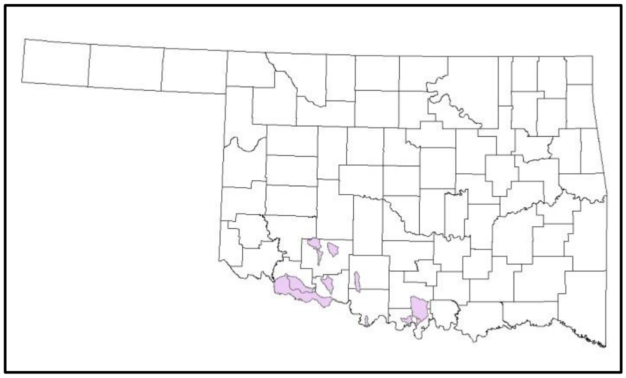
FINAL

2018 BACTERIAL AND TURBIDITY TOTAL MAXIMUM DAILY LOADS FOR OKLAHOMA STREAMS IN THE RED RIVER AREA (OK311100, OK311200, OK311300, OK311310)

Oklahoma Waterbody Identification Numbers

Bills Creek	OK311100010230_00
Walnut Bayou	OK311100010250_00
Fleetwood Creek	OK311100010300_00
Hickory Creek	OK311100020010_10
Dry Creek	OK311200000080_00
Cache Creek, East	OK311300020010_10
Medicine Creek	OK311300040060_00
Red River	OK311310010010_00
Cache Creek, West	OK311310020010_10
Blue Beaver Creek	OK311310020060_00
Little Deep Red Creek	OK311310030040_00



Prepared by:

Oklahoma Department of Environmental Quality

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
AFO	Animal Feeding Operation
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

As promulgated by Section 402 of the Clean Water Act (CWA), the U.S. Environmental Protection Agency (EPA) has delegated authority to the Oklahoma Department of Environmental Quality (DEQ) to partially oversee the National Pollutant Discharge Elimination System (NPDES) Program in the State of Oklahoma. Exceptions are agriculture (retained by State Department of Agriculture, Food, and Forestry), and the oil & gas industry (retained by the Oklahoma Corporation Commission) for which EPA has retained permitting authority. The NPDES Program in Oklahoma, in accordance with an agreement between DEQ and EPA, is implemented via the Oklahoma Pollutant Discharge Elimination System (OPDES) Act [Title 252, Chapter 606 (http://www.deq.state.ok.us/rules/606.pdf)].

This total maximum daily load (TMDL) report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli)*, Enterococci] and turbidity for selected waterbodies in the Red River 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 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 DEQ guidance and procedures. DEQ is required to develop TMDLs for all impaired waterbodies which are on the 303(d) list. Then the draft TMDL goes to EPA for review before submitting it for public comment. After the public comment period, the TMDL is submitted to EPA for final approval. Once EPA approves the final TMDL, then the waterbody is moved to Category 4a of the Integrated Report, where it remains until it reaches compliance with Oklahoma's water quality standards (WQS).

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 in-stream 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 OPDES 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 Red Rivers Study Area, identified in **Table ES-1**, which DEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2014 Integrated Report* for nonsupport of primary body contact recreation (PBCR) or the Fish and Wildlife Propagation-Warm Water Aquatic Community (WWAC) beneficial uses.

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 the Fish & 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 2000 and 2013 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 2014 303(d) list (DEQ 2015).

ES-2.1 Chapter 45: Criteria for Bacteria

The definition of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Title 785, Chapter 45-5-16 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.

ES-2.2 Chapter 46: Implementation of OWQS for Bacteria

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2015b). 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 2015a).

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 are 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 contained three bacterial indicators (fecal coliform, *E. coli* and Enterococci). Since July 1, 2011 the WQS address only *E. coli* and Enterococci bacteria. Therefore, bacterial TMDLs are developed only for *E. coli* and/or Enterococci impaired streams.

Table ES- 1 Excerpt from the 2014 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
OK311100010230_00	Bills Creek	8.43	2025	4	X		N		I
OK311100010250_00	Walnut Bayou	10.82	2025	4	X		N		F
OK311100010300_00	Fleetwood Creek	10.91	2022	3	X	X	N		N*
OK311100020010_10	Hickory Creek	37.28	2019	2	X		N		F
OK311200000080_00	Dry Creek	20.96	2019	2	X	X	N		N*
OK311300020010_10	Cache Creek, East	17.08	2016	1	X		N		N*
OK311300040060_00	Medicine Creek	17.71	2016	1	X		N		F
OK311310010010_00	Red River	88.02	2022	3	X		N**	X	N
OK311310020010_10	Cache Creek, West	19.17	2025	4	X		N		F
OK311310020060_00	Blue Beaver Creek	18.33	2019	2	X		N		I
OK311310030040_00	Little Deep Red Creek	33.57	2016	1	X	X	N		N*

ENT = Enterococci; N = Not attaining; X = Criterion exceeded; I = Insufficient information; F = Fully supporting Source: 2014 Integrated Report, DEQ 2015
*: Due to low DO, not addressed in this report.
**: Impaired for enterococci, but TMDL was done in 2007.

Table ES- 2 Summary of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2000-2013

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Conc (cfu/100 ml)	Assessment Results / Recommended Actions
OK311100010230_00	Bills Creek	*EC*	1	239	Insufficient data / No action
		ENT	1	1,650	Insufficient data / Delist
OK311100010250_00	Walnut Bayou	*EC*	14	43	Meeting WQS / No action
		ENT	14	112	**Impaired / TMDL**
OK311100010300_00	Fleetwood Creek	*EC*	13	561	**Impaired / TMDL**
		ENT	13	982	**Impaired / TMDL**
OK311100020010_10	Hickory Creek	*EC*	11	43	Meeting WQS / No action
		ENT	11	80	**Impaired / TMDL**
OK311200000080_00	Dry Creek	*EC*	4	273	Insufficient data / Delist
		ENT	4	500	Insufficient data / Delist
OK311300020010_10	Cache Creek, East	*EC*	10	40	Meeting WQS / No action
		ENT	10	102	**Impaired / TMDL**
OK311300040060_00	Medicine Creek	*EC*	10	64	Meeting WQS / No action
		ENT	10	144	**Impaired / TMDL**
OK311310010010_00	Red River	*EC*	18	91	Meeting WQS / No action
		ENT	18	131	Impaired and 2007 TMDL / No action
OK311310020010_10	Cache Creek, West	*EC*	10	63	Meeting WQS / No action
		ENT	10	142	**Impaired / TMDL**
OK311310020060_00	Blue Beaver Creek	*EC*	6	69	Insufficient data / No action
		ENT	6	245	**Impaired / TMDL**
OK311310030040_00	Little Deep Red Creek	*EC*	10	128	**Impaired / TMDL**
		ENT	10	425	**Impaired / TMDL**

E. coli (*EC*) water quality criterion = Geometric Mean of 126 counts/100 mL
Enterococci (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL
TMDLs will be developed for waterbodies that are highlighted

ES-2.3 Chapter 45: Criteria for Turbidity

The beneficial use of WWAC 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 2015a). 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.

Table ES- 3 Summary of Turbidity Data Excluding High Flow Samples, 2001-2014

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 / Recommended Actions
OK311100010230_00	Bills Creek	311100010230-001SRF & 311100010230-002SRF	7	0	0%	8	Insufficient data / No action
OK311100010250_00	Walnut Bayou	OK311100-03-0010G & 311100030010-001AT	25	4	16.0%	60	Impaired, but not listed in 303d /**TMDL**
OK311100010300_00	Fleetwood Creek	OK311100-01-0300D	17	2	11.8%	30	Impaired and 2010 TMDL / No action
OK311100020010_10	Hickory Creek	OK311100-02-0010M	21	1	4.8%	16	Meeting WQS / No action
OK311200000080_00	Dry Creek	OK311200-00-0080G	10	2	20.0%	122	Impaired and 2010 TMDL / No action
OK311300020010_10	Cache Creek, East	OK311300-02-0010M	19	2	10.5%	19	Impaired, but not listed in 303d / **TMDL**
OK311300040060_00	Medicine Creek	OK311300-04-0060H	19	0	0%	2	Meeting WQS / No action
OK311310010010_00	Red River	311310010010-001AT	56	25	44.6%	187	**Impaired / TMDL**
OK311310020010_10	Cache Creek, West	OK311310-02-0010M	17	1	5.9%	31	Meeting WQS / Delist
OK311310020060_00	Blue Beaver Creek	OK311310-02-0060G	10	0	0%	1.7	Meeting WQS / No action
OK311310030040_00	Little Deep Red Creek	OK311310-03-0040D	15	6	40.0%	44	Impaired and 2010 TMDL / No action

Table ES- 4 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK311100010250_00	Walnut Bayou	0.81	21.4%	23.9	25%
OK311300020010_10	East Cache Creek	0.82	18.5%	60.0	20%
OK311310010010_00	Red River	0.86	8.3%	86.6	10%

[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)

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

Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2015b) 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-2.5 Chapter 46: Minimum number of samples

Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2015) describes minimum number of samples to assess beneficial use.

785:46-15-3 Data requirements

(d). Minimum number of samples.

(1) Streams. Except when (f) of this Section or any of subsection (e), (h), (i), (j), (k), (l), or (m) of 785:46-15-5applies, a minimum of 10 samples shall be required to assess

beneficial use support due to field parameters including but not limited to DO, pH and temperature, and due to routine water quality constituents including but not limited to coliform bacteria, dissolved solids and salts. Analyses may be aggregated to meet the 10 sample minimum requirements in non-wadable stream reaches that are 25 miles or less in length, and in wadable stream reaches that are 10 miles or less in length, if water quality conditions are similar at all sites. Provided, a minimum of 10 samples shall not be necessary if the existing samples already assure exceedance of the applicable percentage of a prescribed screening level.

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 OPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the OPDES program. OPDES-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. There are 11 active permitted municipal or industrial point source facilities within the Study Area.

Nonpoint sources include those sources that cannot be identified as entering a waterbody at a specific 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 OPDES 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-5 summarizes the point and nonpoint sources that contribute bacteria or TSS to each respective waterbody.

Table ES- 5 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal OPDES Facility	Industrial OPDES Facility	MS4	OPDES No Discharge Facility	CAFO	Mines	Construction Stormwater Permit	Multi-Sector General Permit	Nonpoint Source
OK311100010230_00	**Bills Creek**	Ø	Ø					Ø	Ø	
OK311100010250_00	**Walnut Bayou**				Ø					Bacteria/Turbidity
OK311100010300_00	**Fleetwood Creek**									Bacteria
OK311100020010_10	**Hickory Creek**	O	Ø		Ø			Ø	Ø	Bacteria
OK311200000080_00	**Dry Creek**						Ø		Ø	
OK311300020010_10	**Cache Creek, East**	O	O	O	Ø			Ø	Ø	Bacteria/Turbidity
OK311300040060_00	**Medicine Creek**									Bacteria
OK311310010010_00	**Red River**	Ø	Ø		Ø	Ø		Ø	Ø	Turbidity
OK311310020010_10	**Cache Creek, West**						Ø			Bacteria
OK311310020060_00	**Blue Beaver Creek**									Bacteria
OK311310030040_00	**Little Deep Red Creek**	O			Ø			Ø		Bacteria

O: Facility present in watershed and potential as contributing pollutant

Ø: Facility present in watershed, but not recognized as pollutant

No facility present in watershed

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:

1. Prepare flow duration curves for gaged and ungaged WQM stations.
2. Estimate existing loading in the waterbody using ambient bacterial water quality data.
3. Estimate loading in the waterbody using measured TSS water quality data and turbidity-converted data.
4. Use 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 following are the basic steps in developing a LDC:

1. Obtain daily flow data for the site of interest from the U.S. Geological Survey (USGS), or if unavailable, obtain projected flow from a nearby USGS site.
2. Sort the flow data and calculate the flow exceedance percentiles.
3. Obtain the water quality data.
    - For bacterial TMDLs, obtain the water quality data from the primary contact recreation season (May 1 through September 30).
    - For turbidity TMDLs, obtain available turbidity and TSS water quality data.
4. Display 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.
5. Display a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQ_{goal} for TSS.
6. For bacterial TMDLs, display and differentiate 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.

7. For turbidity TMDLs, match the water quality observations with the flow data from the same date and determine the corresponding exceedance percentile. Plot the flow exceedance percentiles and daily load observations in a load duration plot (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 5-2***

Unit conversion factor = 5.39377

ES-4.3 LDC Summary

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 water quality target can also be calculated under various flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required.

Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. 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.

Historical observations of TSS and/or turbidity concentrations are paired with flow data and are plotted on the LDC for a stream.

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:

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

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.

ES-5.1 Bacterial PRG

For each waterbody the TMDLs presented in this report are expressed as colony forming units (cfu) 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.

Table ES-6 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area.

Table ES- 6 Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate	
		E. coli	Enterococci
OK311100010250_00	Walnut Bayou	-	73.5%
OK311100010300_00	Fleetwood Creek	79.8%	97.0%
OK311100020010_10	Hickory Creek	-	62.8%
OK311300020010_10	Cache Creek, East	-	70.9%
OK311300040060_00	Medicine Creek	-	79.4%
OK311310020010_10	Cache Creek, West	-	79.0%
OK311310020060_00	Blue Beaver Creek	-	87.9%
OK311310030040_00	Little Deep Red Creek	11.5%	93.0%

ES-5.2 TSS PRG

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-7**.

Table ES- 7 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK311100010250_00	Walnut Bayou	63.5%
OK311300020010_10	Cache Creek, East	34.3%
OK311310010010_00	Red River	92.8%

ES-5.3 Seasonal Variation

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5th 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 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.

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 all available consecutive USGS flow records when estimating flows to develop flow exceedance percentiles.

ES-5.4 MOS

Federal regulations (40 CFR §130.7(c)(1)) also require that TMDLs include an MOS. 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**).

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 water quality standards. 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 OPDES permit requires in-stream criteria to be met.

ES - 6 Reasonable Assurance

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

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

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

ES - 7 Public Participation

The public had a 45-day opportunity to review the draft TMDL report and submit written comments. No public comments were received. There was no request for a public meeting. The final TMDL was submitted to EPA for final approval.

SECTION 1 INTRODUCTION

1.1 TMDL Program Background

As promulgated by Section 402 of the Clean Water Act (CWA), the U.S. Environmental Protection Agency (EPA) has delegated authority to the Oklahoma Department of Environmental Quality (DEQ) to partially oversee the National Pollutant Discharge Elimination System (NPDES) Program in the State of Oklahoma. Exceptions are agriculture (retained by State Department of Agriculture, Food, and Forestry), and the oil & gas industry (retained by the Oklahoma Corporation Commission) for which EPA has retained permitting authority. The NPDES Program in Oklahoma, in accordance with an agreement between DEQ and EPA, is implemented via the Oklahoma Pollutant Discharge Elimination System (OPDES) Act [Title 252, Chapter 606 (http://www.deq.state.ok.us/rules/606.pdf)].

Section 303(d) of the CWA and 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 in-stream water quality conditions, so states can implement water quality-based controls to reduce pollution from point and nonpoint sources and restore and maintain water quality (EPA 1991).

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli)* and Enterococci][1] and turbidity for selected waterbodies in the Red River 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 study was 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 in-stream 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 OPDES. 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.

[1] All future references to bacteria in this document imply these two fecal pathogen indicator bacterial groups unless specifically stated otherwise

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, 2014 Integrated Report* for nonsupport of primary body contact recreation (PBCR) or Fish & Wildlife Propagation beneficial uses. The waterbodies considered for TMDL development in this report are listed in **Table 1-1**:

Table 1-1 TMDL Waterbodies

Bills Creek	OK311100010230_00
Walnut Bayou	OK311100010250_00
Fleetwood Creek	OK311100010300_00
Hickory Creek	OK311100020010_10
Dry Creek	OK311200000080_00
Cache Creek, East	OK311300020010_10
Medicine Creek	OK311300040060_00
Red River	OK311310010010_00
Cache Creek, West	OK311310020010_10
Blue Beaver Creek	OK311310020060_00
Little Deep Red Creek	OK311310030040_00

Figure 1-1 shows these Oklahoma waterbodies and their contributing watersheds. This map also displays 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.

TMDLs are required to be developed whenever elevated levels of pathogen indicator bacteria or turbidity are above the WQS numeric criterion. 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 & 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.

Figure 1-1 Red River Watersheds Not Supporting Primary Body Contact Recreation or Fish & Wildlife Propagation Beneficial Uses

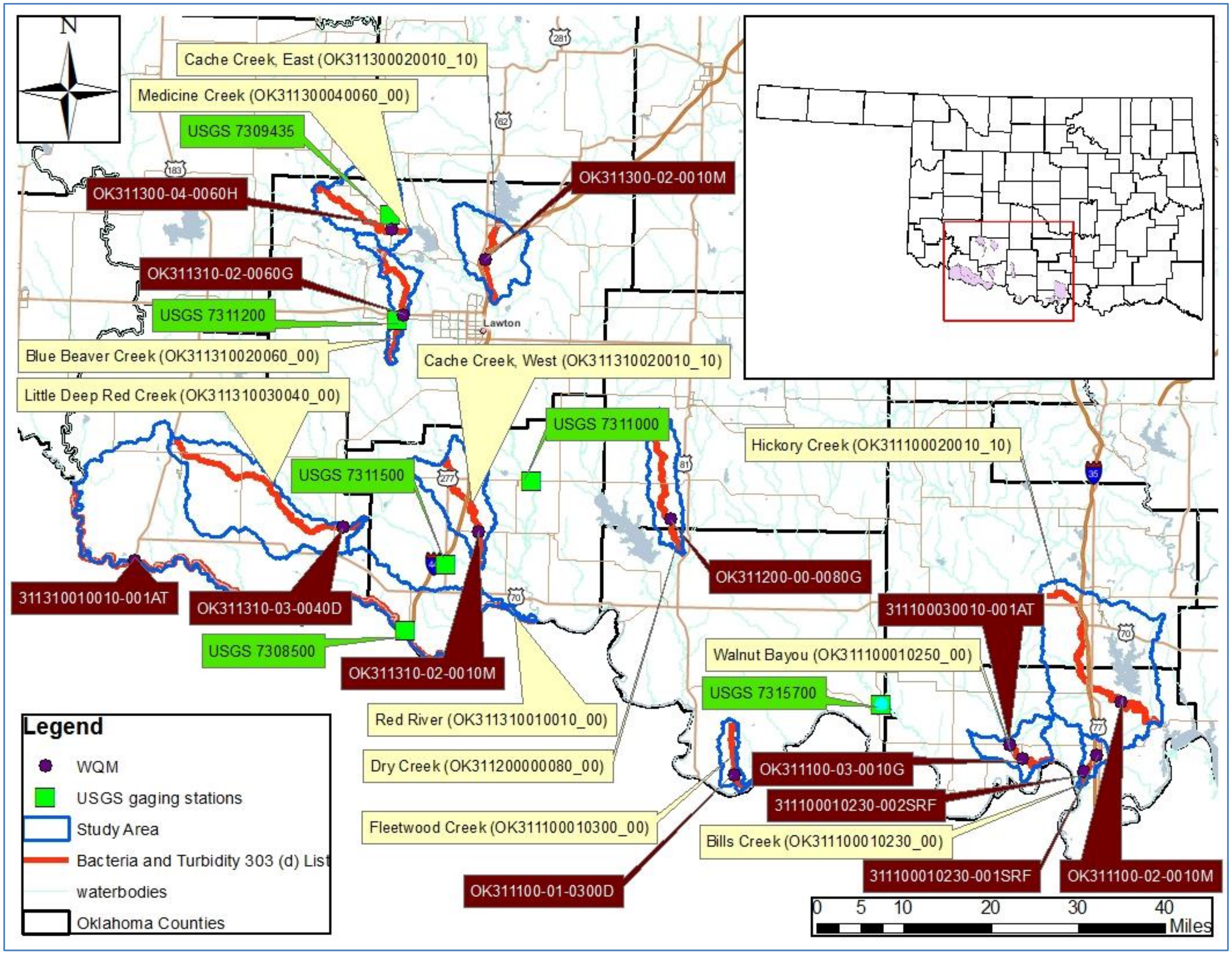


Table 1-2 Water Quality Monitoring Stations used for Assessment of Streams

WQM Station	Waterbody Name	Station Location	Waterbody ID
311100010230-001SRF	Bills Creek	Lat.: 33.93, Long.: -97.13	OK311100010230_00
311100010230-002SRF		Lat.: 33.90, Long.: -97.16	
311100030010-001AT	Walnut Bayou	Lat.: 33.94, Long.: -97.31	OK311100010250_00
OK311100-03-0010G		Lat.: 33.92, Long.: -97.28	
OK311100-01-0300D	Fleetwood Creek	Lat.: 33.88, Long.: -97.86	OK311100010300_00
OK311100-02-0010M	Hickory Creek	Lat.: 34.01, Long.: -97.08	OK311100020010_10
OK311200-00-0080G	Dry Creek	Lat.: 34.30, Long.: -98.00	OK311200000080_00
OK311300-02-0010M	Cache Creek, East	Lat: 34.725, Long: -98.388	OK311300020010_10
OK311300-04-0060H	Medicine Creek	Lat: 34.772, Long: -98.580	OK311300040060_00
311310010010-001AT	Red River	Lat: 34.212, Long: -99.082	OK311310010010_00
OK311310-02-0010M	Cache Creek, West	Lat: 34.275, Long: -98.388	OK311310020010_10
OK311310-02-0060G	Blue Beaver Creek	Lat: 34.631, Long: -98.552	OK311310020060_00
OK311310-03-0040D	Little Deep Red Creek	Lat: 34.278, Long: -98.662	OK311310030040_00

1.2 Watershed Description

1.2.1 General

The Red River study area is located in the southern portion of Oklahoma. The waterbodies and their watersheds addressed in this report are scattered over Carter, Comanche, Cotton, Jefferson, Love, Stephens, and Tillman counties. These counties are part of the Great Central Plains and Cross Timber Level III ecoregions (Woods, A.J, et al 2005). The watersheds in the Study Area are located in the Wichita Uplift and Hollis Basin 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)
Carter	47,557	57
Comanche	124,098	115
Cotton	6,193	10
Jefferson	2,475	8
Love	4,151	18
Stephens	21,904	51
Tillman	7,992	9

Table 1-4 Major Municipalities by Watershed

Waterbody Name	Waterbody ID	Municipalities
Bills Creek	OK311100010230_00	Horseshoe Bend, Thackerville
Walnut Bayou	OK311100010250_00	Burneyville, Marysville
Fleetwood Creek	OK311100010300_00	Belcherville, Fleetwood, Ringgold, Terral
Hickory Creek	OK311100020010_10	Ardmore, Lake Murray, Marietta, Overbrook
Dry Creek	OK311200000080_00	Comanche, Corum, Duncan, Empire, Waurika
Cache Creek, East	OK311300020010_10	Arbuckle Hill, Fort Sill, Lawton
Medicine Creek	OK311300040060_00	Meers, Quanah Mountain, Saddle Mountain
Red River	OK311310010010_00	Augar Creek, Burkburnett, Clara, Cowboy Springs, Davidson, Devol, Frederick, Oklaunion, Sunshine Hill, Thornberry
Cache Creek, West	OK311310020010_10	Cookietown, Randlett, Tayor
Blue Beaver Creek	OK311310020060_00	Mount Scott, Taupa
Little Deep Red Creek	OK311310030040_00	Grandfield, Hackberry Flat, Hollister

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 30 and 39 inches (Oklahoma Climatological Survey 2005).

Table 1-5 Average Annual Precipitation by Watershed

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Bills Creek	OK311100010230_00	38.8
Walnut Bayou	OK311100010250_00	38.0
Fleetwood Creek	OK311100010300_00	33.2
Hickory Creek	OK311100020010_10	38.9
Dry Creek	OK311200000080_00	35.4
Cache Creek, East	OK311300020010_10	32.8
Medicine Creek	OK311300040060_00	33.0
Red River	OK311310010010_00	30.2
Cache Creek, West	OK311310020010_10	32.5
Blue Beaver Creek	OK311310020060_00	32.4
Little Deep Red Creek	OK311310030040_00	30.6

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) 2011 National Land Cover Dataset (USGS 2014). The percentages provided in **Table 1-6** are rounded so in some cases may not total exactly 100%. The land use categories are displayed in **Figure 1-2**. The two most dominant land use categories throughout the Red River Study Area are Grassland/Herbaceous and Cultivated Crops. The aggregated total of developed land ranges from approximately 1.4% of the land use in the Medicine Creek (OK311300040060_00) watershed to 18.0% of the land use in the Bills Creek (OK311100010230_00) watershed. The watersheds targeted for TMDL development in this Study Area range in size from 7,695 acres (Bills Creek, OK311100010230_00) to 248,044 acres (Red River, OK311310010010_00).

Figure 1-2 Land Use Map

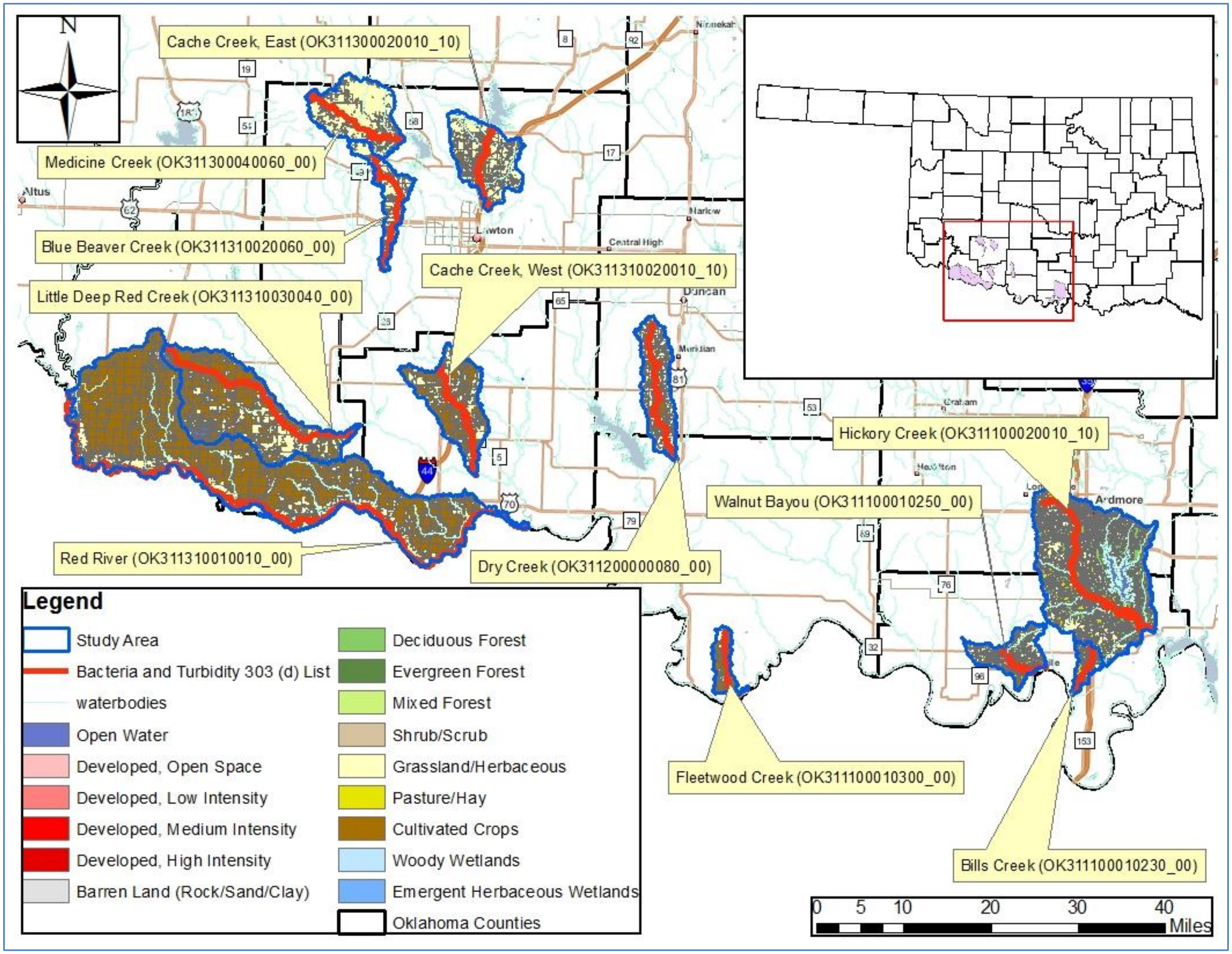


Table 1-6 Land Use Summaries by Watershed

Landuse Category	Watershed										
	Bills Creek	Walnut Bayou	Fleetwood Creek	Hickory Creek	Dry Creek	Cache Creek, East	Medicine Creek	Red River	Cache Creek, West	Blue Beaver Creek	Little Deep Red Creek
Waterbody ID	OK311100010230_00	OK311100010250_00	OK311100010300_00	OK311100020010_10	OK311200000080_00	OK311300020010_10	OK311300040060_00	OK311310010010_00	OK311310020010_10	OK311310020060_00	OK311310030040_00
Open Water	65	181	5	6,893	154	267	38	4,089	129	175	1,596
Developed, Open Space	660	1,319	322	7,035	1,429	2,175	581	10,912	2,235	1,063	3,808
Developed, Low Intensity	391	84		3,987	36	490	11	1,297	237	108	925
Developed, Medium Intensity	249	26		1,467	12	421	4	404	128	29	176
Developed, High Intensity	85	1		623	1	42		147	7		56
Barren Land	11	55	13	302		556		8,065	18		38
Deciduous Forest	593	5,999	923	40,784	3,917	3,046	3,103	2,891	1,835	933	216
Evergreen Forest		104		280	2		514	5	3	50	2
Mixed Forest							363			51	
Shrub/Scrub			256	5	4	52	512	2,368	319	681	983
Grasslands/Herbaceous	2,423	9,535	4,391	47,881	20,584	27,559	35,274	63,166	16,994	16,138	30,328
Pasture/Hay	3,020	2,637	256	19,322	26	144		165	3		28
Cultivated Crops	195	1,433	4,334	1,425	5,145	3,473	850	154,436	21,620	817	52,362
Woody Wetlands	3	2		45				21			
Emergent Herbaceous Wetlands				78	6		9	78	6		86
Total (Acres)	**7,695**	**21,376**	**10,500**	**130,127**	**31,316**	**38,225**	**41,259**	**248,044**	**43,534**	**20,045**	**90,604**
Open Water	0.8	0.8	0.05	5.3	0.5	0.7	0.1	1.6	0.3	0.9	1.8
Developed, Open Space	8.6	6.2	3.1	5.4	4.6	5.7	1.4	4.4	5.1	5.3	4.2
Developed, Low Intensity	5.1	0.4		3.1	0.1	1.3	0.03	0.5	0.5	0.5	1.0
Developed, Medium Intensity	3.2	0.1		1.1	0.04	1.1	0.01	0.2	0.3	0.1	0.2
Developed, High Intensity	1.1	0.005		0.5	0.003	0.1		0.1	0.02		0.1
Barren Land	0.1	0.3	0.1	0.2		1.5		3.3	0.04		0.04
Deciduous Forest	7.7	28.1	8.8	31.3	12.5	8.0	7.5	1.2	4.2	4.7	0.2
Evergreen Forest		0.5		0.2	0.006		1.2	0.002	0.01	0.2	0.002
Mixed Forest							0.9			0.3	
Shrub/Scrub			2.4	0.004	0.01	0.1	1.2	1.0	0.7	3.4	1.1
Grasslands/Herbaceous	31.5	44.6	41.8	36.8	65.7	72.1	85.5	25.5	39.0	80.5	33.5
Pasture/Hay	39.2	12.3	2.4	14.8	0.1	0.4		0.1	0.01		0.03
Cultivated Crops	2.5	6.7	41.3	1.1	16.4	9.1	2.1	62.3	49.7	4.1	57.8
Woody Wetlands	0.04	0.01		0.03				0.01			
Emergent Herbaceous Wetlands				0.06	0.02		0.02	0.03	0.01		0.1
Total (%):	**100.0**	**100.0**	**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. Not all of the waterbodies in this Study Area have historical flow data available. 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. 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 during the time of water quality sampling for turbidity 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 C**.

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 2015b). 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 2015a). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in **Appendix G**. **Table 2-1**, an excerpt from the 2014 Integrated Report (DEQ 2015), lists beneficial uses designated for each 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
- FISH – Fish Consumption
- PBCR – Primary Body Contact Recreation
- PPWS – Public & Private Water Supply
- EWS – Emergency Water Supply
- SWS – Sensitive Water Supply

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

Waterbody ID	Waterbody Name	AES	AG	WWAC	FISH	PBCR	PPWS	EWS	SWS
OK311100010230_00	Bills Creek	I	X	I	X	N			
OK311100010250_00	Walnut Bayou	I	F	F	I	N	I		
OK311100010300_00	Fleetwood Creek	I	F	N	X	N	I		
OK311100020010_10	Hickory Creek	I	F	F	I	N	I		
OK311200000080_00	Dry Creek	F	I	N	X	N	I		
OK311300020010_10	Cache Creek, East	F	N	N	X	N	X		
OK311300040060_00	Medicine Creek	F	F	F	X	N	I		v
OK311310010010_00	Red River	I	N	N	F	N		F	
OK311310020010_10	Cache Creek, West	F	F	F	X	N	I		
OK311310020060_00	Blue Beaver Creek	F	F	I	X	N	F		
OK311310030040_00	Little Deep Red Creek	I	N	N	X	N	I		

F – Fully supporting information | **N** – Not supporting | **I** – Insufficient | **X - Not assessed** | **V - Listed** | Source: **DEQ 2014 Integrated Report**

2.1.1 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 Title 785, Chapter 45-5-16 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.

2.1.2 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 2015b). The following excerpt 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).

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 2015a).

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.

2.1.3 Chapter 45: Criteria for Turbidity

The beneficial use of WWAC 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.

2.1.4 Chapter 46: Implementation of OWQS for Fish and Wildlife Propagation

Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2015b) 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.

2.1.5 Chapter 46: Minimum number of samples

Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2015b) describes minimum number of samples to assess beneficial use.

785:46-15-3 Data requirements

(e). Minimum number of samples.

(1) Streams. Except when (f) of this Section or any of subsection (e), (h), (i), (j), (k), (l), or (m) of 785:46-15-5applies, a minimum of 10 samples shall be required to assess beneficial use support due to field parameters including but not limited to DO, pH and temperature, and due to routine water quality constituents including but not limited to coliform bacteria, dissolved solids and salts. Analyses may be aggregated to meet the 10 sample minimum requirements in non-wadable stream reaches that are 25 miles or less in

length, and in wadable stream reaches that are 10 miles or less in length, if water quality conditions are similar at all sites. Provided, a minimum of 10 samples shall not be necessary if the existing samples already assure exceedance of the applicable percentage of a prescribed screening level.

2.1.6 Prioritization of TMDL Development

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.

After the 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:[1]

Priority 1 watersheds - above the 90th percentile (27 watersheds)

Priority 2 watersheds - 70th to 90th percentile (66 watersheds)

Priority 3 watersheds - 40th to 70th percentile (78 watersheds)

Priority 4 watersheds - below the 40th percentile (141 watersheds)

Each waterbody on the 2014 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. Other priority watersheds are established for TMDL development within the next five years for Priority 2, eight years for Priority 3, and eleven years for Priority 4.

[1] Appendix C, 2014 Integrated Report

Table 2-2 Excerpt from the 2014 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
OK311100010230_00	Bills Creek	8.43	2025	4	X		N		I
OK311100010250_00	Walnut Bayou	10.82	2025	4	X		N		F
OK311100010300_00	Fleetwood Creek	10.91	2022	3	X	X	N		N*
OK311100020010_10	Hickory Creek	37.28	2019	2	X		N		F
OK311200000080_00	Dry Creek	20.96	2019	2	X	X	N		N*
OK311300020010_10	Cache Creek, East	17.08	2016	1	X		N		N*
OK311300040060_00	Medicine Creek	17.71	2016	1	X		N		F
OK311310010010_00	Red River	88.02	2022	3	X		N**	X	N
OK311310020010_10	Cache Creek, West	19.17	2025	4	X		N		F
OK311310020060_00	Blue Beaver Creek	18.33	2019	2	X		N		I
OK311310030040_00	Little Deep Red Creek	33.57	2016	1	X	X	N		N*

ENT = Enterococci; N = Not attaining; X = Criterion exceeded

Source: 2014 Integrated Report, DEQ 2015

*: Due to low DO, not addressed in this report.

**: Impaired for enterococci, but TMDL was done in 2007.

2.2 Problem Identification

This subsection summarizes water quality data caused by elevated levels of impairments.

2.2.1 Bacterial Data Summary

Table 2-3 summarizes water quality data collected during primary contact recreation season from the WQM stations between 2000 and 2013 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 2014 303(d) list (DEQ 2015). Water quality data from the primary contact recreation season are provided in **Appendix A**

For the data collected between 2000 and 2013, evidence of nonsupport of the PBCR use based on *E. coli* or Enterococci exceedances was observed in eight waterbodies [E. coli and Enterococci exceedance on Fleetwood Creek (OK311100010300_00) and Little Deep Red Creek (OK311310030040_00); Enterococci only exceedance on Walnut Bayou (OK311100010250_00), Hickory Creek (OK311100020010_10), East Cache Creek (OK311300020010_10), Medicine Creek (OK311300040060_00), West Cache Creek (OK311310020010_10), and Blue Beaver Creek (OK311310020060_00)]. Rows highlighted in green in **Table 2-3** require TMDLs.

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 in 2001 for Bills Creek (OK311100010230_00) and Dry Creek (OK311200000080_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 2014 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 Oklahoma WQS, DEQ considers base flow conditions to be all flows less than the 25th flow exceedance percentile (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 for samples collected during base flow conditions. 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. Using this qualified data set, 3 of the 11 waterbodies identified in **Table 2-5** indicate nonsupport of the Fish and Wildlife Propagation use based on turbidity levels observed in the waterbody so TMDLs were developed for them. **Table 2-6** summarizes water quality data collected from the WQM stations between 1999 and 2011 for TSS. **Table 2-7** presents a subset of these data for samples collected during base flow conditions. In using TSS as a surrogate to support TMDL development, at least 10 TSS samples are required to conduct the regression analysis between turbidity and TSS. The water quality data analyzed for turbidity and TSS are provided in **Appendix A**.

2.3 Water Quality Targets

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 2015a). According to the Oklahoma WQS [785:45-5-12(f)(7)], the turbidity criterion for streams with WWAC beneficial use is 50 NTUs (OWRB 2015a). 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.

Table 2-3 Summary of Assessment of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2000-2013

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Conc (cfu/100 ml)	Assessment Results / Recommended Actions
OK311100010230_00	Bills Creek	*EC*	1	239	Insufficient data / No action
		ENT	1	1,650	Insufficient data / Delist
OK311100010250_00	Walnut Bayou	*EC*	14	43	Meeting WQS / No action
		ENT	14	112	**Impaired / TMDL**
OK311100010300_00	Fleetwood Creek	*EC*	13	561	**Impaired / TMDL**
		ENT	13	982	**Impaired / TMDL**
OK311100020010_10	Hickory Creek	*EC*	11	43	Meeting WQS / No action
		ENT	11	80	**Impaired / TMDL**
OK311200000080_00	Dry Creek	*EC*	4	273	Insufficient data / Delist
		ENT	4	500	Insufficient data / Delist
OK311300020010_10	Cache Creek, East	*EC*	10	40	Meeting WQS / No action
		ENT	10	102	**Impaired / TMDL**
OK311300040060_00	Medicine Creek	*EC*	10	64	Meeting WQS / No action
		ENT	10	144	**Impaired / TMDL**
OK311310010010_00	Red River	*EC*	18	91	Meeting WQS / No action
		ENT	18	131	Impaired and 2007 TMDL / No action
OK311310020010_10	Cache Creek, West	*EC*	10	63	Meeting WQS / No action
		ENT	10	142	**Impaired / TMDL**
OK311310020060_00	Blue Beaver Creek	*EC*	6	69	Insufficient data / No action
		ENT	6	245	**Impaired / TMDL**
OK311310030040_00	Little Deep Red Creek	*EC*	10	128	**Impaired / TMDL**
		ENT	10	425	**Impaired / TMDL**

E. coli (*EC*) water quality criterion = Geometric Mean of 126 counts/100 mL
Enterococci (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL
TMDLs will be developed for waterbodies that are highlighted

Table 2-4 Summary of All Turbidity Samples, 2001-2014

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)
OK311100010230_00	Bills Creek	311100010230-001SRF & 311100010230-002SRF	7	0	0%	8
OK311100010250_00	Walnut Bayou	OK311100-03-0010G & 311100030010-001AT	27	6	22.2%	61
OK311100010300_00	Fleetwood Creek	OK311100-01-0300D	19	4	21.1%	54
OK311100020010_10	Hickory Creek	OK311100-02-0010M	21	1	4.8%	16
OK311200000080_00	Dry Creek	OK311200-00-0080G	10	2	20.0%	122
OK311300020010_10	Cache Creek, East	OK311300-02-0010M	21	3	14.3%	22
OK311300040060_00	Medicine Creek	OK311300-04-0060H	21	0	0%	3
OK311310010010_00	Red River	311310010010-001AT	58	27	46.6%	215
OK311310020010_10	Cache Creek, West	OK311310-02-0010M	21	1	4.8%	35
OK311310020060_00	Blue Beaver Creek	OK311310-02-0060G	10	0	0%	1.7
OK311310030040_00	Little Deep Red Creek	OK311310-03-0040D	20	9	45.0%	72

Table 2-5 Summary of Turbidity Samples Excluding High Flow Samples, 2001-2014

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/ Recommended Actions
OK311100010230_00	Bills Creek	311100010230-001SRF & 311100010230-002SRF	7	0	0%	8	Insufficient data / No action
OK311100010250_00	Walnut Bayou	OK311100-03-0010G & 311100030010-001AT	25	4	16.0%	60	Impaired, but not listed in 303 (d) / **TMDL**
OK311100010300_00	Fleetwood Creek	OK311100-01-0300D	17	2	11.8%	30	Impaired and 2010 TMDL / No action
OK311100020010_10	Hickory Creek	OK311100-02-0010M	21	1	4.8%	16	Meeting WQS / No action
OK311200000080_00	Dry Creek	OK311200-00-0080G	10	2	20.0%	122	Impaired and 2010 TMDL / No action
OK311300020010_10	Cache Creek, East	OK311300-02-0010M	19	2	10.5%	19	Impaired, but not listed in 303 (d) /**TMDL**
OK311300040060_00	Medicine Creek	OK311300-04-0060H	19	0	0%	2	Meeting WQS / No action
OK311310010010_00	Red River	311310010010-001AT	56	25	44.6%	187	**Impaired / TMDL**
OK311310020010_10	Cache Creek, West	OK311310-02-0010M	17	1	5.9%	31	Meeting WQS / Delist
OK311310020060_00	Blue Beaver Creek	OK311310-02-0060G	10	0	0%	1.7	Meeting WQS / No action
OK311310030040_00	Little Deep Red Creek	OK311310-03-0040D	15	6	40.0%	44	Impaired and 2010 TMDL / No action

Table 2-6 Summary of All TSS Samples, 1999-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK311100010230_00	Bills Creek	311100010230-001SRF & 311100010230-002SRF	0	
OK311100010250_00	Walnut Bayou	OK311100-03-0010G	20	38.7
OK311100010300_00	Fleetwood Creek	OK311100-01-0300D	19	16.5
OK311100020010_10	Hickory Creek	OK311100-02-0010M	20	13.0
OK311200000080_00	Dry Creek	OK311200-00-0080G	16	34.9
OK311300020010_10	Cache Creek, East	OK311300-02-0010M	19	15.3
OK311300040060_00	Medicine Creek	OK311300-04-0060H	20	10.0
OK311310010010_00	Red River	311310010010-001AT	17	1,083.6
OK311310020010_10	Cache Creek, West	OK311310-02-0010M	20	18.2
OK311310020060_00	Blue Beaver Creek	OK311310-02-0060G	10	10.3
OK311310030040_00	Little Deep Red Creek	OK311310-03-0040D	19	53.2

There are no TSS data available for Bills Creek segment OK311100010230_00.

