[2] ENT = Enterococci; units = counts/100 mL.

TABLE A - 2 Turbidity and Total Suspended Solids Data: 1998-2011

Waterbody Name	Waterbody ID	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Poteau River	OK220100010010_00	11/16/1998	38	25	Low
Poteau River	OK220100010010_00	1/19/1999	28	21	Low
Poteau River	OK220100010010_00	2/9/1999	95	66	High
Poteau River	OK220100010010_00	3/9/1999	380	296	High
Poteau River	OK220100010010_00	4/13/1999	70	45	High
Poteau River	OK220100010010_00	5/10/1999	37	29	Low
Poteau River	OK220100010010_00	6/14/1999	389	364	High
Poteau River	OK220100010010_00	7/12/1999	260	156	Low
Poteau River	OK220100010010_00	8/10/1999	68	40	Low
Poteau River	OK220100010010_00	9/22/1999	69	14	Low
Poteau River	OK220100010010_00	10/11/1999	92	56	Low
Poteau River	OK220100010010_00	11/8/1999	84	30	Low
Poteau River	OK220100010010_00	12/7/1999	50	29	Low
Poteau River	OK220100010010_00	1/24/2000	39	57	Low
Poteau River	OK220100010010_00	5/8/2000	181	126	Low
Poteau River	OK220100010010_00	7/18/2000	50	46	Low
Poteau River	OK220100010010_00	8/15/2000	70	58	Low
Poteau River	OK220100010010_00	9/12/2000	92	80	Low
Poteau River	OK220100010010_00	10/10/2000	146	76	Low
Poteau River	OK220100010010_00	11/6/2000	111	12	Low
Poteau River	OK220100010010_00	2/14/2007	195		High
Poteau River	OK220100010010_00	3/20/2007	20		Low
Poteau River	OK220100010010_00	4/17/2007	51		Low
Poteau River	OK220100010010_00	5/22/2007	69		Low
Poteau River	OK220100010010_00	6/26/2007	56		Low
Poteau River	OK220100010010_00	7/31/2007	111		High
Poteau River	OK220100010010_00	8/28/2007	45		Low
Poteau River	OK220100010010_00	10/9/2007	84		Low
Poteau River	OK220100010010_00	11/14/2007	27		Low
Poteau River	OK220100010010_00	12/19/2007	87		Low
Poteau River	OK220100010010_00	2/5/2008	27		Low
Poteau River	OK220100010010_00	4/8/2008	44		High
Poteau River	OK220100010010_00	6/10/2008	21		Low
Poteau River	OK220100010010_00	8/5/2008	46		Low
Poteau River	OK220100010010_00	10/14/2008	34		Low
Poteau River	OK220100010010_00	12/9/2008	17		Low
Poteau River	OK220100010010_00	2/3/2009	33.5		Low
Poteau River	OK220100010010_00	3/17/2009	12		Low
Poteau River	OK220100010010_00	4/14/2009	98		High

Waterbody Name	Waterbody ID	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Poteau River	OK220100010010_00	6/9/2009	24		High
Poteau River	OK220100010010_00	8/4/2009	207		Low
Poteau River	OK220100010010_00	10/7/2009	107.5		High
Poteau River	OK220100010010_00	12/9/2009	17.3		Low
Poteau River	OK220100010010_00	2/17/2010	30		High
Poteau River	OK220100010010_00	4/6/2010	61		High
Poteau River	OK220100010010_00	6/8/2010	32		Low
Poteau River	OK220100010010_00	10/13/2010	42		Low
Poteau River	OK220100010010_00	12/7/2010	23.3		Low
Poteau River	OK220100010010_00	3/1/2011	29.3		Low
Poteau River	OK220100010010_00	4/5/2011	20.5		Low
Poteau River	OK220100010010_00	6/8/2011	30.3		Low
Poteau River	OK220100010010_00	8/2/2011	27.5		Low
Poteau River	OK220100010010_40	6/12/2001	48		Low
Poteau River	OK220100010010_40	7/10/2001	171		Low
Poteau River	OK220100010010_40	1/8/2002	41		Low
Poteau River	OK220100010010_40	2/12/2002	63		Low
Poteau River	OK220100010010_40	3/26/2002	76		High
Poteau River	OK220100010010_40	4/23/2002	78		High
Poteau River	OK220100010010_40	5/21/2002	67		High
Poteau River	OK220100010010_40	11/5/2002	161		High
Poteau River	OK220100010010_40	12/17/2002	51		Low
Bandy Creek	OK220100040080_00	11/13/2002	62.3		NA
Bandy Creek	OK220100040080_00	11/13/2002	28.5		NA
Bandy Creek	OK220100040080_00	7/12/2004	68		NA
Bandy Creek	OK220100040080_00	7/12/2004	65		NA
Bandy Creek	OK220100040080_00	7/12/2004	56		NA
Bandy Creek	OK220100040080_00	3/10/2005	91.9		NA
Bandy Creek	OK220100040080_00	3/10/2005	30.5		NA
Bandy Creek	OK220100040080_00	3/10/2005	22		NA
Sans Bois Creek	OK220200040010_40	6/2/1998	25.5		Low
Sans Bois Creek	OK220200040010_40	9/28/1998	22.1		Low
Sans Bois Creek	OK220200040010_40	4/27/1999	58.4	37.5	High
Sans Bois Creek	OK220200040010_40	5/25/1999	33.8	23.3	High
Sans Bois Creek	OK220200040010_40	6/22/1999	28.6	13	Low
Sans Bois Creek	OK220200040010_40	7/20/1999	18.7	13.5	Low
Sans Bois Creek	OK220200040010_40	8/24/1999	13.1	11	Low
Sans Bois Creek	OK220200040010_40	10/5/1999	31.3	33	Low
Sans Bois Creek	OK220200040010_40	11/9/1999	22	24	Low
Sans Bois Creek	OK220200040010_40	12/14/1999	70.9	30.5	High

Waterbody Name	Waterbody ID	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Sans Bois Creek	OK220200040010_40	1/19/2000	33.6	23.5	Low
Sans Bois Creek	OK220200040010_40	2/21/2000	21.2	14	Low
Sans Bois Creek	OK220200040010_40	3/28/2000	13.2	11	Low
Sans Bois Creek	OK220200040010_40	5/9/2000	39	21	High
Sans Bois Creek	OK220200040010_40	6/13/2000	30.5	23	Low
Sans Bois Creek	OK220200040010_40	7/18/2000	17.9	4	Low
Sans Bois Creek	OK220200040010_40	8/22/2000	5.84	1	Low
Sans Bois Creek	OK220200040010_40	9/26/2000	112	108	Low
Sans Bois Creek	OK220200040010_40	10/30/2000	27.5	22	High
Sans Bois Creek	OK220200040010_40	12/4/2000	44.5	10	Low
Sans Bois Creek	OK220200040010_40	1/16/2001	68.3	1	High
Sans Bois Creek	OK220200040010_40	2/20/2001	29.6	1	High
Sans Bois Creek	OK220200040010_40	3/26/2001	20.3	60	Low
Canadian River	OK220600010119_10	12/7/1998	605	368	Low
Canadian River	OK220600010119_10	1/13/1999	68	74	Low
Canadian River	OK220600010119_10	3/1/1999	27	76	Low
Canadian River	OK220600010119_10	4/21/1999	249	244	High
Canadian River	OK220600010119_10	5/11/1999		484	High
Canadian River	OK220600010119_10	6/15/1999	500	372	Low
Canadian River	OK220600010119_10	7/13/1999	935	620	High
Canadian River	OK220600010119_10	8/11/1999	41	38	Low
Canadian River	OK220600010119_10	9/21/1999	74	48	Low
Canadian River	OK220600010119_10	10/12/1999	23	36	Low
Canadian River	OK220600010119_10	11/9/1999	38	34	Low
Canadian River	OK220600010119_10	12/8/1999	369	212	Low
Canadian River	OK220600010119_10	1/25/2000	20	73	Low
Canadian River	OK220600010119_10	2/14/2000	240	38	Low
Canadian River	OK220600010119_10	5/9/2000	164	472	High
Canadian River	OK220600010119_10	6/14/2000	48	120	Low
Canadian River	OK220600010119_10	7/19/2000	69	98	Low
Canadian River	OK220600010119_10	8/16/2000	20	38	Low
Canadian River	OK220600010119_10	9/13/2000	9	1	Low
Canadian River	OK220600010119_10	10/11/2000	11	10	Low
Canadian River	OK220600010119_10	11/7/2000	346	580	High
Canadian River	OK220600010119_10	1/9/2007	103		Low
Canadian River	OK220600010119_10	2/27/2007	492		Low
Canadian River	OK220600010119_10	3/26/2007	453		High
Canadian River	OK220600010119_10	4/30/2007	177		Low
Canadian River	OK220600010119_10	5/29/2007	677		High
Canadian River	OK220600010119_10	7/2/2007	1001		High

Waterbody Name	Waterbody ID	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Canadian River	OK220600010119_10	8/6/2007	152		High
Canadian River	OK220600010119_10	9/11/2007	1000		High
Canadian River	OK220600010119_10	10/15/2007	51		Low
Canadian River	OK220600010119_10	11/26/2007	25		Low
Canadian River	OK220600010119_10	1/22/2008	35		Low
Canadian River	OK220600010119_10	2/25/2008	213		Low
Canadian River	OK220600010119_10	3/31/2008	77		Low
Canadian River	OK220600010119_10	5/19/2008	149		Low
Canadian River	OK220600010119_10	8/4/2008	19		Low
Canadian River	OK220600010119_10	10/13/2008	37		Low
Canadian River	OK220600010119_10	12/8/2008	16		Low
Canadian River	OK220600010119_10	2/2/2009	41		Low
Canadian River	OK220600010119_10	2/2/2009	41		Low
Canadian River	OK220600010119_10	3/16/2009	27.25		Low
Canadian River	OK220600010119_10	4/13/2009	502.75		High
Canadian River	OK220600010119_10	6/8/2009	38		Low
Canadian River	OK220600010119_10	8/3/2009	95		Low
Canadian River	OK220600010119_10	10/5/2009	47		Low
Canadian River	OK220600010119_10	12/7/2009	36		Low
Canadian River	OK220600010119_10	2/15/2010	114.5		High
Canadian River	OK220600010119_10	4/5/2010	21.3		High
Canadian River	OK220600010119_10	6/7/2010	88		Low
Canadian River	OK220600010119_10	9/28/2010	27.3		Low
Canadian River	OK220600010119_10	10/11/2010	23.8		Low
Canadian River	OK220600010119_10	12/6/2010	12.3		Low
Canadian River	OK220600010119_10	4/4/2011	14.3		Low
Canadian River	OK220600010119_10	6/6/2011	34		Low
Canadian River	OK220600010119_10	8/1/2011	7.3		Low

APPENDIX B: GENERAL METHOD FOR ESTIMATING FLOW FOR UNGAGED STREAMS AND ESTIMATED FLOW EXCEEDANCE PERCENTILES

Appendix B
General Method for Estimating Flow for Ungaged Streams

Flows duration curve will be developed using existing USGS measured flow where the data exist from a gage on the stream segment of interest, or by estimating flow for stream segments with no corresponding flow record. Flow data to support flow duration curves and load duration curves will be derived for each Oklahoma stream segment in the following priority:

i) In cases where a USGS flow gage occurs on, or within one-half mile upstream or downstream of the Oklahoma stream segment.

   a. If simultaneously collected flow data matching the water quality sample collection date are available, these flow measurements will be used.

   b. If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, the gaps in the flow record will be filled, or the record will be extended, by estimating flow based on measured streamflows at a nearby gages. All gages within 150 km radius are identified. For each of the identified gage with a minimum of 99 flow measurements on matching dates, four different regressions are calculated including linear, log linear, logarithmic and exponential regressions. The regression with the lowest root mean square error (RMSE) is chosen for each gage. The potential filling gages are ranked by RMSE from lowest to highest. The record is filled from the first gage (lowest RMSE) for those dates that exist in both records. If dates remain unfilled in the desired timespan of the timeseries, the filling process is repeated with the next gage with the next lowest RMSE and proceeds in this fashion until all missing values in the desired timespan are filled.

   c. The flow frequency for the flow duration curves will be based on measured flows only. The filled timeseries described above is used to match flows to sampling dates to calculate loads.

   d. On a stream impounded by dams to form reservoirs of sufficient size to impact stream flow, only flows measured after the date of the most recent impoundment will be used to develop the flow duration curve. This also applies to reservoirs on major tributaries to the stream.

ii) In the case no coincident flow data are available for a stream segment, but flow gage(s) are present upstream and/or downstream without a major reservoir between, flows will be estimated for the stream segment from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds, and relying on the Natural Resources Conservation Service (NRCS) runoff curve numbers and antecedent rainfall condition. Drainage subbasins will first be delineated for all impaired 303(d)-listed WQM stations, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Parsons will then identify all the USGS gage stations upstream and downstream of the subwatersheds with 303(d) listed WQM stations.

   a. Watershed delineations are performed using ESRI Arc Hydro with a 30 m resolution National Elevation Dataset digital elevation model, and National

Hydrography Dataset (NHD) streams. The area of each watershed will be calculated following watershed delineation.

b. The watershed average curve number is calculated from soil properties and land cover as described in the U.S. Department of Agriculture (USDA) Publication *TR-55: Urban Hydrology for Small Watersheds*. The soil hydrologic group is extracted from NRCS STATSGO soil data, and land use category from the 2001 National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers are estimated at the 30-meter resolution of the NLCD grid as shown in Table 7. The average curve number is then calculated from all the grid cells within the delineated watershed.

c. The average rainfall is calculated for each watershed from gridded average annual precipitation datasets for the period 1971-2000 (Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/, created February 20, 2004).

TABLE B - 1 Runoff Curve Numbers for Various Land Use Categories and Hydrologic Soil Groups

NLCD Land Use Category	Curve number for hydrologic soil group			
	A	B	C	D
0 in case of zero	100	100	100	100
11 Open Water	100	100	100	100
12 Perennial Ice/Snow	100	100	100	100
21 Developed, Open Space	39	61	74	80
22 Developed, Low Intensity	57	72	81	86
23 Developed, Medium Intensity	77	85	90	92
24 Developed, High Intensity	89	92	94	95
31 Barren Land (Rock/Sand/Clay)	77	86	91	94
32 Unconsolidated Shore	77	86	91	94
41 Deciduous Forest	37	48	57	63
42 Evergreen Forest	45	58	73	80
43 Mixed Forest	43	65	76	82
51 Dwarf Scrub	40	51	63	70
52 Shrub/Scrub	40	51	63	70
71 Grasslands/Herbaceous	40	51	63	70
72 Sedge/Herbaceous	40	51	63	70
73 Lichens	40	51	63	70
74 Moss	40	51	63	70
81 Pasture/Hay	35	56	70	77
82 Cultivated Crops	64	75	82	85
90-99 Wetlands	100	100	100	100

d. The method used to project flow from a gaged location to an ungaged location was adapted by combining aspects of two other flow projection methodologies developed by Furness (Furness 1959) and Wurbs (Wurbs 1999).

Furness Method

The Furness method has been employed in Kansas by both the USGS and Kansas Department of Health and Environment to estimate flow-duration curves. The method typically uses maps, graphs, and computations to identify six unique factors of flow duration for ungaged sites. These factors include:

- The mean streamflow and percentage duration of mean streamflow
- The ratio of 1-percent-duration streamflow to mean streamflow
- The ratio of 0.1-percent-duration streamflow to 1-percent-duration streamflow
- The ratio of 50-percent-duration streamflow to mean streamflow
- The percentage duration of appreciable (0.10 ft /s) streamflow
- Average slope of the flow-duration curve

Furness defined appreciable flow as 0.10 ft/s. This value of streamflow was important because, for many years, this was the smallest non-zero streamflow value reported in most Kansas streamflow records. The average slope of the duration curve is a graphical approximation of the variability index, which is the standard deviation of the logarithms of the streamflows (Furness 1959, p. 202-204, figs. 147 and 148). On a duration curve that fits the log-normal distribution exactly, the variability index is equal to the ratio of the streamflow at the 15.87-percent-duration point to the streamflow at the 50-percent-duration point. Because duration curves usually do not exactly fit the log-normal distribution, the average-slope line is drawn through an arbitrary point, and the slope is transferred to a position approximately defined by the previously estimated points.

The method provides a means of both describing shape of the flow duration curve and scaling the magnitude of the curve to another location, basically generating a new flow duration curve with a very similar shape but different magnitude at the ungaged location.

Wurbs Modified NRCS Method

As a part of the Texas water availability modeling (WAM) system developed by Texas Natural Resources Conservation Commission, now known as the Texas Commission on Environmental Quality (TCEQ), and partner agencies, various contractors developed models of all Texas rivers. As a part of developing the model code to be used, Dr. Ralph Wurbs of Texas A&M University researched methods to distribute flows from gaged locations to ungaged locations. (Wurbs 2006) His results included the development of a modified NRCS curve-number (CN) method for distributing flows from gaged locations to ungaged locations.

This modified NRCS method is based on the following relationship between rainfall depth, P in inches, and runoff depth, Q in inches (NRCS 1985; McCuen 2005):

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (1)$$

where:

Q = runoff depth (inches)

P = rainfall (inches)

S = potential maximum retention after runoff begins (inches)

I_a = initial abstraction (inches)

If P < 0.2, Q = 0. Initial abstraction has been found to be empirically related to S by the equation

$$I_a = 0.2*S \qquad (2)$$

Thus, the runoff curve number equation can be rewritten:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (3)$$

S is related to the curve number (CN) by:

$$S = \frac{1000}{CN} - 10 \qquad (4)$$

P and Q in inches must be multiplied by the watershed area to obtain volumes. The potential maximum retention, S in inches, represents an upper limit on the amount of water that can be abstracted by the watershed through surface storage, infiltration, and other hydrologic abstractions. For convenience, S is expressed in terms of a curve number CN, which is a dimensionless watershed parameter ranging from 0 to 100. A CN of 100 represents a limiting condition of a perfectly impervious watershed with zero retention and thus all the rainfall becoming runoff. A CN of zero conceptually represents the other extreme with the watershed abstracting all rainfall with no runoff regardless of the rainfall amount.

First, S is calculated from the average curve number for the gaged watershed. Next, the daily historic flows at the gage are converted to depth basis (as used in equations 1 and 3) by dividing by its drainage area, then converted to inches. Equation 3 is then solved for daily precipitation depth of the gaged site, Pgaged. The daily precipitation depth for the ungaged site is then calculated as the precipitation depth of the gaged site multiplied by the ratio of the long-term average precipitation in the watersheds of the ungaged and gaged sites:

$$P_{ungaged} = P_{gaged}\left(\frac{M_{ungaged}}{M_{gaged}}\right) \qquad (5)$$

where M is the mean annual precipitation of the watershed in inches. The daily precipitation depth for the ungaged watershed, along with the average curve number of the ungaged watershed, are then used to calculate the depth equivalent daily flow Q of the ungaged site. Finally, the volumetric flow rate at the ungaged site is calculated by multiplying by the area of the watershed of the ungaged site and converted to cubic feet.