Table 2-7 Summary of TSS Samples Excluding High Flow Samples, 1999-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK311100010230_00	Bills Creek	311100010230-001SRF & 311100010230-002SRF	0	
OK311100010250_00	Walnut Bayou	OK311100-03-0010G	18	38.8
OK311100010300_00	Fleetwood Creek	OK311100-01-0300D	16	14.1
OK311100020010_10	Hickory Creek	OK311100-02-0010M	20	13.0
OK311200000080_00	Dry Creek	OK311200-00-0080G	15	34.9
OK311300020010_10	Cache Creek, East	OK311300-02-0010M	17	15.1
OK311300040060_00	Medicine Creek	OK311300-04-0060H	18	10.0
OK311310010010_00	Red River	311310010010-001AT	16	967.6
OK311310020010_10	Cache Creek, West	OK311310-02-0010M	16	16.1
OK311310020060_00	Blue Beaver Creek	OK311310-02-0060G	10	10.3
OK311310030040_00	Little Deep Red Creek	OK311310-03-0040D	14	22.7

There are no TSS data available for Bills Creek segment OK311100010230_00.

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 OPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point source dischargers are permitted through the OPDES program. OPDES-permitted facilities that discharge treated wastewater are currently required to monitor for fecal coliform in accordance with their permits. Dischargers with bacterial limits will be required to monitor for *E. coli* when their permits come up for renewal. 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 natural sources or 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 OPDES 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 of bacteria were considered in this report:

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

The 2014 Integrated Water Quality Assessment Report (DEQ 2013) listed potential sources of turbidity as:

- 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
- Unknown sources

The following discussion describes what is known regarding point and nonpoint sources of bacteria and/or TSS in the impaired watersheds. Where information was available on point and nonpoint sources of indicator bacteria and/or TSS data were provided and summarized as part of each category.

3.2 OPDES-Permitted Facilities

Under 40 CFR, §122.2, a point source is described as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. OPDES-permitted facilities classified as point sources that may contribute bacterial or TSS loading into the watersheds include:

- Continuous Point Source Dischargers
  - OPDES municipal wastewater treatment facilities (WWTFs)
  - OPDES Industrial WWTFs
- OPDES-regulated stormwater discharges
  - Municipal separate storm sewer system (MS4) discharges
    - Phase 1 MS4
    - Phase 2 MS4 – OKR04
  - Multi-sector general permits (OKR05)
    - Regulated Sector J Discharges
    - Rock, Sand and Gravel Quarries
  - Construction stormwater discharges (OKR10)
- No-discharge WWTFs
- Sanitary sewer overflow (SSO)
- NPDES Animal Feeding Operations (AFO)
  - Concentrated Animal Feeding Operations (CAFO)
  - Swine Feeding Operation (SFO)
  - Poultry Feeding Operation (PFO)

Four watersheds in the Study Area [Fleetwood Creek, Medicine Creek, West Cache Creek, and Blue Beaver Creek] have no OPDES-permitted facilities within their contributing watershed. There is at least one OPDES-permitted facility in each of the remaining seven watersheds in the Study Area [Bills Creek, Walnut Bayou, Hickory Creek, Dry Creek, East Cache Creek, Red River, and Little Deep Red Creek].

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.

Table 3-1 Point Source Discharges in the Study Area

Receiving stream or facility	Watershed	OPDES Permit No.	Facility	SIC code	Facility Type	Design Flow (MGD)	Ave/Max FC cfu/100mL	Avg/Max TSS mg/L	Expiration Date	Notes
Marietta PWA	Bills Creek	OKP003031	Innovation One LLC	3535	Conveyors and Conveying Equipment	0.0011	N/A	N/A	2/28/2019	Active
		OKP003030	OKTEX Baking			0.0004			1/1/2009	Inactive
Bills Creek OK311100010230_00		OK00202571	Marietta PWA	4952	Sewerage Systems	0.32	200/400	30/45	1/31/2016	Active
Unnamed Tributary of Hickory Creek (OK311100020010_10)	Hickory Creek	OK0034266	Lone Grove WWT	4952	Sewerage Systems	0.764	200/400	15/22.5 Jun – Oct 30/45 Nov - May	7/31/2019	Active
Unnamed Tributary of Spring Branch (OK311100020120_00)		OKG950032	Dolese Bros Ardmore Quarry	1422	Crushed and Broken Limestone	0.0004	N/A	-/45	5/3/2018	Active
Cache Creek, East OK311300020010_10	Cache Creek, East	OK0030295	Fort Sill WWT	4952	Sewerage Systems	4.3	200/400	15/22.5 Apr – Oct 30/45 Nov - Mar	2/28/2018	Active
Lime Creek OK311300020130_00		OKG950031	Dolese Bros Richard's Spur Quarry	1422 1423 1442	Quarry facility	0.0384	N/A	-/45	5/31/2018	Active
Frederick POTW	Red River	OKP003022	Henniges Automotive	3069	Fabricated Rubber Products	0.15	N/A	N/A	1/31/2019	Active
Unnamed Tributary of Suttle Creek (OK311310010090_00)		OK0027189	Frederick Industrial Park	4952	Sewerage Systems	0.15	N/A	90/135	10/31/2018	Active
Unnamed tributary of the Red River (OK311310010010_00)		OK0022578	Devol WWT	4952	Sewerage Systems	0.06	N/A	90/135	11/30/2019	Active
Unnamed tributary of Little Deep Red Creek (OK311310030040_00)	Little Deep Red Creek	OK0027171	Frederick POTW	4952	Sewerage Systems	0.55	200/400	90/135	3/31/2017	Active

NA = not available or not applicable

Table 3-2 Construction Permits Summary

Company Name	County	Permit ID	NOI Received date	Watershed	Estimated Acres	Note
Western Farmers Electric Cooperative	Love	OKR1021536	10/4/2012	Bills Creek	2	In Effect
Clancy & Theys Construction Co	Love	OKR1022460	8/7/2013		11	In Effect
Western Farmers Electric Cooperative	Love	OKR1021894	1/23/2013	Hickory Creek	2	In Effect
Calvary United Pentecostal Church,	Carter	OKR1022166	4/24/2013		4	In Effect
Lance Windel	Carter	OKR1022437	7/30/2013		10	In Effect
Piazza Construction	Carter	OKR1022459	8/7/2013		4	In Effect
Carstensen Contracting Inc	Carter	OKR1022575	9/13/2013		4	In Effect
Piazza Construction	Carter	OKR1022871	12/3/2013		4	In Effect
Purvis Industries	Carter	OKR1023087	2/25/2014		1	In Effect
Crossroads Development Limited Partnership	Carter	OKR108175	12/7/2012		1	In Effect
HE & I Construction Inc	Comanche	OKR1011496	12/7/2012	East Cache Creek	6	In Effect
Zachry Federal Construction Corporation	Comanche	OKR1021404	10/25/2012		12	In Effect
Greenleaf Construction Co Inc	Comanche	OKR1021715	11/16/2012		6	In Effect
Diversified Construction of Oklahoma Inc	Comanche	OKR1022400	7/15/2013		1	In Effect
Comanche County RWD 2	Comanche	OKR1022628	10/3/2013		1	In Effect
Herring Construction Inc	Comanche	OKR1022957	1/6/2014		2	In Effect
Department of Veterans Affairs Ft. Sill National Cemetery	Comanche	OKR1022993	1/17/2014		2	In Effect
Tri City Seal Co Inc	Comanche	OKR1023012	1/23/2014		1	In Effect
The Whiting Turner Contracting Company Inc	Comanche	OKR1023120	3/7/2014		6	In Effect
BRB Contractors Inc	Tillman	OKR1022845	11/25/2013	Little Deep Red Creek	14	In Effect
Fenix Constructors Inc	Tillman	OKR1021406	8/14/2012	Red River	3	In Effect
Sewell Bros Inc	Tillman	OKR1022420	7/25/2013		1	In Effect
T&G Construction Inc	Cotton	OKR1021582	10/15/2012		3	In Effect
Duit Construction Company	Cotton	OKR1022808	11/13/2013		1	In Effect

Table 3-3 Multi-sector General Permits Summary

Company Name	County	Permit ID	NOI Received date	Watershed	SIC	Note
Innovation One LLC	Love	OKR050062	11/21/2011	Bills Creek	3535	In Effect
Michelin North America Inc	Carter	OKR050599	9/22/2011	Hickory Creek	3011	In Effect
Dolese Bros CO	Carter	OKR050720	11/21/2011		1422	In Effect
United Parcel Service Inc.	Carter	OKR050905	12/5/2011		4215	In Effect
City of Ardmore	Carter	OKR050907	9/21/2011		4581	In Effect
Watkins Salvage	Carter	OKR051330	11/9/2011		5015	In Effect
Ardmore Trailer Auto Sales Parts & Service	Carter	OKR051428	10/24/2011		5015	In Effect
AC Nutrition LP	Carter	OKR051709	1/12/2012		2048	In Effect
Rolling Frito-Lay Sales LP	Carter	OKR051962	10/31/2011		4213	In Effect
Empire Auto Salvage	Stephens	OKR051326	11/21/2011	Dry Creek	5015	In Effect
T & G Construction	Comanche	OKR050294	11/22/2011	East Cache Creek	2951	In Effect
Dolese Bros CO Richard's Spur Quarry	Comanche	OKR050733	11/21/2011		1422	In Effect
Doyle and Cynthia Latimer	Comanche	OKR052618	10/17/2013		1429	In Effect
City of Frederick	Tillman	OKR050391	9/29/2011	Red River	4581	In Effect
J & J Used Parts	Tillman	OKR051311	11/22/2011		5015	In Effect
Henniges Automotive Oklahoma Inc.	Tillman	OKR051698	10/3/2011		3053	In Effect

Table 3-4 OPDES No-Discharge Facilities in the Study Area

Facility	Facility ID	County	Facility Type	Type	Watershed
Falconhead Prop. Owners Assoc.	S11104	Love	Lagoon (Total Retention)	Municipal	Walnut Bayou
Golden Oaks Home Owners Assoc.	S10919	Love	Lagoon (Total Retention)	Municipal	Hickory Creek
Huebsch Hsng Addition WWT	S11105	Carter	Lagoon (Total Retention)	Municipal	
Joe Brown Co	10000860	Carter	Lagoon (Total Retention)	Industrial	
Estes MHP WWT	S10918	Carter	Lagoon (Total Retention)	Municipal	
Ardmore Site 5	S30804	Carter	Land Application	Municipal	
Ardmore Site 6	S30804	Carter	Land Application	Municipal	
Ardmore Site 7	S30804	Carter	Land Application	Municipal	
Fox Fire Addition WWT	S11323	Comanche	Lagoon (Total Retention)	Municipal	Cache Creek, East
Maddische Est WWT	S11329	Comanche	Lagoon (Total Retention)	Municipal	
Mega Car Wash	16000590	Comanche	Lagoon (Total Retention)	Industrial	
Wichita Mountain Est #1 (Ferguson) N	S11327	Comanche	Lagoon (Total Retention)	Municipal	
Wichita Mountain Est #2 (S)	S11326	Comanche	Lagoon (Total Retention)	Municipal	
Ft. Sill (Site 4)	S11304	Comanche	Land Application	Municipal	
Ft. Sill (Site 3)	S11304	Comanche	Land Application	Municipal	
Hollister	S11310	Tillman	Lagoon (Total Retention)	Municipal	Little Deep Red Creek
Grandfield	S11311	Tillman	Land Application	Municipal	
Weaver Doc Detention Center	S11382	Tillman	Lagoon (Total Retention)	Municipal	Red River
Davidson	S11401	Tillman	Land Application	Municipal	
Cotton Co RWD # 1 (Randlett) WWT	S11321	Cotton	Lagoon (Total Retention)	Municipal	

Table 3-5 Sanitary Sewer Overflow Summary (1989 - 2014)

Facility Name	NPDES Permit No.	Watershed	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Falconhead		Walnut Bayou	S11104	1	9/28/2003		500	
Marietta	OK00202571	Bills Creek	S10901	27	1/13/1992	10/20/2009	0	60,000
Ardmore		Hickory Creek	S30804	1,196	12/21/1989	3/17/2014	3	1,128,000
Golden Oaks			S10919	2	6/11/1993	1/26/2010	0	168
Lone Grove	OK0034266		S11003	4	7/23/2008	6/16/2011	2	100
Fort Sill WWT	OK0030295	Cache Creek, East	S11304	99	2/28/1990	6/27/2000	Minimal	>6,000,000
Davidson		Red River	S11401	1	6/6/1995		Minimal	
Frederick Industrial Park	OK0027189		S11402	3	2/25/1991	6/11/1995	Minimal	350,000
Devol WWT	OKG580032		S11403	10	10/11/1997	3/1/2001	Minimal	70,000
Frederick POTW	OK0027171	Little Deep Red Creek	S11309	1	6/11/1995		Minimal	
Grandfield			S11311	7	6/5/1995	1/21/2001	Minimal	44,593,920

Figure 3-1 Location of OPDES-Permitted Facilities in the Study Area

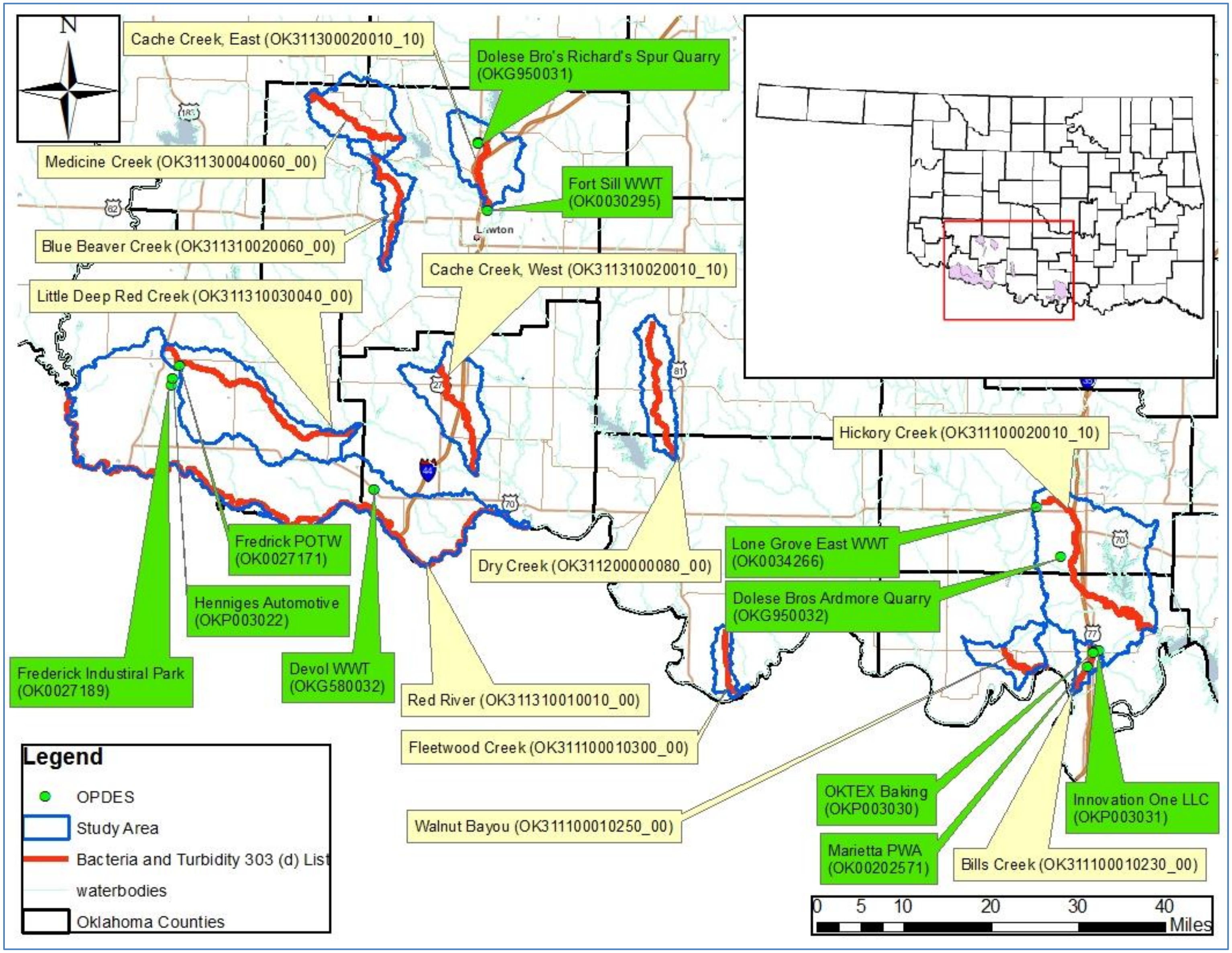


Figure 3-2 Location of Stormwater Permitted Facilities in the Study Area

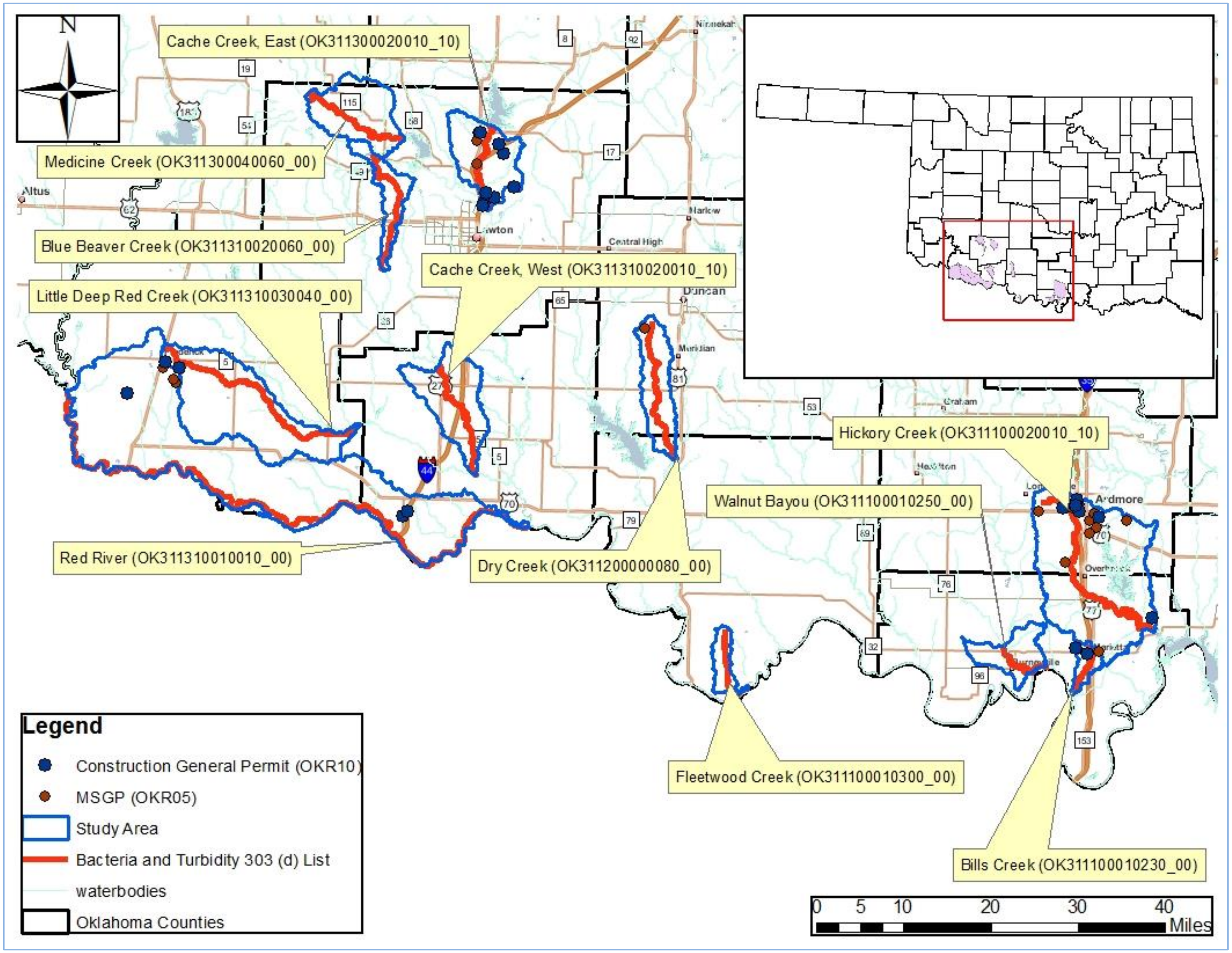


Figure 3-3 Location of CAFOs, No-Discharge Facilities and Mines in the Study Area

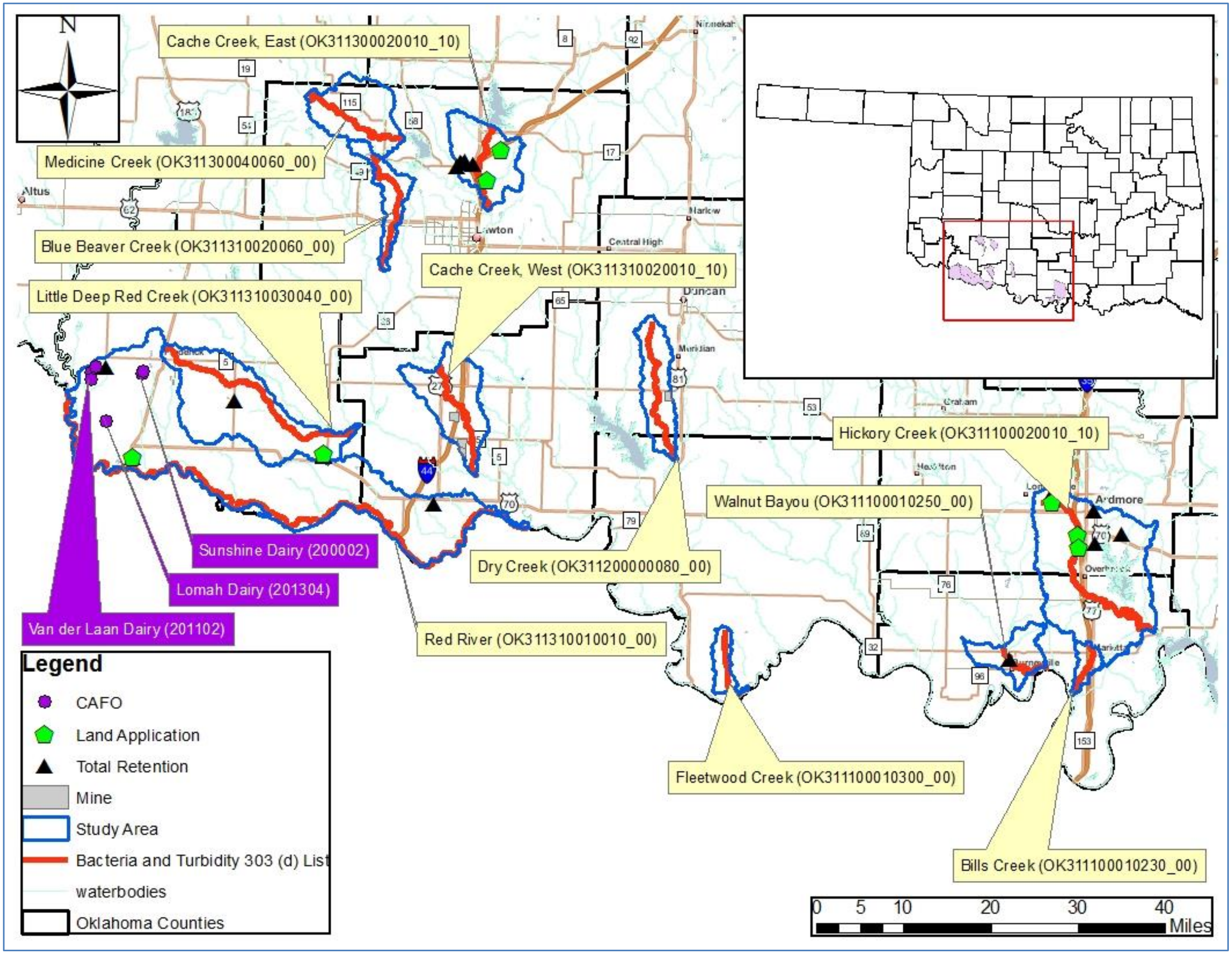
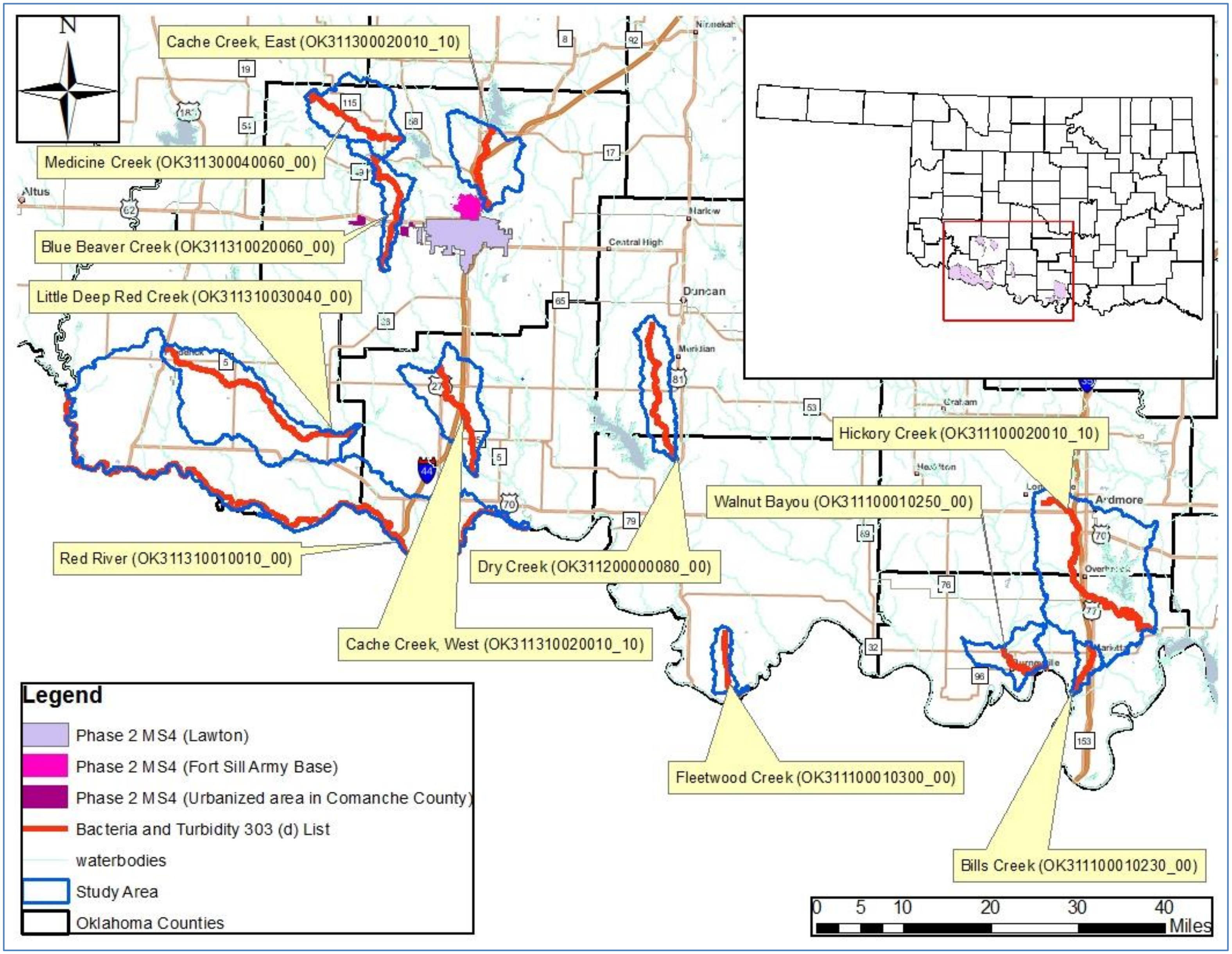


Figure 3-4 Location of Phase II MS4s



3.2.1 Continuous Point Source Dischargers

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 will receive WLAs.

The locations of the OPDES-permitted facilities that discharge wastewater to surface waters addressed in these TMDLs are listed in **Table 3-1** and displayed in **Figure 3-1**.

3.2.1.1 Municipal OPDES WWTFs

There are six active permitted municipal point source facilities within the Study Area. Municipal WWTFs are designated with a Standard Industrial Code (SIC) number 4952. They discharge organic TSS with limits for $CBOD_5$ so they are not considered a potential source of turbidity. Bills Creek and Red River were assessed as insufficient information, fully supporting, or previously developed TMDL for bacteria. Therefore, municipal wastewater treatment plants in the Hickory Creek, East Cache Creek, and Little Deep Red Creek watersheds will receive WLA for bacteria (three facilities; OK0034266, OK0030295, and OK0027171). DMR data for the remaining non-4952 active facilities are provided in **Appendix B**.

3.2.1.2 Industrial OPDES WWTFs

There are four active OPDES industrial point source dischargers in this Study Area, including Pretreatment (OKP00) and General Permit (OKG95). Pretreatment facilities discharge wastewater to municipal wastewater treatment plant. Therefore, they (OKP003031 and OKP003022) don't discharge wastewater to "Water of U.S." and will not receive WLA. Dolese Bros Ardmore Quarry (OKG950032) is in the Hickory Creek watershed impaired for bacteria. Quarry is not considered as bacterial source. Therefore, Dolese Bros Ardmore Quarry will not receive bacteria WLA. In other hand, Dolese Bros Richard's Spur Quarry (OKG950031) is in turbidity impaired East Cache Creek (OK311300020010_10) watershed. It will receive TSS WLA.

3.2.2 Stormwater Permits

Stormwater runoff from OPDES-permitted facilities (MS4s, facilities with multi-sector general permits, and construction sites) can contain impairments. EPA regulations [40 C.F.R. §130.2(h)] require that 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 so permitted stormwater discharges do not impair streams with TSS. Therefore, TSS WLAs for NPDES-regulated stormwater discharges are considered unnecessary in this TMDL report and will not be included in the TMDL calculations. Stormwater runoff from permitted areas can contain high fecal coliform concentrations. Therefore, MS4 areas will receive WLAs for each bacterial indicator exceeding WQSs.

3.2.2.1 Municipal Separate Storm Sewer System Permit

3.2.2.1.1 Phase I MS4

In 1990, EPA developed Phase I of the NPDES Stormwater Program. This program was designed to prevent harmful pollutants in MS4s from being washed by stormwater runoff 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 facilities in the Study Area.

3.2.2.1.2 Phase II MS4 (OKR04)

In 1999, Phase II began requiring certain small MS4s to comply with the NPDES stormwater program. 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," to protect water quality, and to satisfy appropriate water quality requirements of the CWA. Phase II MS4 stormwater programs must address the following six 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

In Oklahoma, Phase II General Permit (OKR04) for small MS4 communities has been in effect since 2005. Information about DEQ's MS4 program can be found on-line at the following DEQ website: www.deq.state.ok.us/WQDnew/stormwater/ms4/. The Fort Sill Army Base is the Phase II MS4s in the Study Area, shown in **Figure 3-4**. It covers 7.6% of the East Cache Creek watershed.

3.2.2.2 Multi-Sector General Permits (OKR05)

A DEQ multi-sector industrial general permit (MSGP) is required for stormwater discharges from all industrial facilities (DEQ 2011) whose Standard Industrial Classification (SIC) code is listed on Table 1-2 of the MSGP. Stormwater discharges from all industrial facilities occur only during or immediately following periods of rainfall and elevated flow conditions. Since turbidity criteria do not apply during these periods, stormwater is not considered a potential source of turbidity impairment.

There are 16 facilities within the Study Area with multi-sector general permits. They are listed in **Table 3-3** and illustrated in **Figure 3-2**.

3.2.2.2.1 Regulated Sector J Discharges

Sector J facilities include crushed stone, construction sand & gravel, and industrial sand mines. The activities in these facilities include the exploration and mining of minerals (e.g., stone, sand, clay, chemical and fertilizer minerals, non-metallic minerals, etc.). A "*mine*" refers to an area of land actively excavated for the production of sand and gravel from natural deposits. Under the MSGP (OKR05), effluent from Sector J facilities include stormwater discharges associated with industrial activity from active and inactive mineral mining and mine dewatering. "*Mine dewatering*" is any water that is impounded or that collects in the mine and is pumped, drained, or otherwise removed from the mine through the efforts of the mine operator. This term also includes wet pit overflows caused solely by direct rainfall and uncontaminated ground water seepage. Specific requirements for Sector J stormwater discharges can be found in Part 12 of the MSGP. Specific effluent limitation guidelines for Sector J SIC codes (1422 - 1429, 1442, and 1446) are referenced in Table 1-3 of the MSGP. The effluent guidelines [40 CFR part 436, Subpart B, C and D] are adopted by reference in the OPDES under OAC 252:606-1-3(b)(8).

Mine dewatering discharges can happen at any time and have the following specific effluent limitations:

- pH 6.0 to 9.0
- TSS Daily Maximum: 45 mg/L
- TSS 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 MSGP. There are no mine dewatering MSGPs in the turbidity TMDL watersheds.

3.2.2.2.2 Rock, Sand and Gravel Quarries

Stormwater from rock, sand and gravel quarries in Oklahoma fall under the MSGP. But **wastewater** generated at quarries is regulated under DEQ General Permit OKG950000. Wastewater discharges regulated by this Permit are process wastewater and stormwater runoff that comes in direct contact with active process areas associated with the mining of stone, sand, and gravel; cutting stone; crushing stone to size; washing and stockpiling of processed stone and sand; and washing and maintenance areas of vehicles and equipment. Permitted activities include discharge of industrial wastewater, construction or operation of industrial surface water impoundments, land application of industrial wastewater for dust suppression, and recycling of wastewater as wash water or cooling water.

Wastewater and stormwater runoff from mining activities have the potential to contain elevated suspended solids and elevated pH due to contact with minerals. Suspended solids, as well as fugitive dust from operations, are a potential source of metals. Oil and grease may be generated due to equipment washing activities.

General Permit OKG950000 does not allow discharge of wastewater into Outstanding Resource Waters, High Quality Waters, Sensitive Public & Private Water Supplies, and Appendix B Waters [OAC 785:45-5-25(c)(2)]. In addition, no discharge is allowed into waterbodies listed as impaired for turbidity in Oklahoma's 303(d) list for which a TMDL has not been performed. Discharges into turbidity-impaired streams are also not allowed if their TMDL indicated that discharge limits more stringent than 45 mg/l for TSS or 6.5-9.0 standard units for pH are required (DEQ 2013).

The General Permit contains technology-based effluent limits of 45 mg/L for TSS, 15 mg/L for oil and grease, and pH range of 6.0–9.0. However, the Permit includes a provision that when exceedances of water quality criteria are determined to be the result of a facility's discharge to receiving waters, DEQ may determine that the facility is no longer eligible for coverage under the General Permit. DEQ will then require the facility to apply for an individual discharge permit with additional chemical-specific limits or toxicity testing requirements as necessary to protect the beneficial uses of the receiving stream.

The locations of quarries and mines in the Study Area are shown in **Figures 3-3** and listed in **Table 3-6**.

Table 3-6 Sand and Gravel Mines

Company Name	County	Permit ID	Product	Permitted Acres	Mining Expiration Date	Watershed
Harvey G. Jenkins (Murphy Sand Pit)	Cotton	L.E.-2108	Sand	10	11/30/2010	West Cache Creek
E & A Materials, Inc.	Cotton	L.E.-1683	Sand & Gravel	150	11/30/2013	
E & A Materials, Inc. (Miller Pit)	Cotton	L.E.-2020	Sand & Gravel	121	4/30/2019	
Miller & Sons Construction	Stephens	L.E.-1847	Sand	3	11/30/2021	Dry Creek

3.2.2.3 General Permit for Construction Activities (OKR10)

A DEQ stormwater general permit for construction activities is required for any stormwater discharges in the State of Oklahoma associated with construction activities that result in land disturbance equal to or greater than one acre or less than one acre if they are part of a larger common plan of development or sale that totals at least one 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 2012). Stormwater discharges occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply. Therefore, stormwater is not considered possible contributor to turbidity impairment. The permits for construction projects that were active during the time period that samples were taken are summarized in **Table 3-2** and shown in **Figure 3-2**. Area was estimated from ArcGIS map.

3.2.3 No-Discharge Facilities

Some facilities are classified as no-discharge. These facilities are required to sign an affidavit of no discharge. For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute indicator bacterial or TSS loading. While 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. For example, discharges from the wastewater facility may occur during large rainfall events that exceed the systems' storage capacities.

There are 18 municipal no-discharge facilities and 2 industrial facilities in the Study Area (see **Table 3-4**). They could be contributing to the elevated levels of in-stream indicator bacterial loading.

3.2.4 Sanitary Sewer Overflows

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 reported between 1989 and 2014. During that period 1,351 overflows were reported ranging from a minimal quantity to over 44.5 million gallons. **Table 3-5** summarizes the SSO occurrences by NPDES facilities. Historical data of reported SSOs are provided in **Appendix I**.

3.2.5 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. ODAFF is the NPDES-permitting authority for animal feeding operations in Oklahoma under what ODAFF calls the Agriculture Pollutant Discharge Elimination System (AgPDES). Through regulations (rules) established by the Oklahoma Concentrated Animal Feeding Operation (CAFO) Act (Title 2, Chapter 1, Article 20 – 40 to Article 20 – 64 of the State Statutes), Swine Feeding Operation (SFO) Act (Title 2, Chapter 1, Article 20 – 1 to Article 20 – 29 of the State Statutes), and Poultry Feeding Operation (PFO) Registration Act (Title 2, Chapter 10-9.1 to 10-9.25 of the State Statutes), AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the State.

All of these animal feeding operations (AFO) require an Animal Waste Management Plan (AWMP) to prevent animal waste from entering any Oklahoma waterbody. These plans outline how the animal feeding operator will prevent direct discharges of animal waste into waterbodies as well as any runoff of waste into waterbodies. The rules for all of these AFOs recommend using the USDA NRCS' Agricultural Waste Management Field Handbook to develop their Plan. NRCS has developed Animal Waste Management software to develop this Plan. The location of each AFO is shown in **Figure 3-3** and is listed in **Table 3-7**.

3.2.5.1 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 2014). AWMP (Section 35:17-4-12), as specified in Oklahoma's CAFO regulations are designed to protect water quality through the use of structures such as dikes, berms, terraces, ditches, to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event.[1] AWMPs may include, but are not limited to, a Comprehensive Nutrient Management Plan per NRCS guidance or Nutrient Management Plan per EPA guidance.

CAFOs are considered no-discharge facilities for the purpose of the TMDL calculations in this report, they are not considered a source of TSS loading, and runoff of animal waste into surface waterbodies or groundwater is prohibited. 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. Potential problems for CAFOs can include animal waste discharges to waters of the State and failure to properly operate wastewater lagoons.

[1] CAFO Animal Waste Management Plan Requirements [Title 35 (ODAFF), Chapter 17 (Water Quality), Subchapter 4 (Concentrated Animal Feeding Operations)] can be found in 35:17-4-12.

Oklahoma CAFO Rules require CAFOs to submit a *Documentation of No Hydrologic Connection* (OAC 35:17-4-10[2]) for all retention structures designed to prevent any leakage of wastewater into waterbodies. Thus, the potential for pollutant loading from CAFOs to a receiving stream is almost non-existent.

Per data provided by ODAFF in April 2014, there are three CAFOs located in the watershed as shown in **Table 3-6**. The locations of the CAFOs are shown in **Figure 3-3**. Most of the CAFOs are not operating at the capacity allowed in their license.

Table 3-7 NPDES-Permitted CAFOs in Study Area

EPA Number	Location ID	ODAFF License Number	Max # of Swine > 55 lbs	Total # of Heifer and Cattle Units at Facility	County	Waterbody ID and Waterbody Name
OKG010407	200805	200002	0	5,440	Tillman	OK311310010010_00 Red River
OKG010406	201102	201102	0	8,760		
N/A	201304	201304	0	10,720		

N/A: Not available

3.2.5.2 SFO

The purpose of the SFO Act is to provide for environmentally responsible construction and expansion of swine feeding operations and to protect the safety, welfare and quality of life of persons who live in the vicinity of a swine feeding operation.[3] According to the SFO Act, a "Concentrated swine feeding operation" is a lot or facility where swine kept for at least ninety (90) consecutive days or more in any twelve-month period and where crops, vegetation, forage growth or post-harvest residues are not grown during the normal growing season on any part of the lot.

SFOs are required to develop a Swine Waste Management Plan[4], to prevent swine waste from being discharged into surface or groundwaters. This Plan includes the BMPs being used to prevent runoff & erosion. The Swine Waste Management Plan may include, but is not limited to, a Comprehensive Nutrient Management Plan (CNMP) per NRCS guidance or Nutrient Management Plan (NMP) per EPA guidance. SFOs are required to store wastewater in Waste Retention Structures (WRS) and either to land apply wastewater or

[2] USDA NRCS design specifications in the USDA NRCS Agricultural Waste Management Field Handbook Chapter 10 shall satisfy documentation of no hydrologic connection so long as the facility is designed by USDA NRCS and does not exceed one thousand (1,000) animal units.

[3] A concentrated swine feeding operation has at least 750 swine that each weighs over 25 kilograms (about 55 pounds), 3,000 weaned swine weighing under 25 kilograms, or 300 swine animal units. A swine animal unit is a unit of measurement for any swine feeding operation calculated by adding the following numbers: The number of swine weighing over twenty-five (25) kilograms, multiplied by four-tenths (0.4), plus the number of weaned swine weighing under twenty-five (25) kilograms multiplied by one-tenth (0.1)

[4] Swine Animal Waste Management Plan Requirements [Title 35 (ODAFF), Chapter 17 (Water Quality), Subchapter 3 (Swine Feeding Operations)] can be found in 35:17-3-14.

make the WRS large enough to be total retention lagoons. SFOs are not allowed to discharge to State waterbodies.

For large SFOs with more than 1,000 animal units, monitoring wells or a leakage detection system for waste retention structures must be installed in order to monitor and control seepage/leakage [OAC 35:17-3-11(e)(6)]. Oklahoma Rules requires SFOs to submit a *Documentation of No Hydrologic Connection* (OAC 35:17-3-12) for all retention structures in order to prevent any leaking of wastewater to waterbodies. Thus, the potential for loading from SFOs to the receiving stream is almost non-existent.

There are no SFOs in this Study Area.

3.2.5.3 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. According to PFO regulations, PFOs are required to develop an AWMP[5] or an equivalent nutrient management plan (NMP) such as the ODAFF or NRCS Comprehensive Nutrient Management Plan (CNMP) or EPA Nutrient Management Plan (EPA's 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. A PFO AWMP must address both nitrogen and phosphorus. In order to comply with this TMDL, the registered PFOs in the watershed and their associated management plans must be reviewed. Most of the PFOs generate dry litter and do not have significant impact on the watershed. Further actions to reduce bacterial loads and achieve progress toward meeting the specified reduction goals must be implemented.

According to the PFO rules, runoff of poultry waste from the application site is prohibited. BMPs and practices must be used to minimize movement of poultry waste to waterbodies. Grassed strips at the edge of the field must be used to prevent runoff from carrying eroded soil and poultry waste into the waterbodies. Poultry waste is not allowed to be applied to land when the ground is saturated or while it is raining; and poultry waste application is prohibited on land with excessive erosion.