In a subsequent study (Wurbs 2006), Wurbs evaluated the predictive ability of various flow distribution methods including:

- Distribution of flows in proportion to drainage area
- Flow distribution equation with ratios for various watershed parameters
- Modified NRCS curve-number method
- Regression equations relating flows to watershed characteristics
- Use of recorded data at gaging stations to develop precipitation-runoff relationships
- Use of watershed (precipitation-runoff) computer models such as SWAT

As a part of the analysis, the methods were used to predict flows at one gaged station to another gage station so that fit statistics could be calculated to evaluate the efficacy of each of the methods. Based upon similar analyses performed for many gaged sites which reinforced the tests performed as part of the study, Wurbs observed that temporal variations in flows are dramatic, ranging from zero flows to major floods. Mean flows are reproduced reasonably well with the all flow distribution methods and the NRCS CN method reproduces the mean closest. Accuracy in predicting mean flows is much better than the accuracy of predicting the flow-frequency relationship. Performance in reproducing flow-frequency relationships is better than for reproducing flows for individual flows.

Wurbs concluded that the NRCS CN method, the drainage area ratio method, and drainage area – CN – mean annual precipitation depth (MP) ratio methods all yield similar levels of accuracy. If the CN and MP are the same for the gaged and ungaged watersheds, the three alternative methods yield identical results. Drainage area is the most important watershed parameter. However, the NRCS method adaptation is preferable in those situations in which differences in CN (land use and soil type) and long-term MP are significantly different between the gaged and ungaged watersheds. The CN and MP are usually similar but not identical.

Generalized Flow Projection Methodology

In the first several versions of the Oklahoma TMDL toolbox, all flows at ungaged sites that required projection from a gaged site were performed with the Modified NRCS CN method. This led a number of problems with flow projections in the early versions. As described previously, the NRCS method, in common with all others, reproduces the mean or central tendency best but the accuracy of the fit degrades towards the extremes of the frequency spectrum. Part of the degradation in accuracy is due to the quite non-linear nature of the NRCS equations. On the low flow end of the frequency spectrum, Equation 2 above constitutes a low flow limit below which the NRCS equations are not applicable at all. Given the flashy nature of most streams in locations for which the toolbox was developed, high and low flows are relatively more common and spurious results from the limits of the equations abounded.

In an effort to increase the flow prediction efficacy and remedy the failure of the NRCS CN method at the extremes of the flow spectrum, a hybrid of the NRCS CN method and the Furness method was developed. Noting the facts that all tested projection methods, and particularly the NRCS CN method, perform best near the central tendency or mean and that none of the methods predict the entire flow frequency spectrum well, an assumption that is implicit in the Furness method is applied. The Furness method implicitly assumes that the shape of the flow frequency curve at an upstream site is related to and similar to the shape of the flow frequency curve at a site downstream. As described previously, the Furness method employs several relationships derived between the mean flows and flows at differing frequencies to replicate the shape of the flow frequency curve at the projected site, while utilizing other regressed relationships to scale the magnitude of the curve. Since, as part of the toolbox calculations, the entire flow frequency curve at a 1% interval is calculated for every USGS gage utilizing very long periods of record, this vector in association with the mean flow was used to project the flow frequency curve.

In the ideal situation flows are projected from an ungaged location from a downstream gaged location. The toolbox also has the capability to project flows from and upstream gaged location if there is no useable downstream gage.

iii) In the rare case where no coincident flow data are available for a WQM station and no gages are present upstream or downstream, flows will be estimated for the WQM station from a gage on an adjacent watershed of similar size and properties, via the same procedure described above for upstream or downstream gages.

References

Furness, L.W., 1959, *Kansas Streamflow Characteristics- Part 1, Flow Duration*: Kansas Water Resources Board Technical Report No. 1.

Wurbs, R.A., and E.D. Sisson, *Evaluation of Methods for Distributing Naturalized Streamflows from Gaged Watersheds to Ungaged Subwatersheds*, Technical Report 179, Texas Water Resources Institute and Texas Natural Resource Conservation Commission, August 1999.

Wurbs, R.A. 2006. *Methods for Developing Naturalized Monthly Flows at Gaged and Ungaged Sites*. Journal of Hydrologic Engineering, January/February 2006, ASCE

TABLE B Estimated Flow Exceedance Percentiles

Stream Name	Poteau River	Poteau River	Brazil Creek	Sallisaw Creek	Sans Bois Creek	Sans Bois Creek	Canadian River
WBID Segment	OK220100010010_00	OK220100010010_40	OK220100030010_00	OK220200030010_20	OK220200040010_10	OK220200040010_40	OK220600010119_10
USGS Gage Reference	07249413	PTA02*	07247015	07249920	07247500	07247500	07231500
Drainage Area (mi^2)	1,767	1,156	230	117	204	89	27,952
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
0	67,000	23,643	17,593	7,083	12,527	5,457	140,000
1	14,670	7,960	3,665	1,725	2,730	1,185	20,000
2	11,500	7,276	2,209	1,015	2,026	883	13,000
3	9,656	7,013	1,632	763	1,725	744	9,830
4	8,610	6,820	1,337	635	1,497	649	7,760
5	8,100	6,651	1,138	518	1,320	573	6,640
6	7,820	6,489	963	455	1,156	500	5,770
7	7,530	6,342	858	392	1,018	438	5,170
8	7,270	6,121	759	356	898	387	4,720
9	7,050	5,961	690	324	784	338	4,270
10	6,785	5,788	617	294	688	295	3,910
11	6,480	5,588	561	267	586	253	3,600
12	6,232	5,358	512	251	509	219	3,330
13	5,970	5,107	457	231	447	193	3,100
14	5,690	4,874	421	215	404	174	2,880
15	5,460	4,635	384	201	365	156	2,670
16	5,186	4,388	354	190	323	139	2,500
17	4,880	4,179	330	181	292	125	2,370
18	4,610	3,974	300	170	266	114	2,250
19	4,340	3,780	286	160	245	105	2,130
20	4,130	3,591	261	153	225	97	2,010
21	3,860	3,330	245	146	209	90	1,910
22	3,660	3,092	228	138	194	84	1,800
23	3,476	2,882	211	132	183	79	1,700
24	3,240	2,724	197	126	172	74	1,620

Stream Name	Poteau River	Poteau River	Brazil Creek	Sallisaw Creek	Sans Bois Creek	Sans Bois Creek	Canadian River
WBID Segment	OK220100010010_00	OK220100010010_40	OK220100030010_00	OK220200030010_20	OK220200040010_10	OK220200040010_40	OK220600010119_10
USGS Gage Reference	07249413	PTA02*	07247015	07249920	07247500	07247500	07231500
Drainage Area (mi^2)	1,767	1,156	230	117	204	89	27,952
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
25	3,073	2,573	185	121	162	69	1,520
26	2,910	2,418	172	114	152	66	1,440
27	2,750	2,283	160	109	146	62	1,370
28	2,570	2,155	149	103	136	58	1,300
29	2,447	2,047	140	100	129	55	1,240
30	2,300	1,947	131	94	121	52	1,180
31	2,190	1,863	124	90	116	50	1,130
32	2,050	1,739	117	85	109	47	1,080
33	1,920	1,605	110	81	102	44	1,020
34	1,800	1,480	103	77	97	42	967
35	1,680	1,387	97	75	90	39	920
36	1,540	1,303	91	70	85	37	880
37	1,435	1,229	86	68	82	35	845
38	1,360	1,136	82	64	77	33	807
39	1,270	1,046	77	61	72	31	770
40	1,190	963	72	57	69	29	740
41	1,100	888	68	55	65	28	713
42	1,000	798	64	53	62	26	686
43	909	707	60	49	59	25	660
44	846	614	58	47	55	23	636
45	760	530	54	45	52	23	614
46	687	476	51	43	50	21	591
47	633	436	48	40	47	20	570
48	566	393	46	38	44	19	550
49	508	348	44	36	42	18	529
50	461	295	42	34	39	17	511

Stream Name	Poteau River	Poteau River	Brazil Creek	Sallisaw Creek	Sans Bois Creek	Sans Bois Creek	Canadian River
WBID Segment	OK220100010010_00	OK220100010010_40	OK220100030010_00	OK220200030010_20	OK220200040010_10	OK220200040010_40	OK220600010119_10
USGS Gage Reference	07249413	PTA02*	07247015	07249920	07247500	07247500	07231500
Drainage Area (mi^2)	1,767	1,156	230	117	204	89	27,952
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
51	415	250	39	33	37	15	495
52	381	216	38	31	33	15	476
53	340	192	35	29	32	14	458
54	309	167	33	28	30	12	441
55	278	150	31	25	28	12	423
56	252	137	30	24	25	11	408
57	229	124	28	23	25	10	391
58	209	114	27	22	23	9.5	375
59	190	104	25	21	22	8.8	358
60	176	97	24	20	20	8.0	341
61	164	87	22	18	18	8.0	325
62	152	79	21	17	17	7.2	311
63	140	72	20	16	16	6.8	295
64	131	66	18	15	15	6.3	280
65	122	61	16	14	14	5.8	269
66	113	57	15	14	13	5.4	257
67	104	53	14	13	12	5.0	246
68	98	50	13	11	11	4.7	233
69	90	47	12	11	11	4.4	220
70	84	45	11	10	10	4.1	209
71	78	44	10	9.2	9.2	3.8	199
72	73	44	9.4	8.4	8.5	3.6	189
73	70	43	8.5	7.6	8.0	3.3	180
74	66	42	7.9	7.1	7.4	3.1	170
75	62	42	7.5	6.6	6.9	2.8	161
76	58	41	7.0	5.9	6.2	2.6	150

Stream Name	Poteau River	Poteau River	Brazil Creek	Sallisaw Creek	Sans Bois Creek	Sans Bois Creek	Canadian River
WBID Segment	OK220100010010_00	OK220100010010_40	OK220100030010_00	OK220200030010_20	OK220200040010_10	OK220200040010_40	OK220600010119_10
USGS Gage Reference	07249413	PTA02*	07247015	07249920	07247500	07247500	07231500
Drainage Area (mi^2)	1,767	1,156	230	117	204	89	27,952
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
77	55	41	6.5	5.4	5.7	2.3	140
78	52	40	6.0	4.7	5.2	2.1	129
79	50	39	5.8	4.3	4.7	2.0	119
80	47	39	5.4	3.7	4.4	1.8	109
81	44	38	5.1	3.3	4.0	1.6	100
82	42	34	4.7	3.0	3.5	1.5	92
83	40	31	4.4	2.6	3.2	1.3	84
84	38	28	4.0	2.4	2.8	1.1	76
85	37	25	3.7	2.2	2.5	0.9	68
86	35	23	3.4	1.8	2.2	0.8	60
87	33	21	3.2	1.6	1.8	0.7	52
88	30	19	2.9	1.3	1.7	0.6	45
89	28	16	2.7	1.0	1.4	0.5	39
90	26	15	2.5	0.8	1.2	0.4	34
91	24	13	2.2	0.6	1.0	0.3	30
92	22	12	2.1	0.4	0.7	0.3	24
93	20	10	1.7	0.3	0.6	0.2	20
94	18	9.0	1.5	0.1	0.4	0.1	16
95	16	6.5	1.3	0.0	0.3	0.1	12
96	15	4.1	1.0	0.0	0.2	0.0	8.2
97	12	2.7	0.8	0.0	0.1	0.0	5.1
98	10	1.7	0.5	0.0	0.0	0.0	2.1
99	8.6	1.0	0.1	0.0	0.0	0.0	0.4
100	2.7	0.0	0.0	0.0	0.0	0.0	0.0

* US Army Corp of Engineers gage station

APPENDIX C: STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix C
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 beneficial uses. No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed.

(d) 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 D: NPDES DISCHARGE MONITORING REPORT DATA STREAMS

TABLE D NPDES Discharge Monitoring Report Data

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OK0040169	001	01/31/2003	1.21	1.77	Not Available	Not Available
OK0040169	001	02/28/2003	0.78	1.32	Not Available	Not Available
OK0040169	001	03/31/2003	0.96	1.36	Not Available	Not Available
OK0040169	001	04/30/2003	1.06	1.42	Not Available	Not Available
OK0040169	001	05/31/2003	1.19	1.5	Not Available	Not Available
OK0040169	001	06/30/2003	1.27	1.79	Not Available	Not Available
OK0040169	001	07/31/2003	1.04	1.45	Not Available	Not Available
OK0040169	001	08/31/2003	0.77	1.42	Not Available	Not Available
OK0040169	001	09/30/2003	1.44	2.33	Not Available	Not Available
OK0040169	001	10/31/2003	1.48	2.21	Not Available	Not Available
OK0040169	001	11/30/2003	1.32	2.33	Not Available	Not Available
OK0040169	001	12/31/2003	1.08	1.49	Not Available	Not Available
OK0040169	001	01/31/2004	0.99	2.09	Not Available	Not Available
OK0040169	001	02/29/2004	0.61	1.93	Not Available	Not Available
OK0040169	001	03/31/2004	0.94	1.41	Not Available	Not Available
OK0040169	001	04/30/2004	1.36	1.84	Not Available	Not Available
OK0040169	001	05/31/2004	1.23	1.72	Not Available	Not Available
OK0040169	001	06/30/2004	1.44	1.96	Not Available	Not Available
OK0040169	001	07/31/2004	1.52	3.1	Not Available	Not Available
OK0040169	001	08/31/2004	1.2	2	Not Available	Not Available
OK0040169	001	09/30/2004	1.38	1.75	Not Available	Not Available
OK0040169	001	10/31/2004	1.5	2.89	Not Available	Not Available
OK0040169	001	11/30/2004	1.55	3.06	Not Available	Not Available
OK0040169	001	12/31/2004	1.32	3	Not Available	Not Available
OK0040169	001	01/31/2005	1.4	2.68	Not Available	Not Available
OK0040169	001	02/28/2005	1.32	2.02	Not Available	Not Available
OK0040169	001	03/31/2005	1.22	1.75	Not Available	Not Available
OK0040169	001	04/30/2005	1.45	2.22	Not Available	Not Available
OK0040169	001	05/31/2005	1.41	1.96	Not Available	Not Available
OK0040169	001	06/30/2005	1.45	2.08	Not Available	Not Available
OK0040169	001	07/31/2005	1.35	2	Not Available	Not Available
OK0040169	001	08/31/2005	1.41	1.91	Not Available	Not Available
OK0040169	001	09/30/2005	1.37	2.95	Not Available	Not Available
OK0040169	001	10/31/2005	1.22	1.71	Not Available	Not Available
OK0040169	001	11/30/2005	1.33	2.91	Not Available	Not Available
OK0040169	001	12/31/2005	1	2.14	Not Available	Not Available
OK0040169	001	01/31/2006	1.3	2.1	Not Available	Not Available
OK0040169	001	02/28/2006	1.51	2.22	Not Available	Not Available
OK0040169	001	03/31/2006	1.89	2.98	Not Available	Not Available
OK0040169	001	04/30/2006	1.33	2.17	Not Available	Not Available
OK0040169	001	05/31/2006	1.69	2.18	Not Available	Not Available

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OK0040169	001	06/30/2006	1.29	1.62	Not Available	Not Available
OK0040169	001	07/31/2006	1.77	2.89	Not Available	Not Available
OK0040169	001	08/31/2006	1.62	2.16	Not Available	Not Available
OK0040169	001	09/30/2006	1.19	1.82	Not Available	Not Available
OK0040169	001	10/31/2006	1.72	3.2	Not Available	Not Available
OK0040169	001	11/30/2006	1.56	2.2	Not Available	Not Available
OK0040169	001	12/31/2006	1.22	1.83	Not Available	Not Available
OK0040169	001	01/31/2007	1.41	2.02	Not Available	Not Available
OK0040169	001	02/28/2007	0.95	1.93	Not Available	Not Available
OK0040169	001	03/31/2007	1.62	2.21	Not Available	Not Available
OK0040169	001	04/30/2007	1.32	1.91	Not Available	Not Available
OK0040169	001	05/31/2007	1.29	1.87	Not Available	Not Available
OK0040169	001	06/30/2007	1.22	1.86	Not Available	Not Available
OK0040169	001	07/31/2007	1.5	2.65	Not Available	Not Available
OK0040169	001	08/31/2007	1.17	2.1	Not Available	Not Available
OK0040169	001	09/30/2007	1.47	2.37	Not Available	Not Available
OK0040169	001	10/31/2007	1.29	1.9	Not Available	Not Available
OK0040169	001	11/30/2007	1.24	1.78	Not Available	Not Available
OK0040169	001	12/31/2007	1.6	2.61	Not Available	Not Available
OK0040169	001	01/31/2008	1.08	1.58	Not Available	Not Available
OK0040169	001	02/29/2008	1.26	3.1	Not Available	Not Available
OK0040169	001	03/31/2008	1.17	1.85	Not Available	Not Available
OK0040169	001	04/30/2008	1.03	3.02	Not Available	Not Available
OK0040169	001	05/31/2008	1.11	1.58	Not Available	Not Available
OK0040169	001	06/30/2008	1.25	1.91	Not Available	Not Available
OK0040169	001	07/31/2008	1.03	2	Not Available	Not Available
OK0040169	001	08/31/2008	1.3	2.18	Not Available	Not Available
OK0040169	001	09/30/2008	1.03	2	Not Available	Not Available
OK0040169	001	10/31/2008	1.18	2.11	Not Available	Not Available
OK0040169	001	11/30/2008	1.17	2.71	Not Available	Not Available
OK0040169	001	12/31/2008	1.23	2.04	Not Available	Not Available
OK0040169	001	01/31/2009	1.28	1.98	Not Available	Not Available
OK0040169	001	02/28/2009	1.21	2.4	Not Available	Not Available
OK0040169	001	03/31/2009	1.21	1.84	Not Available	Not Available
OK0040169	001	04/30/2009	1.29	2.06	Not Available	Not Available
OK0040169	001	05/31/2009	0.93	2.15	Not Available	Not Available
OK0040169	001	06/30/2009	0.9	1.73	Not Available	Not Available
OK0040169	001	07/31/2009	1.36	1.88	Not Available	Not Available
OK0040169	001	08/31/2009	1.15	1.88	Not Available	Not Available
OK0040169	001	09/30/2009	1.42	2.28	Not Available	Not Available
OK0040169	001	10/31/2009	1.4	2.38	Not Available	Not Available