Every poultry feeding operation located in a nutrient-limited watershed[6] and nutrient-vulnerable groundwater shall perform an annual soil test on each land application area prior to the first application of the calendar year. Poultry waste testing shall be performed annually prior to the first application of the calendar year. PFOs located in nutrient limited watersheds should have a nutrient sample analysis from that year to make available. PFOs in non-nutrient limited watersheds perform nutrient sample analysis at least once every three years and need to have available the most recent record..

There are no PFOs in this Study Area.

3.2.6 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

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5 PFO Animal Waste Management Plan Requirements [Title 35 (ODAFF), Chapter 17 (Water Quality), Subchapter 5 (Registered Poultry Feeding Operations)] can be found in 35:17-5-5.

6 Nutrient limited watersheds are defined in the Oklahoma Water Quality Standards (OWQS,-Title 785, Chapter 45). Nutrient limited watersheds can be found in Appendix A of the OWQS. They are the ones designated "NLW" in the "Remarks" column. Nutrient Vulnerable Groundwater can be found in Appendix D: Classifications for Groundwater in Oklahoma of the OWQS.

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.

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 2014 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 2013). Elevated turbidity measurements can be caused by stream bank erosion processes, stormwater runoff events and other channel disturbances.

The following sections provide general information on nonpoint sources contributing bacterial and/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 3-8** in cfu/day provides a relative magnitude of loading in each of the TMDL watersheds impaired for bacteria.

Table 3-8 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
OK311100010230_00	Bills Creek	7,695	72	0.0094	36
OK311100010250_00	Walnut Bayou	21,376	201	0.0094	101
OK311100010300_00	Fleetwood Creek	10,500	53	0.0050	27
OK311100020010_10	Hickory Creek	130,127	1,291	0.0099	646
OK311200000080_00	Dry Creek	31,316	247	0.0079	124
OK311300020010_10	Cache Creek, East	38,225	138	0.0036	69
OK311300040060_00	Medicine Creek	41,259	154	0.0037	77
OK311310010010_00	Red River	248,044	1,211	0.0049	606
OK311310020010_10	Cache Creek, West	43,534	216	0.0050	108
OK311310020060_00	Blue Beaver Creek	20,045	72	0.0036	36
OK311310030040_00	Little Deep Red Creek	90,604	440	0.0049	220

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 stream pollutants 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 3-12 provides estimated numbers of commercially raised farm animals and estimated acreage where manure was applied by watershed. This was calculated using the 2012 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2012) and the percentage of the watershed within each county. If the 2012 USDA county agricultural census data are not available, previous available USDA census data are used. 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. According to **Table 3-12**, 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 in-stream concentrations of bacteria and land application or direct deposition of manure from commercially raised farm animals. There is also not sufficient information available to describe or quantify the contributions of sediment loading caused by commercially raised farm animals responsible for destabilizing stream banks or erosion in pasture fields. 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. **Table 3-9** gives the daily fecal coliform production rates by animal species:

Table 3-9 Daily Fecal Coliform Production Rates by Animal Species

Animal	Daily fecal coliform production rate counts per animal per day
Beef cattle*	1.04E+11
Dairy cattle*	1.01E+11
Horses*	4.20E+08
Goats	1.20E+10
Sheep*	1.20E+10
Swine*	1.08E+10
Ducks*	2.43E+09
Geese*	4.90E+10
Chickens*	1.36E+08
Turkey*	9.30E+07
Deer*	$5x10^8$
Dogs⁂	$3.3x10^9$
Cats⁂	$5.4x10^8$
* According to a livestock study conducted by the ASAE (1999)	
⁂ Schueler 2000	

Using the estimated animal populations and the fecal coliform production rates from **Table 3-9**, 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 3-13**. 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.

3.3.3 Domestic Pets

Fecal matter from dogs and cats, which can be transported to streams by runoff from urban and suburban areas, is a potential source of bacterial loading. On average 37.2% of the nation's households own dogs and 32.4% own cats. In 2007, the average number of pets per household was 1.7 dogs and 2.2 cats (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 3-10** summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-10 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK311100010230_00	Bills Creek	65	73
OK311100010250_00	Walnut Bayou	179	202
OK311100010300_00	Fleetwood Creek	45	51

Waterbody ID	Waterbody Name	Dogs	Cats
OK311100020010_10	Hickory Creek	2,222	2,506
OK311200000080_00	Dry Creek	649	732
OK311300020010_10	Cache Creek, East	1,768	1,994
OK311300040060_00	Medicine Creek	1,809	2,041
OK311310010010_00	Red River	1,127	1,271
OK311310020010_10	Cache Creek, West	201	227
OK311310020060_00	Blue Beaver Creek	927	1,046
OK311310030040_00	Little Deep Red Creek	410	462

Table 3-11 provides an estimate of the fecal coliform production from pets. These estimates are based on estimated fecal coliform production rates from **Table 3-9**.

Table 3-11 Estimated Fecal Coliform Daily Production by Pets (x10^9 counts/day)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK311100010230_00	Bills Creek	213	39	252
OK311100010250_00	Walnut Bayou	591	109	700
OK311100010300_00	Fleetwood Creek	148	27	175
OK311100020010_10	Hickory Creek	7,331	1,353	8,684
OK311200000080_00	Dry Creek	2,141	395	2,536
OK311300020010_10	Cache Creek, East	5,835	1,077	6,912
OK311300040060_00	Medicine Creek	5,971	1,102	7,073
OK311310010010_00	Red River	3,719	686	4,405
OK311310020010_10	Cache Creek, West	664	122	786
OK311310020060_00	Blue Beaver Creek	3,059	565	3,624
OK311310030040_00	Little Deep Red Creek	1,352	250	1,602

Table 3-12 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Goats	Sheep & Lambs	Hogs & Pigs	Chickens & Turkeys	Ducks & Geese	Acres of Manure Application
OK311100010230_00	Bills Creek	557	1	55	21	4	5	18	0	19
OK311100010250_00	Walnut Bayou	1,547	3	153	59	10	15	51	1	54
OK311100010300_00	Fleetwood Creek	1,694	4	17	2	1	4	10	0	10
OK311100020010_10	Hickory Creek	10,986	16	857	357	104	83	519	7	670
OK311200000080_00	Dry Creek	3,641	4	184	75	50	16	115	1	74
OK311300020010_10	Cache Creek, East	3,128	12	124	70	49	34	194	1	31
OK311300040060_00	Medicine Creek	3,396	12	129	73	53	76	200	1	37
OK311310010010_00	Red River	24,117	2,362	217	175	94	10	171	2	496
OK311310020010_10	Cache Creek, West	5,502	1	61	19	52	5	59	0	N/A
OK311310020060_00	Blue Beaver Creek	1,640	6	65	37	26	18	102	1	16
OK311310030040_00	Little Deep Red Creek	8,043	1,110	65	71	13	2	45	1	233

N/A: Not available

Table 3-13 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	Chickens & Turkeys	Ducks & Geese	Total
OK311100010230_00	Bills Creek	57,928	101	23	252	48	54	2	0	58,409
OK311100010250_00	Walnut Bayou	160,888	303	64	708	120	162	7	2	162,255
OK311100010300_00	Fleetwood Creek	176,176	404	7	24	12	43	1	0	176,668
OK311100020010_10	Hickory Creek	1,142,544	1,616	360	4,284	1,248	896	71	17	1,151,036
OK311200000080_00	Dry Creek	378,664	404	77	900	600	173	16	2	380,836
OK311300020010_10	Cache Creek, East	325,312	1,212	52	840	588	367	26	2	328,400
OK311300040060_00	Medicine Creek	353,184	1,212	54	876	636	821	27	2	356,813
OK311310010010_00	Red River	2,508,168	238,562	91	2,100	1,128	108	23	5	2,750,185
OK311310020010_10	Cache Creek, West	572,208	101	26	228	624	54	8	0	573,249
OK311310020060_00	Blue Beaver Creek	170,560	606	27	444	312	194	14	2	172,160
OK311310030040_00	Little Deep Red Creek	836,472	112,110	27	852	156	22	6	2	949,647

3.3.4 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 2012). 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 3-14** 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):

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

Table 3-14 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks / Mile^2
OK311100010230_00	Bills Creek	25	53	2	80	4.4
OK311100010250_00	Walnut Bayou	71	147	6	224	4.4
OK311100010300_00	Fleetwood Creek	54	18	2	74	1.1
OK311100020010_10	Hickory Creek	1,854	1,205	33	3,092	5.9
OK311200000080_00	Dry Creek	673	300	6	979	6.1
OK311300020010_10	Cache Creek, East	2,150	245	7	2,402	4.1

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks / Mile^2
OK311300040060_00	Medicine Creek	2,199	256	8	2,463	4.0
OK311310010010_00	Red River	1,613	380	19	2,012	1.0
OK311310020010_10	Cache Creek, West	233	91	8	332	1.3
OK311310020060_00	Blue Beaver Creek	1,127	129	4	1,260	4.1
OK311310030040_00	Little Deep Red Creek	619	124	4	747	0.9

The average of number of people per household was calculated to be from 1.9 to 2.4 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 in **Table 3-15.**

Table 3-15 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)
OK311100010230_00	Bills Creek	7,695	53	6	33
OK311100010250_00	Walnut Bayou	21,376	147	18	100
OK311100010300_00	Fleetwood Creek	10,500	18	2	10
OK311100020010_10	Hickory Creek	130,127	1,205	145	827
OK311200000080_00	Dry Creek	31,316	300	36	206
OK311300020010_10	Cache Creek, East	38,225	245	29	184
OK311300040060_00	Medicine Creek	41,259	256	31	195
OK311310010010_00	Red River	248,044	380	46	246
OK311310020010_10	Cache Creek, West	43,534	91	11	61
OK311310020060_00	Blue Beaver Creek	20,045	129	15	95
OK311310030040_00	Little Deep Red Creek	90,604	124	15	79

3.4 Summary of Sources of Impairment

3.4.1 Bacteria

There are no continuous, permitted point sources of bacteria in the Walnut Bayou, Fleetwood Creek, Medicine Creek, West Cache Creek, or Blue Beaver Creek watersheds which require bacterial TMDLs. Therefore, the conclusion is that nonsupport of PBCR use in these watersheds is caused by nonpoint sources of bacteria. Hickory Creek (OK311100020010_10), East Cache Creek (OK311300020010_10), and Little Deep Red Creek (OK311310030040_00) have a continuous point source discharger that may contribute bacteria. However, available data suggests that the proportion of bacteria from point sources is minor. There are three CAFOs (24,920 units) which could possibly contribute bacterial loading into the Red River watershed. But CAFOs are not allowed to discharge or allow the runoff of animal waste so they are not considered to be major sources of bacteria as long as they are in compliance with their Nutrient Management Plans and Animal Waste Management Plans as outlined in the ODAFF CAFO Rules. Therefore the various nonpoint sources are considered to be the major source of bacterial loading in each watershed that requires a TMDL.

Eight stream segments in **Table 3-16,** except Bills Creek, Dry Creek, and Red River, 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 demonstrate that wild birds and mammals represent a major source of the fecal bacteria found in streams.

Table 3-16 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
OK311100010230_00	Bills Creek	99.45%	0.43%	0.06%	0.06%
OK311100010250_00	Walnut Bayou	99.45%	0.43%	0.06%	0.06%
OK311100010300_00	Fleetwood Creek	99.88%	0.10%	0.01%	0.01%
OK311100020010_10	Hickory Creek	99.13%	0.75%	0.06%	0.07%
OK311200000080_00	Dry Creek	99.25%	0.66%	0.03%	0.05%
OK311300020010_10	Cache Creek, East	97.86%	2.06%	0.02%	0.05%
OK311300040060_00	Medicine Creek	97.98%	1.94%	0.02%	0.05%
OK311310010010_00	Red River	99.81%	0.16%	0.02%	0.01%
OK311310020010_10	Cache Creek, West	99.83%	0.14%	0.2%	0.01%
OK311310020060_00	Blue Beaver Creek	97.87%	2.06%	0.02%	0.05%
OK311310030040_00	Little Deep Red Creek	99.80%	0.17%	0.02%	0.01%

The magnitude of loading to land surfaces may not reflect the magnitude of loading to a stream. 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, one of them, East Cache Creek (OK311300020010_10), has minor industrial permitted sources of TSS that will necessitate a WLA. The East Cache Creek and Red River 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

4.1 POLLUTANT LOADS AND TMDLS

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 (WLA, LA, and MOS) as described in the following mathematical equation:

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

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 (PRGs) 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.

4.2 DETERMINE 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 2001 to 2014 at stations within the Study Area.

4.2.1 Steps Prior to Regression

Prior to developing the regression, the following steps are taken to refine the dataset:

- Remove data collected under high flow conditions exceeding the base-flow criterion. This means that measurements corresponding to flow exceedance percentiles lower than 25th are not be 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 is 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,

- Check the non-detect rate. Non-detects (censored data) are TSS sample observations less than the detection limit (10 mg/L). If the percent of non-detects is ≤ 15%, follow the steps outlined in Section 4.2.2. If the percent of non-detects is > 15%, follow the steps outlined in Section 4.2.3.

4.2.2 Non-Detect Rate Less Than or Equal to (≤) 15%

For observed data where the non-detect rate is less than or equal to (≤) 15%, EPA (2006) recommends using substitution. 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 in-stream turbidity values. For this purpose, an alternate regression fitting procedure known as the line of organic correlation (LOC) was applied. To apply LOC, TSS samples of less than 10 were replaced with 9.99 and then both turbidity and TSS data were log-transformed to minimize effects of their non-linear data distribution. 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:

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

*m*1 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

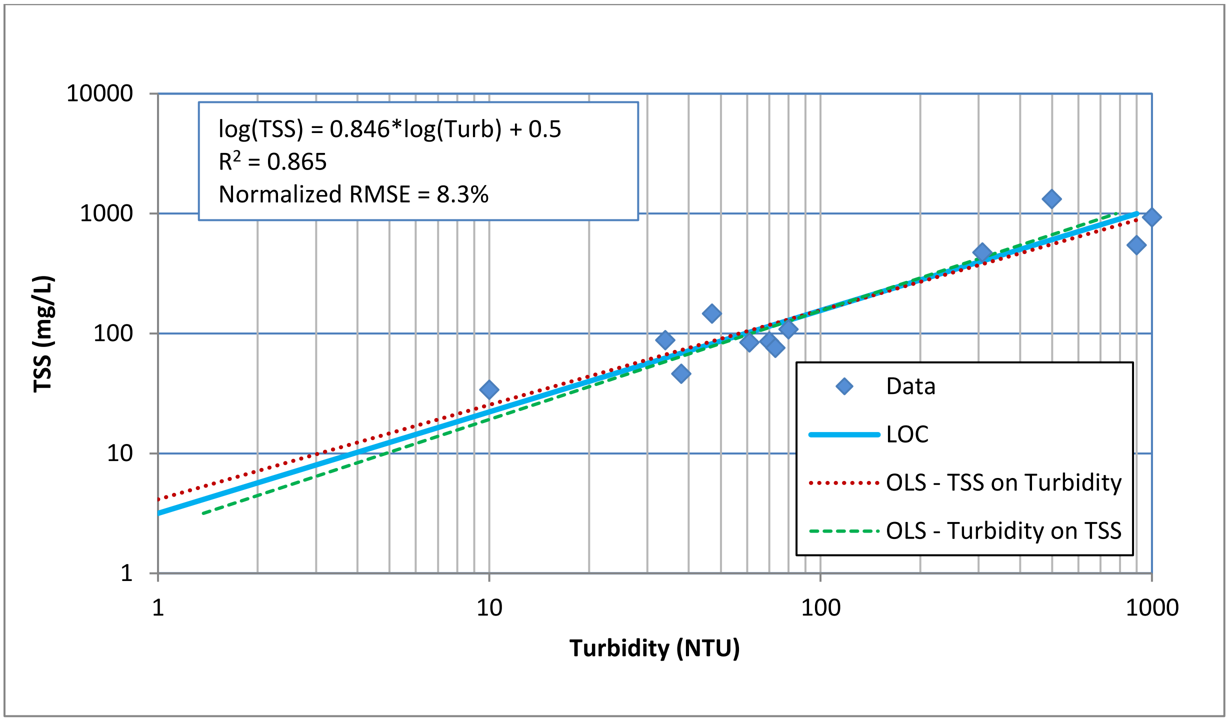
s_x is the standard deviation of the turbidity measurements

The r can range from -1 to 1 with 0 indicating no correlation, and negative r indicating an inverse correlation. Correlation values of 0 to 0.5 indicate a weaker correlation whereas values greater than 0.5 indicate a strong correlation. As a result, correlations of approximately 0.5 or greater are commonly used in TMDL studies (Christensen, Jian, and Ziegler; 2000). This Study considered an R-square (R^2 or coefficient of determination) value of approximately 0.5 or greater to represent a satisfactory relationship between turbidity and TSS, if based on at least 10 observations.

The intercept of the LOC (*b*1) 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 8.3% which means the root mean square error (RMSE) is 8.3% 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 Red River (OK311310010010_00)



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.

4.2.3 Non-Detect Rate is Greater Than 15%

For observed data where the non-detect rate is greater than 15%, follow these steps:

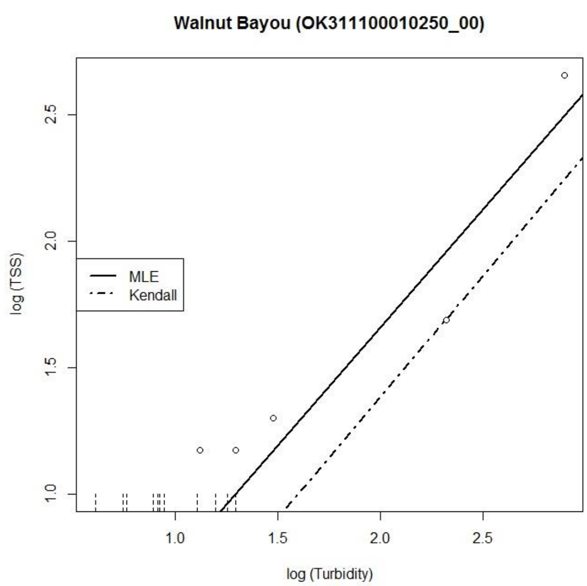
- If the number of samples is less than 25 (Helsel, 2002; p. 360), combine sample data based on their ecoregion, geological area, and beneficial use.
- Log-transform both turbidity and TSS data to minimize effects of their non-linear data distributions.
- Use methods for estimating summary statistics of data which include non-detects: simple substitution, distributional, and robust methods (Helsel and Hirsch, 2002).

- Compare results for the mean and the variance for desirable methods. Extrapolated values are not considered as estimates for specific samples, but only used collectively to estimate summary statistics.
- Choose regression methods for data-sets containing non-detects depend on distribution of data. If the data are linear and normally distributed without outliers, parametric methods may be used. Non-parametric methods may be used regardless of whether or not they are linear (Huston and Juarez-Colunga, 2009).
- Use statistical software (such as Excel, JMP, R, Minitab, or SAS) to calculate the turbidity-TSS relationship. Then, the TSS goal is computed based on regression coefficients.
- Replace Less-thans with their detection limits for percentage reduction goal (PRG) calculation. Detection limit substitution may not be the best estimation method, but it is the best conservative method for calculating PRG.

If a small proportion of the observations are not detected, these may be substituted with a value (EPA 2006), the detection limit (dl) in this study. However, substituting for non-detects may incorrectly alter the mean and the variance (**Appendix D**). Therefore, censored data regression was issued for the data set of censoring greater than 15%. Before determining the relationship between turbidity and TSS, censored data were set as a range from one (TSS=1[1] mg/L) to detection limit (TSS=10 mg/L). Then, turbidity and TSS data were log-transformed and statistical software R determined regression relationships.

With statistical software R, maximum likelihood estimation (MLE) or non-parametric approaches can estimate correlation and regression coefficients as shown in **Figure 4-2**. If extreme outliers were not present in the sample data and the distributions of points were close to trend line (**Appendix E**), parametric method (MLE) performed similar or slightly better than non-parametric method (Kendall's tau).

Figure 4-2 Regression estimates by parametric and non-parametric method



After computing TSS goal with estimated regression, censored data were replaced with their detection limit (dl). This simple substitution is the most conservative to calculate PRG among

[1] Having a TSS of "0" would be almost impossible because there is always some sediment in the background. Consequently, "1" is used as the lowest amount of TSS.

estimation methods for censored data. Then, Normalized Root Mean Square Error (NRMSE) and R-square (R^2) were computed as:

$$RMSE = (Standard\ Error\ of\ Slope) \cdot \sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

$$NRMSE = \frac{RMSE}{\bar{y}}$$

$$R^2 = 1 - \left[\frac{exp\left(loglik_{intercept}\right)}{exp\left(loglik_{model}\right)}\right]^{\frac{2}{n}}$$

Where x_i = log(turbidity)$_i$, y_i = log(TSS)$_i$, i = 1…n, $\bar{x}$ = average of x_i, $\bar{y}$ = average of y_i, and n = number of observations.

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

4.3 Steps to Calculating 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 identify whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the following steps that are described in Subsections 4.3.1 through 4.3.3:

1. Prepare flow duration curves for gaged and ungaged WQM stations.
2. Estimate existing loading in the waterbody using ambient bacterial water quality data.
3. Estimate loading in the waterbody using measured TSS water quality data and turbidity-converted data.
4. Use 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.

4.3.1 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. Five of the nine waterbodies required TMDL 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**.

To estimate flows at an ungaged site:

- Identify an upstream or downstream flow gage.
- Calculate the contributing drainage areas of the ungaged sites and the flow gage.
- Calculate 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 to support the Oklahoma TMDL Toolbox.

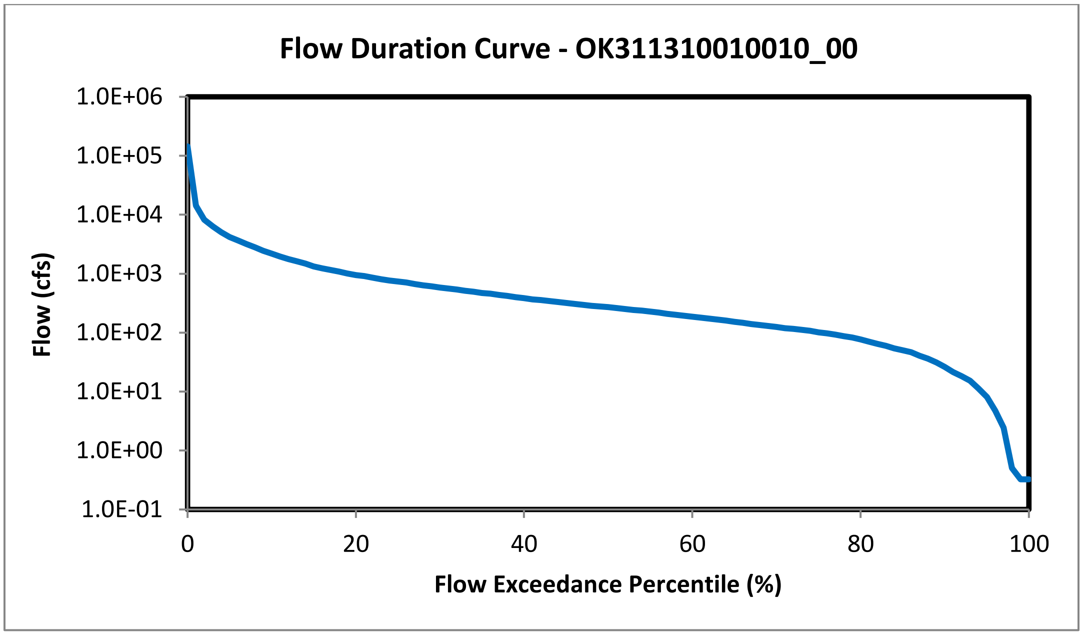
The USGS National Water Information System serves as the primary source of flow measurements for the Oklahoma TMDL Toolbox. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream gages in adjacent states, were retrieved for use in the Oklahoma 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 4-3**.

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

Figure 4-3 Flow Duration Curve for the Red River (OK311310010010_00)



4.3.2 Using Flow Duration Curves to Calculate Load Duration Curves

4.3.2.1 Bacteria

Existing in-stream loads can be calculated using LDCs. For bacteria:

- Calculate the geometric mean of all water quality observations from the period of record selected for the waterbody.
- Convert 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.

4.3.2.2 TSS

- Match the water quality observations with the flow data from the same date.
- Convert 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).

4.3.3 Using Load Duration Curves to Develop TMDLs

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).

4.3.3.1 Step 1 - Generate LDCs

LDCs are similar in appearance to flow duration curves.

For bacteria, the ordinate is expressed in terms of a bacterial load in cfu/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 equation in Section 4.3.3.1.1 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 TSS, the ordinate is expressed in terms of a load in lbs/day. The curve represents the water quality target for TSS from **Table 5-2** expressed in terms of a load obtained through multiplication of the TSS goal by the continuum of flows historically observed at the site.

The following are the basic steps in developing an LDC:

1. Obtain daily flow data for the site of interest from the USGS.
2. Sort the flow data and calculate flow exceedance percentiles.
3. For bacteria, obtain water quality data for the primary contact recreation season (May 1 through September 30).
4. Obtain available turbidity and TSS water quality data.
5. Display 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 bacteria and TSS goal for turbidity).
6. For bacterial TMDLs, display 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 LDC (See Section 5).
7. For turbidity TMDLs, match the water quality observations with the flow data from the same date and determine the corresponding exceedance percentile (See Section 5).
8. 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.

As noted earlier, runoff has a strong influence on loading of nonpoint pollution. 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).

4.3.3.1.1 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

Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. 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.

4.3.3.1.2 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 5-2

Unit conversion factor = 5.39377

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.

4.3.3.2 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. MOS is set to be the next percentile (count by 5%) greater than the NRMSE. For example, for any NRMSE greater than 10% but less than 15%, MOS will be 15%.

4.3.3.3 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. Recent EPA guidance includes OPDES-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."

WLA for WWTF

For watersheds with permitted point sources discharging the pollutant of concern, OPDES 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 OPDES wastewater discharger are then summed to represent the total WLA for a given segment. Using this information, WLAs can be calculated using the approach as shown in the equations below.

4.3.3.3.1 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

4.3.3.3.2 WLA for TSS

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

Where:

WQ goal= Waterbody specific water quality goal provided in Table 5-2, or monthly TSS limit in the current permit, whichever is smaller

Flow (mgd) = permitted flow or average monthly flow

Unit conversion factor = 8.3445

4.3.3.4 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 OPDES 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.

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

4.3.3.4.1 Bacterial WLAs 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.

4.3.3.4.2 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.

4.3.3.5 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 (PRG) 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:

1. If the geometric mean of the reduced values of all samples is less than the geometric mean standards (for bacteria) or

2. If no more than 10% of the reduced values of the samples under flow-base conditions exceed the TMDL (for turbidity).

4.3.3.5.1 WLA Load Reduction

The WLA load reduction for bacteria was not calculated as it was assumed that continuous dischargers (OPDES-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.

4.3.3.5.2 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.

E. coli and Enterococci: WQSs are considered to be met if the geometric mean of all future data is maintained below the geometric mean criteria (TMDL).

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

Regression methods used in this report depend on the percentage of censored data. When censored data are less than or equal to 15%, the line of organic correlation (LOC) is applied with simple substitution of detection limit for censored data. When censored data are greater than 15%, maximum likelihood estimation (MLE) is applied for the data set without extreme outliers. Therefore, MLE was used for Walnut Bayou and East Cache Creek and LOC was used for the Red River. The percentage of censored data was shown in **Table 5-1**.

Table 5-1 Censored TSS data in base flow

Waterbody ID	Waterbody Name	Total number of TSS data	Number of censored data (# of samples falling below the 10 mg/L detection limit)	Percent of censored data (% of samples falling below the 10 mg/L detection limit)
OK311100010250_00	Walnut Bayou	17	12	70.6
OK311300020010_10	East Cache Creek	17	13	76.5
OK311310010010_00	Red River	12	0	0

Using the LOC and MLE methods described in Section 4.2, correlations between TSS and turbidity were developed for establishing the statistics of the regressions and the resulting TSS goals were provided in **Table 5-2**. The regression analysis for each impaired waterbody in the Study Area using the LOC or MLE method is displayed in **Figures 5-1** through **5-3**.

Table 5-2 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK311100010250_00	Walnut Bayou	0.81	21.4%	23.9	25%
OK311300020010_10	East Cache Creek	0.82	18.5%	60.0	20%
OK311310010010_00	Red River	0.86	8.3%	86.6	10%

[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)

Figure 5-1 Linear Regression for TSS-Turbidity for Walnut Bayou (OK311100010250_00)

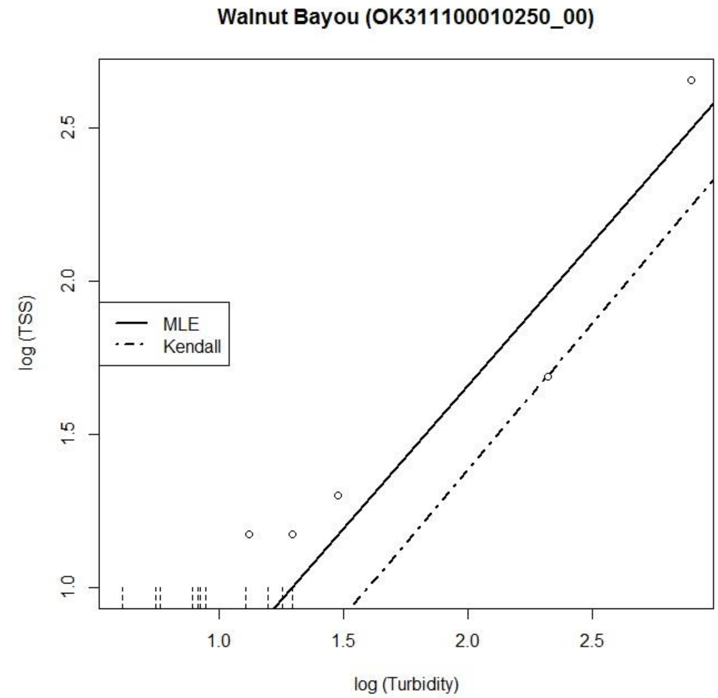


Figure 5-2 Linear Regression for TSS-Turbidity for East Cache Creek (OK311300020010_10)

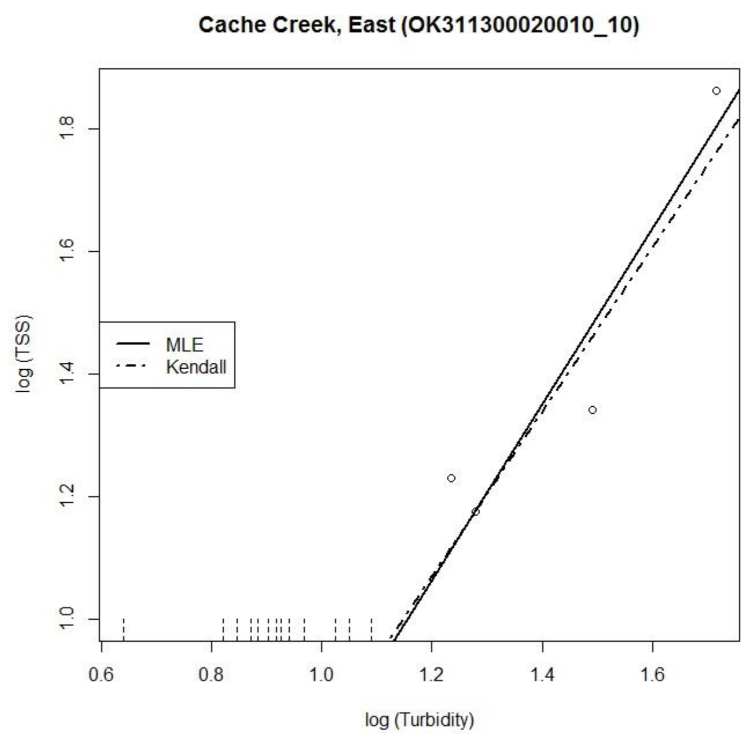
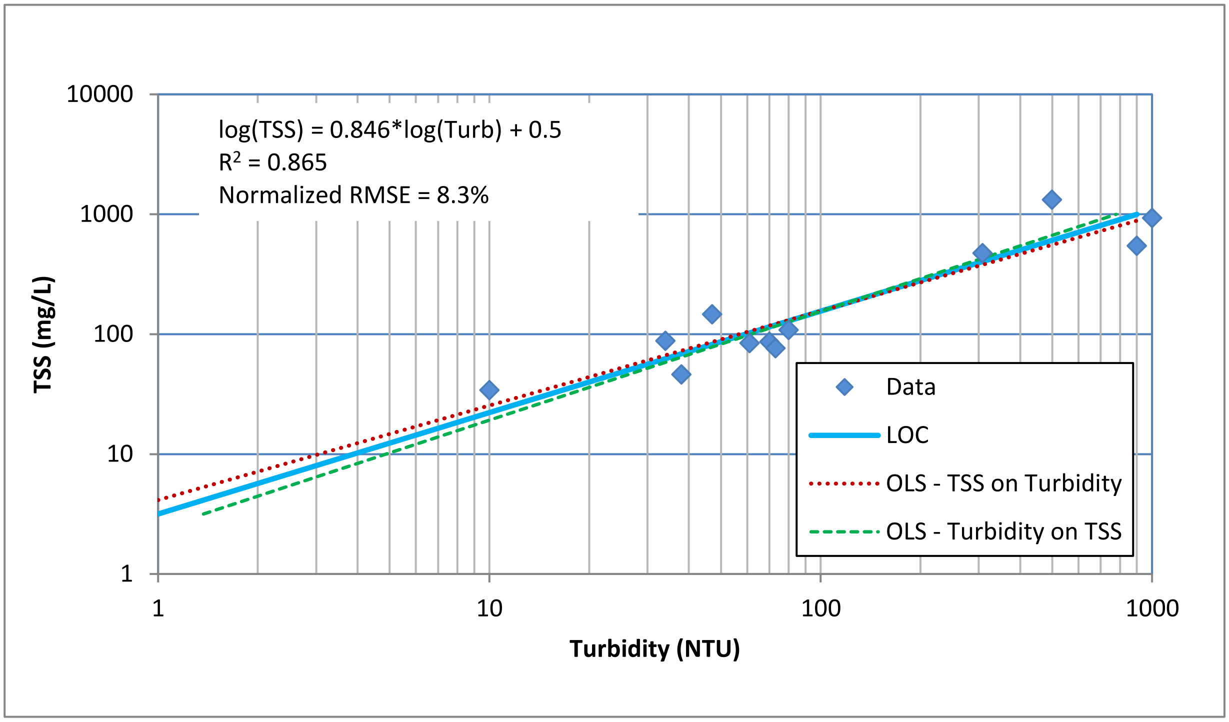


Figure 5-3 Linear Regression for TSS-Turbidity for the Red River (OK311310010010_00)



5.2 Flow Duration Curve

Following the same procedures described in Section 4.3.1, a flow duration curve for each stream segment requiring a TMDL in the Study Area was developed. These are shown in **Figure 5-4** through **Figure 5-12**.

No active flow gage exists on Walnut Bayou (OK311100010250_00), Fleetwood Creek (OK311100010300_00), and Hickory Creek (OK311100020010_10). Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07315700 located in an adjacent watershed (Mud Creek near Courtney, OK) since they are geographically close and have similar land uses. The flow duration curve was based on measured flows from 1960 to 2014.

The flow duration curve for East Cache Creek (OK311300020010_10) was developed based on the flow data from 1969 to 2014 at USGS gage station 07311000 on East Cache Creek near Walters, OK.

No flow gage exists on Medicine Creek (OK311300040060_00). Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07309435 located in Jimmy Creek near Meers, OK since they are geographically close and have similar land uses. The flow duration curve was based on measured flows from 2008 to 2014.

The flow duration curve for the Red River (OK311310010010_00) was developed based on the flow data from 1994 to 2014 at USGS gage station 07308500 on the Red River near Burkburnett, TX.

No flow gage exists on West Cache Creek (OK311310020010_10). Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07311500 located in an adjacent watershed (Deep Red Creek near Randlett, OK) since they are geographically close and have similar land uses. The flow duration curve was based on measured flows from 1949 to 2014.

The flow duration curve for Blue Beaver Creek (OK311310020060_00) was developed based on the flow data from 1964 to 2003 at USGS gage station 07311200 on Blue Beaver Creek near Cache, OK.

The flow duration curve for Little Deep Red Creek (OK311310030040_00) was developed based on the flow data from 1949 to 2014 at USGS gage station 07311500 on Deep Red Creek near Randlett, OK.

Figure 5-4 Flow Duration Curve for Walnut Bayou (OK311100010250_00)

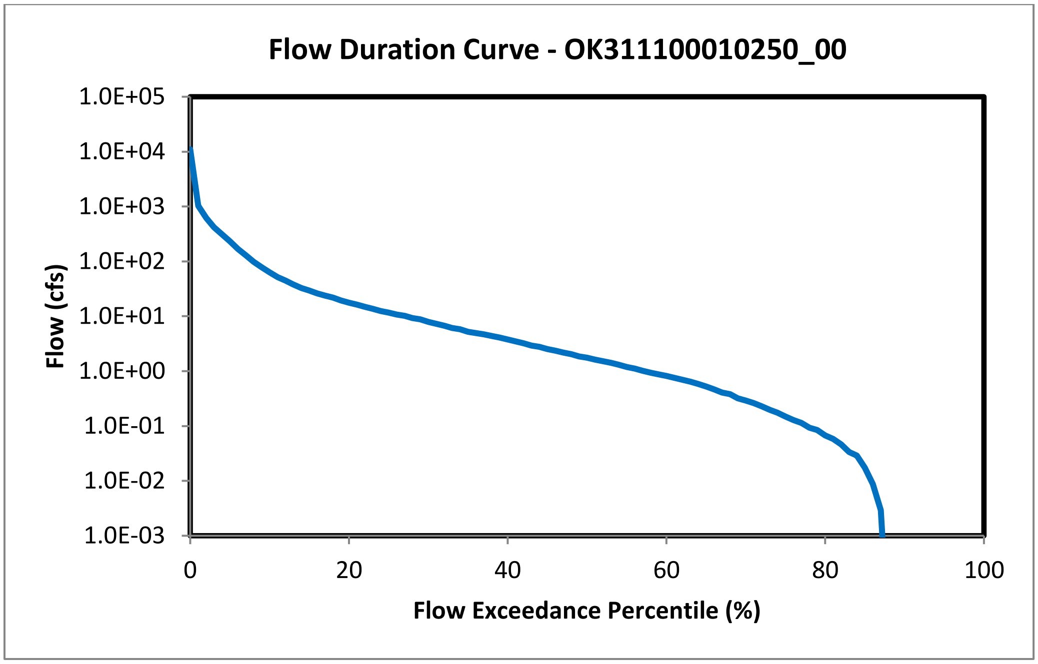


Figure 5-5 Flow Duration Curve for Fleetwood Creek (OK311100010300_00)

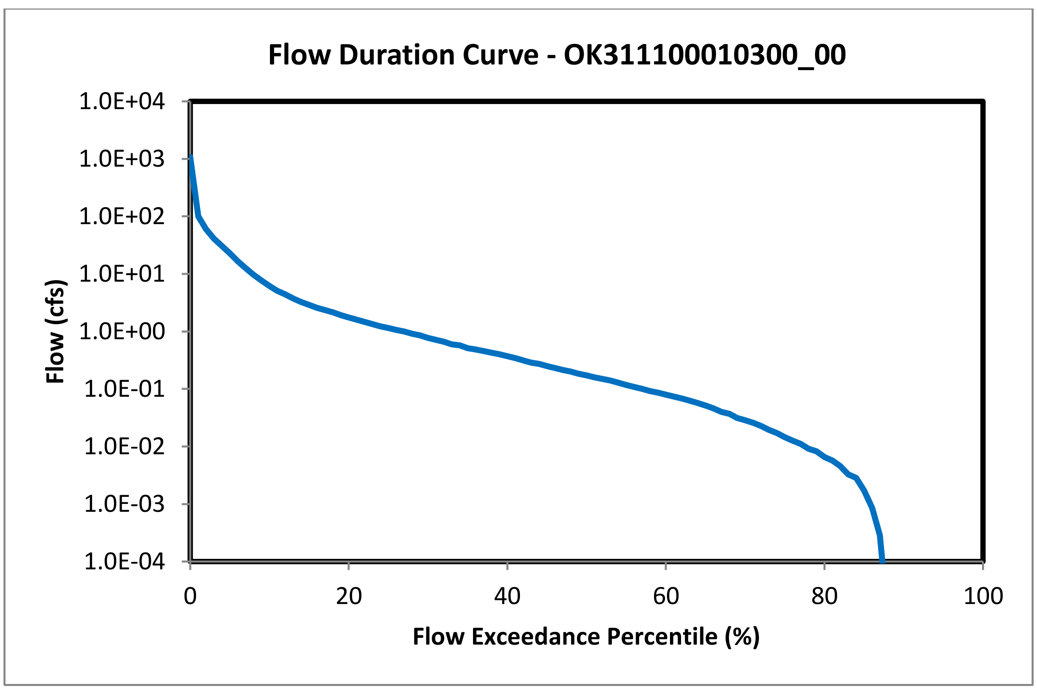


Figure 5-6 Flow Duration Curve for Hickory Creek (OK311100020010_10)

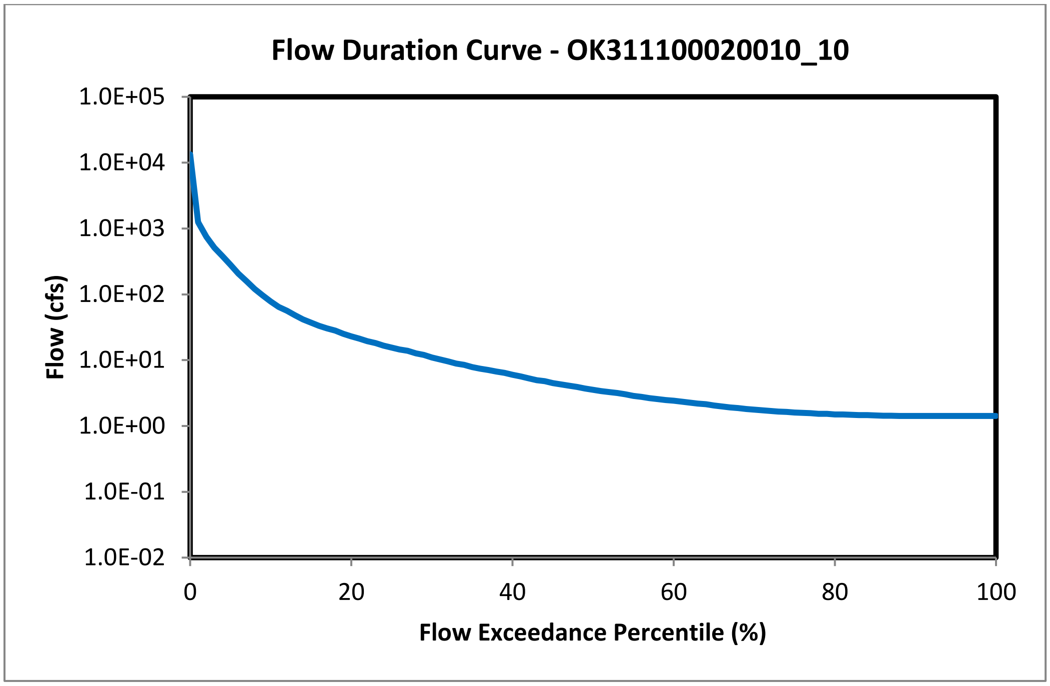


Figure 5-7 Flow Duration Curve for Cache Creek, East (OK311300020010_10)