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OK0040169	001	11/30/2009	1.45	2.62	Not Available	Not Available
OK0040169	001	12/31/2009	1.34	1.95	Not Available	Not Available
OK0040169	001	01/31/2010	1.18	1.91	Not Available	Not Available
OK0040169	001	02/28/2010	1.12	1.68	Not Available	Not Available
OK0040169	001	03/31/2010	1.14	2.05	Not Available	Not Available
OK0040169	001	04/30/2010	1.09	1.93	Not Available	Not Available
OK0040169	001	05/31/2010	1.24	1.8	Not Available	Not Available
OK0040169	001	06/30/2010	1.27	2.06	Not Available	Not Available
OK0040169	001	07/31/2010	1.28	1.94	Not Available	Not Available
OK0040169	001	08/31/2010	1.23	1.99	Not Available	Not Available
OK0040169	001	09/30/2010	1.28	2.18	Not Available	Not Available
OK0040169	001	10/31/2010	1.4	3.22	Not Available	Not Available
OK0040169	001	11/30/2010	1.39	2.26	Not Available	Not Available
OK0040169	001	12/31/2010	1.28	2.63	Not Available	Not Available
OK0040169	001	01/31/2011	1.04	2.02	Not Available	Not Available
OK0040169	001	02/28/2011	1.03	1.9	Not Available	Not Available
OK0040169	001	03/31/2011	0.43	2.56	Not Available	41
OK0040169	001	04/30/2011	0.39	2.06	Not Available	26
OK0040169	001	05/31/2011	0.59	2.48	Not Available	26
OK0040169	001	06/30/2011	0.35	1.54	Not Available	5
OK0040169	001	07/31/2011	0.48	2.32	Not Available	22
OK0040169	001	08/31/2011	0.35	1.97	Not Available	8
OK0040169	001	09/30/2011	0.39	1.37	Not Available	35.5
OK0040169	001	10/31/2011	0.49	1.69	Not Available	23.5
OK0040169	001	11/30/2011	0.73	2.2	Not Available	21
OK0040169	001	12/31/2011	0.59	2.82	Not Available	34
OK0040169	001	01/31/2012	0.38	1.65	Not Available	26
OK0040169	001	02/29/2012	0.41	1.5	Not Available	15
OK0040169	001	03/31/2012	0.44	1.6	Not Available	28.5
OK0040169	001	04/30/2012	0.23	1.57	Not Available	28.5
OK0040169	001	05/31/2012	0.44	2.45	Not Available	27.5
OK0040169	001	06/30/2012	0.37	1.43	Not Available	32
OK0040169	001	07/31/2012	0.44	1.47	Not Available	5
OK0040169	001	08/31/2012	0.57	1.64	Not Available	42.5
OK0040169	001	09/30/2012	0.44	1.49	Not Available	31
OK0040169	001	10/31/2012	0.67	2.48	Not Available	22.5
OK0040169	001	11/30/2012	0.56	2.53	Not Available	32
OK0040169	001	12/31/2012	0.46	2.25	Not Available	15
OK0040169	001	01/31/2013	0.63	2.2	Not Available	18
OK0042781	001	01/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	02/28/2003	Not Available	Not Available	Not Available	Not Available

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OK0042781	001	03/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	04/30/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	05/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	06/30/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	07/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	08/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	09/30/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	10/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	11/30/2003	0.07	0.14	12	12
OK0042781	001	12/31/2003	Not Available	Not Available	Not Available	Not Available
OK0042781	001	01/31/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	02/29/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	03/31/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	04/30/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	05/31/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	06/30/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	07/31/2004	Not Available	Not Available	Not Available	Not Available
OK0042781	001	08/31/2004	0.78	3.23	Not Available	6
OK0042781	001	09/30/2004	0.02	0.65	Not Available	7
OK0042781	001	10/31/2004	0.67	1.34	Not Available	39
OK0042781	001	11/30/2004	0.43	0.86	Not Available	25
OK0042781	001	12/31/2004	0.32	6.4	Not Available	7
OK0042781	001	01/31/2005	0.35	1.9	Not Available	6
OK0042781	001	02/28/2005	1.3	2.6	Not Available	1
OK0042781	001	03/31/2005	0.04	0.09	Not Available	29
OK0042781	001	04/30/2005	0.02	3.2	Not Available	7
OK0042781	001	05/31/2005	0.12	3.23	Not Available	39
OK0042781	001	06/30/2005	0.01	0.65	Not Available	27
OK0042781	001	07/31/2005	Not Available	Not Available	Not Available	Not Available
OK0042781	001	08/31/2005	0.01	0.01	0	19
OK0042781	001	09/30/2005	0.01	0.01	Not Available	14
OK0042781	001	10/31/2005	0.01	0.03	Not Available	20
OK0042781	001	11/30/2005	0.01	0.02	8	13
OK0042781	001	12/31/2005	0.01	0.02	30	10
OK0042781	001	01/31/2006	0.02	0.02	35	17
OK0042781	001	02/28/2006	0.02	0.02	35	11
OK0042781	001	03/31/2006	0.02	0.02	10	10
OK0042781	001	04/30/2006	0.08	0.16	35	8
OK0042781	001	05/31/2006	0.01	0.02	42	42
OK0042781	001	06/30/2006	0.01	0.01	35	33
OK0042781	001	07/31/2006	0.02	0.02	35	23

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OK0042781	001	08/31/2006	0.02	0.02	35	15
OK0042781	001	09/30/2006	0.01	0.02	35	31
OK0042781	001	10/31/2006	0.01	0.02	35	37
OK0042781	001	11/30/2006	0.03	0.15	35	54
OK0042781	001	12/31/2006	0.02	0.03	35	53
OK0042781	001	01/31/2007	0.01	0.04	35	28
OK0042781	001	02/28/2007	0.01	0.17	35	12
OK0042781	001	03/31/2007	0.01	0.01	35	44
OK0042781	001	04/30/2007	0.17	2.7	35	23
OK0042781	001	05/31/2007	0.03	5.2	35	34
OK0042781	001	06/30/2007	0.01	6.5	35	10
OK0042781	001	07/31/2007	0.01	0.02	35	17
OK0042781	001	08/31/2007	0.01	0.02	35	28
OK0042781	001	09/30/2007	0.02	0.03	35	15
OK0042781	001	10/31/2007	0.02	0.03	35	18
OK0042781	001	11/30/2007	0.02	0.03	35	19
OK0042781	001	12/31/2007	0.01	0.02	35	20
OK0042781	001	01/31/2008	0.01	0.02	35	3
OK0042781	001	02/29/2008	0.01	0.02	35	8
OK0042781	001	03/31/2008	0.02	0.03	35	70
OK0042781	001	04/30/2008	0.02	0.03	35	19
OK0042781	001	05/31/2008	0.02	0.03	35	61
OK0042781	001	06/30/2008	0.02	0.03	35	19
OK0042781	001	07/31/2008	0.01	0.02	35	13
OK0042781	001	08/31/2008	0.01	0.01	35	14
OK0042781	001	09/30/2008	0.02	0.03	35	11
OK0042781	001	10/31/2008	0.03	0.03	35	14
OK0042781	001	11/30/2008	0.03	0.03	35	12
OK0042781	001	12/31/2008	0.01	0.01	35	14
OK0042781	001	01/31/2009	0.02	0.02	35	21
OK0042781	001	02/28/2009	0.02	0.02	3.5	23
OK0042781	001	03/31/2009	0.01	0.02	35	15
OK0042781	001	04/30/2009	0.01	0.01	12	12
OK0042781	001	05/31/2009	0.01	0.01	15	15
OK0042781	001	06/30/2009	0.02	0.02	35	8
OK0042781	001	07/31/2009	0.01	0.03	35	12
OK0042781	001	08/31/2009	0.01	0.01	35	11
OK0042781	001	09/30/2009	0.02	0.03	17	17
OK0042781	001	10/31/2009	0.02	0.03	35	46
OK0042781	001	11/30/2009	0.01	0.01	35	14
OK0042781	001	12/31/2009	0.01	0.01	35	17

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OK0042781	001	01/31/2010	0.02	0.03	35	9
OK0042781	001	02/28/2010	0.02	0.02	35	13
OK0042781	001	03/31/2010	0.02	0.02	1	1
OK0042781	001	04/30/2010	0.02	0.02	35	10
OK0042781	001	05/31/2010	0.03	0.04	35	4
OK0042781	001	06/30/2010	0.01	0.01	35	10
OK0042781	001	07/31/2010	0	0	35	11
OK0042781	001	08/31/2010	Not Available	Not Available	Not Available	Not Available
OK0042781	001	09/30/2010	Not Available	Not Available	Not Available	Not Available
OK0042781	001	10/31/2010	Not Available	Not Available	Not Available	Not Available
OK0042781	001	11/30/2010	Not Available	Not Available	Not Available	Not Available
OK0042781	001	12/31/2010	Not Available	Not Available	Not Available	Not Available
OK0042781	001	01/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	02/28/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	03/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	04/30/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	05/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	06/30/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	07/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	08/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	09/30/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	10/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	11/30/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	12/31/2011	Not Available	Not Available	Not Available	Not Available
OK0042781	001	01/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	02/29/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	03/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	04/30/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	05/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	06/30/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	07/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	08/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	09/30/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	10/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	11/30/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	12/31/2012	Not Available	Not Available	Not Available	Not Available
OK0042781	001	01/31/2013	Not Available	Not Available	Not Available	Not Available
OKG380011	001	06/30/2004	Not Available	Not Available	Not Available	Not Available
OKG380011	001	07/31/2004	Not Available	Not Available	Not Available	Not Available
OKG380011	001	08/31/2004	Not Available	Not Available	Not Available	Not Available
OKG380011	001	09/30/2004	Not Available	Not Available	Not Available	Not Available

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OKG380011	001	10/31/2004	Not Available	Not Available	Not Available	Not Available
OKG380011	001	11/30/2004	Not Available	Not Available	Not Available	Not Available
OKG380011	001	12/31/2004	Not Available	Not Available	Not Available	Not Available
OKG380011	001	01/31/2005	Not Available	Not Available	Not Available	Not Available
OKG380011	001	02/28/2005	0.08	Not Available	3	Not Available
OKG380011	001	03/31/2005	Not Available	Not Available	Not Available	Not Available
OKG380011	001	04/30/2005	0.08	Not Available	1	Not Available
OKG380011	001	05/31/2005	0.08	Not Available	6	Not Available
OKG380011	001	06/30/2005	0.08	Not Available	1	Not Available
OKG380011	001	07/31/2005	0.08	Not Available	1	Not Available
OKG380011	001	08/31/2005	0.07	Not Available	10	Not Available
OKG380011	001	09/30/2005	0.08	Not Available	1	Not Available
OKG380011	001	10/31/2005	0.1	Not Available	1	Not Available
OKG380011	001	11/30/2005	0.08	Not Available	1	Not Available
OKG380011	001	12/31/2005	0.07	Not Available	1	Not Available
OKG380011	001	01/31/2006	0.07	Not Available	1	Not Available
OKG380011	001	02/28/2006	0.09	Not Available	1	Not Available
OKG380011	001	03/31/2006	0.08	Not Available	1	Not Available
OKG380011	001	04/30/2006	0.08	Not Available	8	Not Available
OKG380011	001	05/31/2006	0.08	Not Available	1	Not Available
OKG380011	001	06/30/2006	0.08	Not Available	1	Not Available
OKG380011	001	07/31/2006	0.08	Not Available	1	Not Available
OKG380011	001	08/31/2006	0.07	Not Available	1	Not Available
OKG380011	001	09/30/2006	0.08	Not Available	1	Not Available
OKG380011	001	10/31/2006	0.08	Not Available	1	Not Available
OKG380011	001	11/30/2006	0.11	Not Available	1	Not Available
OKG380011	001	12/31/2006	0.11	Not Available	4	Not Available
OKG380011	001	01/31/2007	0.09	Not Available	1	Not Available
OKG380011	001	02/28/2007	0.08	Not Available	1	Not Available
OKG380011	001	03/31/2007	0.07	Not Available	5	Not Available
OKG380011	001	04/30/2007	0.08	Not Available	1	Not Available
OKG380011	001	05/31/2007	0.08	Not Available	1	Not Available
OKG380011	001	06/30/2007		Not Available		Not Available
OKG380011	001	07/31/2007	0.12	Not Available	16	Not Available
OKG380011	001	08/31/2007	0.11	Not Available	1	Not Available
OKG380011	001	09/30/2007	0.09	Not Available	1	Not Available
OKG380011	001	10/31/2007	0.1	Not Available	3	Not Available
OKG380011	001	11/30/2007	0.09	Not Available	1	Not Available
OKG380011	001	12/31/2007	0.1	Not Available	1	Not Available
OKG380011	001	01/31/2008	0.1	Not Available	1	Not Available
OKG380011	001	02/29/2008	0.09	Not Available	1	Not Available

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OKG380011	001	03/31/2008	0.11	Not Available	3	Not Available
OKG380011	001	04/30/2008	0.23	Not Available	1	Not Available
OKG380011	001	05/31/2008	0.08	Not Available	1	Not Available
OKG380011	001	06/30/2008	0.07	Not Available	1	Not Available
OKG380011	001	07/31/2008	0.07	Not Available	3	Not Available
OKG380011	001	08/31/2008	0.08	Not Available	4	Not Available
OKG380011	001	09/30/2008	0.07	Not Available	9	Not Available
OKG380011	001	10/31/2008	0.06	Not Available	1	Not Available
OKG380011	001	11/30/2008	0.01	Not Available	4	Not Available
OKG380011	001	12/31/2008	0.07	Not Available		Not Available
OKG380011	001	01/31/2009	0.06	Not Available	1	Not Available
OKG380011	001	02/28/2009	0.04	Not Available	1	Not Available
OKG380011	001	03/31/2009	0.06	Not Available	6	Not Available
OKG380011	001	04/30/2009	0.08	Not Available	14	Not Available
OKG380011	001	05/31/2009	0.06	Not Available	6	Not Available
OKG380011	001	06/30/2009	0.07	Not Available	0	Not Available
OKG380011	001	07/31/2009	0.06	Not Available	3	Not Available
OKG380011	001	08/31/2009	0.08	Not Available	Not Available	Not Available
OKG380011	001	09/30/2009	0.08	Not Available	2	Not Available
OKG380011	001	10/31/2009	0.08	Not Available	4	Not Available
OKG380011	001	11/30/2009	0.11	Not Available	31	Not Available
OKG380011	001	12/31/2009	0.06	Not Available	8	Not Available
OKG380011	001	01/31/2010	0.11	Not Available	9	Not Available
OKG380011	001	02/28/2010	0.14	Not Available	1	Not Available
OKG380011	001	03/31/2010	0.08	Not Available	1	Not Available
OKG380011	001	04/30/2010	0.02	Not Available	1	Not Available
OKG380011	001	05/31/2010	0.05	Not Available	2	Not Available
OKG380011	001	06/30/2010	0.07	Not Available	5	Not Available
OKG380011	001	07/31/2010	0.08	Not Available	7	Not Available
OKG380011	001	08/31/2010	0.09	Not Available	6	Not Available
OKG380011	001	09/30/2010	0.09	Not Available	8	Not Available
OKG380011	001	10/31/2010	0.09	Not Available	4	Not Available
OKG380011	001	11/30/2010	0.09	Not Available	5	Not Available
OKG380011	001	12/31/2010	0.15	Not Available	8	Not Available
OKG380011	001	01/31/2011	0.1	Not Available	10	Not Available
OKG380011	001	02/28/2011	0.05	Not Available	3	Not Available
OKG380011	001	03/31/2011	0.03	Not Available	5	Not Available
OKG380011	001	04/30/2011	0.07	Not Available	5	Not Available
OKG380011	001	05/31/2011	0.05	Not Available	15	Not Available
OKG380011	001	06/30/2011	0.05	Not Available	3	Not Available
OKG380011	001	07/31/2011	0.03	Not Available	10	Not Available

NPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OKG380011	001	08/31/2011	0.04	Not Available	7	Not Available
OKG380011	001	09/30/2011	0.05	Not Available	10	Not Available
OKG380011	001	10/31/2011	0.02	Not Available	3	Not Available
OKG380011	001	11/30/2011	0.02	Not Available	3	Not Available
OKG380011	001	12/31/2011	0.07	Not Available	5	Not Available
OKG380011	001	01/31/2012	0.04	Not Available	17	Not Available
OKG380011	001	02/29/2012	0.05	Not Available	8	Not Available
OKG380011	001	03/31/2012	0.05	Not Available	12	Not Available
OKG380011	001	04/30/2012	0.07	Not Available	3	Not Available
OKG380011	001	05/31/2012	0.06	Not Available	4	Not Available
OKG380011	001	06/30/2012	0.07	Not Available	3	Not Available
OKG380011	001	07/31/2012	0.07	Not Available	3	Not Available
OKG380011	001	08/31/2012	0.07	Not Available	4	Not Available
OKG380011	001	09/30/2012	0.06	Not Available	3	Not Available
OKG380011	001	10/31/2012	0.06	Not Available	6	Not Available
OKG380011	001	11/30/2012	0.05	Not Available	5	Not Available
OKG380011	001	12/31/2012	0.05	Not Available	5	Not Available
OKG380011	001	01/31/2013	0.06	Not Available	4	Not Available

APPENDIX E: DEQ SANITARY SEWER OVERFLOW DATA: 2000-2012

TABLE E DEQ Sanitary Sewer Overflow Data -- 2000-2012

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Wilburton	5/29/2007	S20104	0.10	High School L.S.	1	X		Broken line
Wilburton	4/10/2010	S20104	2.00	W. Of Golf Course & Hunnicutt Ln.	50	X		Malfunction
Wilburton	8/5/2006	S20104	43.00	Hunnicut & Golf Course Rd. In Pasture	250	X		Relief valve stuck from debris
Wilburton	1/12/2007	S20104	0.00	S.W. 9th & 270 Hwy W	415	X		Rain
Wilburton	3/18/2003	S20104	7.00	S.W. 9th & 270 Hwy W.	500	X		Rains
Wilburton	1/9/2008	S20104	6.00	Choctaw L.S. On Hwy 2n	500	X		Broken lines
Wilburton	4/10/2008	S20104	4.00	4th Mh Up From Pleasant Hill Liftstation (South)	500	X		Rain
Wilburton	4/10/2008	S20104	2.50	Sw 9th St & 270 Hwy West	500	X		Rain
Wilburton	3/8/2010	S20104	0.00	Vo-Tech Lift Station	500	X		Broken main
Wilburton	6/26/2007	S20104	1.80	Latimer General Hospital Hwy 2n	565	X		Rain & grease
Wilburton	7/13/2007	S20104	1.00	Pleasant Hill L.S.	600	X		Rain
Wilburton	1/12/2007	S20104	2.10	Pleasant Hill L.S.	625	X		Rain
Wilburton	11/30/2006	S20104	3.00	S.W. 9th & Hwy 270	905	X		Rain
Wilburton	11/29/2006	S20104	6.20	Latimer General Hospital	1,000	X		Rain
Wilburton	4/11/2012	S20104	0.00	Blk. N. On Leland St.	1,000	X		Leakage
Wilburton	1/12/2005	S20104	1.70	Corner Of S.W. 9th & 270 Hwy	1,080	X		Rains
Wilburton	8/12/2008	S20104	2.90	S.W. 9th & 270 Hwy W.	1,150	X		Rain
Wilburton	8/25/2007	S20104	1.00	Latimer General Hospital	1,200	X		Rain
Wilburton	1/12/2007	S20104	4.30	Latimer General Hospital At Hwy 2n	1,270	X		Rain
Wilburton	12/29/2006	S20104	4.20	Latimer General Hospital	1,310	X		Rain
Wilburton	1/12/2005	S20104	1.40	In Front of Southeast Hardware N. on Hwy 2n	1,390	X		Rains
Wilburton	8/11/2008	S20104	2.40	Choctaw L.S.	1,400	X		Rain
Wilburton	8/12/2008	S20104	2.40	4th Mh From Pleasant Hill L.S.	1,440	X		Rain
Wilburton	9/9/2007	S20104	1.00	S.W. 9th & 270 Hwy	1,500			Rain
Wilburton	4/9/2008	S20104	3.50	Southwest 9th & 270 Hwy W	1,500	X		Rain
Wilburton	4/9/2008	S20104	26.25	In Front Of Latimer County Hospital	1,500	X		Rain
Wilburton	9/12/2003	S20104	3.00	S.W. 9th & 270 Hwy	1,800	X		Rain
Wilburton	9/12/2003	S20104	3.00	Hwy 2 N & South E. Hardmure	1,800	X		Rain
Wilburton	12/29/2006	S20104	6.20	Pleasant Hill South L.S.	1,815	X		Rain
Wilburton	6/20/2007	S20104	3.30	Latiner General Hospital	1,940	X		Rain