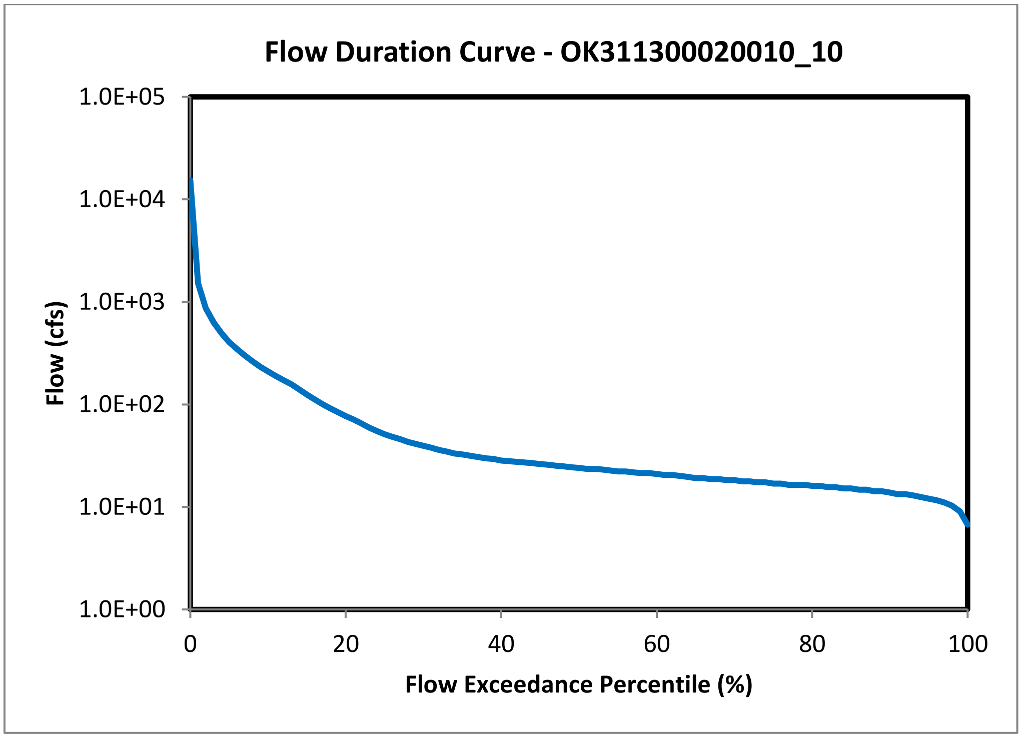


Figure 5-8 Flow Duration Curve for Medicine Creek (OK311300040060_00)

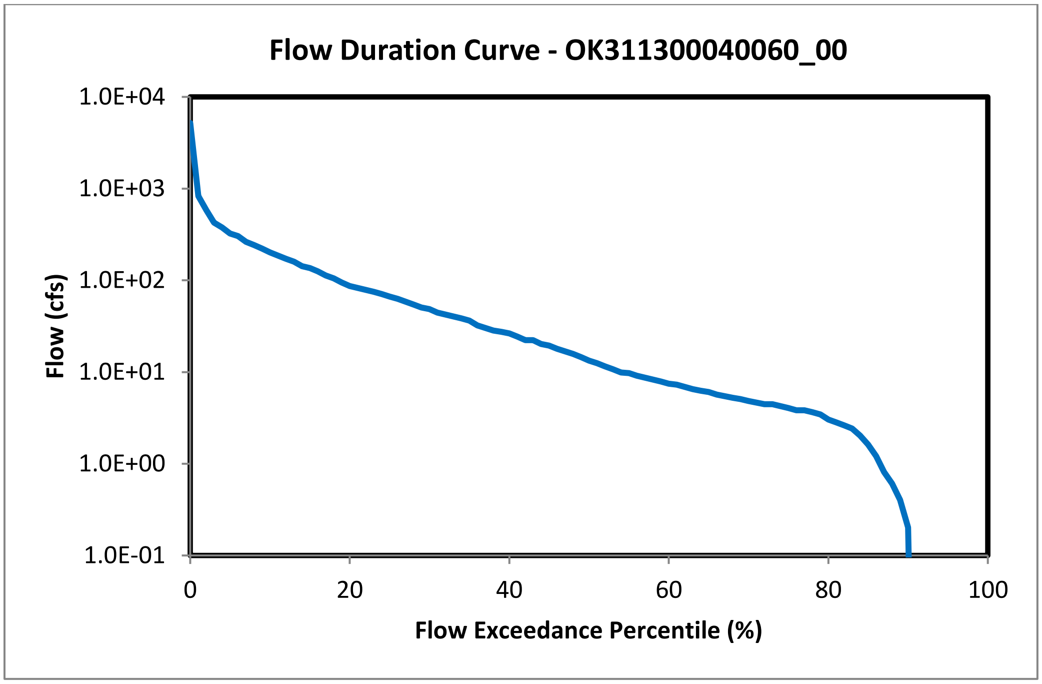


Figure 5-9 Flow Duration Curve for the Red River (OK311310010010_00)

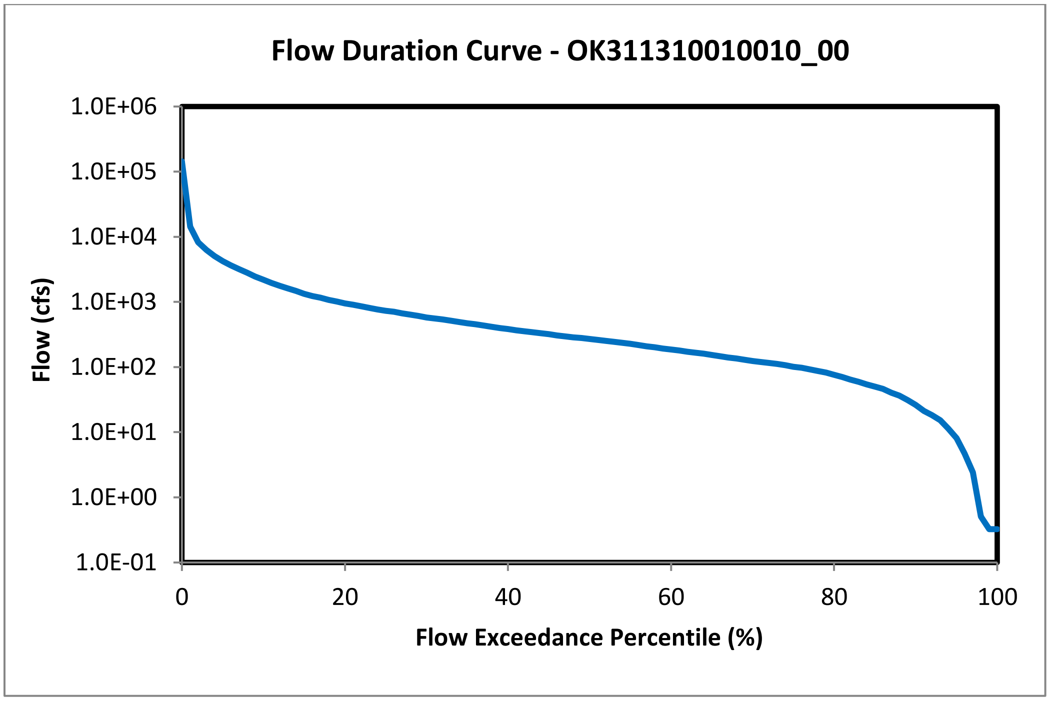


Figure 5-10 Flow Duration Curve for Cache Creek, West (OK311310020010_10)

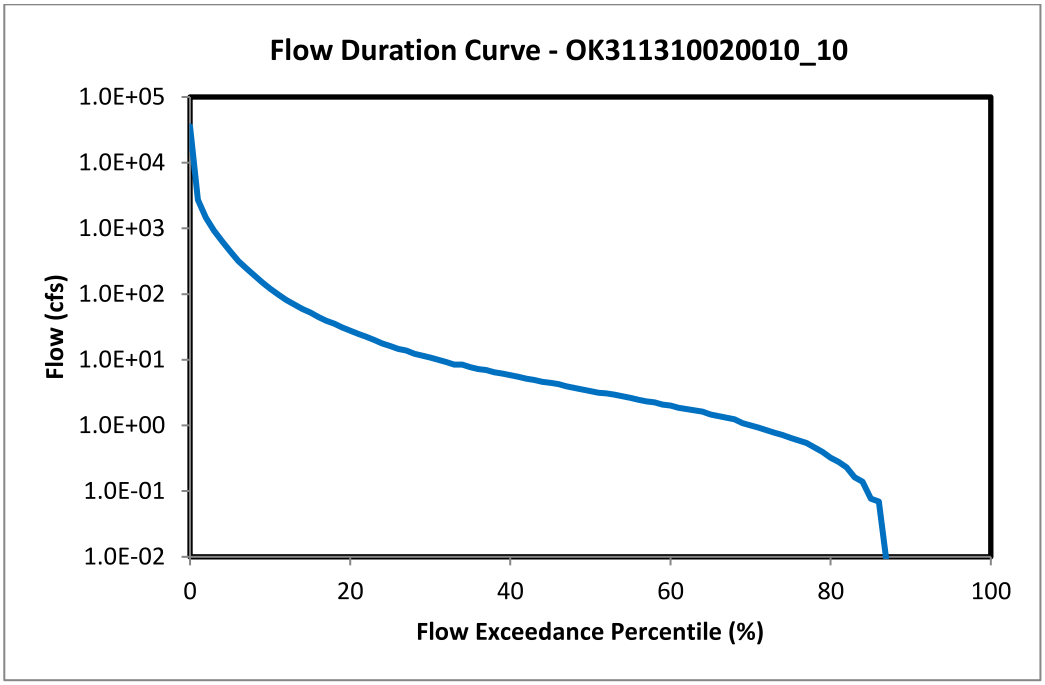


Figure 5-11 Flow Duration Curve for Blue Beaver Creek (OK311310020060_00)

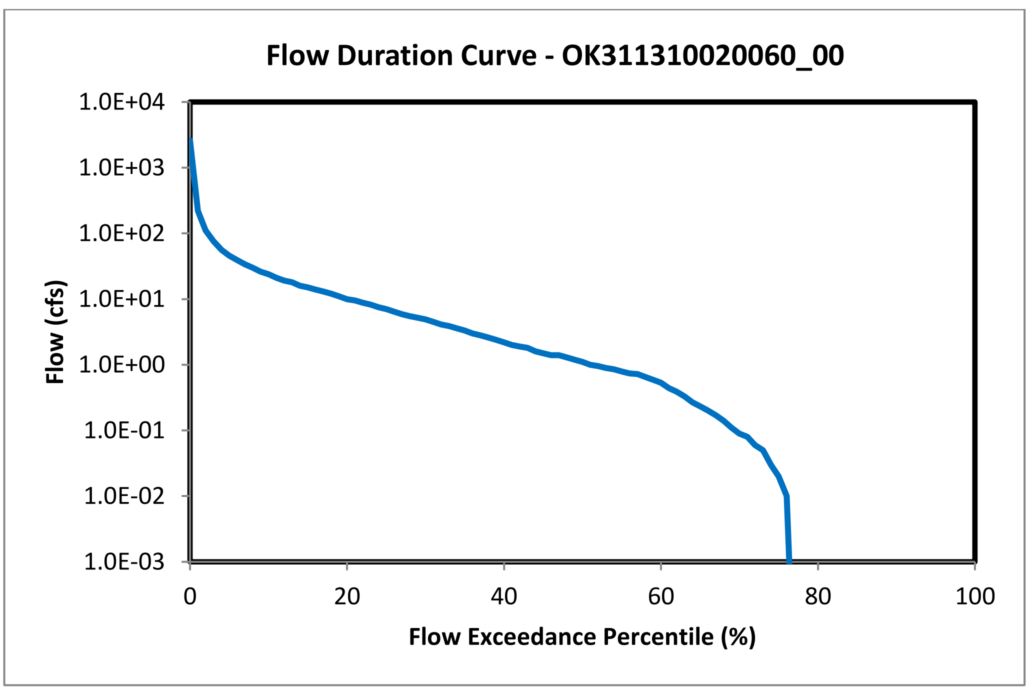
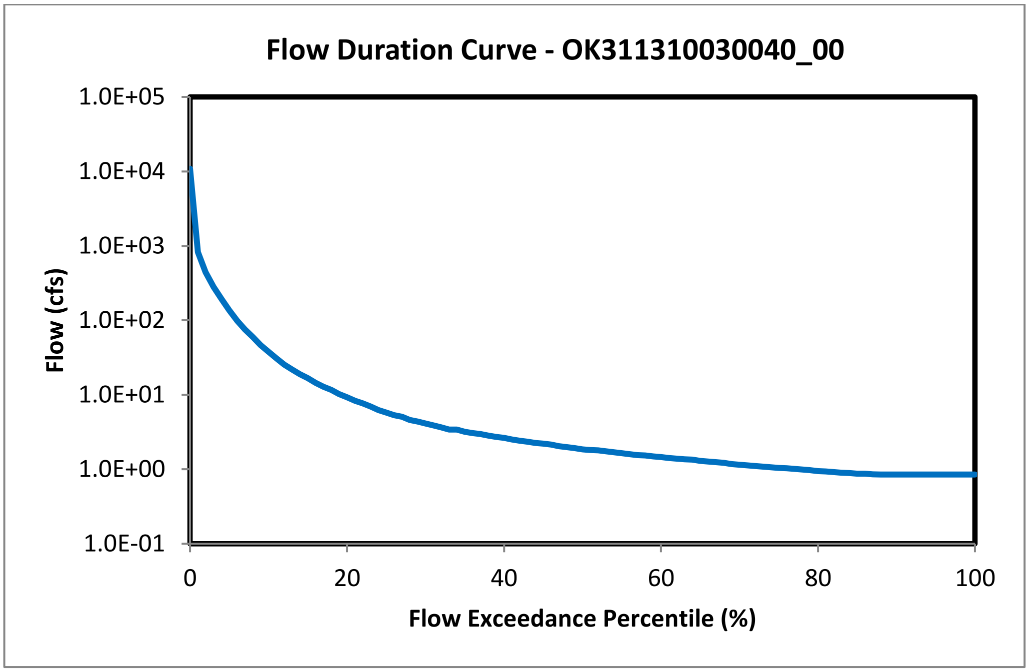


Figure 5-12 Flow Duration Curve for Little Deep Red Creek (OK311310030040_00)



5.3 Estimated Loading and Critical Conditions

EPA regulations [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 in-stream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs.

5.3.1 Bacterial LDCs

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 2000 to 2013 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 5-13** through **5-22**.

The LDC for Walnut Bayou (**Figure 5-13**) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK311100-03-0010G and 311100030010-001AT.

The LDC for Fleetwood Creek (**Figures 5-14** and **5-15**) is based on *E. coli* and Enterococci measurements during primary contact recreation season at WQM stations OK311100-01-0300D.

The LDC for Hickory Creek (**Figure 5-16**) is based on Enterococci measurements during primary contact recreation season at WQM stations OK311100-02-0010M. The horizontal WLA reflects the continuous discharge using the permitted design flow (0.764 mgd) of the municipal discharger, Lone Grove WWTF (OK0034266).

The LDC for Cache Creek, East (**Figure 5-17**) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK311300-02-0010M. The WLA reflects the influence of the MS4 discharge at high flow and the continuous discharge of the municipal discharger with the permitted design flow (4.3 MGD), Fort Sill WWT (OK0030295), at low flow.

The LDC for Medicine Creek (**Figure 5-18**) is based on Enterococci measurements during primary contact recreation season at WQM stations OK311300-04-0060H.

The LDCs for Cache Creek, West (**Figure 5-19**) are based on Enterococci measurements during primary contact recreation season at WQM stations OK311310-02-0010M.

The LDCs for Blue Beaver Creek (**Figure 5-20**) are based on Enterococci measurements during primary contact recreation season at WQM stations OK311310-02-0060G.

The LDC for Little Deep Red Creek (**Figures 5-21** and **5-22**) is based on *E. coli* and Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK311310-03-0040D. The horizontal WLA reflects the continuous discharge using the permitted design flow (0.55 mgd) of the municipal discharger, Frederick POTW (OK0027171).

Figure 5-13 Load Duration Curve for Enterococci in Walnut Bayou (OK311100010230_00)

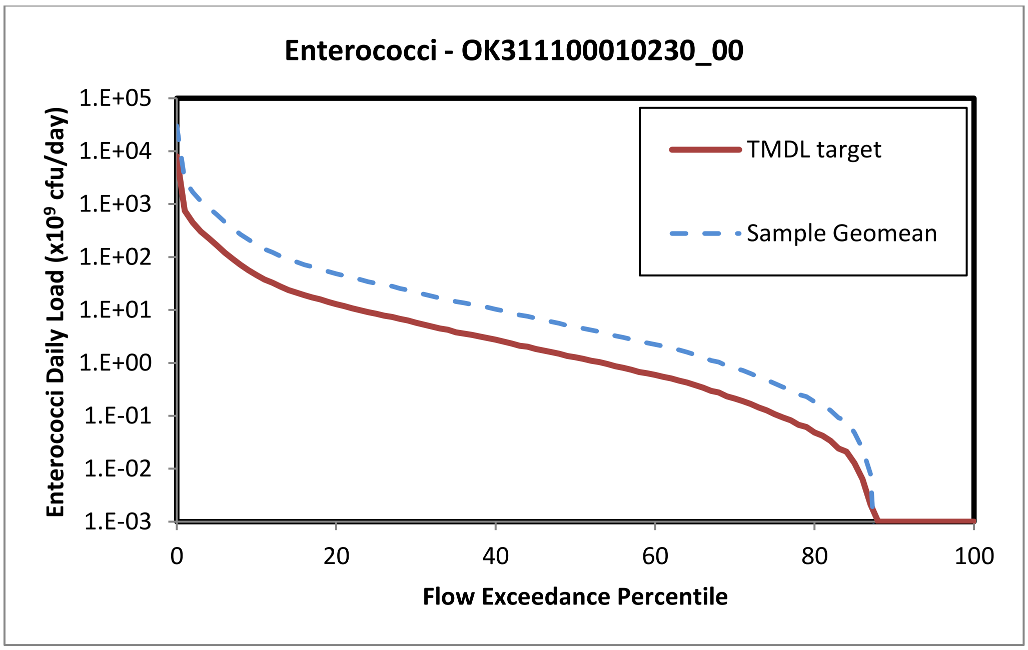


Figure 5-14 Load Duration Curve for *E. coli* in Fleetwood Creek (OK311100010300_00)

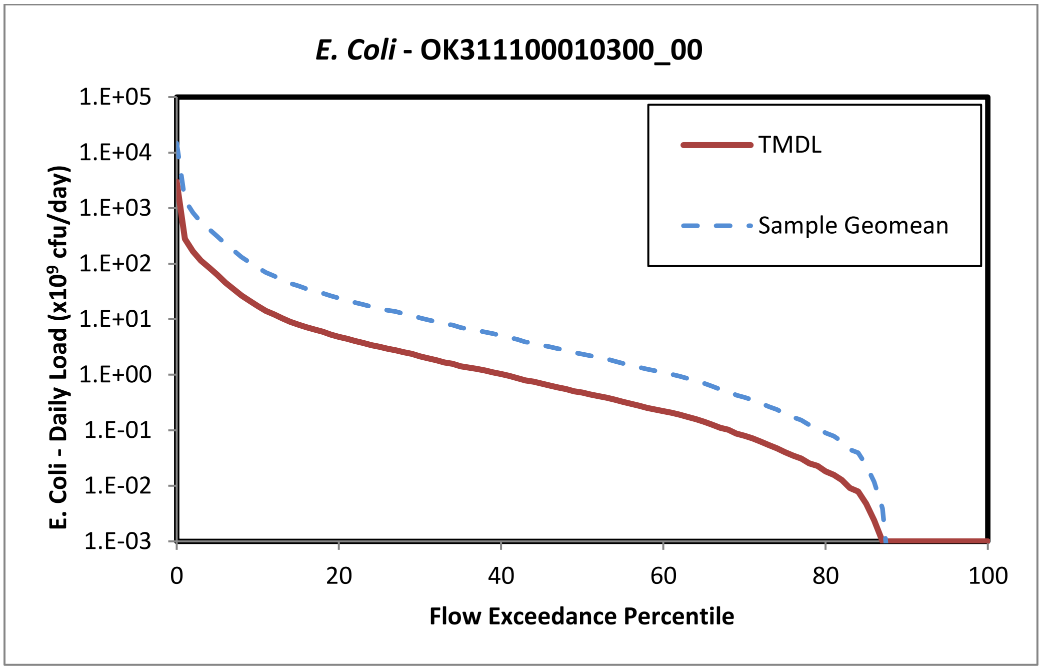


Figure 5-15 Load Duration Curve for Enterococci in Fleetwood Creek (OK311100010300_00)

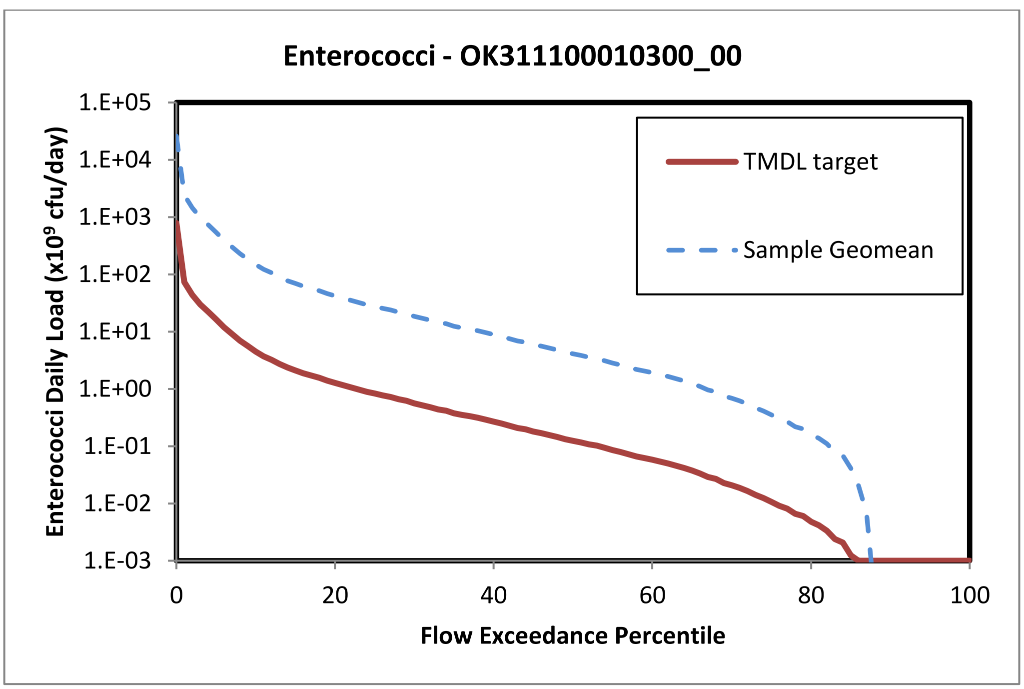


Figure 5-16 Load Duration Curve for Enterococci in Hickory Creek (OK311100020010_10)

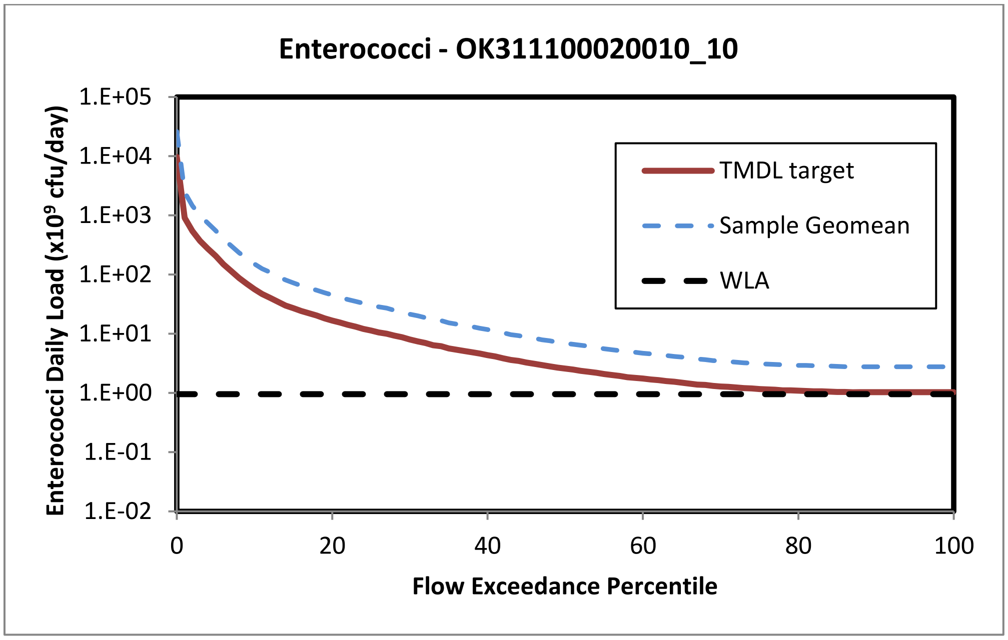


Figure 5-17 Load Duration Curve for Enterococci in Cache Creek, East (OK311300020010_10)

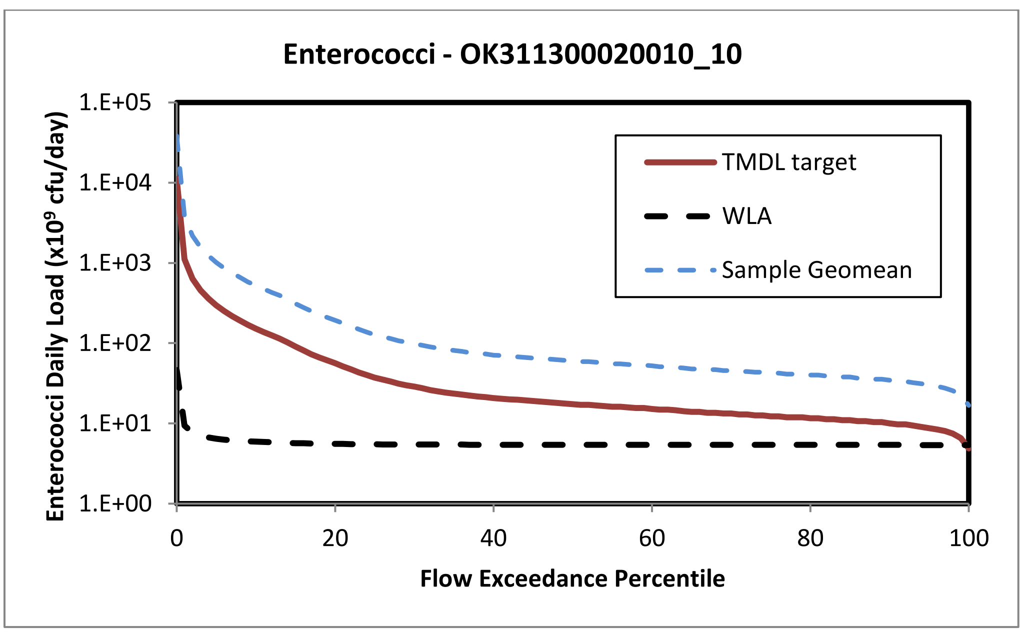


Figure 5-18 Load Duration Curve for Enterococci in Medicine Creek (OK311300040060_00)

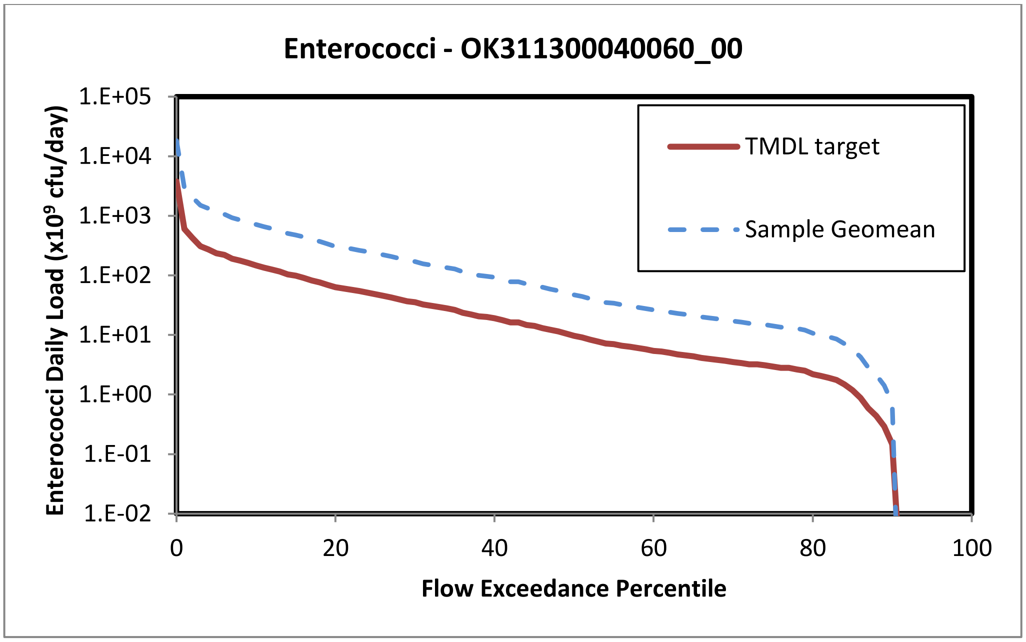


Figure 5-19 Load Duration Curve for Enterococci in Cache Creek, West (OK311310020010_10)

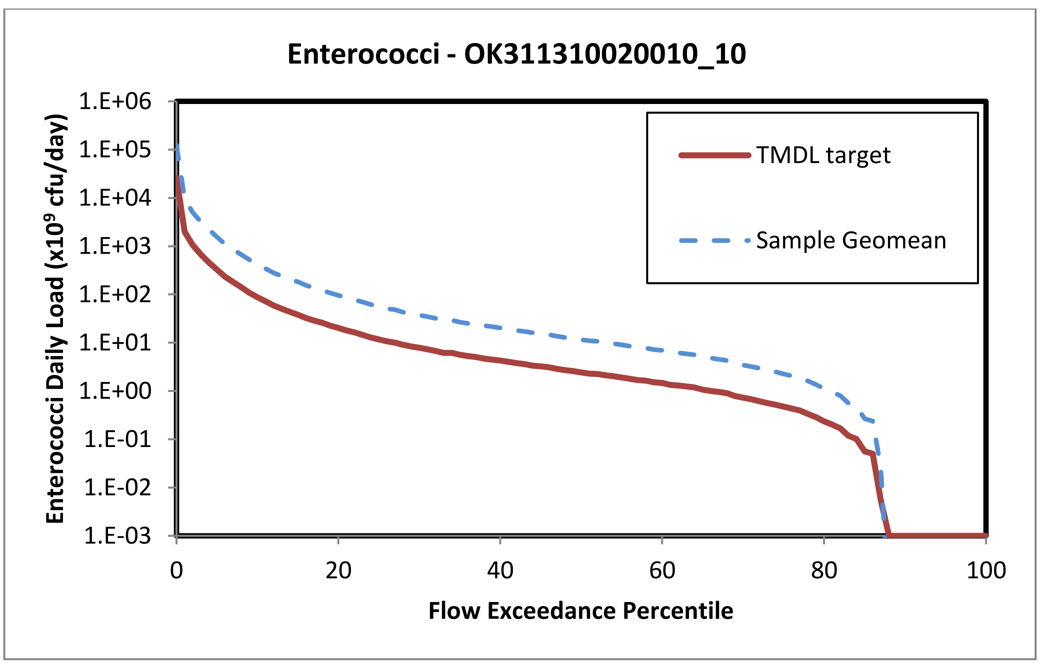


Figure 5-20 Load Duration Curve for Enterococci in Blue Beaver Creek (OK311310020060_00)

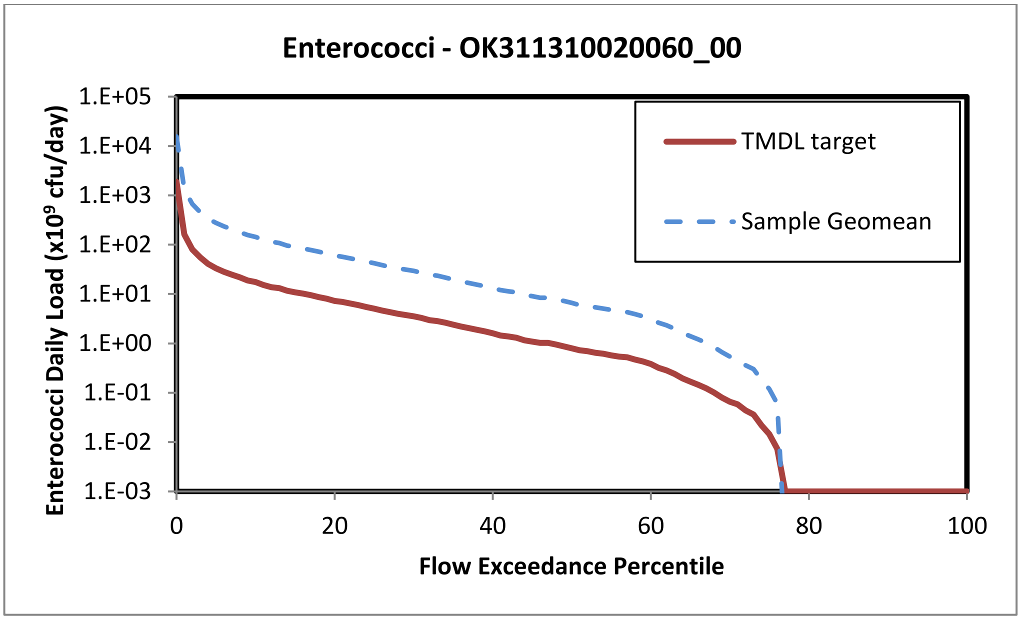


Figure 5-21 Load Duration Curve for *E. coli* in Little Deep Red Creek (OK311310030040_00)

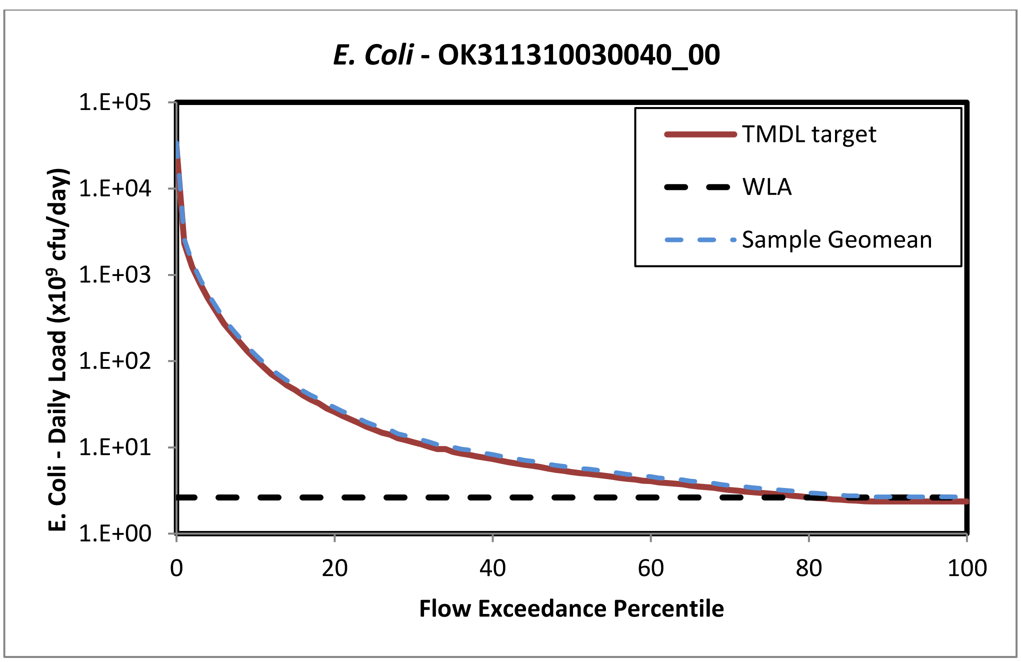
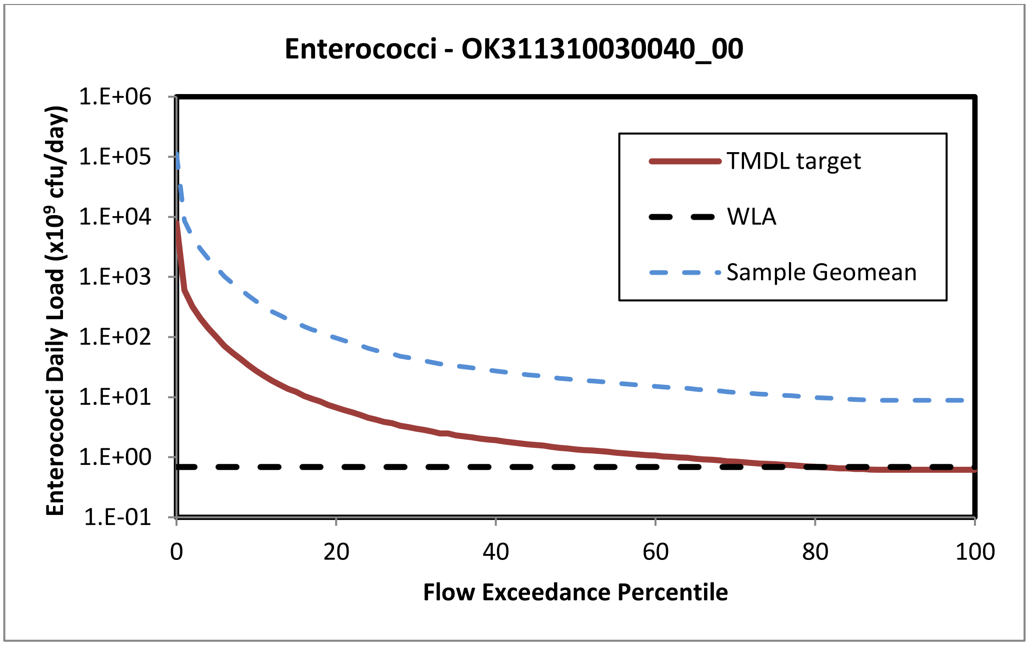


Figure 5-22 Load Duration Curve for Enterococci in Little Deep Red Creek (OK311310030040_00)



5.3.2 TSS LDCs

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 2001 to 2014 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.

Figure 5-23 through **Figure 5-25** 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 5-23 Load Duration Curve for Total Suspended Solids in the Walnut Bayou (OK311100010250_00)

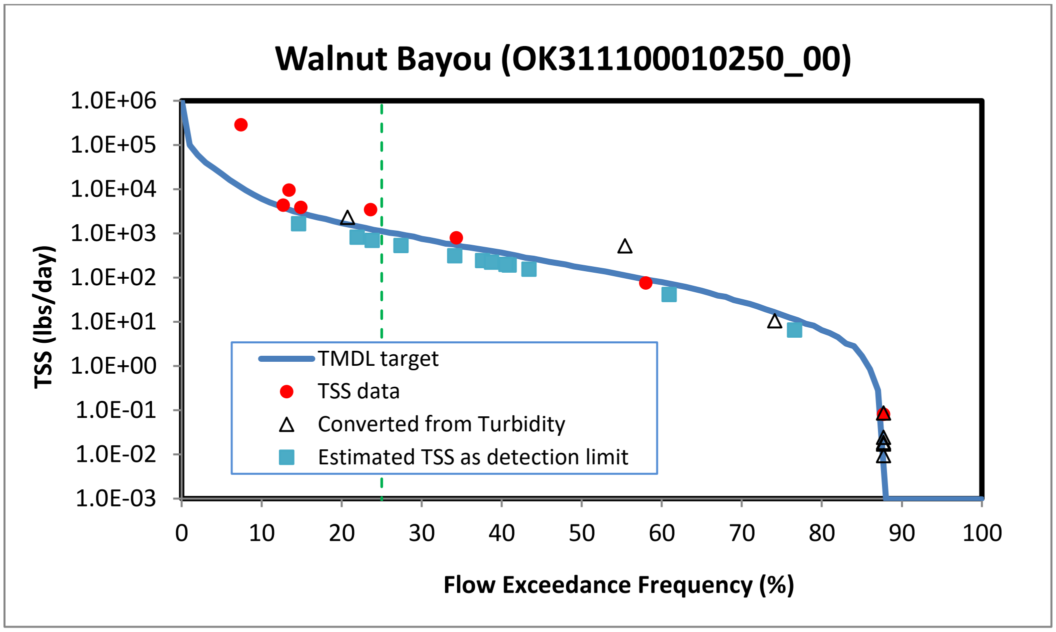


Figure 5-24 Load Duration Curve for Total Suspended Solids in Cache Creek, East (OK311300020010_10)

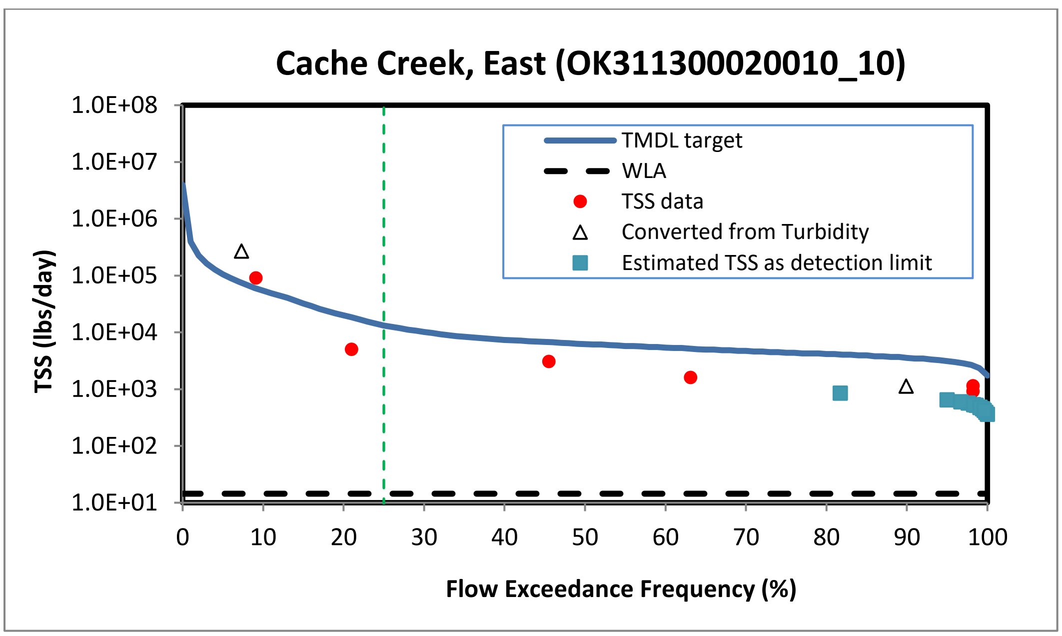
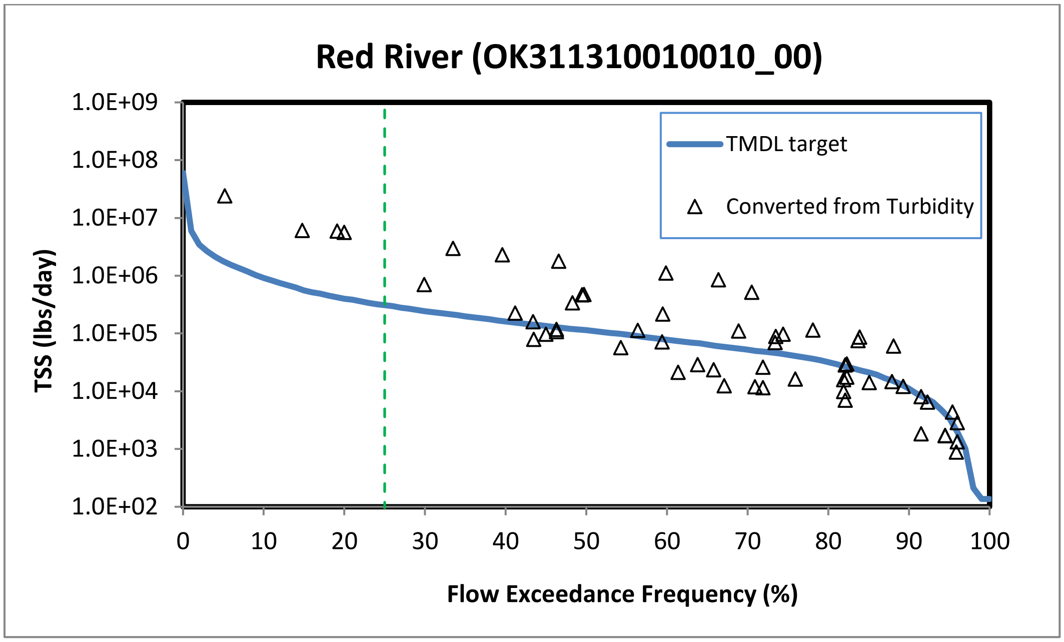


Figure 5-25 Load Duration Curve for Total Suspended Solids in the Red River (OK311310010010_00)



5.3.3 Establish 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.

5.3.3.1 Bacterial PRGs

PRGs for bacteria 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 5-3** 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 11.5% to 97.0%.