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Wilburton	10/8/2002	S20104	0.00	High School L.S.	2,000	X		Line stopped
Wilburton	6/9/2007	S20104	2.20	Southeast Hardware Hwy 2n	2,000	X		Rain
Wilburton	3/18/2008	S20104	2.70	S.W. 9th St. & Hwy 270 W	2,000	X		Rain
Wilburton	11/5/2006	S20104	3.80	In Front Of Latimer General Hospital	2,290	X		Rain
Wilburton	11/5/2006	S20104	4.00	Pleasant Hill South L.S.	2,370	X		Rain
Wilburton	7/2/2007	S20104	4.30	Latimer General Hospital Hwy 2n	2,550	X		Rain
Wilburton	9/9/2007	S20104	3.40	Pleasant Hill South L.S.	2,600			Rain
Wilburton	9/9/2007	S20104	3.40	Front Of Latimer General Hospital	2,800			Rain
Wilburton	3/18/2008	S20104	1.50	Latimer Co. General Hospital	3,000	X		Rain
Wilburton	8/12/2008	S20104	2.80	2nd Mh From Pleasant Hill L.S.	3,420	X		Rain
Wilburton	1/24/2007	S20104	168.00	Industrial Park Plant	3,500	X		Pump failure
Wilburton	6/26/2007	S20104	2.20	Pleasant Hill L.S.	3,720	X		Rain
Wilburton	12/30/2006	S20104	6.50	S.W. 9th & Hwy 270	3,860	X		Rain
Wilburton	3/19/2002	S20104	30.00	Corner Of S.W. 9th & 270 Hwy W.	3,900	X		Rain
Wilburton	6/5/2002	S20104	7.50	N. Of Hwy #2 N. Of West Side Of Hwy	4,500	X		Rain
Wilburton	3/3/2008	S20104	7.50	4th Mh Pleasant Hill L.S. South	4,500	X		Rain
Wilburton	7/13/2007	S20104	2.30	Southeast Hardware On Hwy 2n	4,875	X		Rain
Wilburton	8/11/2008	S20104	5.50	S.W. 9th & Hwy 270w	4,950	X		Rain
Wilburton	1/31/2002	S20104	8.00	N. On Hwy 2 On Left Across From Ray's Store	5,000	X		Rain
Wilburton	6/15/2007	S20104	4.20	Southeast Hardware On Hwy 2n	5,000	X		Rain
Wilburton	4/9/2008	S20104	4.00	4th Mh Up From Pleasant Hill Liftstation (South)	5000	X		Rain
Wilburton	4/9/2008	S20104	15.00	Choctaw Lift Station	5,000	X		Rain
Wilburton	11/5/2006	S20104	4.20	Pleasant Hill L.S.	5,060	X		Rain
Wilburton	8/12/2008	S20104	2.80	3rd Mh From Pleasant Hill L.S.	5,130	X		Rain
Wilburton	8/11/2008	S20104	5.70	4th Mh From Pleasant Hill L.S.	5,145	X		Rain
Wilburton	7/13/2007	S20104	5.40	Pleasant Hill L.S.	18,810	X		Rain
Wilburton	9/9/2007	S20104	5.50	Pleasant Hill South L.S.	19,500			Rain
Wilburton	3/18/2002	S20104	0.00	Across From Roy's Store N. Of Hwy 2 On W. Side	21,600	X		Rain
Wilburton	11/5/2006	S20104	7.80	Front Of Southeast Hardware Hwy 2n	23,350	X		Rain

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Wilburton	3/18/2008	S20104	1.60	2nd Mh Pleasant Hill L.S. South	24,510	X		Rain
Wilburton	3/3/2008	S20104	12.40	3rd Mh Pleasant Hill L.S. South	26,180	X		Rain
Wilburton	3/3/2008	S20104	12.40	2nd Mh Pleasant Hill L.S. South	26,180	X		Rain
Wilburton	6/26/2007	S20104	3.50	By Swiss Cleaners On Hwy 2n	26,800	X		Rain & grease
Wilburton	4/11/2005	S20104	2.40		30,000	X		L.s. failed
Wilburton	11/5/2006	S20104	2.60	Industrial Park Plant	30,000	X		Rain
Wilburton	12/29/2006	S20104	20.00	In Front Of Southeast Hardware Hwy 2n	30,000	X		Rain
Wilburton	8/18/2007	S20104	1.30	Pleasant Hill L.S.	30,000	X		Power loss
Wilburton	10/8/2007	S20104	4.50	Southeast Hardware Hwy 2n	30,000	X		Rain
Wilburton	10/8/2007	S20104	4.50	Pleasant Hill South	30,000	X		Rain
Wilburton	10/8/2007	S20104	4.50	Pleasant Hill South L.S.	30,000	X		Rain
Wilburton	11/29/2006	S20104	18.00	Southwest Hardware At Hwy 2n	32,070	X		Rain
Wilburton	6/5/2002	S20104	11.00	In Front Of Latimer General Hospital	34,500	X		Rain
Wilburton	3/18/2008	S20104	24.60	Southwest Hardware Store @ Hwy 2n	37,850	X		Rain
Wilburton	3/3/2008	S20104	37.50	Southwest Hardware - Hwy 2n	40,500	X		Rain
Wilburton	3/18/2008	S20104	13.60	3rd Mh Pleasant Hill L.S. South	40,850	X		Rain
Wilburton	7/2/2007	S20104	16.80	In Front Of Southeast Hardware Hwy 2 South	51,375	X		Rain
Wilburton	4/9/2008	S20104	17.00	2nd Mh Up From Pleasant Hill Liftstation	52,250	X		Rain
Wilburton	1/12/2007	S20104	1.40	Southeast Hardware & Hwy 2n	78,100	X		Rain
Wilburton	4/9/2008	S20104	17.00	3rd Mh Up From Pleasant Hill Liftstation	78,375	X		Rain
Wilburton	4/9/2008	S20104	19.00	In Front Of Southeast Hardware Hwy 2 N	82,050	X		Rain
Wilburton	3/21/2005	S20104	4.50	Bandy Creek L.S.	100,000	X		Power failure
Wilburton	12/29/2006	S20104	120.00	Industrial Park Aeration Basins			X	Rain
Wilburton	8/21/2007	S20104	0.00					Power surge
Wilburton	4/9/2008	S20104	0.00					
Wilburton	2/24/2010	S20104	0.00	Pleasant Hill L.S.		X		Electrical failure
Heavener	6/1/2004	S20119	0	S. End Of City	600	X		Fuse blown
Heavener	11/10/2004	S20119	0.4	416 East 1st	300	X		Grease
Heavener	7/12/2006	S20119	0.4	East 2nd & Old Pike Rd.	2,700	X		Ruptured force main
Heavener	7/26/2006	S20119	0.2	Lift Station	400	X		Electrical failure

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Heavener	8/1/2006	S20119	1	107 E. Ave "B"	500	X		Grease
Heavener	3/18/2008	S20119	16	West Ave."C" By Carwash	4,800	X		Rain
Heavener	3/18/2008	S20119	21.5	W. "I" St. & Hwy 59	6,500	X		I&i
Heavener	3/16/2009	S20119	0	701 West Avenue 'E"		X		Motors burned out
Heavener	3/17/2009	S20119	6	L.S. #5 S. Of Ok Feed Mill	3,600	X		Malfunction
Heavener	4/7/2009	S20119	0	Lift Station Next To Kcs Round House	5,000	X		Grease
Heavener	7/29/2009	S20119	0	In Alley Behind 400 W. Ave. "D"	50	X		Debris
Heavener	8/12/2009	S20119	2.3	1000 Cornett		X		Grease & roots
Heavener	8/12/2009	S20119	0					
Heavener	9/26/2009	S20119	56.5	Highland Park Addition	3,150	X		Broken main
Heavener	10/12/2009	S20119	0	Behind 504 West "G"	200	X		Stopped line
Heavener	12/3/2009	S20119	0	200 W. 4th	100	X		
Heavener	12/5/2009	S20119	2	Lift Station	500	X		Station down
Heavener	1/13/2010	S20119	2	Lori Lane & Holly Rd. In Alley	500	X		Line hit by back hoe
Heavener	6/2/2010	S20119	0	Lagoon		X		Broken line
Heavener	7/26/2010	S20119	1.5	1007 Townsend Ave.	200	X		Roots, grease & rags
Heavener	8/2/2010	S20119	0.1	1002 Townsend Ave.	5	X		Blockage
Heavener	11/18/2010	S20119	3.3	506 West Ave. E.	100	X		Grease
Heavener	11/29/2010	S20119	0	312 Daily		X		Debris & junk
Heavener	12/6/2010	S20119	1.5	310 Walker	500	X		Grease
Heavener	1/9/2011	S20119	72		5,000			Rock broke line
Heavener	3/1/2011	S20119	0.5	304 West	200	X		Blockage
Heavener	3/3/2011	S20119	0	Wilson St.	200			Grease & rags
Heavener	3/25/2011	S20119	0	Fowler & Olive	50	X		Rags
Heavener	3/31/2011	S20119	0	403 W. Avenue "G'	50	X		Line stoppage
Heavener	4/6/2011	S20119	2.5	700 Blk. W. Avenue "E"	200			Rags
Heavener	8/17/2011	S20119	1	N. Of Lift Station #6	200	X		Lightning
Heavener	12/2/2011	S20119	1	Lift Station #6	1,000	X		Broken pipe
Pocola	1/13/2000	S20102	7.3	Fuller St. Beside Day Care Center	6,000	X		Roots & grease
Pocola	2/9/2000	S20102		Gray St.	2,000			Main break