Table 5-3 TMDL Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate	
		E. coli	Enterococci
OK311100010250_00	Walnut Bayou	-	73.5%
OK311100010300_00	Fleetwood Creek	79.8%	97.0%
OK311100020010_10	Hickory Creek	-	62.8%
OK311300020010_10	Cache Creek, East	-	70.9%
OK311300040060_00	Medicine Creek	-	79.4%
OK311310020010_10	Cache Creek, West	-	79.0%
OK311310020060_00	Blue Beaver Creek	-	87.9%
OK311310030040_00	Little Deep Red Creek	11.5%	93.0%

5.3.3.2 TSS PRGs

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 three waterbodies included in this TMDL report are summarized in **Table 5-4** and range from 34.3% to 92.8%.

Table 5-4 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK311100010250_00	Walnut Bayou	63.5%
OK311300020010_10	Cache Creek, East	34.3%
OK311310010010_00	Red River	92.8%

5.4 WASTELOAD ALLOCATION

5.4.1 Bacterial WLA

For bacterial TMDLs, OPDES-permitted facilities are allocated a daily wasteload calculated as their permitted flow rate multiplied by the in-stream geometric mean water quality criterion. In other words, the facilities are required to meet in-stream criteria in their discharge. **Table 5-5** summarizes the WLA for the OPDES-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 OPDES 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 OPDES 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 OPDES 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 5-5 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 OPDES permit requires in-stream criteria to be met.

Permitted stormwater discharges are considered point sources. The Fort Sill Army Base is the designated Phase II MS4s within the watersheds of the Study Area impaired for contact recreation. Therefore, they will receive WLAs for MS4s.

Table 5-5 Bacterial Wasteload Allocations for OPDES-Permitted Facilities

Waterbody ID	Stream Name	Name	NPDES Permit No.	Current Disinfection Requirement	Design Flow (MGD)	Wasteload Allocation ($x10^9$ cfu/day)	
						EC	ENT
OK311100020010_10	Hickory Creek	**Lone Grove WWTF**	OK0034266	Yes	0.764	-	0.955
OK311300020010_10	Cache Creek, East	**Fort Sill WWT**	OK0030295	Yes	4.3	-	5.37
OK311310030040_00	Little Deep Red Creek	**Frederick POTW**	OK0027171	Yes	0.55	2.62	0.687

5.4.2 Total Suspended Solids WLA

OPDES-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 in-stream criteria in their discharge. If the current monthly TSS limits of a facility are greater than in-stream TSS criteria, the new limits equal to in-stream criteria will be applied to the facility as their permit is renewed. **Table 5-6** summarizes the WLA for the OPDES-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 5-2, or monthly TSS limit in the current permit, whichever is smaller

Flow (mgd) = average monthly flow

Unit conversion factor = 8.3445

Table 5-6 Total Suspended Solids Wasteload Allocations for OPDES-Permitted Facilities

Waterbody ID & Waterbody Name	OPDES Permit No.	Name	Average Monthly Flow (mgd)	Effluent TSS Target (mg/L)	Daily Maximum TSS limit (mg/L)	Wasteload Allocation (lb/day)
Cache Creek, East OK311300020010_10	OKG950031	Dolese Bros Richard's Spur Quarry	0.0384	60.0	**45.0** [a]	14.4

[a] Maximum Daily TSS limit was used due to no Monthly Average TSS limit.

By definition, any stormwater discharge occurs during periods of rainfall and elevated flow conditions. Elevated turbidity levels may be expected during, and for several days after, a runoff event. However, Oklahoma's Water Quality Standards specify that the criteria for turbidity "apply only to seasonal base flow conditions" [OAC 785:45-5-12(f)(7)]. Therefore, Oklahoma Water

Quality Standard for turbidity does not apply to stormwater runoff from the watershed, including MS4. The development for future growth will affect turbidity levels in the watershed, but stormwater runoff from development sites are not covered by the WQSs. 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 Permit Implication

5.4.3.1 Bacterial Permit Limitations

All point source dischargers, except MS4s, were assigned a wasteload allocation in **Table 5-5** and will receive a permit limit equal to the water quality standard as their permits are reissued. They are also required to meet water quality standards at the end of pipe. MS4s are considered as point sources and are assigned a wasteload allocation. However, due the nature of stormwater discharges and the typical lack of information on which to base numeric water quality-based effluent limitations, the TMDL requirements are implemented through establishing a comprehensive stormwater management program (SWMP) or storm water pollution prevention plan (SWPPP).

Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacterial load from existing discharges are considered consistent with the TMDL provided that the OPDES permits require in-stream criteria to be met.

5.4.3.2 TSS Permit Limitations

Stormwater discharges from MS4s, industrial facilities, and construction sites 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 in this TMDL report.

The general permit for rock, sand and gravel quarries (OKG950000) 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.

The TSS limits for water treatment plant with backwash discharge, mines with dewatering operations or any other facilities with TSS limits but without BOD or CBOD limitations can be determined as follows:

- If the corresponding TSS target in **Table 5-2** was equal to or greater than the daily maximum limit in the current permit, the permit TSS limits stay the same and the TMDL has no impact on the permit limits when a permit is renewed.
- If the corresponding TSS target in **Table 5-2** was less than the daily maximum limit in the current permit, the corresponding TSS target in **Table 5-2** will become the daily maximum limit when the permit is renewed.
- The TMDLs do not place specific requirements for monthly average limit. The permitting authority will determine the proper monthly average limit. However, under no circumstances, will the monthly average limit in the renewed permit be greater than the monthly average limit in the current permit (anti-backsliding rule).

5.4.4 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 loading to each waterbody emanates 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:

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

The following 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:

$$\mathbf{LA = TMDL - WLA\_{_{WWTF}} - WLA\_{_{MS4}} - WLA\_{_{growth}} - MOS}$$

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. 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 all avaiable consecutive 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 25%. **Table 5-2** 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:

$$\boldsymbol{TMDL = \Sigma\, WLA + LA + MOS}$$

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 OPDES permit requires in-stream 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 5-7** and **5-8** summarize the TMDL, WLA, LA and MOS loadings at the 50% flow percentile. **Tables 5-9** through **5-18** 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 5-19** to **5-21** present the allocations for total suspended solids.

Table 5-7 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)
Walnut Bayou	OK311100010250_00	ENT	1.41E+09	0	0	1.27E+09	1.41E+08
Fleetwood Creek	OK311100010300_00	*EC*	5.28E+08	0	0	4.76E+08	5.28E+07
		ENT	1.38E+08	0	0	1.25E+08	1.38E+07
Hickory Creek	OK311100020010_10	ENT	2.86E+09	9.55E+08	0	1.62E+09	2.86E+08
Cache Creek, East	OK311300020010_10	ENT	1.94E+10	5.37E+09	4.43E+07	1.20E+10	1.94E+09
Medicine Creek	OK311300040060_00	ENT	1.08E+10	0	0	9.70E+09	1.08E+09
Cache Creek, West	OK311310020010_10	ENT	2.68E+09	0	0	2.41E+09	2.68E+08
Blue Beaver Creek	OK311310020060_00	ENT	8.88E+08	0	0	7.99E+08	8.88E+07
Little Deep Red Creek	OK311310030040_00	*EC*	5.73E+09	2.62E+09	0	2.53E+09	5.73E+08
		ENT	1.50E+09	6.87E+08	0	6.63E+08	1.50E+08

Table 5-8 Summaries of TSS TMDLs

Stream Name	Waterbody ID	Pollutant	TMDL (lbs/day)	WLA (lbs/day)	$WLA_{\_MS4}$ (lbs/day)	$WLA_{\_Growth}$ (lbs/day)	LA (lbs/day)	MOS (lbs/day)
Walnut Bayou	OK311100010250_00	TSS	225	0	0	2.2	166	56
Cache Creek, East	OK311300020010_10	TSS	7,759	14.4	0	78	6,116	1,552
Red River	OK311310010010_00	TSS	126,125	0	0	1,261	112,252	12,613

Table 5-9 Enterococci TMDL Calculations for Walnut Bayou (OK311100010250_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	10,998	8.88E+12	0	0	7.99E+12	8.88E+11
5	231	1.87E+11	0	0	1.68E+11	1.87E+10
10	63	5.07E+10	0	0	4.57E+10	5.07E+09
15	29	2.37E+10	0	0	2.14E+10	2.37E+09
20	18	1.43E+10	0	0	1.29E+10	1.43E+09
25	12	9.40E+09	0	0	8.46E+09	9.40E+08
30	7.9	6.34E+09	0	0	5.71E+09	6.34E+08
35	5.2	4.23E+09	0	0	3.81E+09	4.23E+08
40	3.8	3.05E+09	0	0	2.75E+09	3.05E+08
45	2.5	2.04E+09	0	0	1.84E+09	2.04E+08
50	1.7	1.41E+09	0	0	1.27E+09	1.41E+08
55	1.2	9.63E+08	0	0	8.67E+08	9.63E+07
60	0.8	6.58E+08	0	0	5.92E+08	6.58E+07
65	0.5	4.23E+08	0	0	3.81E+08	4.23E+07
70	0.3	2.35E+08	0	0	2.11E+08	2.35E+07
75	0.1	1.20E+08	0	0	1.08E+08	1.20E+07
80	0.07	5.40E+07	0	0	4.86E+07	5.40E+06
85	0.02	1.41E+07	0	0	1.27E+07	1.41E+06
90	0	0	0	0	0	0
95	0	0	0	0	0	0
100	0	0	0	0	0	0

Table 5-10 *E. coli* TMDL Calculations for Fleetwood Creek (OK311100010300_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1,080	3.33E+12	0	0	3.00E+12	3.33E+11
5	23	6.99E+10	0	0	6.29E+10	6.99E+09
10	6.2	1.90E+10	0	0	1.71E+10	1.90E+09
15	2.9	8.90E+09	0	0	8.01E+09	8.90E+08
20	1.7	5.37E+09	0	0	4.84E+09	5.37E+08
25	1.1	3.52E+09	0	0	3.17E+09	3.52E+08
30	0.77	2.38E+09	0	0	2.14E+09	2.38E+08
35	0.51	1.59E+09	0	0	1.43E+09	1.59E+08
40	0.37	1.14E+09	0	0	1.03E+09	1.14E+08
45	0.25	7.66E+08	0	0	6.90E+08	7.66E+07
50	0.17	5.28E+08	0	0	4.76E+08	5.28E+07
55	0.12	3.61E+08	0	0	3.25E+08	3.61E+07
60	0.08	2.47E+08	0	0	2.22E+08	2.47E+07
65	0.05	1.59E+08	0	0	1.43E+08	1.59E+07
70	0.03	8.81E+07	0	0	7.93E+07	8.81E+06
75	0.015	4.49E+07	0	0	4.04E+07	4.49E+06
80	0.007	2.03E+07	0	0	1.82E+07	2.03E+06
85	0.002	5.28E+06	0	0	4.76E+06	5.28E+05
90	0	0	0	0	0	0
95	0	0	0	0	0	0
100	0	0	0	0	0	0

Table 5-11 Enterococci TMDL Calculations for Fleetwood Creek (OK311100010300_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1,080	8.72E+11	0	0	7.85E+11	8.72E+10
5	23	1.83E+10	0	0	1.65E+10	1.83E+09
10	6.2	4.98E+09	0	0	4.48E+09	4.98E+08
15	2.9	2.33E+09	0	0	2.10E+09	2.33E+08
20	1.7	1.41E+09	0	0	1.27E+09	1.41E+08
25	1.1	9.23E+08	0	0	8.30E+08	9.23E+07
30	0.77	6.23E+08	0	0	5.61E+08	6.23E+07
35	0.51	4.15E+08	0	0	3.74E+08	4.15E+07
40	0.37	3.00E+08	0	0	2.70E+08	3.00E+07
45	0.25	2.01E+08	0	0	1.81E+08	2.01E+07
50	0.17	1.38E+08	0	0	1.25E+08	1.38E+07
55	0.12	9.46E+07	0	0	8.51E+07	9.46E+06
60	0.08	6.46E+07	0	0	5.81E+07	6.46E+06
65	0.05	4.15E+07	0	0	3.74E+07	4.15E+06
70	0.03	2.31E+07	0	0	2.08E+07	2.31E+06
75	0.015	1.18E+07	0	0	1.06E+07	1.18E+06
80	0.007	5.31E+06	0	0	4.78E+06	5.31E+05
85	0.002	1.38E+06	0	0	1.25E+06	1.38E+05
90	0	0	0	0	0	0
95	0	0	0	0	0	0
100	0	0	0	0	0	0

Table 5-12 Enterococci TMDL Calculations for Hickory Creek (OK311100020010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day) Lone Grove WWT	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	13,389	1.08E+13	9.55E+08	0	9.73E+12	1.08E+12
5	283	2.28E+11	9.55E+08	0	2.04E+11	2.28E+10
10	78	6.29E+10	9.55E+08	0	5.57E+10	6.29E+09
15	37	3.00E+10	9.55E+08	0	2.61E+10	3.00E+09
20	23	1.86E+10	9.55E+08	0	1.58E+10	1.86E+09
25	16	1.26E+10	9.55E+08	0	1.04E+10	1.26E+09
30	11	8.87E+09	9.55E+08	0	7.03E+09	8.87E+08
35	7.8	6.29E+09	9.55E+08	0	4.71E+09	6.29E+08
40	6.0	4.86E+09	9.55E+08	0	3.42E+09	4.86E+08
45	4.5	3.63E+09	9.55E+08	0	2.32E+09	3.63E+08
50	3.5	2.86E+09	9.55E+08	0	1.62E+09	2.86E+08
55	2.9	2.32E+09	9.55E+08	0	1.13E+09	2.32E+08
60	2.4	1.95E+09	9.55E+08	0	7.97E+08	1.95E+08
65	2.1	1.66E+09	9.55E+08	0	5.40E+08	1.66E+08
70	1.8	1.43E+09	9.55E+08	0	3.34E+08	1.43E+08
75	1.6	1.29E+09	9.55E+08	0	2.08E+08	1.29E+08
80	1.5	1.21E+09	9.55E+08	0	1.36E+08	1.21E+08
85	1.4	1.16E+09	9.55E+08	0	9.21E+07	1.16E+08
90	1.4	1.15E+09	9.55E+08	0	7.67E+07	1.15E+08
95	1.4	1.15E+09	9.55E+08	0	7.67E+07	1.15E+08
100	1.4	1.15E+09	9.55E+08	0	7.67E+07	1.15E+08

Table 5-13 Enterococci TMDL Calculations for Cache Creek, East (OK311300020010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
			Fort Sill WWT	Fort Sill		
0	15,347	1.24E+13	5.37E+09	4.09E+10	1.11E+13	1.24E+12
5	407	3.28E+11	5.37E+09	1.06E+09	2.89E+11	3.28E+10
10	209	1.69E+11	5.37E+09	5.38E+08	1.46E+11	1.69E+10
15	125	1.01E+11	5.37E+09	3.13E+08	8.49E+10	1.01E+10
20	77	6.23E+10	5.37E+09	1.86E+08	5.05E+10	6.23E+09
25	51	4.12E+10	5.37E+09	1.16E+08	3.16E+10	4.12E+09
30	40	3.19E+10	5.37E+09	8.56E+07	2.33E+10	3.19E+09
35	32	2.62E+10	5.37E+09	6.67E+07	1.81E+10	2.62E+09
40	28	2.30E+10	5.37E+09	5.61E+07	1.52E+10	2.30E+09
45	26	2.12E+10	5.37E+09	5.02E+07	1.36E+10	2.12E+09
50	24	1.94E+10	5.37E+09	4.43E+07	1.20E+10	1.94E+09
55	22	1.79E+10	5.37E+09	3.95E+07	1.07E+10	1.79E+09
60	21	1.69E+10	5.37E+09	3.60E+07	9.78E+09	1.69E+09
65	19	1.54E+10	5.37E+09	3.13E+07	8.49E+09	1.54E+09
70	18	1.47E+10	5.37E+09	2.89E+07	7.85E+09	1.47E+09
75	17	1.37E+10	5.37E+09	2.54E+07	6.89E+09	1.37E+09
80	16	1.29E+10	5.37E+09	2.30E+07	6.25E+09	1.29E+09
85	15	1.22E+10	5.37E+09	2.06E+07	5.60E+09	1.22E+09
90	14	1.11E+10	5.37E+09	1.71E+07	4.64E+09	1.11E+09
95	12	9.72E+09	5.37E+09	1.24E+07	3.36E+09	9.72E+08
100	6.7	5.42E+09	5.37E+09	0	0	4.53E+07

Table 5-14 Enterococci TMDL Calculations for Medicine Creek (OK311300040060_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	5,196	4.20E+12	0	0	3.78E+12	4.20E+11
5	324	2.61E+11	0	0	2.35E+11	2.61E+10
10	202	1.63E+11	0	0	1.47E+11	1.63E+10
15	135	1.09E+11	0	0	9.84E+10	1.09E+10
20	87	7.02E+10	0	0	6.32E+10	7.02E+09
25	67	5.39E+10	0	0	4.85E+10	5.39E+09
30	49	3.92E+10	0	0	3.53E+10	3.92E+09
35	36	2.94E+10	0	0	2.64E+10	2.94E+09
40	26	2.12E+10	0	0	1.91E+10	2.12E+09
45	19	1.57E+10	0	0	1.41E+10	1.57E+09
50	13	1.08E+10	0	0	9.70E+09	1.08E+09
55	10	7.84E+09	0	0	7.05E+09	7.84E+08
60	7.5	6.04E+09	0	0	5.44E+09	6.04E+08
65	6.1	4.90E+09	0	0	4.41E+09	4.90E+08
70	4.9	3.92E+09	0	0	3.53E+09	3.92E+08
75	4.0	3.26E+09	0	0	2.94E+09	3.26E+08
80	3.0	2.45E+09	0	0	2.20E+09	2.45E+08
85	1.6	1.31E+09	0	0	1.18E+09	1.31E+08
90	0.2	1.63E+08	0	0	1.47E+08	1.63E+07
95	0	0	0	0	0	0
100	0	0	0	0	0	0

Table 5-15 Enterococci TMDL Calculations for Cache Creek, West (OK311310020010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	35,713	2.88E+13	0	0	2.60E+13	2.88E+12
5	448	3.62E+11	0	0	3.26E+11	3.62E+10
10	121	9.76E+10	0	0	8.79E+10	9.76E+09
15	52	4.23E+10	0	0	3.81E+10	4.23E+09
20	28	2.24E+10	0	0	2.02E+10	2.24E+09
25	16	1.31E+10	0	0	1.18E+10	1.31E+09
30	11	8.72E+09	0	0	7.85E+09	8.72E+08
35	7.7	6.23E+09	0	0	5.60E+09	6.23E+08
40	5.9	4.73E+09	0	0	4.26E+09	4.73E+08
45	4.5	3.61E+09	0	0	3.25E+09	3.61E+08
50	3.3	2.68E+09	0	0	2.41E+09	2.68E+08
55	2.6	2.12E+09	0	0	1.91E+09	2.12E+08
60	2.0	1.62E+09	0	0	1.46E+09	1.62E+08
65	1.5	1.18E+09	0	0	1.06E+09	1.18E+08
70	1.0	8.10E+08	0	0	7.29E+08	8.10E+07
75	0.65	5.23E+08	0	0	4.71E+08	5.23E+07
80	0.32	2.62E+08	0	0	2.35E+08	2.62E+07
85	0.08	6.23E+07	0	0	5.60E+07	6.23E+06
90	0	0	0	0	0	0
95	0	0	0	0	0	0
100	0	0	0	0	0	0

Table 5-16 Enterococci TMDL Calculations for Blue Beaver Creek (OK311310020060_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2,600	2.10E+12	0	0	1.89E+12	2.10E+11
5	46	3.71E+10	0	0	3.34E+10	3.71E+09
10	24	1.94E+10	0	0	1.74E+10	1.94E+09
15	15	1.21E+10	0	0	1.09E+10	1.21E+09
20	10	8.07E+09	0	0	7.27E+09	8.07E+08
25	7	5.65E+09	0	0	5.09E+09	5.65E+08
30	4.9	3.96E+09	0	0	3.56E+09	3.96E+08
35	3.3	2.66E+09	0	0	2.40E+09	2.66E+08
40	2.2	1.78E+09	0	0	1.60E+09	1.78E+08
45	1.5	1.21E+09	0	0	1.09E+09	1.21E+08
50	1.1	8.88E+08	0	0	7.99E+08	8.88E+07
55	0.8	6.38E+08	0	0	5.74E+08	6.38E+07
60	0.5	4.28E+08	0	0	3.85E+08	4.28E+07
65	0.23	1.88E+08	0	0	1.69E+08	1.88E+07
70	0.09	7.27E+07	0	0	6.54E+07	7.27E+06
75	0.02	1.61E+07	0	0	1.45E+07	1.61E+06
80	0	0	0	0	0	0
85	0	0	0	0	0	0
90	0	0	0	0	0	0
95	0	0	0	0	0	0
100	0	0	0	0	0	0

Table 5-17 *E. coli* TMDL Calculations for Little Deep Red Creek (OK311310030040_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
			Frederick POTW			
0	10,855	3.35E+13	2.62E+09	0	3.01E+13	3.35E+12
5	137	4.23E+11	2.62E+09	0	3.78E+11	4.23E+10
10	38	1.16E+11	2.62E+09	0	1.02E+11	1.16E+10
15	17	5.18E+10	2.62E+09	0	4.40E+10	5.18E+09
20	9.3	2.86E+10	2.62E+09	0	2.32E+10	2.86E+09
25	5.8	1.78E+10	2.62E+09	0	1.34E+10	1.78E+09
30	4.1	1.27E+10	2.62E+09	0	8.84E+09	1.27E+09
35	3.2	9.85E+09	2.62E+09	0	6.24E+09	9.85E+08
40	2.6	8.12E+09	2.62E+09	0	4.68E+09	8.12E+08
45	2.2	6.81E+09	2.62E+09	0	3.51E+09	6.81E+08
50	1.9	5.73E+09	2.62E+09	0	2.53E+09	5.73E+08
55	1.6	5.08E+09	2.62E+09	0	1.95E+09	5.08E+08
60	1.5	4.50E+09	2.62E+09	0	1.43E+09	4.50E+08
65	1.3	4.00E+09	2.62E+09	0	9.72E+08	4.00E+08
70	1.2	3.56E+09	2.62E+09	0	5.82E+08	3.56E+08
75	1.0	3.23E+09	2.62E+09	0	2.83E+08	3.23E+08
80	0.95	2.93E+09	2.62E+09	0	9.56E+06	2.93E+08
85	0.87	2.70E+09	2.62E+09	0	0.00E+00	7.10E+07
90	0.85	2.62E+09	2.62E+09	0	0.00E+00	0.00E+00
95	0.85	2.62E+09	2.62E+09	0	0.00E+00	0.00E+00
100	0.85	2.62E+09	2.62E+09	0	0.00E+00	0.00E+00

Table 5-18 Enterococci TMDL Calculations for Little Deep Red Creek (OK311310030040_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day) Frederick POTW	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	10,855	8.76E+12	6.87E+08	0	7.89E+12	8.76E+11
5	137	1.11E+11	6.87E+08	0	9.89E+10	1.11E+10
10	38	3.04E+10	6.87E+08	0	2.66E+10	3.04E+09
15	17	1.36E+10	6.87E+08	0	1.15E+10	1.36E+09
20	9.3	7.50E+09	6.87E+08	0	6.06E+09	7.50E+08
25	5.8	4.66E+09	6.87E+08	0	3.51E+09	4.66E+08
30	4.1	3.34E+09	6.87E+08	0	2.32E+09	3.34E+08
35	3.2	2.58E+09	6.87E+08	0	1.63E+09	2.58E+08
40	2.6	2.13E+09	6.87E+08	0	1.23E+09	2.13E+08
45	2.2	1.78E+09	6.87E+08	0	9.19E+08	1.78E+08
50	1.9	1.50E+09	6.87E+08	0	6.63E+08	1.50E+08
55	1.6	1.33E+09	6.87E+08	0	5.10E+08	1.33E+08
60	1.5	1.18E+09	6.87E+08	0	3.74E+08	1.18E+08
65	1.3	1.05E+09	6.87E+08	0	2.55E+08	1.05E+08
70	1.2	9.33E+08	6.87E+08	0	1.52E+08	9.33E+07
75	1.0	8.46E+08	6.87E+08	0	7.41E+07	8.46E+07
80	0.95	7.67E+08	6.87E+08	0	2.50E+06	7.67E+07
85	0.87	7.06E+08	6.87E+08	0	0.00E+00	1.86E+07
90	0.85	6.87E+08	6.87E+08	0	0.00E+00	0.00E+00
95	0.85	6.87E+08	6.87E+08	0	0.00E+00	0.00E+00
100	0.85	6.87E+08	6.87E+08	0	0.00E+00	0.00E+00

Table 5-19 Total Suspended Solids TMDL Calculations for Walnut Bayou (OK311100010250_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
0	10,998	N/A	N/A	N/A	N/A	N/A	N/A
5	231	N/A	N/A	N/A	N/A	N/A	N/A
10	63	N/A	N/A	N/A	N/A	N/A	N/A
15	29	N/A	N/A	N/A	N/A	N/A	N/A
20	18	N/A	N/A	N/A	N/A	N/A	N/A
25	12	1,499	0	0	15	1,109	375
30	7.9	1,011	0	0	10	749	253
35	5.2	674	0	0	6.7	499	169
40	3.8	487	0	0	4.9	360	122
45	2.5	326	0	0	3.3	241	81
50	1.7	225	0	0	2.2	166	56
55	1.2	154	0	0	1.5	114	38
60	0.8	105	0	0	1.0	78	26
65	0.5	67	0	0	0.7	50	17
70	0.3	37	0	0	0.4	28	9.4
75	0.1	19	0	0	0.2	14	4.8
80	0.07	8.6	0	0	0.1	6.4	2.2
85	0.02	2.3	0	0	0.0	1.7	0.6
90	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0

NA = Not Applicable

Table 5-20 Total Suspended Solids TMDL Calculations for Cache Creek, East (OK311300020010_10)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
			Dolese Bros Richard's Spur Quarry				
0	15,347	N/A	N/A	N/A	N/A	N/A	N/A
5	407	N/A	N/A	N/A	N/A	N/A	N/A
10	209	N/A	N/A	N/A	N/A	N/A	N/A
15	125	N/A	N/A	N/A	N/A	N/A	N/A
20	77	N/A	N/A	N/A	N/A	N/A	N/A
25	51	16,502	14.4	0	165	13,022	3,300
30	40	12,776	14.4	0	128	10,078	2,555
35	32	10,483	14.4	0	105	8,267	2,097
40	28	9,193	14.4	0	92	7,248	1,839
45	26	8,476	14.4	0	85	6,682	1,695
50	24	7,759	14.4	0	78	6,116	1,552
55	22	7,186	14.4	0	72	5,663	1,437
60	21	6,756	14.4	0	68	5,323	1,351
65	19	6,183	14.4	0	62	4,870	1,237
70	18	5,896	14.4	0	59	4,644	1,179
75	17	5,466	14.4	0	55	4,304	1,093
80	16	5,180	14.4	0	52	4,078	1,036
85	15	4,893	14.4	0	49	3,851	979
90	14	4,463	14.4	0	45	3,511	893
95	12	3,890	14.4	0	39	3,058	778
100	6.7	2,170	14.4	0	22	1,700	434

N/A = Not Applicable

Table 5-21 Total Suspended Solids TMDL Calculations for the Red River (OK311310010010_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
0	144,000	N/A	N/A	N/A	N/A	N/A	N/A
5	4,209	N/A	N/A	N/A	N/A	N/A	N/A
10	2,180	N/A	N/A	N/A	N/A	N/A	N/A
15	1,330	N/A	N/A	N/A	N/A	N/A	N/A
20	951	N/A	N/A	N/A	N/A	N/A	N/A
25	734	342,380	0	0	3,424	304,719	34,238
30	580	270,482	0	0	2,705	240,729	27,048
35	473	220,512	0	0	2,205	196,256	22,051
40	383	178,848	0	0	1,788	159,175	17,885
45	319	148,987	0	0	1,490	132,599	14,899
50	270	126,125	0	0	1,261	112,252	12,613
55	227	106,016	0	0	1,060	94,354	10,602
60	186	86,934	0	0	869	77,371	8,693
65	153	71,537	0	0	715	63,668	7,154
70	124	58,006	0	0	580	51,626	5,801
75	101	47,275	0	0	473	42,075	4,728
80	76	35,611	0	0	356	31,694	3,561
85	50	23,480	0	0	235	20,897	2,348
90	26	12,282	0	0	123	10,931	1,228
95	8.1	3,791	0	0	38	3,374	379
100	0.3	152	0	0	1.5	135	15

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: www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf. **Table 5-22** 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 5-22 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

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 other agencies that collect water monitoring information and/or address water quality problems associated with nonpoint source pollution. These agencies at the State level are DEQ, OWRB, Corporation Commission (for oil & gas activities), and ODAFF [they are the NPDES-permitting authority for CAFOs and SFOs in Oklahoma under what ODAFF calls the Agriculture Pollutant Discharge Elimination System (AgPDES)]. The agencies at the Federal level are EPA, USGS, U.S. Army Corps of Engineers (USACE) & the National Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA). 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.

The reduction rates called for in this TMDL report are as high as 97.0% for bacteria and 92.8% for TSS. DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of 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 some basic approaches that may apply to such revisions.

- **Remove 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 swim in bacterially-impaired waterbodies, thus constituting an existing use. Existing uses cannot be removed.
- **Modify 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.
- **Revise 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 discharge limitations less than or equal to the water quality standards numerical criteria. Therefore, reasonable assurance is derived from Oklahoma Pollutant Discharge Elimination System (OPDES). The wasteload allocations for MS4s will be implemented through the OPDES MS4 permits. MS4 permits contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or stormwater pollution prevention plan (SWP3) to implement best management practices (BMPs), public education and outreach, and illicit discharge elimination.

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

SECTION 6 PUBLIC PARTICIPATION

This TMDL report has been preliminary reviewed by EPA. After EPA reviewed this draft TMDL report, DEQ was given approval to submit this report for public notice. A public notice will be sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who have requested all copies of TMDL public notices. The public notice will also be posted at the DEQ website: http://www.deq.state.ok.us/wqdnew/index.htm.

The public comment period lasts 45 days. During that time, the public has the opportunity to review the TMDL report and make written comments. Depending on the interest and responses from the public, a public meeting may be held within the watershed affected by the TMDLs in this report. If a public meeting is held, the public will also have opportunities to ask questions and make formal oral comments at the meeting and/or to submit written comments at the public meeting.

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

After EPA's final approval, each TMDL will be adopted into the Water Quality Management Plan (WQMP). These TMDLs provide a mathematical solution to meet ambient water quality criterion with a given set of facts. 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 are reviewed to ensure that the in-stream criterion is predicted to be met.

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APPENDIX A: AMBIENT WATER QUALITY DATA

Table Appendix A-1 Bacterial Data: 2001 to 2013

Waterbody Name	WQM Station	Date	*EC*[1]	ENT[2]
Bills Creek	311100010230-001SRF	6/20/2001	404	2000
Bills Creek	311100010230-002SRF	6/20/2001	74	1300
Walnut Bayou	OK311100-03-0010G	6/6/2006	40	35
Walnut Bayou	OK311100-03-0010G	7/11/2006	15	5
Walnut Bayou	OK311100-03-0010G	5/27/2009	350	70
Walnut Bayou	OK311100-03-0010G	8/4/2009	10	50
Walnut Bayou	OK311100-03-0010G	9/9/2009	5	40
Walnut Bayou	OK311100-03-0010G	9/14/2009	320	1,400
Walnut Bayou	OK311100-03-0010G	5/25/2010	50	150
Walnut Bayou	OK311100-03-0010G	6/29/2010	60	180
Walnut Bayou	OK311100-03-0010G	8/3/2010	20	40
Walnut Bayou	OK311100-03-0010G	8/24/2010	25	55
Walnut Bayou	OK311100-03-0010G	9/14/2010	120	240
Walnut Bayou	311100010250-001AT	5/28/2013	142.1	2,419.6
Walnut Bayou	311100010250-001AT	6/3/2013	129.1	343.6
Walnut Bayou	311100010250-001AT	7/9/2013	6.20	118.7
Fleetwood Creek	OK311100-01-0300D	5/9/2005	385	70
Fleetwood Creek	OK311100-01-0300D	6/6/2005	780	740
Fleetwood Creek	OK311100-01-0300D	7/5/2005	1000	1,000
Fleetwood Creek	OK311100-01-0300D	9/13/2005	1000	410
Fleetwood Creek	OK311100-01-0300D	6/6/2006	490	350
Fleetwood Creek	OK311100-01-0300D	5/26/2009	665	380
Fleetwood Creek	OK311100-01-0300D	8/3/2009	70	850
Fleetwood Creek	OK311100-01-0300D	9/14/2009	1,860	2,000
Fleetwood Creek	OK311100-01-0300D	5/25/2010	740	940
Fleetwood Creek	OK311100-01-0300D	6/28/2010	2,400	10,000
Fleetwood Creek	OK311100-01-0300D	8/3/2010	80	1,780
Fleetwood Creek	OK311100-01-0300D	8/24/2010	260	1,880
Fleetwood Creek	OK311100-01-0300D	9/14/2010	1,150	5,200
Hickory Creek	OK311100-02-0010M	6/6/2006	45	100
Hickory Creek	OK311100-02-0010M	7/11/2006	155	95
Hickory Creek	OK311100-02-0010M	5/27/2009	30	30
Hickory Creek	OK311100-02-0010M	8/4/2009	30	140
Hickory Creek	OK311100-02-0010M	9/9/2009	5	10
Hickory Creek	OK311100-02-0010M	9/14/2009	560	920
Hickory Creek	OK311100-02-0010M	5/25/2010	40	50
Hickory Creek	OK311100-02-0010M	6/29/2010	50	100
Hickory Creek	OK311100-02-0010M	8/3/2010	10	20

Waterbody Name	WQM Station	Date	*EC*[1]	ENT[2]
Hickory Creek	OK311100-02-0010M	8/24/2010	65	380
Hickory Creek	OK311100-02-0010M	9/14/2010	40	60
Dry Creek	OK311200-00-0080G	5/7/2001	588	8,000
Dry Creek	OK311200-00-0080G	6/11/2001	160	400
Dry Creek	OK311200-00-0080G	7/16/2001	263	106
Dry Creek	OK311200-00-0080G	8/20/2001	225	185
East Cache Creek	OK311300-02-0010M	5/26/2009	960	340
East Cache Creek	OK311300-02-0010M	6/29/2009	20	10
East Cache Creek	OK311300-02-0010M	8/3/2009	10	60
East Cache Creek	OK311300-02-0010M	9/15/2009	20	100
East Cache Creek	OK311300-02-0010M	5/5/2010	50	240
East Cache Creek	OK311300-02-0010M	5/24/2010	45	190
East Cache Creek	OK311300-02-0010M	6/28/2010	70	1,100
East Cache Creek	OK311300-02-0010M	8/2/2010	10	30
East Cache Creek	OK311300-02-0010M	9/13/2010	60	50
East Cache Creek	OK311300-02-0010M	9/20/2010	30	80
Medicine Creek	OK311300-04-0060H	5/26/2009	450	430
Medicine Creek	OK311300-04-0060H	6/29/2009	5	15
Medicine Creek	OK311300-04-0060H	8/3/2009	20	90
Medicine Creek	OK311300-04-0060H	9/15/2009	140	820
Medicine Creek	OK311300-04-0060H	5/5/2010	40	50
Medicine Creek	OK311300-04-0060H	5/24/2010	140	100
Medicine Creek	OK311300-04-0060H	6/28/2010	120	530
Medicine Creek	OK311300-04-0060H	8/2/2010	60	100
Medicine Creek	OK311300-04-0060H	9/13/2010	40	170
Medicine Creek	OK311300-04-0060H	9/20/2010	120	180
Red River	311310010010-001AT	5/10/2004	148	80
Red River	311310010010-001AT	5/25/2004	110	60
Red River	311310010010-001AT	6/8/2004	164	5,100
Red River	311310010010-001AT	6/15/2004	96	100
Red River	311310010010-001AT	6/29/2004	12,033	3,100
Red River	311310010010-001AT	7/13/2004	31	200
Red River	311310010010-001AT	8/4/2004	10	10
Red River	311310010010-001AT	8/16/2004	10	10
Red River	311310010010-001AT	9/8/2004	10	20
Red River	311310010010-001AT	9/21/2004	31	10
Red River	311310010010-001AT	5/2/2006	63	10
Red River	311310010010-001AT	5/31/2006	17,329	7,270
Red River	311310010010-001AT	6/6/2006	36	47

Waterbody Name	WQM Station	Date	*EC*[1]	ENT[2]
Red River	311310010010-001AT	6/27/2006	15	47
Red River	311310010010-001AT	7/18/2006	41	10
Red River	311310010010-001AT	5/22/2013	110.6	2,419.6
Red River	311310010010-001AT	6/3/2013	260.3	2,419.6
Red River	311310010010-001AT	6/18/2013	91.1	488.4
West Cache Creek	OK311310-02-0010M	5/26/2009	340	430
West Cache Creek	OK311310-02-0010M	6/29/2009	30	130
West Cache Creek	OK311310-02-0010M	8/3/2009	10	10
West Cache Creek	OK311310-02-0010M	9/15/2009	320	800
West Cache Creek	OK311310-02-0010M	5/5/2010	130	200
West Cache Creek	OK311310-02-0010M	5/24/2010	65	90
West Cache Creek	OK311310-02-0010M	6/28/2010	150	660
West Cache Creek	OK311310-02-0010M	8/2/2010	10	20
West Cache Creek	OK311310-02-0010M	9/13/2010	80	380
West Cache Creek	OK311310-02-0010M	9/20/2010	30	80
Blue Beaver Creek	OK311310-02-0060G	8/28/2000	10	210
Blue Beaver Creek	OK311310-02-0060G	5/7/2001	218	6,000
Blue Beaver Creek	OK311310-02-0060G	6/11/2001	10	120
Blue Beaver Creek	OK311310-02-0060G	7/16/2001	154	218
Blue Beaver Creek	OK311310-02-0060G	8/20/2001	400	165
Blue Beaver Creek	OK311310-02-0060G	9/24/2001	80	40
Little Deep Red Creek	OK311310-03-0040D	5/26/2009	80	60
Little Deep Red Creek	OK311310-03-0040D	6/29/2009	180	520
Little Deep Red Creek	OK311310-03-0040D	8/3/2009	140	1,000
Little Deep Red Creek	OK311310-03-0040D	9/15/2009	680	480
Little Deep Red Creek	OK311310-03-0040D	5/5/2010	80	310
Little Deep Red Creek	OK311310-03-0040D	5/24/2010	90	370
Little Deep Red Creek	OK311310-03-0040D	6/28/2010	180	2,400
Little Deep Red Creek	OK311310-03-0040D	8/2/2010	40	130
Little Deep Red Creek	OK311310-03-0040D	9/13/2010	240	420
Little Deep Red Creek	OK311310-03-0040D	9/20/2010	70	860

[1] EC = *E. coli*; units = counts/100 mL.

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

Table Appendix A-1 Turbidity and Total Suspended Solids Data (1999-2014)

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Bills Creek	311100010230-001SRF	6/20/2001	12.0		No rain
Bills Creek	311100010230-001SRF	3/26/2002	7.0		2
Bills Creek	311100010230-001SRF	4/23/2002	7.0		1
Bills Creek	311100010230-001SRF	10/22/2002	21.0		1
Bills Creek	311100010230-002SRF	6/20/2001	1.0		No rain
Bills Creek	311100010230-002SRF	3/26/2002	8.0		2
Bills Creek	311100010230-002SRF	4/23/2002	6.0		1
Bills Creek	311100010230-002SRF	10/22/2002	11.0		2
Bills Creek	311100010230-002SRF	11/18/2002	5.0		2
Bills Creek	311100010230-002SRF	2/12/2003	5.0		2
Walnut Bayou	OK311100-03-0010G	5/27/2009	64.2	49	Elevated
Walnut Bayou	OK311100-03-0010G	7/1/2009	8.85	<10	Slightly Elevated
Walnut Bayou	OK311100-03-0010G	8/4/2009	19.8	<10	Slightly Elevated
Walnut Bayou	OK311100-03-0010G	8/12/2009	22.3		Base Flow
Walnut Bayou	OK311100-03-0010G	9/9/2009	13.3	15	No rain
Walnut Bayou	OK311100-03-0010G	10/13/2009	208	49	0.31 inches of rain
Walnut Bayou	OK311100-03-0010G	11/17/2009	8.47	<10	Slightly Elevated
Walnut Bayou	OK311100-03-0010G	1/5/2010		24	No rain
Walnut Bayou	OK311100-03-0010G	2/9/2010	782	455	0.85 inches of rain
Walnut Bayou	OK311100-03-0010G	3/4/2010	18	<10	Slightly Elevated
Walnut Bayou	OK311100-03-0010G	4/13/2010	8.23	<10	Base Flow
Walnut Bayou	OK311100-03-0010G	5/25/2010	30	20	Slightly Elevated
Walnut Bayou	OK311100-03-0010G	6/29/2010	5.58	<10	Base Flow
Walnut Bayou	OK311100-03-0010G	8/3/2010	19.7	15	Low Flow
Walnut Bayou	OK311100-03-0010G	9/14/2010	74.3	26	Elevated
Walnut Bayou	OK311100-03-0010G	10/19/2010	8.4	<10	No rain
Walnut Bayou	OK311100-03-0010G	11/30/2010	7.85	<10	Base Flow
Walnut Bayou	OK311100-03-0010G	1/11/2011	15.7	<10	Base Flow
Walnut Bayou	OK311100-03-0010G	2/15/2011	12.9	<10	Slightly Elevated
Walnut Bayou	OK311100-03-0010G	3/22/2011	4.1	<10	Base Flow
Walnut Bayou	OK311100-03-0010G	4/26/2011	5.83	<10	Base Flow
Walnut Bayou	311100030010-001AT	1/28/2013	8.3		2
Walnut Bayou	311100030010-001AT	3/26/2013	3.0		2
Walnut Bayou	311100030010-001AT	6/4/2013	189.0		3
Walnut Bayou	311100030010-001AT	8/19/2013	32.7		1
Walnut Bayou	311100030010-001AT	10/28/2013	53.3		2

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Walnut Bayou	311100030010-001AT	1/21/2014	6.3		2
Walnut Bayou	311100030010-001AT	3/10/2014	5.7		3
Fleetwood Creek	OK311100-01-0300D	5/26/2009	14	<10	Slightly Elevated
Fleetwood Creek	OK311100-01-0300D	7/1/2009	27.2	46	0.39 inches of rain
Fleetwood Creek	OK311100-01-0300D	7/15/2009	179		No rain
Fleetwood Creek	OK311100-01-0300D	8/3/2009	33.9	<10	Base Flow
Fleetwood Creek	OK311100-01-0300D	10/13/2009	21.1	<10	0.13 inches of rain
Fleetwood Creek	OK311100-01-0300D	11/17/2009	5.53	<10	0.03 inches of rain
Fleetwood Creek	OK311100-01-0300D	1/5/2010		<10	Elevated
Fleetwood Creek	OK311100-01-0300D	2/9/2010	142	15	Elevated
Fleetwood Creek	OK311100-01-0300D	3/4/2010	56.1	<10	Base Flow
Fleetwood Creek	OK311100-01-0300D	4/13/2010	16.7	<10	Base Flow
Fleetwood Creek	OK311100-01-0300D	5/25/2010	16.8	<10	Slightly Elevated
Fleetwood Creek	OK311100-01-0300D	6/28/2010	16.8	<10	Trace
Fleetwood Creek	OK311100-01-0300D	8/3/2010	23.5	25	No rain
Fleetwood Creek	OK311100-01-0300D	9/14/2010	376	63	Elevated
Fleetwood Creek	OK311100-01-0300D	10/19/2010	6.69	<10	0.02 inches of rain
Fleetwood Creek	OK311100-01-0300D	11/30/2010	4.32	<10	Low Flow
Fleetwood Creek	OK311100-01-0300D	1/10/2011	8.25	<10	Trace
Fleetwood Creek	OK311100-01-0300D	2/14/2011	6.23	<10	Slightly Elevated
Fleetwood Creek	OK311100-01-0300D	3/22/2011	42.9	14	Trace
Fleetwood Creek	OK311100-01-0300D	4/26/2011	31.4	20	Base Flow
Hickory Creek	OK311100-02-0010M	5/27/2009	7.27	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	7/1/2009	3.9	<10	No rain
Hickory Creek	OK311100-02-0010M	8/4/2009	11.3	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	9/9/2009	16.6	13	No rain
Hickory Creek	OK311100-02-0010M	10/13/2009	25.5	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	11/17/2009	1.95	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	1/5/2010		<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	2/9/2010	193	64	0.87 inches of rain
Hickory Creek	OK311100-02-0010M	3/4/2010	5	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	4/13/2010	5.16	<10	Base Flow

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Hickory Creek	OK311100-02-0010M	5/25/2010	5.42	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	6/2/2010	4.82		Base Flow
Hickory Creek	OK311100-02-0010M	6/14/2010	2.03		Low Flow
Hickory Creek	OK311100-02-0010M	6/29/2010	6.91	<10	Base Flow
Hickory Creek	OK311100-02-0010M	8/3/2010	11.1	12	No Rain
Hickory Creek	OK311100-02-0010M	9/14/2010	12.1	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	10/19/2010	2.44	<10	No rain
Hickory Creek	OK311100-02-0010M	11/30/2010	9.26	<10	Base Flow
Hickory Creek	OK311100-02-0010M	1/11/2011	5.02	<10	Base Flow
Hickory Creek	OK311100-02-0010M	2/15/2011	7.29	<10	Slightly Elevated
Hickory Creek	OK311100-02-0010M	3/22/2011	3.17	<10	Base Flow
Hickory Creek	OK311100-02-0010M	4/26/2011	5.25	<10	Slightly Elevated
Dry Creek	OK311200-00-0080G	5/15/2000		47	No rain
Dry Creek	OK311200-00-0080G	6/19/2000		118	Trace
Dry Creek	OK311200-00-0080G	11/6/2000		132	No rain
Dry Creek	OK311200-00-0080G	12/11/2000		2	Slightly Elevated
Dry Creek	OK311200-00-0080G	1/22/2001		4	Base Flow
Dry Creek	OK311200-00-0080G	2/26/2001		36	Elevated
Dry Creek	OK311200-00-0080G	4/2/2001		<1	Base Flow
Dry Creek	OK311200-00-0080G	5/7/2001	25.8	27	Base Flow
Dry Creek	OK311200-00-0080G	6/11/2001	5.22	<5	Low Flow
Dry Creek	OK311200-00-0080G	6/25/2001	3.22		Base Flow
Dry Creek	OK311200-00-0080G	7/16/2001	3.52	<1	Low Flow
Dry Creek	OK311200-00-0080G	8/20/2001	12.5	11	No rain
Dry Creek	OK311200-00-0080G	10/29/2001	1000	85	No rain
Dry Creek	OK311200-00-0080G	12/10/2001	1.77	<10	No rain
Dry Creek	OK311200-00-0080G	1/15/2002	4.25	<10	No rain
Dry Creek	OK311200-00-0080G	2/19/2002	135	58	0.45 inches of rain
Dry Creek	OK311200-00-0080G	3/25/2002	29.8	12	No rain
East Cache Creek	OK311300-02-0010M	5/26/2009	104		0.54 inches of rain
East Cache Creek	OK311300-02-0010M	6/11/2009	19.2		Low Flow
East Cache Creek	OK311300-02-0010M	6/29/2009	19	15	0.07 inches of rain
East Cache Creek	OK311300-02-0010M	8/3/2009	30.9	22	0.02 inches of rain
East Cache Creek	OK311300-02-0010M	9/15/2009	8.25	<10	Base Flow
East Cache Creek	OK311300-02-0010M	10/12/2009	102	21	High Flow

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
East Cache Creek	OK311300-02-0010M	11/16/2009	7.98	<10	Base Flow
East Cache Creek	OK311300-02-0010M	12/21/2009	8.42	<10	Trace
East Cache Creek	OK311300-02-0010M	2/8/2010	51.9	73	0.15 inches of rain
East Cache Creek	OK311300-02-0010M	3/8/2010	18.2	13	High Flow
East Cache Creek	OK311300-02-0010M	4/12/2010	6.62	<10	Base Flow
East Cache Creek	OK311300-02-0010M	5/24/2010	17.2	17	Base Flow
East Cache Creek	OK311300-02-0010M	6/28/2010	12.3	<10	Base Flow
East Cache Creek	OK311300-02-0010M	8/2/2010	4.36	<10	Base Flow
East Cache Creek	OK311300-02-0010M	9/13/2010	8.74	<10	Base Flow
East Cache Creek	OK311300-02-0010M	10/18/2010	11.2	<10	Base Flow
East Cache Creek	OK311300-02-0010M	11/29/2010	7.44	<10	Base Flow
East Cache Creek	OK311300-02-0010M	1/10/2011	7.64	<10	Base Flow
East Cache Creek	OK311300-02-0010M	2/14/2011	9.29	<10	Base Flow
East Cache Creek	OK311300-02-0010M	3/21/2011	10.6	<10	Base Flow
East Cache Creek	OK311300-02-0010M	4/25/2011	7	<10	Base Flow
Medicine Creek	OK311300-04-0060H	5/26/2009	11.7	<10	Elevated
Medicine Creek	OK311300-04-0060H	6/1/2009	1.21		Base Flow
Medicine Creek	OK311300-04-0060H	6/29/2009	1.41	<10	0.07 inches of rain
Medicine Creek	OK311300-04-0060H	8/3/2009	3.24	<10	Base Flow
Medicine Creek	OK311300-04-0060H	9/15/2009	12.4	<10	Elevated
Medicine Creek	OK311300-04-0060H	10/12/2009	4.13	<10	Slightly Elevated
Medicine Creek	OK311300-04-0060H	11/16/2009	0.76	<10	Base Flow
Medicine Creek	OK311300-04-0060H	12/21/2009	0.48	<10	Base Flow
Medicine Creek	OK311300-04-0060H	2/8/2010	11.4	<10	0.15 inches of rain
Medicine Creek	OK311300-04-0060H	3/8/2010	2.39	<10	Slightly Elevated
Medicine Creek	OK311300-04-0060H	4/12/2010	1.05	<10	Base Flow
Medicine Creek	OK311300-04-0060H	5/24/2010	1.07	<10	Base Flow
Medicine Creek	OK311300-04-0060H	6/28/2010	3.34	<10	Base Flow
Medicine Creek	OK311300-04-0060H	8/2/2010	0.89	<10	Base Flow
Medicine Creek	OK311300-04-0060H	9/13/2010	0.088	<10	Base Flow
Medicine Creek	OK311300-04-0060H	10/18/2010	0.52	<10	Base Flow
Medicine Creek	OK311300-04-0060H	11/29/2010	1	<10	Base Flow
Medicine Creek	OK311300-04-0060H	1/10/2011	0.78	<10	Base Flow
Medicine Creek	OK311300-04-0060H	2/14/2011	0.96	<10	Base Flow
Medicine Creek	OK311300-04-0060H	3/21/2011	0.93	<10	Base Flow
Medicine Creek	OK311300-04-0060H	4/25/2011	0.64	<10	Base Flow

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Red River	311310010010-001AT	5/24/1999		202	0.32 inches of rain
Red River	311310010010-001AT	6/21/1999		1,332	3
Red River	311310010010-001AT	7/19/1999	70	86	3
Red River	311310010010-001AT	8/16/1999	499	1,320	2
Red River	311310010010-001AT	9/20/1999	1,000	930	0.05 inches of rain
Red River	311310010010-001AT	10/31/1999	1,000	2,940	2.44 inches of rain
Red River	311310010010-001AT	11/28/1999		12	No rain
Red River	311310010010-001AT	12/20/1999	73	76	No rain
Red River	311310010010-001AT	1/24/2000	10	34	No rain
Red River	311310010010-001AT	2/29/2000	80	108	No rain
Red River	311310010010-001AT	5/22/2000	47	146	No rain
Red River	311310010010-001AT	6/26/2000	308	472	3
Red River	311310010010-001AT	7/31/2000	34	88	3
Red River	311310010010-001AT	8/29/2000	38	46	2
Red River	311310010010-001AT	10/31/2000	899	545	2
Red River	311310010010-001AT	11/27/2000	61	84	2
Red River	311310010010-001AT	5/5/2008	40		2
Red River	311310010010-001AT	5/20/2008	30		2
Red River	311310010010-001AT	6/3/2008	143		2
Red River	311310010010-001AT	6/16/2008	21		2
Red River	311310010010-001AT	6/30/2008	234		2
Red River	311310010010-001AT	7/14/2008	71		2
Red River	311310010010-001AT	7/29/2008	112		2
Red River	311310010010-001AT	8/11/2008	50		2
Red River	311310010010-001AT	8/25/2008	1,000		2
Red River	311310010010-001AT	9/9/2008	47		2
Red River	311310010010-001AT	9/22/2008	152		2
Red River	311310010010-001AT	10/8/2008	1,000		2
Red River	311310010010-001AT	10/20/2008	989		3
Red River	311310010010-001AT	11/4/2008	50		2
Red River	311310010010-001AT	11/17/2008	16		2
Red River	311310010010-001AT	12/1/2008	8		2
Red River	311310010010-001AT	12/15/2008	8		2
Red River	311310010010-001AT	1/12/2009	7		2
Red River	311310010010-001AT	2/2/2009	14		2
Red River	311310010010-001AT	2/23/2009	9		2
Red River	311310010010-001AT	3/10/2009	10		2

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Red River	311310010010-001AT	3/23/2009	23		2
Red River	311310010010-001AT	4/6/2009	27.7		2
Red River	311310010010-001AT	4/20/2009	1,000	>10,000	2
Red River	311310010010-001AT	5/4/2009	718		3
Red River	311310010010-001AT	5/18/2009	1,000		0.41 inches of rain
Red River	311310010010-001AT	6/8/2009	35.7		2
Red River	311310010010-001AT	6/29/2009	171		2
Red River	311310010010-001AT	7/27/2009	27		2
Red River	311310010010-001AT	9/28/2009	38.33		3
Red River	311310010010-001AT	11/16/2009	22		2
Red River	311310010010-001AT	1/11/2010	13.3		2
Red River	311310010010-001AT	4/12/2010	23.3		2
Red River	311310010010-001AT	5/24/2010	69		2
Red River	311310010010-001AT	9/7/2010	152		2
Red River	311310010010-001AT	11/1/2010	230.7		2
Red River	311310010010-001AT	12/6/2010	15		No rain
Red River	311310010010-001AT	4/11/2011	14.7		2
Red River	311310010010-001AT	6/20/2011	41.7		2
Red River	311310010010-001AT	8/29/2011	64		1
Red River	311310010010-001AT	10/31/2011	25.7		1
Red River	311310010010-001AT	12/12/2011	101		0.18 inches of rain
Red River	311310010010-001AT	1/30/2012	7.3		2
Red River	311310010010-001AT	4/23/2012	57.7		3
Red River	311310010010-001AT	6/18/2012	1,000		5
Red River	311310010010-001AT	9/4/2012	70.7		2
Red River	311310010010-001AT	10/15/2012	227.7		1
Red River	311310010010-001AT	2/4/2013	37.7		2
Red River	311310010010-001AT	3/4/2013	95		No rain
Red River	311310010010-001AT	4/29/2013	41.3		2
Red River	311310010010-001AT	6/10/2013	680.7		3
Red River	311310010010-001AT	7/29/2013	1,000		5
Red River	311310010010-001AT	8/26/2013	172.7		2
Red River	311310010010-001AT	10/14/2013	209.3		2
Red River	311310010010-001AT	2/25/2014	15.3		2
Red River	311310010010-001AT	3/18/2014	14.7		2
Red River	311310010010-001AT	5/12/2014	42		2
Red River	311310010010-001AT	6/16/2014	1,000		3

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
West Cache Creek	OK311310-02-0010M	5/26/2009	33	21	Elevated
West Cache Creek	OK311310-02-0010M	6/17/2009	8.57		Low Flow
West Cache Creek	OK311310-02-0010M	6/29/2009	21	17	0.12 inches of rain
West Cache Creek	OK311310-02-0010M	8/3/2009	35.4	23	0.04 inches of rain
West Cache Creek	OK311310-02-0010M	9/15/2009	150	65	Elevated
West Cache Creek	OK311310-02-0010M	10/12/2009	77.4	<10	Base Flow
West Cache Creek	OK311310-02-0010M	11/16/2009	2.43	<10	Base Flow
West Cache Creek	OK311310-02-0010M	12/21/2009	0.95	<10	Base Flow
West Cache Creek	OK311310-02-0010M	2/8/2010	77.1	27	0.23 inches of rain
West Cache Creek	OK311310-02-0010M	3/8/2010	8.7	<10	Elevated
West Cache Creek	OK311310-02-0010M	4/12/2010	2.43	<10	Base Flow
West Cache Creek	OK311310-02-0010M	5/24/2010	3.74	<10	Base Flow
West Cache Creek	OK311310-02-0010M	6/28/2010	6.01	<10	Low Flow
West Cache Creek	OK311310-02-0010M	8/2/2010	4.39	<10	No rain
West Cache Creek	OK311310-02-0010M	9/13/2010	13	<10	1.13 inches of rain
West Cache Creek	OK311310-02-0010M	10/18/2010	35	22	No rain
West Cache Creek	OK311310-02-0010M	11/29/2010	5.19	<10	No rain
West Cache Creek	OK311310-02-0010M	1/10/2011	4.95	<10	0.02 inches of rain
West Cache Creek	OK311310-02-0010M	2/14/2011	5.92	<10	No rain
West Cache Creek	OK311310-02-0010M	3/21/2011	8.75	<10	No rain
West Cache Creek	OK311310-02-0010M	4/25/2011	221	58	0.24 inches of rain
Blue Beaver Creek	OK311310-02-0060G	5/7/2001	4.15	<5	Base Flow
Blue Beaver Creek	OK311310-02-0060G	6/11/2001	1.97	12	Low Flow
Blue Beaver Creek	OK311310-02-0060G	7/16/2001	1.47	2	0.03 inches of rain
Blue Beaver Creek	OK311310-02-0060G	8/20/2001	1.4	6	0.02 inches of rain
Blue Beaver Creek	OK311310-02-0060G	9/24/2001	1.19	<10	No rain
Blue Beaver Creek	OK311310-02-0060G	10/29/2001	2.67	<10	Low Flow
Blue Beaver Creek	OK311310-02-0060G	12/10/2001	0.98	<10	No rain
Blue Beaver Creek	OK311310-02-0060G	1/15/2002	0.66	28	Low Flow
Blue Beaver Creek	OK311310-02-0060G	2/19/2002	1.31	<10	0.14 inches of rain
Blue Beaver Creek	OK311310-02-0060G	3/25/2002	0.76	<10	No rain
Little Deep Red Creek	OK311310-03-0040D	5/26/2009	40.8	34	Elevated
Little Deep Red Creek	OK311310-03-0040D	6/17/2009	56.9		Slightly Elevated

Waterbody Name	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Little Deep Red Creek	OK311310-03-0040D	6/29/2009	77.6	50	1.01 inches of rain
Little Deep Red Creek	OK311310-03-0040D	8/3/2009	450	287	Elevated
Little Deep Red Creek	OK311310-03-0040D	9/15/2009	194	116	Elevated
Little Deep Red Creek	OK311310-03-0040D	10/12/2009	215	36	Base Flow
Little Deep Red Creek	OK311310-03-0040D	11/16/2009	13.7	<10	Base Flow
Little Deep Red Creek	OK311310-03-0040D	12/21/2009	9.93	<10	Base Flow
Little Deep Red Creek	OK311310-03-0040D	3/8/2010	19.7	206	High Flow
Little Deep Red Creek	OK311310-03-0040D	4/12/2010	40	35	Base Flow
Little Deep Red Creek	OK311310-03-0040D	5/24/2010	67.9	60	Base Flow
Little Deep Red Creek	OK311310-03-0040D	6/28/2010	37.6	24	Base Flow
Little Deep Red Creek	OK311310-03-0040D	8/2/2010	18.2	22	Base Flow
Little Deep Red Creek	OK311310-03-0040D	9/13/2010	51.4	27	Slightly Elevated
Little Deep Red Creek	OK311310-03-0040D	10/18/2010	13.9	27	Base Flow
Little Deep Red Creek	OK311310-03-0040D	11/29/2010	5.17	<10	Base Flow
Little Deep Red Creek	OK311310-03-0040D	1/10/2011	6.8	<10	Base Flow
Little Deep Red Creek	OK311310-03-0040D	2/14/2011	12.2	<10	Base Flow
Little Deep Red Creek	OK311310-03-0040D	3/21/2010	58.5	27	Base Flow
Little Deep Red Creek	OK311310-03-0040D	4/25/2011	51	<10	Base Flow

* Stream flow conditions (1=none, 2=light, 3=moderate, 4=heavy (Elevated), 5=stormwater (High Flow). If flow conditions are not available, rainfall data for three days including the sample day were used.

APPENDIX B: OPDES DISCHARGE MONITORING REPORT DATA

Table Appendix B-1 OPDES Discharge Monitoring Report Data

OPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OKG950031	001	03/31/2008	0.031	0.085	6	6
OKG950031	001	04/30/2008	0.0173	0.0173	2	2
OKG950031	001	05/31/2008	0.003	0.0043	8	8
OKG950031	001	06/30/2008	0.0248	0.049	5	5
OKG950031	001	07/31/2008	0.0392	0.059	2	2
OKG950031	001	08/31/2008	0.0472	0.059	BELOW DETECT	BELOW DETECT
OKG950031	001	09/30/2008	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE
OKG950031	001	10/31/2008	0.0199	0.0317	4	4
OKG950031	001	11/30/2008	0.0398	0.049	6	6
OKG950031	001	12/31/2008	0.0103	0.0245	5	5
OKG950031	001	01/31/2009	0.3172	1.5754	7	7
OKG950031	001	02/28/2009	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE
OKG950031	001	03/31/2009	0.0133	0.0245	3	3
OKG950031	001	04/30/2009	0.0252	0.049	BELOW DETECT	BELOW DETECT
OKG950031	001	05/31/2009	0.0486	0.1008	33	33
OKG950031	001	06/30/2009	0.0317	0.0317	20	20
OKG950031	001	07/31/2009	0.0346	0.072	25	25
OKG950031	001	08/31/2009	0.0295	0.049	12	12
OKG950031	001	09/30/2009	0.0789	0.1555	9	9
OKG950031	001	10/31/2009	0.0067	0.0173	27	27
OKG950031	001	11/30/2009	0.0495	0.085	9.5	9.5
OKG950031	001	12/31/2009	0.0539	0.085	27.5	27.5
OKG950031	001	01/31/2010	0.072	0.1354	12	12
OKG950031	001	02/28/2010	0.01649	0.049	BELOW DETECT	BELOW DETECT
OKG950031	001	03/31/2010	0.0281	0.059	BELOW DETECT	BELOW DETECT
OKG950031	001	04/30/2010	0.1315	0.1771	2.5	2.5
OKG950031	001	05/31/2010	0.0756	0.1166	BELOW DETECT	BELOW DETECT
OKG950031	001	06/30/2010	0.04	0.072	6	6
OKG950031	001	07/31/2010	0.0641	0.1166	3	3
OKG950031	001	08/31/2010	0.0403	0.085	8	8
OKG950031	001	09/30/2010	0.1377	0.409	36.5	36.5
OKG950031	001	10/31/2010	0.1303	0.1771	4.5	4.5
OKG950031	001	11/30/2010	0.0876	0.1555	7.5	7.5
OKG950031	001	12/31/2010	0.0702	0.1008	8	8
OKG950031	001	01/31/2011	0.1076	0.2779	BELOW DETECT	BELOW DETECT

OPDES No.	Outfall	Monitoring Date	Flow (MGD)		TSS (mg/L)	
			Monthly Ave	Daily Max	Monthly Ave	Daily Max
OKG950031	001	02/28/2011	0.0007	0.0007	19.5	19.5
OKG950031	001	03/31/2011	0.0058	0.0058	22.5	22.5
OKG950031	001	04/30/2011	0.0007	0.0007	16	16
OKG950031	001	05/31/2011	0.0058	0.0058	7	7
OKG950031	001	06/30/2011	0.0245	0.0245	3	3
OKG950031	001	07/31/2011	0.0086	0.0086	8.5	8.5
OKG950031	001	08/31/2011	0.0007	0.0007	9	9
OKG950031	001	09/30/2011	0.0007	0.0007	13	13
OKG950031	001	10/31/2011	0.0007	0.0007	11	11
OKG950031	001	11/30/2011	0.0029	0.0029	15.5	15.5
OKG950031	001	12/31/2011	0.0058	0.0058	8	8
OKG950031	001	01/31/2012	0.013	0.013	18.5	18.5
OKG950031	001	02/29/2012	0.0001	0.0001	13.2	13.2
OKG950031	001	03/31/2012	0.1008	0.1008	14	14
OKG950031	001	04/30/2012	0.1008	0.1008	32	32
OKG950031	001	05/31/2012	0.0029	0.0029	29.2	29.2
OKG950031	001	06/30/2012	0.0086	0.0086	12.4	12.4
OKG950031	001	07/31/2012	0.0086	0.0086	12	12
OKG950031	001	08/31/2012	0.1008	0.1008	10.8	10.8
OKG950031	001	09/30/2012	0.1771	0.1771	67.6	67.6
OKG950031	001	10/31/2012	0.0001	0.0001	29.6	29.6
OKG950031	001	11/30/2012	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE
OKG950031	001	12/31/2012	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE
OKG950031	001	01/31/2013	0.0086	0.0086	58.4	58.4
OKG950031	001	02/28/2013	0.0317	0.0317	14.8	14.8
OKG950031	001	03/31/2013	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE	NO DISCHARGE
OKG950031	001	04/30/2013	0.0029	0.0029	4	4
OKG950031	001	05/31/2013	0.0029	0.0029	BELOW DETECT	BELOW DETECT
OKG950031	001	06/30/2013	0.0086	0.0086	16.4	16.4
OKG950031	001	07/31/2013	0.0058	0.0058	2.8	2.8
OKG950031	001	08/31/2013	0.0001	0.0001	4	4
OKG950031	001	09/30/2013	0.0001	0.0001	3.6	3.6
OKG950031	001	10/31/2013	0.0029	0.0029	4.4	4.4
OKG950031	001	11/30/2013	0.0029	0.0029	5.2	5.2
OKG950031	001	12/31/2013	0.0029	0.0029	5	5
OKG950031	001	01/31/2014	0.0001	0.0001	4.5	4.5
OKG950031	001	02/28/2014	0.0086	0.0086	5	5

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

Appendix C

General Method for Estimating Flow for Ungaged Streams

Flows duration curve were developed using existing USGS measured flow where the data existed 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 were derived for each Oklahoma stream segment in the following priority:

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

1. If simultaneously collected flow data matching the water quality sample collection dates were available, those flow measurements were used.

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

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

4. On streams impounded by dams to form reservoirs of sufficient size to impact stream flow, only flows measured after the date of the most recent impoundment was used to develop the flow duration curve. This also applied to reservoirs on major tributaries to the streams.

B. In the case no coincident flow data were available for a stream segment, but flow gage(s) were present upstream and/or downstream without a major reservoir between, flows were 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 sub-basins were first delineated for all impaired 303(d)-listed WQM stations, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Then all the USGS gage stations were identified upstream and downstream of the sub-watersheds with 303(d) listed WQM stations.

1. Watershed delineations were 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 was calculated following watershed delineation.

2. The watershed average curve number was 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 soil data, and land use category from the National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers were estimated at the 30-meter resolution of the NLCD grid as shown in **Table Appendix C-1**. The average curve number was then calculated from all the grid cells within the delineated watershed.

3. The average rainfall was 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 Appendix C-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

4. 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 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) 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):

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

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

$$I_a = 0.2*S \quad \textbf{(2)}$$

Thus, the runoff curve number equation can be rewritten:

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

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

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

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:

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

<u>Where:</u>

M = 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.

C. 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 Appendix C-2 Estimated Flow Exceedance Percentiles

Stream Name	Walnut Bayou	Fleetwood Creek	Hickory Creek	East Cache Creek	Medicine Creek	Red River	West Cache Creek	Blue Beaver Creek	Little Deep Red Creek
WBID Segment	OK311100010230_00	OK311100010300_00	OK311100020010_10	OK311300020010_10	OK311300040060_00	OK311310010010_00	OK311300020010_10	OK311310020060_00	OK311310030040_00
USGS Gage Reference	07315700	07315700	07315700	07311000	07309435	07308500	07311500	07311200	07311500
USGS Gage Drainage Area (mi²)	574	574	574	694	3.2	20,570	604	24.6	604
Watershed Drainage Area (mi²)	167	16.4	203	308	64.5	20,570	466	24.6	142
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
0	10,998	1,080	13,388	15,347	5,196	144,000	35,713	2,600	10,855
1	1,030	101	1,254	1,527	829	14,298	2,714	221	826
2	614	60	747	871	582	8,250	1,450	111	442
3	416	41	507	627	425	6,300	926	76	282
4	311	31	379	494	376	5,050	630	56	192
5	231	23	281	407	324	4,209	448	46	137
6	168	16	204	346	303	3,629	320	39	98
7	128	13	156	299	263	3,190	246	34	76
8	98	10	119	263	243	2,809	193	30	60
9	78	7.6	95	233	222	2,450	150	26	47
10	63	6.2	77	209	202	2,180	121	24	38
11	52	5.1	63	189	186	1,960	99	21	31
12	45	4.4	55	172	172	1,770	81	19	25
13	38	3.7	46	157	160	1,620	69	18	22
14	33	3.2	40	140	143	1,480	59	16	19
15	29	2.9	36	125	135	1,330	52	15	17
16	26	2.6	32	112	125	1,230	45	14	14
17	24	2.3	29	100	113	1,160	39	13	13
18	22	2.1	27	91	105	1,080	35	12	12
19	19	1.9	24	84	95	1,010	31	11	10
20	18	1.7	22	77	87	951	28	10	9.3
21	16	1.6	20	71	83	909	25	10	8.4

Stream Name	Walnut Bayou	Fleetwood Creek	Hickory Creek	East Cache Creek	Medicine Creek	Red River	West Cache Creek	Blue Beaver Creek	Little Deep Red Creek
WBID Segment	OK311100010230_00	OK311100010300_00	OK311100020010_10	OK311300020010_10	OK311300040060_00	OK311310010010_00	OK311300020010_10	OK311310020060_00	OK311310030040_00
USGS Gage Reference	07315700	07315700	07315700	07311000	07309435	07308500	07311500	07311200	07311500
USGS Gage Drainage Area (mi²)	574	574	574	694	3.2	20,570	604	24.6	604
Watershed Drainage Area (mi²)	167	16.4	203	308	64.5	20,570	466	24.6	142
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
22	15	1.5	18	65	79	855	22	8.8	7.6
23	14	1.3	17	59	75	806	20	8.2	6.9
24	13	1.2	15	55	71	769	18	7.6	6.2
25	12	1.1	14	51	67	734	16	7.0	5.8
26	11	1.1	13	48	63	709	15	6.4	5.3
27	10	1.0	12	46	59	667	14	5.9	5.1
28	9.3	0.91	11	43	55	636	12	5.5	4.6
29	8.7	0.86	11	41	51	610	12	5.2	4.4
30	7.9	0.77	10	40	49	580	11	4.9	4.1
31	7.3	0.71	8.9	38	44	559	10	4.5	3.9
32	6.7	0.66	8.2	36	42	537	9.3	4.1	3.7
33	6.1	0.60	7.5	35	40	515	8.5	3.9	3.4
34	5.8	0.57	7.1	33	38	493	8.5	3.6	3.4
35	5.2	0.51	6.4	32	36	473	7.7	3.3	3.2
36	4.9	0.49	6.1	32	32	456	7.3	3.0	3.1
37	4.7	0.46	5.7	31	30	435	6.9	2.8	3.0
38	4.4	0.43	5.3	30	28	417	6.5	2.6	2.8
39	4.1	0.40	5.0	29	27	399	6.2	2.4	2.7
40	3.8	0.37	4.6	28	26	383	5.9	2.2	2.6
41	3.5	0.34	4.3	28	24	367	5.5	2.0	2.5
42	3.2	0.31	3.9	28	22	355	5.2	1.9	2.4
43	2.9	0.29	3.6	27	22	344	4.9	1.8	2.4
44	2.8	0.27	3.4	27	20	332	4.6	1.6	2.3

Stream Name	Walnut Bayou	Fleetwood Creek	Hickory Creek	East Cache Creek	Medicine Creek	Red River	West Cache Creek	Blue Beaver Creek	Little Deep Red Creek
WBID Segment	OK311100010230_00	OK311100010300_00	OK311100020010_10	OK311300020010_10	OK311300040060_00	OK311310010010_00	OK311300020010_10	OK311310020060_00	OK311310030040_00
USGS Gage Reference	07315700	07315700	07315700	07311000	07309435	07308500	07311500	07311200	07311500
USGS Gage Drainage Area (mi²)	574	574	574	694	3.2	20,570	604	24.6	604
Watershed Drainage Area (mi²)	167	16.4	203	308	64.5	20,570	466	24.6	142
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
45	2.5	0.25	3.1	26	19	319	4.5	1.5	2.2
46	2.4	0.23	2.9	26	18	307	4.2	1.4	2.1
47	2.2	0.21	2.7	25	17	296	3.9	1.4	2.0
48	2.0	0.20	2.5	25	16	286	3.7	1.3	2.0
49	1.9	0.18	2.3	24	15	278	3.5	1.2	1.9
50	1.7	0.17	2.2	24	13	270	3.3	1.1	1.9
51	1.6	0.16	2.0	24	13	260	3.2	1.0	1.8
52	1.5	0.15	1.9	24	12	252	3.1	1.0	1.8
53	1.4	0.14	1.8	23	11	243	2.9	0.89	1.7
54	1.3	0.13	1.6	23	10	235	2.8	0.85	1.7
55	1.2	0.12	1.5	22	10	227	2.6	0.79	1.6
56	1.1	0.11	1.4	22	9.1	218	2.5	0.74	1.6
57	1.0	0.10	1.3	22	8.7	208	2.3	0.72	1.6
58	0.9	0.091	1.2	21	8.3	200	2.2	0.65	1.5
59	0.9	0.086	1.1	21	7.9	193	2.1	0.59	1.5
60	0.8	0.080	1.0	21	7.5	186	2.0	0.53	1.5
61	0.8	0.074	0.95	20	7.3	179	1.9	0.44	1.4
62	0.7	0.069	0.88	20	6.9	172	1.8	0.39	1.4
63	0.6	0.063	0.81	20	6.5	166	1.7	0.33	1.4
64	0.6	0.057	0.74	20	6.3	160	1.6	0.27	1.3
65	0.5	0.051	0.67	19	6.1	153	1.5	0.23	1.3
66	0.5	0.046	0.59	19	5.7	146	1.4	0.20	1.3
67	0.4	0.040	0.52	19	5.5	140	1.3	0.17	1.2

Stream Name	Walnut Bayou	Fleetwood Creek	Hickory Creek	East Cache Creek	Medicine Creek	Red River	West Cache Creek	Blue Beaver Creek	Little Deep Red Creek
WBID Segment	OK311100010230_00	OK311100010300_00	OK311100020010_10	OK311300020010_10	OK311300040060_00	OK311310010010_00	OK311300020010_10	OK311310020060_00	OK311310030040_00
USGS Gage Reference	07315700	07315700	07315700	07311000	07309435	07308500	07311500	07311200	07311500
USGS Gage Drainage Area (mi²)	574	574	574	694	3.2	20,570	604	24.6	604
Watershed Drainage Area (mi²)	167	16.4	203	308	64.5	20,570	466	24.6	142
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
68	0.4	0.037	0.49	19	5.3	135	1.2	0.14	1.2
69	0.3	0.031	0.42	18	5.1	129	1.1	0.11	1.2
70	0.3	0.029	0.38	18	4.9	124	1.0	0.09	1.2
71	0.3	0.026	0.35	18	4.7	119	0.93	0.08	1.1
72	0.2	0.023	0.31	18	4.4	115	0.85	0.06	1.1
73	0.2	0.019	0.27	17	4.4	111	0.77	0.05	1.1
74	0.2	0.017	0.24	17	4.2	107	0.72	0.03	1.1
75	0.1	0.015	0.21	17	4.0	101	0.65	0.02	1.0
76	0.1	0.013	0.18	17	3.8	97	0.59	0.01	1.0
77	0.1	0.011	0.17	16	3.8	92	0.54	0	1.0
78	0.1	0.0091	0.15	16	3.6	87	0.46	0	1.0
79	0.1	0.0083	0.13	16	3.4	82	0.39	0	1.0
80	0.1	0.0066	0.11	16	3.0	76	0.32	0	0.95
81	0.1	0.0057	0.10	16	2.8	70	0.28	0	0.94
82	0.05	0.0046	0.08	16	2.6	64	0.23	0	0.92
83	0.03	0.0033	0.07	16	2.4	60	0.16	0	0.90
84	0.03	0.0029	0.06	15	2.0	54	0.14	0	0.89
85	0.02	0.0017	0.05	15	1.6	50	0.08	0	0.87
86	0.01	0.0009	0.04	15	1.2	46	0.07	0	0.87
87	0.003	0.0003	0.03	15	0.8	40	0.01	0	0.85
88	0	0	0.03	14	0.6	36	0	0	0.85
89	0	0	0.03	14	0.4	31	0	0	0.85
90	0	0	0.03	14	0.2	26	0	0	0.85

Stream Name	Walnut Bayou	Fleetwood Creek	Hickory Creek	East Cache Creek	Medicine Creek	Red River	West Cache Creek	Blue Beaver Creek	Little Deep Red Creek
WBID Segment	OK311100010230_00	OK311100010300_00	OK311100020010_10	OK311300020010_10	OK311300040060_00	OK311310010010_00	OK311300020010_10	OK311310020060_00	OK311310030040_00
USGS Gage Reference	07315700	07315700	07315700	07311000	07309435	07308500	07311500	07311200	07311500
USGS Gage Drainage Area (mi²)	574	574	574	694	3.2	20,570	604	24.6	604
Watershed Drainage Area (mi²)	167	16.4	203	308	64.5	20,570	466	24.6	142
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
91	0	0	0.03	13	0	21	0	0	0.85
92	0	0	0.03	13	0	18	0	0	0.85
93	0	0	0.03	13	0	15	0	0	0.85
94	0	0	0.03	12	0	11	0	0	0.85
95	0	0	0.03	12	0	8.1	0	0	0.85
96	0	0	0.03	12	0	4.7	0	0	0.85
97	0	0	0.03	11	0	2.4	0	0	0.85
98	0	0	0.03	10	0	0.5	0	0	0.85
99	0	0	0.03	9.1	0	0.3	0	0	0.85
100	0	0	0.03	6.7	0	0.3	0	0	0.85

APPENDIX D: CENSORED DATA ESTIMATION FOR THE LOWER RED RIVER-LITTLE RIVER BASIN

Censored Data Estimation for the Lower Red River-Little River Basin

1. Background

Sample size is an important feature of any empirical study. In this Study, two out of three waterbodies required turbidity TMDL listed in **Table Appendix D-1** have less than or equal to five countable TSS data. The small sample size (less than 25) has been shown to produce estimates with large bias and poor statistical representation. To lessen these problems, the data for Walnut Bayou and East Cache Creek were combined under assumption of similar distribution and uniform characteristics. They were assumed as log-normal distribution with equivalent mean (μ) and standard deviation (σ). This assumption can hold because sampling locations are geologically closed and sampling areas are located in same geological province as the Wichita Uplift. They are also part of the Central Great Plains and Cross Timbers Level III ecoregions.

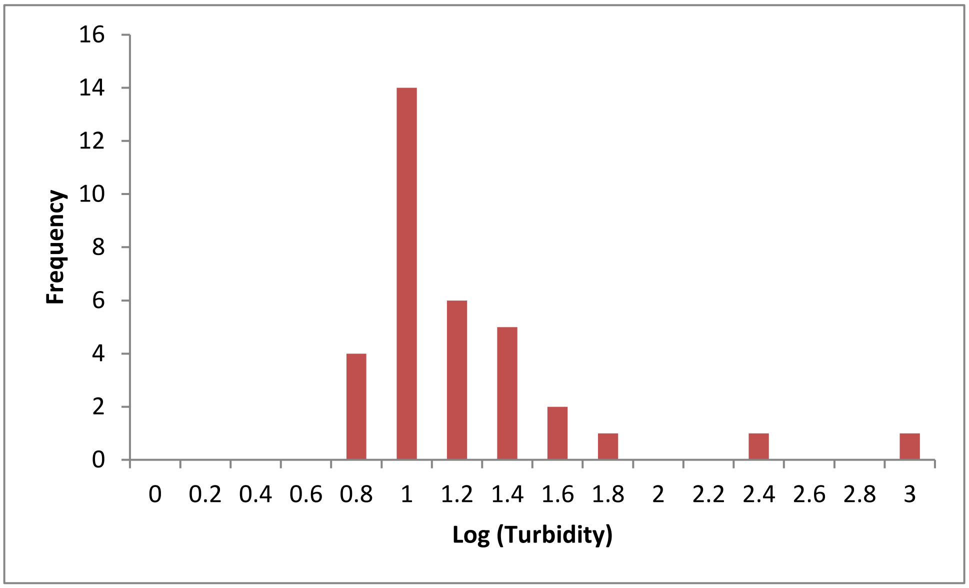
Table Appendix D-1 Censored TSS Data in Base Flow for CWAC waterbodies

WBID	Waterbody name	Total number of TSS data	Number of censored data	% of censored data
OK311100010250_00	Walnut Bayou	17	12	70.6%
OK311300020010_10	Cache Creek, East	17	13	76.5%
OK311310010010_00	Red River	12	0	0%
Total		**46**	**25**	**54.3%**

In addition to this, turbidity data can be combined with above assumption, then so does TSS (TSS is common surrogate for turbidity). Combined turbidity data of Walnut Bayou and East Cache Creek in **Table Appendix D-1** are illustrated in **Figure Appendix D-1**. It demonstrated log-normal distribution and difference in log-mean between combined data and each stream data was approximately 8%.

Among combined data for TSS, about 74% of TSS data are censored-data, recorded as 10 mg/L of detection limits (dl). Methods for estimating these non-detects (censored data) can be divided into the three classes: simple substitution, distributional, and robust methods.

Figure Appendix D-1 Histogram of Combined Turbidity Data

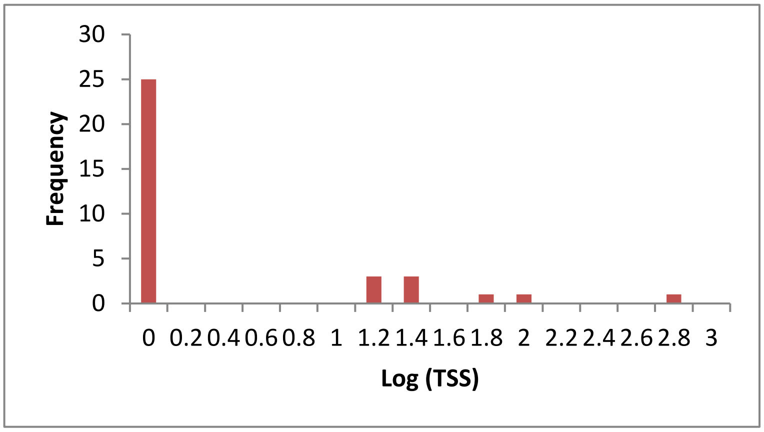


2. Simple Substitution Methods

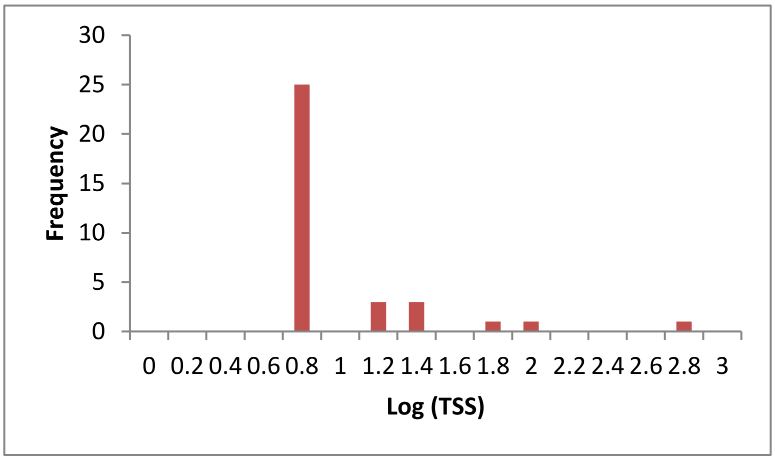
Simple substitution methods substitute a single value such as one-half the reporting limit for each less-than values (censored data). Summary statistics are calculated and shown in **Table Appendix D-2** and **Figure Appendix D-2**.

The distribution resulting from simple substitution methods have large gaps and do not appear realistic. Substitution of one produced estimates of mean and median which were biased low, while substituting the reporting limit resulted in estimates above the true value. Results for the standard deviation and interquartile range (IQR), and for substituting one-half the reporting limit, were also far less desirable than alternative methods discussed below.