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Pocola	5/8/2000	S20102	1.1	Mh N. Of L.S.	500	X		Electrical shortage
Pocola	5/29/2000	S20102	3.5	Main L.S. - Plant	20,000	X		Pump failure
Pocola	6/21/2000	S20102	6	Headworks	20,000	X		Rain
Pocola	6/21/2000	S20102	6	Cox Field L.S.	20,000	X		Rain
Pocola	6/21/2000	S20102	3	WWTF	800,000			Rain
Pocola	6/21/2000	S20102	1.5	Mh N. Of L.S.	10,000			Rain
Pocola	8/17/2000	S20102	1	Farris St. L.S.	1,000	X		Electrical burnout
Pocola	9/26/2000	S20102	0.7	Mh S. Of L.S.	5,000	X		Fuse blown
Pocola	11/24/2000	S20102	23	Cox Field L.S.	120,000	X		Rain
Pocola	11/24/2000	S20102	23	Mh S. Of Main L.S.	75,000	X		Rain
Pocola	11/25/2000	S20102	2.3	Clarifier	250,000		X	Rain
Pocola	11/25/2000	S20102	4.3	Headworks	8,000	X		Rain
Pocola	12/14/2000	S20102	4.6	Wwp	45,000	X		Electrical shortage
Pocola	12/26/2000	S20102	5	Cox L.S.	35,000	X		Power failure
Pocola	12/28/2000	S20102	120	Main Plant	432,000	X		Electrical problem
Pocola	1/11/2001	S20102	11	Main Plant	110,000		X	Rain
Pocola	1/29/2001	S20102		Plant	800,000	X		Rain
Pocola	1/29/2001	S20102	8	Cox Field L.S.	50,000	X		Backup
Pocola	2/14/2001	S20102		Cox Field L.S.	130,000	X		Rain
Pocola	2/14/2001	S20102		Wwp			X	Rain
Pocola	2/14/2001	S20102		Plant			X	Rain
Pocola	2/15/2001	S20102	31	Headworks	12,000	X		I&i
Pocola	2/16/2001	S20102	13	L.S.	24,000	X		Rain
Pocola	4/15/2001	S20102	4	Cox Field L.S.	10,000	X		Rain
Pocola	4/15/2001	S20102	4	Cox Field L.S.	10,000			Rain
Pocola	5/21/2001	S20102	2	WWTF	2,000		X	Flow
Pocola	5/21/2001	S20102	3	Cox Field L.S.	400	X		Rain
Pocola	5/30/2001	S20102	8	Cox Field L.S.	20,000	X		Back-up
Pocola	5/30/2001	S20102		WWTF	100,000		X	Rain
Pocola	11/4/2001	S20102	10	Mh At Plant	10,000	X		Construction at plant

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Pocola	1/14/2002	S20102	4.5	WWTF	10,000	X		Construction
Pocola	1/28/2002	S20102	6	WWTF	10,000	X		Pump failure
Pocola	3/19/2002	S20102	72	WWTF	432,000	X		Overflow
Pocola	3/19/2002	S20102	9	Cox Field L.S.	20,000	X		Power failure
Pocola	3/22/2002	S20102	0	Cox Field L.S.	150,000	X		Rain/ l.s. down
Pocola	3/22/2002	S20102	0	Cox Field L.S.				Electrical problem
Pocola	4/7/2002	S20102	21	Bradley Field L.S.	22,000	X		Rain
Pocola	4/7/2002	S20102	7	N. Of Lift Station	50,000	X		Rain
Pocola	3/13/2003	S20102	4	N. Of Plant	24,000	X		Malfunction
Pocola	6/2/2003	S20102	5.5	Bradley Field L.S.	5,000	X		Malfunction
Pocola	11/2/2003	S20102	6.5	Sunset Estates	8,000	X		Broken pipe
Pocola	12/19/2003	S20102	0.4	Headworks	5,000	X		Broken line
Pocola	2/8/2004	S20102	2.4	Plant	35,000	X		Pump failure
Pocola	2/19/2004	S20102	9.5	N. Of Choctaw Casino	20,000	X		Clogged line
Pocola	3/18/2004	S20102	2.5	Plant	40,000	X		Pump malfunction
Pocola	4/23/2004	S20102	1.2	Plant	12,000	X		Pump failure
Pocola	6/20/2004	S20102	1.3	Plant	35,000		X	Rain
Pocola	6/22/2004	S20102	17.6	Plant	36,000		X	Rain
Pocola	7/3/2004	S20102	48	Plant	450,000	X		Rain
Pocola	9/29/2004	S20102	3	Plant	24,500		X	Cleaning tanks
Pocola	11/24/2004	S20102	8.5	Plant	300,000	X		Rain
Pocola	1/5/2005	S20102	2.4	Plant	150	X		Pump failure
Pocola	8/29/2005	S20102	3		3,375	X		Malfunction
Pocola	1/5/2006	S20102	0	Choctaw Casino Line	200,000	X		Blockage
Pocola	1/24/2006	S20102	8.5	Choctaw Line S. Of Facility	15,000	X		Grease
Pocola	2/27/2006	S20102	34	Behind Choctaw Casino	12,000	X		Grease
Pocola	11/30/2006	S20102	1	Lift Station At Church St.	40,000	X		Rain
Pocola	11/30/2006	S20102	2.2	Bradley Field L.S.		X		Rain
Pocola	12/22/2006	S20102		S. Of Plant	70,000	X		Mh top popped off
Pocola	2/22/2007	S20102	0	Bradley Field	210,000	X		Pumps burn-out

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Pocola	3/20/2008	S20102	0	603 Morris St.		X		Rain
Pocola	4/10/2008	S20102	0	Plant	150,000		X	Rain
Pocola	4/24/2008	S20102	32.4	Lift Station	175,000	X		Malfunction
Pocola	9/4/2008	S20102	26	605 Morris St.		X		Owner cleaning out lines on property
Pocola	9/8/2008	S20102	8.5	End Of Victor Ave.		X		Trash
Pocola	1/11/2010	S20102	5	Driveway To Plant	50	X		Frozen line
Pocola	7/10/2012	S20102	5	102 Walls Rd.	200	X		Force main damage
Pocola	8/7/2012	S20102	16	Plant	0.078			Blockage
Quinton	3/17/2000	S20202	6	Lagoon	1,440		X	Rain
Quinton	10/26/2000	S20202	8.5	Lagoons	2,125		X	Equipment failure
Quinton	11/19/2002	S20202	10	Lagoon	2,200		X	Leaking line
Quinton	4/10/2008	S20202	44.5	Sanbois Creek	1.5 MILL		X	Rain
Quinton	5/4/2009	S20202	8	Plant	4.5 MILN		X	Rain
Quinton	9/14/2009	S20202	72	San Bois Creek	>3 MILLN		X	Rain
Quinton	10/9/2009	S20202	149	San Bois Creek	4 MILLN		X	Rains
Quinton	2/13/2010	S20202	31.5	San Bois Creek	900,000		X	I&i
Quinton	3/23/2010	S20202	79	San Bois Creek	>3 MILLN		X	Weather
Quinton	7/10/2010	S20202	71.5	San Boise Creek	>3 MILLN		X	Rain
Leflore Co. RWD #5	7/10/2012	S20114	15	East Railroad St.	34,500	X		Lightning blew out motor
Leflore Co. RWD #5	4/8/2002	S20114	0	Town Of Howe, North Railroad St		X		Rain
Bokoshe	4/2/2004	S20115	25.2	Choctaw Housing Project	500	X		Pump failure
Bokoshe	4/25/2011	S20115	6	South St. & Elm	500	X		Rain
Calvin	7/16/2008	S20666	0	721 Hwy 1		X		Blockage

APPENDIX F: RESPONSE TO PUBLIC COMMENTS

Scott A. Thompson
Executive Director

Mary Fallin
Governor

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Response to the Public Comment Received for the Draft Bacterial and Turbidity TMDL Report for the Lower Arkansas River Area

March 25, 2014

Comment sent by via email from Robert Vaughan, P.E. Infrastructure Solutions Group, LLC; Mehlburger Brawley Consulting Engineers:

I have reviewed the Proposed Modification to Incorporate Lower Arkansas River Bacterial and Turbidity TMDLs into Oklahoma's Water Quality Management Plan and have one minor comment.

The Town of Calvin has disinfection facilities at their wastewater treatment lagoons. It was constructed in 2011.

Response:

That correction was made to Table 5-4 and to the Lower Arkansas TMDL 208 Factsheet.

Thank you for your comment.