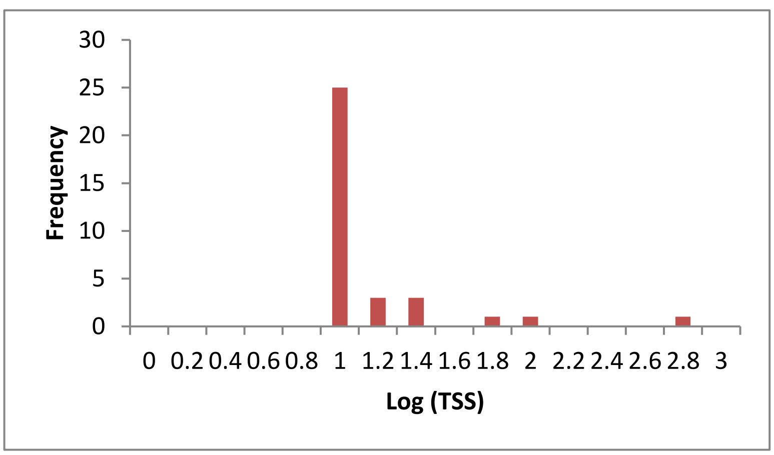
Figure Appendix D-2: Histograms for Simple Substitution Methods



(a) Substitute one [(log(TSS) = 0] for all less-thans



(b) Substitute one-half the reporting limit for all less-thans



(c) Substitute the reporting limit for all less-thans

3. Distributional Methods

Distributional methods use the characteristics of an assumed distribution to estimate summary statistics. Data both below (non-detects) and above (detects) the reporting limit are assumed follow a log-normal distribution. Given a distribution, estimates of summary statistics are computed which best match the observed concentrations above the reporting limit and the percentage of data below the limit. Maximum-likelihood estimation (MLE) is used to estimate summary statistics in this study.

Cohen's procedure can be used for left-censored lognormal distribution (Gilbert, 1987). This hand calculated estimation is compared with estimation results from EXCEL and R (**Table Appendix D-2**). Cohen's procedure is followed below:

$$h = \frac{(n-k)}{n}$$

$$\bar{y}_u = \frac{\sum_{i=1}^{k} y_i}{k}$$

$$s_u{}^2 = \frac{\sum_{i=1}^{k} (y_i - \bar{y}_u)^2}{k}$$

$$\hat{\gamma} = \frac{s_u{}^2}{(\bar{y}_u - y_0)^2}$$

$$\hat{\mu}_y = \bar{y}_u - \hat{\lambda}(\bar{y}_u - y_0)$$

$$\hat{\sigma}_y{}^2 = s_u{}^2 + \hat{\lambda}(\bar{y}_u - y_0)^2$$

$$\hat{\mu} = exp\left(\hat{\mu}_y + \frac{\hat{\sigma}_y{}^2}{2}\right)$$

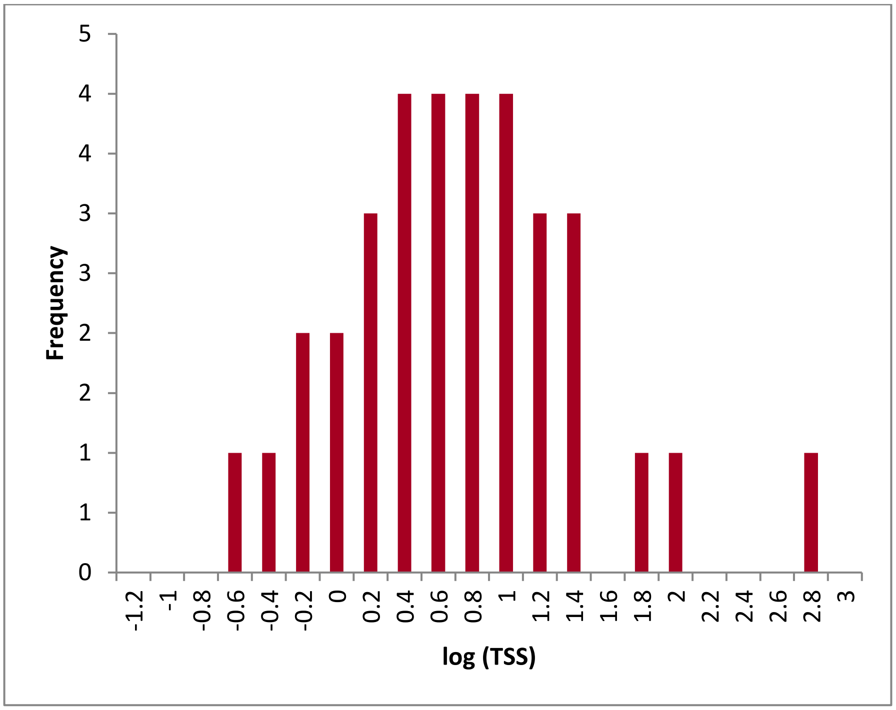
$$\hat{\sigma}^2 = \hat{\mu}^2\left[exp\left(\hat{\sigma}_y{}^2\right) - 1\right]$$

Where n = total number of observed TSS, k = number out of n that are above dl, y_i = ln $(TSS)_i$, y_0 = ln (dl), $\hat{\lambda}$ = 2.2 based on h and $\hat{\gamma}$ from Table A15 (Gilbert, 1987), $\hat{\mu}$ = the mean of the lognormal distribution, and $\hat{\sigma}^2$ = the variance of the lognormal distribution.

For EXCEL, calculation includes following steps that are described below:

- Build normal distribution curve for log-transformed TSS data with guessed μ and σ.
- Draw probability density function (pdf) for detects.
- Minimize area difference under the curve for above two distribution curves in the same range of x-axis with solver in EXCEL by changing μ and σ.

Figure Appendix D-3: EXCEL Histograms for Distributional Methods (MLE)



For R, the R code shown below can be used.

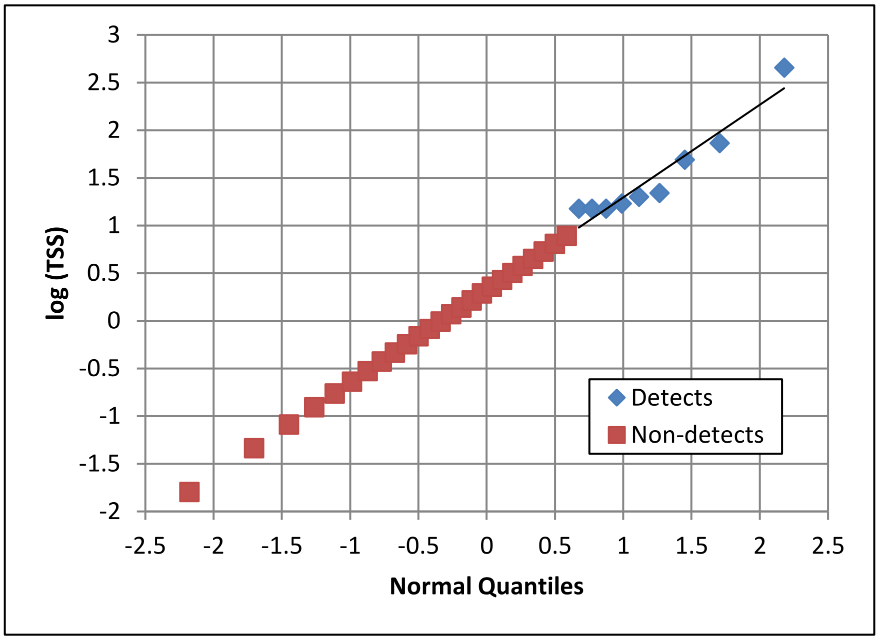
```
read.csv("d:/CWAC.csv", header=T)
data=read.csv("d:/CWAC.csv", header=T)
data_mle=with(data,cenmle(TSS,TSSCen), dis='lognormal')
data_mle
```

4. Robust Methods

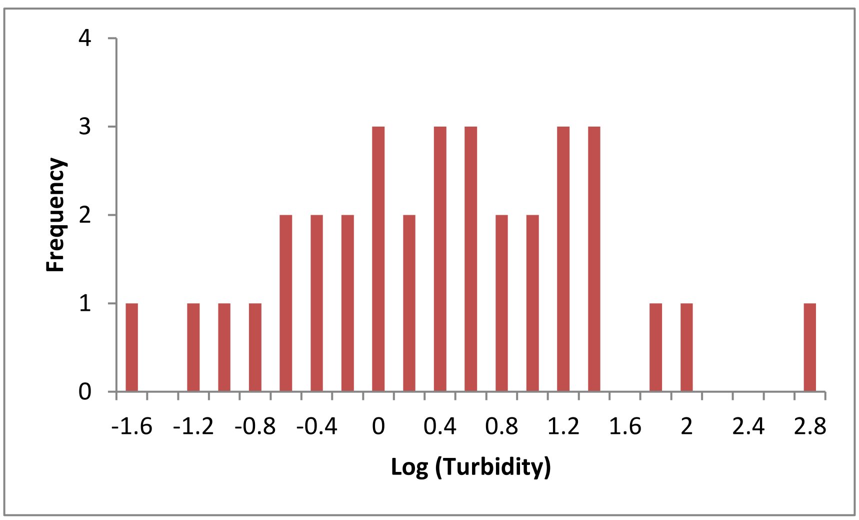
Robust methods combine observed data above the reporting limit with below-limit values extrapolated assuming a distributional shape, in order to compute estimates of summary statistics. A distribution is fit to the data above the reporting limit by either MLE or probability plot procedures, but the fitted distribution is used only to extrapolate a collection of values below the reporting limit.

First, Regression of log of concentration (TSS) verse normal score is used to extrapolate “fill-in” values below the reporting limit. Then, these “fill-ins” are retransformed back to original units, and combined with data above the reporting limit to compute estimates of summary statistics.

Figure Appendix D-4: Robust Method of Estimating Summary Statistics



(a) Normal Quantiles



(b) Histogram for Robust Regression on Order Statistics (ROS)

5. Results

Either Robust ROS or MLE had shown to perform well for estimating the median and IQR in this Study when comparing to turbidity distribution. In addition to this, estimations could be compared for their 75th percentile (15 mg/L TSS). Substitution for detection limit, MLE, and Robust ROS estimated 75th percentile close to 15 mg/L. However, substitution for detection limit estimated 25th percentile at detection limit and this was not realistic. Therefore, simple substitution method was not a good method for estimating statistics as well as substituting non-detects.

Use of these methods rather than simple substitution methods for censored data should substantially lower estimation errors for summary statistics. However, extrapolating censored data obtained using one of the estimation methods listed in **Table Appendix D-2** may produce coefficients strongly dependent on the values extrapolated in the regression analysis. Therefore, alternative methods capable of incorporating censored observations are described in **Appendix E**. In this study, dl substitution was used for conservative PRG calculation because dl is believed to be greater than actual concentration of censored data.

Table Appendix D-2: Summary Statistics

Category	Censored data estimation		Mean	Standard deviation	25th percentile	Median	75th percentile	IQR
Turbidity	All detects		41.3	135.4	7.9	9.1	17.8	9.9
TSS	dl subbed		27.4	76.6	10.0	10.0	13.8	3.8
	dl/2 subbed		23.7	77.5	5.0	5.0	12.5	7.5
	One [log(TSS)=0]subbed		20.8	78.2	1.0	1.0	11.5	10.5
	MLE	Cohen's	20.9	160.6	n/a	n/a	n/a	n/a
		EXCEL	23.0	77.7	1.8	5.1	13.8	11.9
		R	21.1	159.8	n/a	2.8	n/a	n/a
	Robust ROS	EXCEL	21.4	78.1	0.5	2.1	13.2	12.7
		R	21.0	78.2	n/a	1.3	n/a	n/a

n/a = not available

References

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Wiley.

APPENDIX E: CENSORED DATA REGRESSION

Censored Data Regression for the Lower Red River-Little River Basin

1. Background

With censored data the use of ordinary least squares (OLS) for regression is prohibited (See Table D-1; Helsel and Hirsch, 2002). Coefficients for slopes and intercept cannot be computed without values for the censored observations, and substituting fabricated values may produce coefficients strongly dependent on the values substituted. Two alternative methods capable of incorporating censored observations are described below. All data are log-tranformed and censored data are set as a range from one (TSS=1 mg/L; log (TSS) = 0) to detection limit (TSS=10 mg/L; log (TSS) = 1).

2. Maximum Likelihood Estimation (MLE)

Maximum likelihood estimation (MLE) in the presence of censored data is very similar to the estimation that occurs when conducting a standard linear regression. The difference is that the likelihood that is computed when censored values are present explicitly accounts for the values below the detection limit (dl).

Assumptions for correlation and regression type maximum likelihood estimators include:

- The presence of a linear trend in the data;
- Observations are approximately normally distributed about the estimated trend line;
- Variances are approximately equal in magnitude at all points along the trend line; and
- Independent observations.

The relationship between two variables is presented with the correlation coefficient (Loglik-r) and p-value in Table E-1.

3. Non-Parametric Approaches

Non-parametric measures of association tend to evaluate the monotonic association between two variables. This means that such methods are evaluating whether values of the response tend to increase as values of the explanatory variable increase (or vice versa). These non-parametric measures do not quantify how big the increase or decrease is, merely whether there is an increase or decrease. This means that non-parametric methods should be useful at evaluating whether there is an increasing or decreasing trend in the data, regardless of whether or not it is linear.

One of the most popular non-parametric measures of association between variables in water quality is Kendall's tau (Huston & Juarez-Colunga, 2009). Like other measures of correlation, Kendall's tau falls between -1 and 1, where values close to 1 indicate a strong positive association and values close to -1 indicate a strong negative association. Values of tau near 0 indicate little or no association. Kendall’s tau was used in this study because of the high number of non-detects (censored data). Because tau depends only on the ranks of the data and not the values themselves, it can be used in cases where some of the data are censored (Helsel and Hirsch, 2002).

To estimate regression coefficient and correlation when censored observations are present, the following R[10] code shown as an example for Walnut Bayou:

```
read.csv("d:/Walnutlog.csv", header=T)
data=read.csv("d:/Walnutlog.csv", header=T)
with(data,cenxyplot(x=Turbidity,xcen=0,y=TSS,ycen=TSSCen,log="",
main="Walnut Bayou (OK311100010250_00)",
xlab="log (Turbidity)",
ylab="log (TSS)",
```

[10] R is a computer language and environment for statistical computing and graphics. http://www.r-project.org/

```
)
)
mle.reg=cenreg(Cen(obs=data$TSS,censored=data$TSSCen)~data$Turbidity,dist="gaussian")
data.Kendall=cenken(y=data$TSS, ycen=data$TSSCen,x=data$Turbidity,xcen=data$TurCen)
abline(mle.reg,lty=4,lwd=2)
lines(data.Kendall,lwd=2)
legend(x="left",legend=c("Kendall","MLE"),lty=c(1,4),lwd=2)
```

4. Results

Figure Appendix E-1: Trend lines estimated for Walnut Bayou by MLE and non-parametric methods

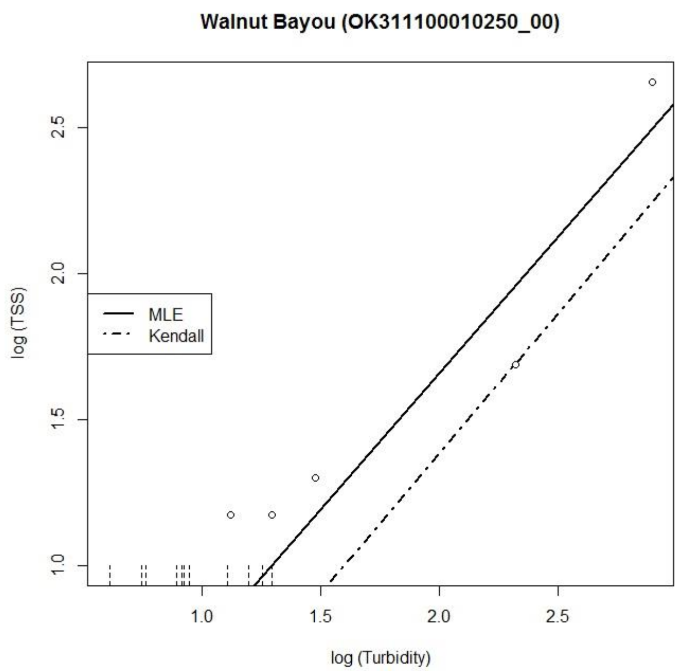
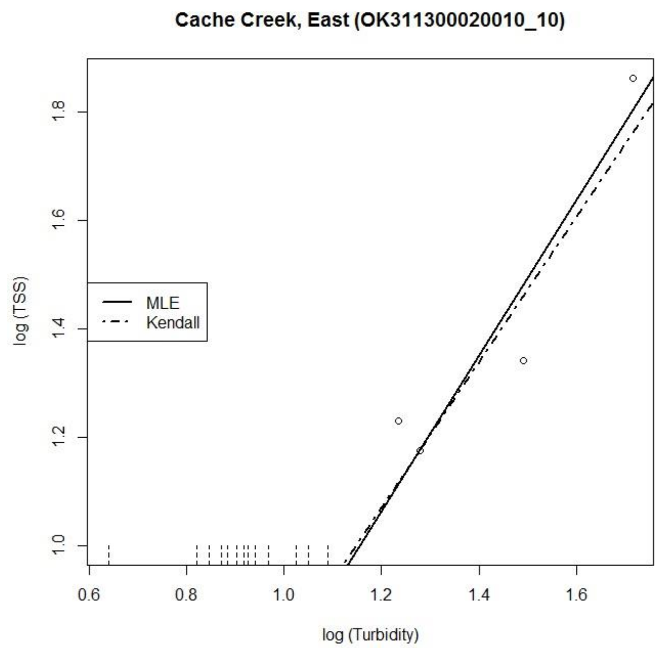


Figure Appendix E-2: Trend lines estimated for East Cache Creek by MLE and non-parametric methods



Non-parametric methods have been described as robust compared to parametric ones. This means that when extreme outliers are present, or the distribution of points is highly unusual, non-parametric methods are recommended. In less extreme situations, non-parametric methods perform similarly or slightly worse than MLE methods (Huston & Juarez-Colunga, 2009). In this Study, the MLE method estimated correlation better than Kendall's tau. All two waterbodies had acceptable R-square values (0.81 and 0.82; see **Table Appendix E-1**).

Table Appendix E-1: Regression Statistics with Censored Data

WBID	Waterbody name	MLE Method					Non-parametric method				
		TSS target (mg/L)	Slope	Intercept	Loglik-r (R^2)	p-value	TSS target (mg/L)	Slope	Intercept	tau	p-value
OK311100010250_00	**Walnut Bayou**	23.9	0.934	-0.208	0.90 (**0.81**)	1.2E-07	12.5	0.958	-0.531	0.45	0.0008
OK311300020010_10	**Cache Creek, East**	60.0	1.431	-0.653	0.90 (**0.82**)	1.0E-07	54.8	1.339	-0.536	0.41	0.0006

References

Helsel, D.R., and Hirsch R.M., 2002. Statistical Methods in Water Resources. Techniques of Water-Resources Investigations, Book 4, Chapter. A3, U.S. Geological Survey, 522 p., http://pubs.usgs.gov/twri/twri4a3/

Huston, C and E Juarez-Colunga 2009. Guidelines for computing summary statistics for data-sets containing non-detects. Department of Statistics and Actuarial Science, Simon Fraser University.

APPENDIX F: DIRECT CALCULATION OF PERCENT REDUCTION GOALS FROM TURBIDITY DATA

Direct Calculation of Percent Reduction Goals from Turbidity Data

1. Background

Regression of censoring greater than 50% is not truly appropriate. However, there is no alternative to find relationship between TSS and turbidity for this study.

Percent reduction goals (PRGs) were computed directly from turbidity data and compared with regression method. PRG agreement between methods can be used as verification of regression method. For this purpose, 10% explicit MOS was applied in direct calculation to meet no more than 10% of the samples exceed the standards. Then, these PRGs were compared with PRGs from regression in this study.

2. Regression Methods

Except for the Red River (LOC regression), censored data MLE regression was applied to all turbidity impaired waterbodies in this study. Censored data were 70.6% and 76.5% of base flow TSS data. Regression methods were explained in Section 4.1 and results from this method were summarized in **Table Appendix F-1**. MOS for MLE regression ranged from 10% to 25% because they were calculated based on NRMSE.

3. Results

PRG differences between regression method and direct calculation were less than 15% except East Cache Creek. PRGs from regression method were similar to those from direct calculation, except East Cache Creek. However, PRG for East Cache Creek was not underestimated in the regression method. MLE method was more conservative than direct calculation for East Cache Creek. Therefore, MLE method was appropriate for this data set.

Table Appendix F-1: Percent Reduction Goals

WBID	Waterbody name	MLE Method			Direct Calculation		
		TSS target (mg/L)	MOS (%)	PRG (%)	Turbidity target (NTU)	MOS (%)	PRG (%)
OK311310010010_00	Red River	86.6	10	92.8	50	10	95.5
OK311100010250_00	Walnut Bayou	23.9	25	63.5	50	10	76.2
OK311300020010_10	East Cache Creek	60.0	20	34.3	50	10	5.3

APPENDIX G: STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix G
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 H: DEQ SANITARY SEWER OVERFLOW DATA (1989-2014)

Table Appendix H-1 DEQ Sanitary Sewer Overflow Data (1989-2014)

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	1/12/2004	0.00	800 BLK MILES ST. S.W.	1,000			OBSTRUCTION
ARDMORE	S30804	5/28/2004	0.00	CHICKASAW HILLS HOUSING ADDITION	1,000			BLOCKAGE
ARDMORE	S30804	12/11/2004	0.00	400 LOCUST	800	X		BLOCKAGE
ARDMORE	S30804	5/15/2006	0.00	MT. WASHINGTON RD.				BLOCKAGE
ARDMORE	S30804	7/3/2007	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	7/17/2007	0.00	1202 HOWARD S.W.				
ARDMORE	S30804	8/17/2001			150			
ARDMORE	S30804	11/9/2001	1.00	KNOX RD. - ASTERICK PL. APTS	75	X		BLOCKAGE
ARDMORE	S30804	12/21/1989		AT LIFT STATION #5	144720			FREEZING OF THE FLOAT SWITCH
ARDMORE	S30804	1/17/1990		LIFT STATION #5	9400			HEAVY RAINS
ARDMORE	S30804	2/1/1990		LIFT STATION #3	7099			HEAVY RAINFALL
ARDMORE	S30804	2/20/1990		ARDMORE INDUSTRIAL AIRPARK LIFT STATION	76885			PUMP FAILURE
ARDMORE	S30804	2/26/1990		LIFT STATION #3	14917			HEAVY RAINFALL
ARDMORE	S30804	2/26/1990		LIFT STATION #5	23663			HEAVY RAINFALL
ARDMORE	S30804	3/6/1990		EAST SIDE PUMPING STATION	74000			HEAVY RAINFALL
ARDMORE	S30804	4/19/1990		LAKE MURRAY LIFT STATION(LS#5)	1128000			BYPASS DUE TO HEAVY RAINFALL
ARDMORE	S30804	4/19/1990		EAST SIDE PUMPING STATION(LS#3)	177600			BYPASS DUE TO HEAVY RAINFALL
ARDMORE	S30804	4/29/1990		LAKE MURRAY PUMPING STATION(LS#5)	188000			BYPASS DUE TO HEAVY RAINFALL
ARDMORE	S30804	4/30/1990		EAST SIDE PUMPING STATION(LS#3)	74000			BYPASS DUE TO HEAVY RAINFALL
ARDMORE	S30804	11/28/1990		LAKE MURRY LIFT	100000			RAIN
ARDMORE	S30804	12/30/1990		LIFT STA	37600			FUSE BOX
ARDMORE	S30804	12/31/1990		LIFT STA	56400			FUSE BOX
ARDMORE	S30804	1/2/1991		LIFT STA	28200			SE BOX
ARDMORE	S30804	2/6/1991			16450			CHANICAL PROBLEMS
ARDMORE	S30804	3/22/1991		DOG POUND	15864			RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	3/28/1991		ANDERSON	47592			PUMP DOWN
ARDMORE	S30804	3/30/1991		LAKE MURRAY	112800			CONSTRUCTION
ARDMORE	S30804	3/31/1991		LAKE MURRAY	112800			CONSTRUCTION
ARDMORE	S30804	4/8/1991		LAKE MURRAY	56400			CONSTRUCTION
ARDMORE	S30804	4/14/1991		LAKE MURRAYN	376000			STOPPAGES DUE TO CONSTUCTION
ARDMORE	S30804	4/15/1991		CHICKASAW HOUSING	282000			STOPPAGES DUE TO CONSTRUCTION
ARDMORE	S30804	6/4/1991		AIR PARK	225608			PUMP FAILURE
ARDMORE	S30804	6/8/1991		DOG POUND	56402			HEAVY RAIN
ARDMORE	S30804	6/8/1991		LAKE MURRAY	75203			HEAVY RAIN
ARDMORE	S30804	6/10/1991		AIR PARK	225608			PUMP FAILURE
ARDMORE	S30804	7/8/1991	8.00	Chickasaw housing l.s.	37600	X		Electrical service interruption
ARDMORE	S30804	8/7/1991	14.00	Anderson lift station	32900	X		Mechanical failure
ARDMORE	S30804	9/7/1991		Lake Murray pump station	214210	X		Flooding conditions
ARDMORE	S30804	9/16/1991	16.00	LAKE MURRAY LIFT STATION	173200	X		EXCESSIVE RAINFALL
ARDMORE	S30804	9/16/1991	24.00	DOG POUND LIFT STATION	112804	X		EXCESSIVE RAINFALL
ARDMORE	S30804	9/18/1991	9.00	LAKE MURRAY LIFT STATION	97400	X		EXCESSIVE RAINFALL
ARDMORE	S30804	10/15/1991	7.00	LAKE MURRAY LIFT STATION	67800	X		PUMP FAILURE
ARDMORE	S30804	10/28/1991		CHICKASAW LIFT STATION	282000	X		EXCESSIVE RAINFALL
ARDMORE	S30804	12/16/1993	2.00	MYALL ROAD	5000	X		LINE STOPPAGE
ARDMORE	S30804	12/28/1993	24.00	MOUNT WASHINGTON ROAD	0	X		LINE BLOCKAGE
ARDMORE	S30804	12/28/1993	24.00	HEATHER ROAD	0	X		OBSTRUCTION IN THE MANHOLE
ARDMORE	S30804	2/4/1994	23.00	BY DAKOTA'S RESTURANT	0	X		LINE BLOCKAGE
ARDMORE	S30804	2/14/1994	0.00	BURGER KING ON BROADWAY36	0	X		GREASE STOPPAGE
ARDMORE	S30804	2/23/1994	7.00	T C LEASING	0	X		LINE BLOCKAGE
ARDMORE	S30804	3/15/1994	3.00	MOUNT WASHINGTON AND CAMPELL	0	X		LINE BLOCKAGE
ARDMORE	S30804	3/21/1994	4.00	1015 SOUTH COMMERCE	500	X		LINE BLOCKAGE
ARDMORE	S30804	4/6/1994	3.00	1722 WILDWOOD	0	X		LINE STOPPAGE
ARDMORE	S30804	4/13/1994	1.00	115 H N W	13000	X		LINE BLOCKAGE
ARDMORE	S30804	4/13/1994	72.00	F STREET S W	100	X		LINE BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	5/16/1994	48.00	EAST OF REFINERY	40000	X		ROOT STOPPAGE
ARDMORE	S30804	6/13/1994	0.00	'A' LIFT STATION DISCHARGE LINE	0	X		BREAK IN THE LINE'S CREEK CROSSING
ARDMORE	S30804	10/6/1994	0.00	BEHIND BOY SCOUT OFFICE IN FIELD	1500	X		LINE STOPPAGE
ARDMORE	S30804	10/11/1994	0.00	COUNTRY WOODS LANE	0	X		LINE BLOCKAGE
ARDMORE	S30804	11/17/1994	2.00	PRETREATMENT AREA	0	S	T	OPPAGE
ARDMORE	S30804	11/20/1994	0.00	1OTH AND E STREET SE	0	X		LINE BLOCKAGE
ARDMORE	S30804	12/2/1994	4.00	101 H WEST	0	X		GREASE STOPPAGE
ARDMORE	S30804	12/6/1994	12.00	101 H S W	0	X		LINE STOPPAGE(DEBRIS)
ARDMORE	S30804	12/21/1994	168.00	BEHIND COUNTY JAIL	0	X		DEBRIS BLOCKAGE
ARDMORE	S30804	12/23/1994	1.00	101 H NW	0	X		ROOT STPPAGE
ARDMORE	S30804	1/4/1995	2.00	SUNSET AND MYALL	0	X		LINE BLOCKAGE
ARDMORE	S30804	1/25/1995	12.00	COUNTRYWOOD LANE	0	X		LINE BLOCKAGE
ARDMORE	S30804	2/1/1995	8.00	"K" AND WHITE STREET	1000	X		LINE BLOCKAGEN THE LINE
ARDMORE	S30804	2/6/1995	48.00	MOUNT WASHINGTON ROAD	1500	X		ROOT BLOCKAGE
ARDMORE	S30804	2/14/1995	8.00	519 NORTH DRIVE	500	X		LINE BLOCKAGE
ARDMORE	S30804	2/26/1995	5.00	9TH AND CARTER	1000	X		LINE STOPPAGE
ARDMORE	S30804	3/1/1995	2.00	110 H NW	0	X		LINE BLOCKAGE
ARDMORE	S30804	3/10/1995	2.00	500 D STREET SE	500	X		LINE BLOCKAGE
ARDMORE	S30804	3/20/1995	0.00	GRAVES ROAD	0	X		FAULTY CHECK VALVE
ARDMORE	S30804	3/24/1995	5.00	2ND AND I NORTH EAST	500	X		LINE STOPPAGE
ARDMORE	S30804	4/9/1995	0.00	SUNSET AND MAYALL	500	X		LINE BLOCKAGE
ARDMORE	S30804	4/25/1995	2.00	HI LEWIS LEASING	200	X		LINE STOPPAGE
ARDMORE	S30804	5/8/1995	10.00	LIFT STATION 'A'	0	X		RAIN I/I
ARDMORE	S30804	5/18/1995	0.00	BEHIND TERRACE INN	0	X		LINE BROKEN
ARDMORE	S30804	5/18/1995	0.00	BEHIND TERRACE INN	0	X		LINE BLOCKAGE
ARDMORE	S30804	6/7/1995	48.00	2000 VETRANS BLVD	0	X		COLLASPED LINE
ARDMORE	S30804	6/26/1995	3.00	101 H NORTHWEST	300	X		LINE STOPPAGE
ARDMORE	S30804	8/3/1995	0.00	I40 AND HIWAY 142 BEHIND DAKOTA'S RESTURANT	0	X		LINE BLOCKAGE
ARDMORE	S30804	8/26/1995	0.00	MT WASHINGTON RD 1 MILE NORTH OF 142 BYPASS	0	X		DAMAGED LINE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	9/11/1995	2.00	TOWN & COUNTRY LIFT STATION	0	X		PUMP FAILURE
ARDMORE	S30804	10/12/1995	24.00	14 FREEMAN	3000	X		UNK
ARDMORE	S30804	10/17/1995	4.00	101 H NW	500	X		BLOCKAGE
ARDMORE	S30804	11/6/1995	1.00	OVERLAND ROUTE	150	X		BLOCKAGE
ARDMORE	S30804	11/13/1995	1.00	100 'H' NORTHWEST	500	X		LINE BLOCKAGE
ARDMORE	S30804	11/15/1995	1.00	#10 OVERLAND	50	X		LINE STOPPAGE
ARDMORE	S30804	11/19/1995	2.00	B & MONROE NE	200	X		LINE STOPPAGE
ARDMORE	S30804	12/13/1995	24.00	'P'STREET SOTHWEST	0	X		LINE BLOCKAGE
ARDMORE	S30804	12/29/1995		BEHIND A GYMNASIUM	500	X		BLOCKAGE IN LINE
ARDMORE	S30804	1/7/1996	8.00	101 8TH ST. NW	500	X		BLOCKAGE IN THE LINE
ARDMORE	S30804	1/29/1996	8.00	DAKOTAS RESTAURANT	500	X		BLOCKAGE IN THE LINE
ARDMORE	S30804	2/11/1996	24.00	ROCKFORD & MYALL RD.	500	X		BLOCKAGE IN SYSTEM
ARDMORE	S30804	2/13/1996		801 N S. WEST		X		ROOTS IN THE LINE
ARDMORE	S30804	2/20/1996	0.00	MILL ST. & STANLEY	0	X		LINE SEPARATION
ARDMORE	S30804	3/3/1996		1206 OAKRIDGE				
ARDMORE	S30804	3/7/1996	2.00	1206 OAKRIDGE	500	X		ROOTS IN LINE
ARDMORE	S30804	3/12/1996	8.00	115 MONROE	14	X		LINE BLOCKAGE
ARDMORE	S30804	3/13/1996	2.00	913 4 ST. N.E.	500	X		BLOCKAGE IN LINES
ARDMORE	S30804	3/15/1996	2.00	CORNER OF K & 6TH ST. NW	500	X		
ARDMORE	S30804	3/21/1996	2.00	TACO BUENO	500	X		GREASE STOP UP
ARDMORE	S30804	3/25/1996	2.00	VICINITY OF 6TH & K N.W.	500	X		BLOCKAGE IN LINES
ARDMORE	S30804	4/19/1996	2.00	101 "H" N.W.	300	X		BLOCKAGE IN LINES
ARDMORE	S30804	4/21/1996		STANLEY & S. WASHINGTON				BLOCKAGE
ARDMORE	S30804	4/23/1996	2.00	8TH N.W. & N. COMMERCE	250	X		BLOCKAGE IN LINES
ARDMORE	S30804	5/8/1996		I & 3RD ST.	1000	X		BLOCKAGE IN LINES
ARDMORE	S30804	5/10/1996	8.00	BROOKHAVEN & MILE SW	500	X		ROOTS
ARDMORE	S30804	5/16/1996		K ST. & E. MAIN		X		BLOCKAGE
ARDMORE	S30804	5/22/1996		F S.W. & MCKLISH				BLOCKAGE
ARDMORE	S30804	6/11/1996	1.00	602 N. COMMERCE	200	X		
ARDMORE	S30804	7/18/1996		COMMERCE & MCCOLLOUGH		X		BLOCKAGE IN LINES
ARDMORE	S30804	7/25/1996	6.00	114 "H" N.W.	200	X		BLOCKAGE IN SYSTEM

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	7/29/1996	1.00	HOLIDAY DR. & BROADWAY	200			LINE BLOCKAGE
ARDMORE	S30804	8/6/1996	1.00	6TH ST. NW & COMMERCE	100	X		LINE BLOCKAGE
ARDMORE	S30804	8/19/1996		REMINGTON CT. & SUNSET DR.		X		ROOTS
ARDMORE	S30804	8/22/1996	2.00	WASHINGTON & STANLEY	500	X		BLOCKAGE
ARDMORE	S30804	9/5/1996	1.00	13TH & "C" S.E.	200			BLOCKAGE IN LINE
ARDMORE	S30804	9/13/1996		MILL & STANLEY S.E.				LINE BLOCKAGE
ARDMORE	S30804	9/20/1996		1000 "A" N.E.				LINE BLOCKAGE
ARDMORE	S30804	9/29/1996		6TH & "N" S.W.				
ARDMORE	S30804	10/16/1996		MELODY & MYALL S.W.		X		BLOCKAGE
ARDMORE	S30804	10/17/1996		118 "I" N.E.		X		ROOTS
ARDMORE	S30804	10/24/1996		HEDGES RD.				PRESSURE RELEASE VALVE FAILURE
ARDMORE	S30804	11/19/1996	1.00	10TH & "F" S.E.	0			LINE BLOCKAGE
ARDMORE	S30804	11/25/1996	3.00	LIFT STATION "A"	4	X		BREAKER FAILURE
ARDMORE	S30804	12/2/1996		MAYO MOBILE HOME				BLOCKAGE
ARDMORE	S30804	12/4/1996		TERRACE INN				GREASE & ROOTS
ARDMORE	S30804	1/9/1997	8.00	7TH & S AVE.	0			LINE BLOCKAGE
ARDMORE	S30804	1/10/1997	4.00	13TH & "A" N.E.	0			LINE BLOCKAGE
ARDMORE	S30804	1/15/1997	4.00	MOUNTAIN VIEW MALL	500			BLOCKAGE
ARDMORE	S30804	1/16/1997		MT WASHINGTON RD. & VETERANS BLVD.				ROOTS
ARDMORE	S30804	1/24/1997		STANLEY & S. WASHINGTON		X		BLOCKAGE
ARDMORE	S30804	2/11/1997		WILKINSON'S NURSERY				LINE BLOCKAGE
ARDMORE	S30804	2/14/1997	16.00	2ND. & "A" N.E.	250	X		LINE BLOCKAGE
ARDMORE	S30804	2/18/1997	4.00	15 & HARDROVE	500	X		BLOCKAGE
ARDMORE	S30804	3/11/1997		110 "H" NW		X		LINE BLOCKAGE
ARDMORE	S30804	3/19/1997		118 "I" ST. NE				ROOTS
ARDMORE	S30804	3/21/1997		MT. WASHINGTON RD. BEHIND CHURCH				
ARDMORE	S30804	3/27/1997		"D" S.E. & LAKE MURRAY		X		GREASE
ARDMORE	S30804	3/28/1997	0.70	FREEMAN & MT. WASHINGTON RD.	<1,000			CLOGGED
ARDMORE	S30804	3/31/1997		BROADWAY & "A" N.E.				BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	4/2/1997		"K" & 2ND N.W.				BLOCKAGE
ARDMORE	S30804	4/9/1997		BURGER KING AT HOLIDAY DR.		X		LINE BLOCKAGE
ARDMORE	S30804	4/18/1997		KNOX ROAD				LINE BLOCKAGE
ARDMORE	S30804	4/22/1997		PLAINVIEW SCHOOL				LINE BLOCKAGE
ARDMORE	S30804	4/23/1997	2.00	"F" & 10TH S.E.	<250			LINE BLOCKAGE
ARDMORE	S30804	4/28/1997		1600 "P" S.E.				LINE BLOCKAGE
ARDMORE	S30804	4/28/1997		ELMBROOK NURSING HOME				LINE BLOCKAGE
ARDMORE	S30804	5/9/1997	1.00	F & 10TH ST. S.E.	250			BLOCKAGE
ARDMORE	S30804	6/13/1997		6TH & WOLVERTON				LINE STOPPAGE
ARDMORE	S30804	8/26/1997		HOLIDAY DR.				LINE BLOCKAGE
ARDMORE	S30804	9/11/1997		"F" ST. S.W.	>1,000			LINE BLOCKAGE
ARDMORE	S30804	10/20/1997		DREW ST. S.W.				BLOCKAGE
ARDMORE	S30804	11/18/1997		6TH & "O" ST. SW				LINE BLOCKAGE
ARDMORE	S30804	11/24/1997		101 "H" NW				LINE BLOCKAGE
ARDMORE	S30804	12/9/1997		629 2ND SE	1000			LINE BLOCKAGE
ARDMORE	S30804	12/15/1997	2.00	100 FREEMAN	<500			BLOCKAGE
ARDMORE	S30804	12/15/1997		629 2ND S.E.				BLOCKAGE
ARDMORE	S30804	12/19/1997	1.00	10TH S.E. & LAKE MURRAY DR.	<500			LINE BLOCKAGE
ARDMORE	S30804	1/5/1998		224 "F" S.E.				BLOCKAGE
ARDMORE	S30804	1/5/1998		"C" S.E. & BOYD		X		LINE BLOCKAGE
ARDMORE	S30804	1/5/1998		12TH AVE. NW				BLOCKAGE
ARDMORE	S30804	1/29/1998	1.00	300 SUNSET	<500	X		BLOCKAGE
ARDMORE	S30804	3/4/1998		TIFFANY PLAZA				LINE BLOCKAGE
ARDMORE	S30804	3/16/1998	4.00	SUTTON ROAD	10000			EXCESSIVE RAINS/INFLOW & INFILTRATION
ARDMORE	S30804	3/30/1998		3RD N.E.				BLOCKAGE
ARDMORE	S30804	4/7/1998	24.00	PLAINVIEW RD.		X		BLOCKAGE
ARDMORE	S30804	4/7/1998		DORNICK HILLS LIFT STATION				PUMP FAILURE
ARDMORE	S30804	4/14/1998		418 FIRST S.E.				BLOCKAGE IN LINE
ARDMORE	S30804	5/18/1998		BEHIND ARDMORE SELFSTORAGE BUILDINGS ON VETERAN'S BLVD				BLOCKAGE IN THELINE
ARDMORE	S30804	8/17/1998		BROADWAY & "A" N.W.	1,000	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	10/8/1998	5.00	118 "I" N.E.	1,000			BLOCKAGE
ARDMORE	S30804	10/8/1998		MT. WASHINGTON RD. 1/4 MILE N. OF VETERANS BLVD.		X		LEAKING RELEASE VALVE
ARDMORE	S30804	10/9/1998		S. OF CHATANOOGA LOOP				RELEASE VALVE ON MAIN FAILED
ARDMORE	S30804	10/15/1998		WINN DIXIE		X		BLOCKAGE
ARDMORE	S30804	11/9/1998		7TH & "N" S.W.	>1,000			BLOCKAGE
ARDMORE	S30804	12/28/1998	1.00	#8 CHAMPION STATION	500			BLOCKAGE
ARDMORE	S30804	2/2/1999	8.00	101 "H" N.W.	1,000			BLOCKAGE
ARDMORE	S30804	2/12/1999	8.00	MT. WASHINGTON & 142	1,000			BLOCKAGE
ARDMORE	S30804	2/24/1999		3RD & "A" N.E.				BLOCKAGE
ARDMORE	S30804	2/24/1999		3RD & "A" N.E.				BLOCKAGE
ARDMORE	S30804	3/5/1999		MONROE & REFINERY RD.				BLOCKAGE
ARDMORE	S30804	3/9/1999	8.00	CHICKASAW TOWERS	1,000			BLOCKAGE
ARDMORE	S30804	3/22/1999		COUNTRY WOODS ESTATES		X		BLOCKAGE
ARDMORE	S30804	3/23/1999		1ST & "C" ST. S.E.		X		BLOCKAGE
ARDMORE	S30804	5/9/1999		HOLLINGSWORTH BETWEEN COMMERCIAL & SUNSET				BLOCKAGE
ARDMORE	S30804	5/12/1999		"D" N.E. & MAIN ST				BLOCKAGE
ARDMORE	S30804	7/8/1999		100 BLK "H" ST N.W.				BLOCKAGE
ARDMORE	S30804	7/13/1999		CHICKASAW TOWERS				BLOCKAGE
ARDMORE	S30804	7/20/1999		4TH ST N.W. & NORTH DR.				BLOCKAGE
ARDMORE	S30804	8/2/1999		EASTWOOD CIRLE & WOODSIDE DR.				BLOCKAGE
ARDMORE	S30804	9/9/1999		RR AT 3RD & MAIN N.E.				BLOCKAGE
ARDMORE	S30804	9/28/1999		ROSS RD. & INDUSTRIAL VILLAGE RD.		X		BLOCKAGE
ARDMORE	S30804	10/27/1999		EAST OF MELODY LN ON MYALL RD.		X		BLOCKAGE
ARDMORE	S30804	11/9/1999		HOLIDAY DR. & ROCKFORD RD.				BLOCKAGE
ARDMORE	S30804	11/29/1999		SUNSET & W. MAIN		X		BLOCKED MAIN
ARDMORE	S30804	12/14/1999		2ND & "K" N.W./1811 9TH N.W.		X		BLOCKAGE/ODOR
ARDMORE	S30804	12/22/1999		"K" & EAST BROADWAY				BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	1/20/2000		PLAINVIEW & MYALL		X		BLOCKAGE
ARDMORE	S30804	2/10/2000		2ND & "K" N.W.		X		BLOCKAGE
ARDMORE	S30804	3/3/2000	24.00	ROCKFORD & 12TH N.W.	12,000	X		VALVE FAILURE
ARDMORE	S30804	3/8/2000	8.00	12TH N.W. & N. ROCKFORD RD.	8,000	X		VALVE FAILURE
ARDMORE	S30804	3/21/2000	1.00	VETERANS BLVD. & SOFTBALL COMPLEX RD.	135,000	X		RUPTURED MAIN
ARDMORE	S30804	4/13/2000	0.50	520 S. WILLARD	200	X		STOPPAGE
ARDMORE	S30804	4/17/2000		SUNSET & BROADWAY		X		BLOCKAGE
ARDMORE	S30804	5/15/2000		101 "H" N.W.				BLOCKAGE
ARDMORE	S30804	5/15/2000		101 "H" N.W.		X		BLOCKAGE
ARDMORE	S30804	5/15/2000	2.00	511 "G" S.W.	500	X		GREASE
ARDMORE	S30804	6/12/2000		101 "H" N.W.				BLOCKAGE
ARDMORE	S30804	8/22/2000		E. OF COMMERCE & S. OF MYALL		X		TREE ROOTS & GREASE
ARDMORE	S30804	9/9/2000		816 FREEMAN				BUCKET IN LINE
ARDMORE	S30804	11/13/2000		7TH & "S"				BLOCKAGE
ARDMORE	S30804	12/1/2000		E. OF COMMERCE & S. OF MYALL		X		ROOTS
ARDMORE	S30804	12/11/2000	1.00	1115 COUNTRY WOOD ESTATES	750	X		HOLE IN LINE
ARDMORE	S30804	12/21/2000	2.00	COUNTRY WOOD ESTATES	2,000	X		VALVE STUCK
ARDMORE	S30804	1/11/2001		AT 3RD "S" ST	20,000	X		ROOTS
ARDMORE	S30804	1/11/2001		E. SIDE OF TRUCK BYPASS	3,000	X		ROOTS
ARDMORE	S30804	1/11/2001	120.00	SUTTON RD	20,000	X		ROOTS
ARDMORE	S30804	1/30/2001	3.00	1323 S. COMMERCE	5,000	X		GREASE
ARDMORE	S30804	3/5/2001						
ARDMORE	S30804	4/11/2001	48.00	920 ISABELL	500	X		OBSTRUCTION
ARDMORE	S30804	4/27/2001	48.00	DORNICK HILLS L.S.	20,000	X		HOLE IN LINE
ARDMORE	S30804	5/1/2001						
ARDMORE	S30804	5/3/2001	48.00	SUTTON RD.	8,000			BLOCKAGE
ARDMORE	S30804	5/6/2001	48.00	CHAMPION STATION	7,000			MAIN VALVE FAILURE
ARDMORE	S30804	5/6/2001	1.00	PINE & ASH	150	X		BLOCKAGE
ARDMORE	S30804	5/30/2001	2.00	L.S. "A " AT HEDGES RD	30,000			POWER OUTAGE
ARDMORE	S30804	9/13/2001	2.50	1219 SOUTH ROCKFORD RD.	350	X		ROOTS

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	9/20/2001	5.00	PETROLEUM LAND TREATMENT UNIT ON SUTTON RD.	1,000	X		ROOTS
ARDMORE	S30804	10/4/2001	5.00	L.S. D ON 1610 MCLAINE RD	5,000			MAIN BREAK
ARDMORE	S30804	10/8/2001	9.00	244 EAST WOOD LN.	4,800	X		HOLE IN LINE
ARDMORE	S30804	10/23/2001	2.00	MYALL RD BETWEEN MELODY & WESTERN HEIGHTS	2,500	X		ROOTS
ARDMORE	S30804	11/6/2001	1.50	1902 KNOX RD.	200	X		BLOCKAGE
ARDMORE	S30804	11/8/2001	1.00	109 "H" ST	75	X		BLOCKAGE
ARDMORE	S30804	11/9/2001	1.00	1902 KNOX RD	75	X		BLOCKAGE
ARDMORE	S30804	11/13/2001	77.00	DORNICK HILLS L.S.	35,000	X		AIR LOCKED FORCE MAIN
ARDMORE	S30804	11/19/2001	0.50	MESA & MT. WASHINGTON RD.	500			TRYING TO REPAIR MAIN
ARDMORE	S30804	1/29/2002	0.00	2605 W. BROADWAY				
ARDMORE	S30804	2/7/2002	0.00	2302 KNOX RD.	7,000	X		PLUGGED LINE
ARDMORE	S30804	3/15/2002	2.00	115 MONROE N.E.	1,000	X		ROOTS
ARDMORE	S30804	3/18/2002	0.50	10TH & MYAH S.E.	500	X		OBSTRUCTION
ARDMORE	S30804	3/27/2002	1.50	"H" ST & 2ND N.W.	<500	X		BROKEN MAIN
ARDMORE	S30804	3/28/2002	2.50	DORNICK HILLS L.S.	<500	X		MALFUNCTION
ARDMORE	S30804	4/12/2002	1.00	LAKE MURRAY DR. & "D" ST	>500	X		OBSTRUCTION
ARDMORE	S30804	4/15/2002	3.60	CHATANOOGA RD.	1,500	X		OBSTRUCTION
ARDMORE	S30804	4/19/2002	4.00	W. OF MT. WASHINGTON RD.	5,000	X		OBSTRUCTION
ARDMORE	S30804	5/8/2002	1.70	MT. WASHINGTON 1 BLK S. OF 142 BYPASS	3,500	X		OBSTRUCTION
ARDMORE	S30804	5/15/2002	1.00	"H" & N.W. BEHIND CHICKASAW TOWERS	<500	X		LINE BLOCKAGE
ARDMORE	S30804	7/8/2002	0.00	MYALL & S. PLAINVIEW RD.	<500	X		BUSTED LINE
ARDMORE	S30804	7/9/2002	0.00	500 E. OF HWY 142 BYPASS	20,000	X		OBSTRUCTION
ARDMORE	S30804	8/22/2002	4.00	S.E. FENCE OF PLAINVIEW SCHOOL	<500	X		BROKEN PIPE
ARDMORE	S30804	8/26/2002	1.00	2ND & "H"	<500	X		BLOCKAGE
ARDMORE	S30804	9/24/2002	6.50	DREW ST. & COMMERCE	1,000	X		BLOCKAGE
ARDMORE	S30804	10/4/2002	0.00	E. OF MIDDLE SCHOOL ON HWY 142	100	X		PLUGGED LINE
ARDMORE	S30804	11/16/2002	0.00	1000 BLK OF S. COMMERCE	80,000	X		DEBRIS

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	12/8/2002	0.00	CHATTANOOGA RD. & RAILHEAD ST.	<1,000	X		DEBRIS
ARDMORE	S30804	12/17/2002	1.30	CLOVERLEAF DR. & ROCKFORD RD.	<100	X		BROKEN PIPE
ARDMORE	S30804	12/24/2002	3.00	1219 S. ROCKFORD RD.	3,000	X		BLOCKAGE
ARDMORE	S30804	12/31/2002	0.40	DEAD END OF CHATANOOGA RD.	<250	X		BLOCKAGE
ARDMORE	S30804	1/2/2003	1.30	AUGUSTA & ROCKFORD RD.	<1,000	X		DEBRIS
ARDMORE	S30804	1/10/2003	0.70	312 ASH	<1,000	X		OBSTRUCTION
ARDMORE	S30804	1/24/2003	3.00	CARTER & 9TH	<1,000	X		OBSTRUCTION
ARDMORE	S30804	1/24/2003	1.00	"C" & BOYD	500	X		OBSTRUCTION
ARDMORE	S30804	1/27/2003	0.00	S. OF 110 "S" ST N.E.	6,000	X		OBSTRUCTION
ARDMORE	S30804	2/13/2003	0.50	CHAMPION STATION N.W.	150	X		DEBRIS
ARDMORE	S30804	2/15/2003	0.00	ISABEL RD. & MYALL RD.	1,000	X		OBSTRUCTION
ARDMORE	S30804	2/19/2003	9.50	MESA RD. - 1/2 MILE WEST OF REFINERY RD.	40,000	X		CRACK IN PIPE
ARDMORE	S30804	3/17/2003	2.40	ROCKFORD RD. & 12TH	500	X		BLOCKAGE
ARDMORE	S30804	3/24/2003	13.50	FLOYD & ALLEN	200	X		BLOCKAGE
ARDMORE	S30804	3/26/2003	4.00	1806 W. MAIN	2,500	X		BLOCKAGE
ARDMORE	S30804	4/7/2003	1.50	110 "H" ST.	<200	X		BLOCKAGE
ARDMORE	S30804	4/11/2003	0.00	25 ROCKFORD RD.	12,000	X		ROOTS
ARDMORE	S30804	4/14/2003	0.00	25 ROCKFORD RD.	10,000	X		BLOCKAGE
ARDMORE	S30804	5/12/2003	0.50	2ND & "K" N.W.	750	X		OBSTRUCTION
ARDMORE	S30804	5/31/2003	5.00	CHATTANOOGA & RAILWAY RD.	<1,000	X		BLOCKAGE
ARDMORE	S30804	6/2/2003	1.50	518 "D" S.E.	1,000	X		OBSTRUCTION
ARDMORE	S30804	6/3/2003	1.30	6TH & "D" S.E.	<250	X		OBSTRUCTION
ARDMORE	S30804	6/5/2003	1.40	RAILHEAD EXPRESS & STATION RD.	<500	X		OBSTRUCTION
ARDMORE	S30804	6/10/2003	2.00	"L" & SAM NOBLE PKWY	4,000	X		BROKEN LINE
ARDMORE	S30804	6/10/2003	0.00	118 8TH ST. S.E.	500	X		OBSTRUCTION
ARDMORE	S30804	6/24/2003	0.40	3RD & "L" N.E.	<250	X		OBSTRUCTION
ARDMORE	S30804	6/24/2003	0.40	"K" & 2ND	<500	X		OBSTRUCTION
ARDMORE	S30804	6/30/2003	0.70	104 "H" ST. N.W.	500	X		BLOCKAGE
ARDMORE	S30804	7/12/2003	0.60	1570 CHICKASAW LAKE CLUB	200	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	8/14/2003	1.30	918 3RD N.E.	1,000	X		BLOCKAGE
ARDMORE	S30804	8/21/2003	0.70	1201 "L" N.E.	1,500	X		BROKEN PIPE
ARDMORE	S30804	9/8/2003	3.00	9TH & CARTER S.E.	<1,000	X		OBSTRUCTION
ARDMORE	S30804	9/15/2003	0.50	"H" ST. N.W.	<500	X		BLOCKAGE
ARDMORE	S30804	9/16/2003	1.00	ROCKFORD RD. & WOOD-N-CREEK	200	X		OBSTRUCTION
ARDMORE	S30804	9/19/2003	2.00	12TH & ROCKFORD RD.	30,000	X		BLOCKAGE
ARDMORE	S30804	10/1/2003	1.00	CAMPBELL & MT. WASHINGTON	2,000	X		BLOCKAGE
ARDMORE	S30804	10/9/2003	3.30	4 N.W. & NORTH DR.	3,500	X		OBSTRUCTION
ARDMORE	S30804	10/27/2003	0.80	"H" & 1ST	<300	X		OBSTRUCTION
ARDMORE	S30804	11/6/2003	3.00	DORNICK HILLS	1,000		X	MALFUNCTION
ARDMORE	S30804	11/11/2003	1.90	513 ECHOL HOLLOW TR.	75	X		ROOTS
ARDMORE	S30804	11/15/2003	1.00	STANLEY & WASHINGTON	500	X		OBSTRUCTION
ARDMORE	S30804	11/19/2003	0.70	12TH & ROCKFORD RD.	<300	X		OBSTRUCTION
ARDMORE	S30804	11/21/2003	0.50	N. COMMERCE & MERRICK AVE	<500	X		OSTRUCTION
ARDMORE	S30804	11/28/2003	12.00	S. OF 3600 SUTTON RD.	3,000	X		BLOCKAGE
ARDMORE	S30804	12/19/2003	0.50	2ND & "H" ST	100	X		BLOCKAGE
ARDMORE	S30804	12/26/2003	0.50	2701 12TH N.W.	700	X		OBSTRUCTION
ARDMORE	S30804	1/7/2004	1.00	1024 S. COMMERCE	1,000	X		BLOCKAGE
ARDMORE	S30804	1/12/2004	1.00	800 BLK. MYALL ST. S.W.	1,000	X		BLOCKAGE
ARDMORE	S30804	2/18/2004	2.00	1107 FRANKLIN	200	X		OBSTRUCTION
ARDMORE	S30804	2/24/2004	7.00	S. OF 3600 SUTTON RD.	1,000	X		FLOODING
ARDMORE	S30804	3/4/2004	0.70	CAMPBELL & MT. WASHINGTON RD.	500	X		RAINS
ARDMORE	S30804	3/4/2004	1.50	S. OF 3600 SUTTON RD.	1,000	X		RAIN
ARDMORE	S30804	3/7/2004	1.00	S. OF BROADWAY & COMMERCE	500	X		OBSTRUCTION
ARDMORE	S30804	3/8/2004	1.30	S. SIDE OF LOWES STORE	1,500	X		OBSTRUCTION
ARDMORE	S30804	3/9/2004	1.00	W. OF ASHBROOK APTS. ON KNOX RD.	1,000	X		OBSTRUCTION
ARDMORE	S30804	3/18/2004	0.70	6TH & FRISCO	500	X		BLOCKAGE
ARDMORE	S30804	4/5/2004	1.00	10TH & "A" ST. S.E.	500	X		BLOCKAGE
ARDMORE	S30804	4/6/2004	2.00	BEHIND ATLAS ROOFING CO. - 142 BYPASS	1,500	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	4/13/2004	0.50	W. MAIN	500	X		BLOCKAGE
ARDMORE	S30804	4/23/2004	0.00	3600 SUTTON RD.	3,000	X		STORM WATER
ARDMORE	S30804	4/27/2004	1.00	EAST SIDE OF 2605 W. BROADWAY	1,000	X		BLOCKAGE
ARDMORE	S30804	5/10/2004	0.00	CHICKASAW CLUB LAKE RD.	1,500	X		BLOCKAGE
ARDMORE	S30804	5/25/2004	0.00	601 ANDERSON ST. S.E.	100	X		BLOCKAGE
ARDMORE	S30804	5/30/2004	0.00		1,000			BLOCKED LINE
ARDMORE	S30804	6/6/2004	0.00	ATLAS ROOFING NEAR RR	5,000	X		BLOCKAGE
ARDMORE	S30804	6/9/2004	0.00	3600 SUTTON RD.	4,000	X		RAIN
ARDMORE	S30804	6/13/2004	0.00	402 PARK ST.	5,000	X		BLOCKED LINE
ARDMORE	S30804	6/16/2004	2.00	"H" ST. N.W.	500	X		BLOCKAGE
ARDMORE	S30804	6/30/2004	1.50	1522 MT. WASHINGTON				RAINS
ARDMORE	S30804	6/30/2004	2.40	1522 BLK. MT WASHINGTON RD.	750	X		RAINS
ARDMORE	S30804	6/30/2004	0.00	S. OF 3600 SUTTON	5,000	X		FLOOD WATERS
ARDMORE	S30804	7/1/2004	0.00	E. OF REFINERY RD. ON DEAD END OF MONROE	>1,000	X		RAINS
ARDMORE	S30804	7/23/2004	7.50	MYALL & MELODY DR.	500	X		OBSTRUCTION
ARDMORE	S30804	9/13/2004	6.40	GENE AUTRY , OKLA	50,000		X	LAGOON DOWN FOR REPAIRS
ARDMORE	S30804	9/14/2004	24.00	402 PARK	5,000	X		BLOCKAGE
ARDMORE	S30804	9/17/2004	0.00	N. 142 BYPASS, E. OF MT. WASHINGTON	1,000	X		BLOCKAGE
ARDMORE	S30804	9/27/2004	0.00	1809 W. MAIN	2,000	X		BLOCKAGE
ARDMORE	S30804	9/29/2004	2.00	1809 W. MAIN	500	X		BLOCKAGE
ARDMORE	S30804	10/3/2004	2.00	"H" ST. N.W.	500	X		LINE BLOCKAGE
ARDMORE	S30804	10/6/2004	0.60	MELODY & MYALL	500	X		BLOCKAGE
ARDMORE	S30804	10/6/2004	2.20	1401 MONROE	1,000	X		BLOCKAGE
ARDMORE	S30804	10/11/2004	0.00	S. OF 3600 SUTTON RD.	5,000	X		FLOODING
ARDMORE	S30804	10/27/2004	0.50	"Q" & "I" ST. S.W.	300	X		BLOCKAGE
ARDMORE	S30804	10/27/2004	1.50	1401 MONROE	1,000	X		BLOCKAGE
ARDMORE	S30804	11/1/2004	0.50	1401 MONROE	2,000	X		BLOCKAGE
ARDMORE	S30804	11/3/2004	0.00	S. OF 3600 SUTTON RD.	3,000	X		FLOODING
ARDMORE	S30804	11/12/2004	0.00	400 CAMERON AVE.				DAMAGED PIPE
ARDMORE	S30804	11/12/2004	0.50	2605 W. BROADWAY	1,000	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	11/17/2004	12.00	S. OF 3600 SUTTON RD.	5,000	X		RAIN
ARDMORE	S30804	11/18/2004	1.50	"E" & 9TH S.E.	500	X		BLOCKAGE
ARDMORE	S30804	11/23/2004	1.50	400 CAMERON AVE	2,000	X		DAMAGED PIPE
ARDMORE	S30804	12/3/2004	0.50	24TH & MONROE N.E.	500	X		BROKEN PIPE
ARDMORE	S30804	12/7/2004	1.00	N. OF DOWNTOWN AIRPARK	1,000	X		BLOCKAGE
ARDMORE	S30804	12/9/2004	1.50	N.E. OF BURGER KING ON BROADWAY	2,000	X		BLOCKAGE
ARDMORE	S30804	12/10/2004	0.00	400 LOCUST	800	X		BLOCKAGE
ARDMORE	S30804	12/20/2004	2.00	715 VIRGINIA LN.	300	X		BLOCKAGE
ARDMORE	S30804	12/23/2004	0.00	1217 ROCKFORD RD.	<1,000	X		BLOCKAGE
ARDMORE	S30804	12/27/2004	2.50	"H" ST. N.W.	1,000	X		BLOCKAGE
ARDMORE	S30804	1/4/2005	0.50	AUGUSTA RD.	100	X		BLOCKAGE
ARDMORE	S30804	1/5/2005	48.00	S. OF 3600 SUTTON RD.	5,000	X		RAINS
ARDMORE	S30804	1/24/2005	0.50	402 PARK ST. S.E.	300	X		BLOCKAGE
ARDMORE	S30804	1/29/2005	2.00	MT. WASHINGTON & COTTONWOOD	1,000	X		BLOCKAGE
ARDMORE	S30804	2/9/2005	10.50	3600 SUTTON RD.	4,500	X		OVERFLOW
ARDMORE	S30804	2/12/2005	10.00	S. OF 36TH & SUTTON RD.	2,000	X		RAIN
ARDMORE	S30804	2/18/2005	0.50	1315 SUNSET DR.	50	X		BLOCKAGE
ARDMORE	S30804	2/25/2005	1.00	6TH & FRISCO S.W.	2,000	X		BLOCKAGE
ARDMORE	S30804	3/1/2005	0.50	1809 W. MAIN	700	X		BLOCKAGE
ARDMORE	S30804	3/2/2005	1.50	W. OF ASHBROOK APTS.	1,500	X		BLOCKAGE
ARDMORE	S30804	3/4/2005	0.70	118 "I" ST N.E.	100	X		BLOCKAGE
ARDMORE	S30804	3/10/2005	0.40	3 & "K" N.W.	300	X		BLOCKAGE
ARDMORE	S30804	3/31/2005	1.00	2701 12TH ST. N.W. IN FRONT OF LOWES	200	X		BLOCKAGE
ARDMORE	S30804	4/1/2005	0.00	N. OF ROSS ST. N.E.	5,000	X		BLOCKAGE
ARDMORE	S30804	4/4/2005	0.00	E. OF 142 BYPASS BRIDGE	1,200	X		BLOCKAGE
ARDMORE	S30804	4/13/2005	0.50	2423 W. VETERANS BLVD.	500	X		BLOCKAGE
ARDMORE	S30804	5/2/2005	1.50	ARDMORE H.S. ON PRACTICE FIELD	50	X		BLOCKAGE
ARDMORE	S30804	5/3/2005	0.00	PETTIT & MCCULLOH	1,000	X		BROKEN PIPE
ARDMORE	S30804	6/5/2005	8.00	S. OF 3600 SUTTON RD.	5,000			RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	6/8/2005	0.00	1708 9TH N.W.	1,500	X		BLOCKAGE
ARDMORE	S30804	7/2/2005	5.00	11TH & "K" N.E.	2,000	X		BLOCKAGE
ARDMORE	S30804	7/11/2005	0.00	118 "I" ST. N.E.		X		BLOCKAGE
ARDMORE	S30804	8/15/2005	53.50	3600 SUTTON RD.	10,000	X		RAIN
ARDMORE	S30804	9/1/2005	0.50	1807	20			BLOCKAGE
ARDMORE	S30804	9/9/2005	0.50	COTTONWOOD & ASH N.W.	500	X		BLOCKED LINE
ARDMORE	S30804	9/24/2005	3.00	S. OF POLO'S RESTAURANT	500	X		BLOCKAGE
ARDMORE	S30804	9/30/2005	0.00	BEHIND TIFFANY'S PLAZA MALL IN WOODED AREA		X		LINE BLOCKAGE
ARDMORE	S30804	12/9/2005	0.00	STANLEY & S. WASHINGTON	500	X		BLOCKAGE
ARDMORE	S30804	12/14/2005	2.00	402 PARK ST. S.E.	500	X		BLOCKAGE
ARDMORE	S30804	12/15/2005	0.70	2215 REMINGTON CT.	200	X		BLOCKAGE
ARDMORE	S30804	12/22/2005	3.00	RAILWAY EXPRESS S.W. BEHIND 2 FROGS	1,000	X		BLOCKAGE
ARDMORE	S30804	12/22/2005	1.20	1900 4TH N.W.	500	X		BLOCKAGE
ARDMORE	S30804	12/27/2005	0.00	9TH & CARTER	200	X		BLOCKAGE
ARDMORE	S30804	1/4/2006	0.40	1302 3RD S.W.	200	X		BLOCKAGE
ARDMORE	S30804	1/18/2006	0.00	2605 W. BROADWAY		X		AIR RELEASE VALVE WAS OPENED
ARDMORE	S30804	2/7/2006	1.00	1204 S. ROCKFORD	300	X		BLOCKAGE
ARDMORE	S30804	2/16/2006	3.00	9TH & CARTER	200	X		BLOCKAGE
ARDMORE	S30804	3/16/2006	1.50	CAMPBELL & WASHINGTON	200	X		BLOCKAGE
ARDMORE	S30804	3/19/2006	1.00	3600 SUTTON RD.	500	X		RAIN
ARDMORE	S30804	3/27/2006	4.00	1809 7TH N.W.	700	X		BLOCKAGE
ARDMORE	S30804	4/3/2006	24.00	2ND & "I" ST. N.E.	600	X		BLOCKAGE
ARDMORE	S30804	4/3/2006	0.00	1409 OAK RIDGE	1,500	X		BLOCKAGE
ARDMORE	S30804	4/3/2006	2.00	101 "H" ST. N.W.	250	X		BLOCKAGE
ARDMORE	S30804	5/7/2006	0.00	2605 W. BROADWAY		X		BLOCKAGE
ARDMORE	S30804	5/8/2006	10.00	2831 HEDGES RD	500	X		PUMP FAILURE
ARDMORE	S30804	5/8/2006	2.00	2ND & "K" N.W.	200	X		LINE BLOCKAGE
ARDMORE	S30804	5/12/2006	0.90	403 LOCUST ST.	500	X		BLOCKAGE
ARDMORE	S30804	6/12/2006	0.00	WILLOW PARK APTS. - MONROE N.E.	1,500	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	6/28/2006	0.00	MONROE & "B" N.W.		X		LINE BLOCKAGE
ARDMORE	S30804	8/9/2006	0.50	110 "H" ST. N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	8/10/2006	9.00	2ND & "I" ST N.E.	<1,000	X		BLOCKAGE
ARDMORE	S30804	9/1/2006	0.40	3600 SUTTON RD.	200	X		BLOCKAGE
ARDMORE	S30804	9/5/2006	3.20	MT. WASHINGTON RD.	<1,000	X		BLOCKAGE
ARDMORE	S30804	9/7/2006	0.00	BURGER KING ON BROADWAY		X		BLOCKAGE
ARDMORE	S30804	11/20/2006	2.00	701 ROSEWOOD	200	X		BLOCKAGE
ARDMORE	S30804	11/27/2006	0.00	ASH & PINE N.W.	750	X		BLOCKAGE
ARDMORE	S30804	12/12/2006	0.00	GRACE BAPTIST TEMPLE- MT. WASHINGTON RD.		X		BLOCKAGE
ARDMORE	S30804	12/15/2006	0.00	WILLOWBROOK APTS.		X		LINE BREAK
ARDMORE	S30804	12/18/2006	1.00	811 ROCKFORD PL.	<100	X		BLOCKAGE
ARDMORE	S30804	12/20/2006	0.00	118 "I" ST. N.E.		X		BLOCKAGE
ARDMORE	S30804	1/17/2007	1.50	1115 8TH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	1/22/2007	0.00	2702 CROSSROADS	1,000	X		BLOCKAGE
ARDMORE	S30804	2/1/2007	0.60	110 "H" ST. N.W.	500	X		BLOCKAGE
ARDMORE	S30804	2/5/2007	0.00	N. OF OAK HALL SCHOOL		X		BLOCKAGE
ARDMORE	S30804	2/8/2007	0.00	SOUTH OF MAYO TRAILER PARK				BLOCKAGE
ARDMORE	S30804	2/21/2007	0.00	MT. WASHINGTON RD.		X		BLOCKAGE
ARDMORE	S30804	2/28/2007	0.00	13TH & "A" ST. N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	3/7/2007	0.00	"O" ST. & 1ST ST. N.W.	200	X		PLUG LEAKING
ARDMORE	S30804	3/12/2007	0.40	"A" & MONROE	300	X		BLOCKAGE
ARDMORE	S30804	3/15/2007	0.00	W. OF VETERANS CENTER		X		BLOCKAGE
ARDMORE	S30804	3/28/2007	0.00	300 ASH N.W.	<1,000			BLOCKAGE
ARDMORE	S30804	3/30/2007	2.00	3600 SUTTON RD.	2,000		X	RAIN
ARDMORE	S30804	5/3/2007	24.00	3600 SUTTON RD.	5,000		X	RAIN
ARDMORE	S30804	5/5/2007	0.00	1341 S. COMMERCE	20	X		BLOCKAGE
ARDMORE	S30804	5/17/2007	2.40	1ST & "P" ST. S.W.	500	X		LINE BLOCKAGE
ARDMORE	S30804	5/23/2007	0.00	ROCKFORD & W. BROADWAY	<1,000	X		BLOCKAGE
ARDMORE	S30804	5/23/2007	0.00	W. END OF ROSS @ RAILROAD TRACK	1,200	X		BLOCKAGE
ARDMORE	S30804	5/27/2007	0.00	3600 SUTTON RD.		X		RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	5/29/2007	0.00	1341 S. COMMERCE		X		BLOCKAGE
ARDMORE	S30804	5/29/2007	0.00	1341 S. COMMERCE				
ARDMORE	S30804	5/30/2007	2.10	1900 HARMONY LN				FLOODING
ARDMORE	S30804	6/12/2007	0.00	1601 4TH AVE. N.W.		X		BLOCKAGE
ARDMORE	S30804	6/13/2007	4.00	2902 MT. WASHINGTON	<1,000	X		BLOCKAGE
ARDMORE	S30804	6/14/2007	1.00	606 "D" N.W.	100	X		RAIN
ARDMORE	S30804	6/14/2007	1.50	111 N. COMMERCE	<100	X		RAIN
ARDMORE	S30804	6/15/2007	0.00	2605 W. BROADWAY		X		BLOCKAGE
ARDMORE	S30804	6/19/2007	0.00	1900 MELODY		X		RAIN
ARDMORE	S30804	6/20/2007	0.00	111 N. COMMERCE	<500	X		RAIN
ARDMORE	S30804	6/20/2007	0.00	1341 S. COMMERCE		X		RAIN
ARDMORE	S30804	6/21/2007	2.50	2902 MT. WASHINGTON RD.	>1,000	X		BLOCKAGE
ARDMORE	S30804	6/22/2007	54.00	3600 SUTTON RD.		X		RAIN
ARDMORE	S30804	6/22/2007	0.00	111 N. COMMERCE		X		FLOODING
ARDMORE	S30804	6/26/2007	17.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	6/26/2007	0.00	111 N. COMMERCE				RAIN
ARDMORE	S30804	6/26/2007	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	6/26/2007	242.40	3600 SUTTON RD.		X		RAIN
ARDMORE	S30804	6/27/2007	2.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	6/27/2007	0.40	N. SUNSET		X		BLOCKAGE
ARDMORE	S30804	6/29/2007	2.50	"I" ST. & THIRD N.E.		X		RAIN
ARDMORE	S30804	7/2/2007	4.50	3RD & "K" ST. N.W.		X		RAIN
ARDMORE	S30804	7/2/2007	0.00	1900 HARMONY LN.		X		RAIN
ARDMORE	S30804	7/3/2007	0.00	SUNSET & MELODY		X		RAIN
ARDMORE	S30804	7/3/2007	0.00	1800 MELODY		X		RAIN
ARDMORE	S30804	7/3/2007	0.00	1900 HARMONY		X		RAIN
ARDMORE	S30804	7/3/2007	0.00	1132 MELODY		X		RAIN
ARDMORE	S30804	7/4/2007	2.50	9TH & "E" ST. S.E.	500	X		RAIN
ARDMORE	S30804	7/10/2007	0.00	1341 S. COMMERCE		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	3RD & "I" ST N.E.		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	3600 SUTTON RD.		X		RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	7/10/2007	0.00	"B" & MONROE N.E.		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	3ND & "K" N.W.		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	3RD & "I" N.W.		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	1900 HARMONY		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	13TH & "C" S.E.		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	1800 HARMONY		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	7/10/2007	0.00	924 3RD N.W.		X		RAIN
ARDMORE	S30804	7/13/2007	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	7/13/2007	0.00	1002 HOWARD ST. S.W.	100	X		BUSTED PIPE
ARDMORE	S30804	7/20/2007	0.00	1811 9TH N.W.		X		BLOCKAGE
ARDMORE	S30804	7/26/2007	0.00	S.E. VETERANS & MT WASHINGTON				BLOCKAGE
ARDMORE	S30804	7/29/2007	0.00	E. OF PLAINVIEW SCHOOL ON MYALL RD.		X		BLOCKAGE
ARDMORE	S30804	7/30/2007	0.00	1029 "K" N.E.	500	X		BLOCKAGE
ARDMORE	S30804	7/31/2007	0.00	"H" ST. N.W. @1ST & 2ND	500	X		
ARDMORE	S30804	8/3/2007	0.00	2410 OAK HOLLOW		X		BLOCKAGE
ARDMORE	S30804	8/3/2007	0.00	2410 OAK HOLLOW				
ARDMORE	S30804	8/12/2007	0.00	2605 WOODEN CREEK		X		BLOCKAGE
ARDMORE	S30804	8/14/2007	0.70	"L" N.E. @ HUNTINGTON FALLS APTS.	<200	X		BLOCKAGE
ARDMORE	S30804	8/17/2007	2.60	4TH & "E" ST. N.W.	500	X		BLOCKAGE
ARDMORE	S30804	9/7/2007		226 7TH N.W.	100			BLOCKAGE
ARDMORE	S30804	9/10/2007	0.20	226 7TH N.W.	20	X		BLOCKAGE
ARDMORE	S30804	9/18/2007	4.50	422 N. ASH N.W.	1,000	X		BLOCKAGE
ARDMORE	S30804	9/23/2007	0.00	2900 MYALL RD.	500	X		VALVE LEAK
ARDMORE	S30804	9/25/2007	0.00	"K" & 11TH ST. N.E.	200	X		BLOCKAGE
ARDMORE	S30804	10/2/2007	0.40	4TH & "N" N.E.	175	X		BLOCKAGE
ARDMORE	S30804	10/2/2007	0.00	222 7TH AVE. N.W.	25	X		BLOCKAGE
ARDMORE	S30804	10/3/2007	0.00	1722 WILDEWOOD	400	X		BLOCKAGE
ARDMORE	S30804	10/4/2007	1.30	"M" ST. & 4TH AVE. N.E	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	10/15/2007	0.50	SUNSET & W. BROADWAY	<100	X		BLOCKAGE
ARDMORE	S30804	10/20/2007	0.00	810 BURCH	<500	X		BLOCKAGE
ARDMORE	S30804	10/22/2007	0.00	751 MCCULLOUGH	35	X		BLOCKAGE
ARDMORE	S30804	10/23/2007	0.00	6TH & "C" ST. S.E.	30	X		BLOCKAGE
ARDMORE	S30804	10/27/2007	0.00	311 ANDERSON ST. S.E.	55	X		BLOCKAGE
ARDMORE	S30804	10/27/2007		900 BLK. ASH N.W.	35	X		BLOCKAGE
ARDMORE	S30804	11/4/2007	0.30	"H" ST. & 4TH S.W.	3	X		BLOCKAGE
ARDMORE	S30804	11/9/2007	2.00	200 BLK. 6TH AVE S.E.	100	X		BLOCKAGE
ARDMORE	S30804	11/13/2007	0.00	226 7TH AVE. N.W.	200	X		BLOCKAGE
ARDMORE	S30804	11/17/2007	0.00	143 LUCILLE DR.	10	X		BLOCKAGE
ARDMORE	S30804	11/20/2007	0.00	1612 6TH S.W.	20	X		BLOCKAGE
ARDMORE	S30804	11/21/2007	0.00	120 "P" ST. N.E.	200	X		BLOCKAGE
ARDMORE	S30804	11/26/2007	0.00	400 EAST LAKE MURRAY DR.	100	X		BLOCKAGE
ARDMORE	S30804	11/26/2007	0.40	507 OAK N.W.	100	X		BLOCKAGE
ARDMORE	S30804	11/28/2007	0.00	2316 AUGUSTA S.W.	150	X		BLOCKAGE
ARDMORE	S30804	11/30/2007	2.00	426 LOCUST	100	X		BLOCKAGE
ARDMORE	S30804	11/30/2007	0.00	308 10TH S.E.	100	X		BLOCKAGE
ARDMORE	S30804	12/3/2007	0.00	308 10TH AVE. S.E.	25	X		BLOCKAGE
ARDMORE	S30804	12/7/2007	0.00	1008 "A" N.W.	300	X		BLOCKAGE
ARDMORE	S30804	12/7/2007		601 "C" S.E.	100	X		BLOCKAGE
ARDMORE	S30804	12/11/2007	1.60	111 N. COMMERCE	100	X		RAIN
ARDMORE	S30804	12/12/2007	0.90	412 EASTWOOD CT.	50	X		BLOCKAGE
ARDMORE	S30804	12/13/2007	0.40	109 "H" N.W.	100	X		BLOCKAGE
ARDMORE	S30804	12/13/2007	1.40	317 E. VETERANS BLVD.	50	X		BLOCKAGE
ARDMORE	S30804	12/20/2007	0.00	4TH & "H" ST. N.E.	100	X		BLOCKAGE
ARDMORE	S30804	12/21/2007	0.00	108 FREEMAN ST.	50	X		BLOCKAGE
ARDMORE	S30804	12/21/2007	0.00	415 4TH AVE. N.W.	100	X		BLOCKAGE
ARDMORE	S30804	12/30/2007	1.00	COMMERCE & BIXBY	30	X		BLOCKAGE
ARDMORE	S30804	1/3/2008	0.60	TIFFANY PLAZA ON N. SIDE	500	X		BLOCKAGE
ARDMORE	S30804	1/8/2008	0.00	MOUNTAIN VIEW MALL - 1211 N. COMMERCE	100	X		BLOCKAGE
ARDMORE	S30804	1/10/2008	0.50	303 "G" ST. S.E.	50	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	1/11/2008	0.00	920 S. ROCKFORD	50	X		BLOCKAGE
ARDMORE	S30804	1/14/2008	0.00	1309 4TH ST. N.E.	50	X		BLOCKAGE
ARDMORE	S30804	1/15/2008	0.60	118 "I" ST. N.E.	1,000	X		BLOCKAGE
ARDMORE	S30804	1/16/2008	0.00	KNOX & CRYSTALWOOD RD.	1,000	X		BLOCKAGE
ARDMORE	S30804	1/17/2008	0.00	115 MONROE	1,000	X		BLOCKAGE
ARDMORE	S30804	1/21/2008	0.00	PLAINVIEW SCHOOL @ 1140 S. PLAINVIEW RD.	50	X		BLOCKAGE
ARDMORE	S30804	1/23/2008	0.00	VACANT LOT @ ANDERSON & HEATH	25	X		BROKEN PIPE
ARDMORE	S30804	1/25/2008	0.00	115 MONROE	1,000	X		BLOCKAGE
ARDMORE	S30804	1/28/2008	0.00	709 "G" N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	1/28/2008	1.50	1204 S. ROCKFORD	100	X		BLOCKAGE
ARDMORE	S30804	1/29/2008	0.00	401 7TH AVE. N.E.	500	X		BLOCKAGE
ARDMORE	S30804	1/30/2008	0.60	711 ROCKFORD S.W.	500	X		BLOCKAGE
ARDMORE	S30804	2/1/2008	0.00	5TH & "C" S.W.	100	X		BLOCKAGE
ARDMORE	S30804	2/1/2008	0.30	115 MONROE N.E.	500	X		BLOCKAGE
ARDMORE	S30804	2/1/2008	0.00	MCLISH & S. COMMERCE	100	X		BLOCKAGE
ARDMORE	S30804	2/3/2008	0.00	1432 STONEBRIDGE PL.	<50	X		BLOCKAGE
ARDMORE	S30804	2/4/2008	2.00	1011 W. SPRINGDALE LOOP	<50	X		BLOCKAGE
ARDMORE	S30804	2/4/2008	0.00	7TH & "F" S.E.	250	X		BLOCKAGE
ARDMORE	S30804	2/5/2008	0.00	4 TIFFANY PLAZA	500	X		BLOCKAGE
ARDMORE	S30804	2/11/2008	0.00	710 ROFF	20	X		BLOCKAGE
ARDMORE	S30804	2/19/2008	2.00	1601 7TH AVE. N.W.	150	X		BLOCKAGE
ARDMORE	S30804	2/26/2008	0.30	511 VETERANS BLVD. (ARDMORE MIDDLE SCHOOL)	50	X		BLOCKAGE
ARDMORE	S30804	2/26/2008	0.00	EAST HWY 142	100	X		BLOCKAGE
ARDMORE	S30804	2/28/2008	0.00	415 4TH N.W.	25	X		BLOCKAGE
ARDMORE	S30804	3/2/2008	0.00	6TH & "E" S.E.	60	X		RAIN
ARDMORE	S30804	3/3/2008	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	3/17/2008	0.00	401 7TH N.E.	250	X		BLOCKAGE
ARDMORE	S30804	3/18/2008	0.00	S. OF REFINERY ON 142		X		RAIN
ARDMORE	S30804	3/18/2008	0.00	1650 SAM NOBLE PKWY		X		RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	3/18/2008	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	3/18/2008	0.00	9TH & "E" S.E.		X		RAIN
ARDMORE	S30804	3/18/2008	0.00	HWY 142, W. OF PUBLIC WORKS		X		RAIN
ARDMORE	S30804	3/18/2008	0.00	"K" & 2ND N.W.		X		RAIN
ARDMORE	S30804	3/19/2008	12.00	S. OF 3600 SUTTON RD.	1,000	X		RAIN
ARDMORE	S30804	3/24/2008	0.00	9TH & "K" N.W.	100	X		BLOCKAGE
ARDMORE	S30804	3/25/2008	0.00	4TH & "N" N.E.	50	X		BLOCKAGE
ARDMORE	S30804	3/26/2008	0.00	"F" & GRAND N.W.	50	X		BLOCKAGE
ARDMORE	S30804	3/26/2008	0.00	3RD & "K" N.W.	100	X		BLOCKAGE
ARDMORE	S30804	3/27/2008	0.00	619 INTERSTATE DR.	<1,000	X		BLOCKAGE
ARDMORE	S30804	3/29/2008	0.00	"H" & 5TH ST. S.W.	<50	X		BLOCKAGE
ARDMORE	S30804	4/1/2008	0.00	103 "G" N.W.		X		BLOCKAGE
ARDMORE	S30804	4/3/2008	0.00	WILKINSON'S NURSERY @ 25 ROCKFORD RD.	1,000	X		BLOCKAGE
ARDMORE	S30804	4/4/2008	0.00	2605 W. BROADWAY AT BURGER KING	100	X		LEAKING AIR RELEASE VALVE
ARDMORE	S30804	4/10/2008	0.00	6TH & "B" N.W.	100	X		RAIN
ARDMORE	S30804	4/10/2008	0.00	111 N. COMMERCE	100	X		RAIN
ARDMORE	S30804	4/13/2008	11.50	433 "H" S.W.	25	X		BROKEN PIPE
ARDMORE	S30804	4/14/2008	0.00	N. OF 142 @ MT. WASHINGTON & REFINERY RD.	1,000	X		BLOCKAGE
ARDMORE	S30804	4/16/2008	0.00	315 4TH N.W.	100	X		BLOCKAGE
ARDMORE	S30804	4/18/2008	0.70	W. MAIN S.W. & 1ST S.W. ON "P" ST.	100	X		BLOCKAGE
ARDMORE	S30804	4/21/2008	0.70	1503 W. MAIN	<50	X		BLOCKAGE
ARDMORE	S30804	4/22/2008	0.00	517 15TH N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	4/25/2008	0.00	CHATTANOOGA & RAILHEAD LOOP	250	X		BLOCKAGE
ARDMORE	S30804	4/28/2008	0.00	MT WASHINGTON RD. BEHIND GRACE BAPTIST TEMPLE	1,000	X		BLOCKAGE
ARDMORE	S30804	5/2/2008	1.70	7TH & "Q" ST. S.W.	50	X		BLOCKAGE
ARDMORE	S30804	5/6/2008	0.00	111 COMMERCE		X		RAIN
ARDMORE	S30804	5/9/2008	0.00	1302 3RD S.W.	50	X		BLOCKAGE
ARDMORE	S30804	5/17/2008	1.00	200 BLK. "N" ST N.E.	50	X		BLOCKAGE
ARDMORE	S30804	5/21/2008	0.00	ASH & PINE ST. N.W.		X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	5/22/2008	0.00	1410 W. MAIN	200	X		BLOCKAGE
ARDMORE	S30804	5/27/2008	0.80	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	6/2/2008	0.00	402 PARK ST.	<100	X		BLOCKAGE
ARDMORE	S30804	6/2/2008	0.00	1638 CHICKASAW LAKE CLUB DR.	<50	X		BLOCKAGE
ARDMORE	S30804	6/3/2008	0.00	1219 S. ROCKFORD	100	X		BLOCKAGE
ARDMORE	S30804	6/7/2008	2.00	CHICKASAW LAKE CLUB RD.	150	X		BLOCKAGE
ARDMORE	S30804	6/9/2008	0.00	HURST RD. & N. COMMERCE		X		RAIN
ARDMORE	S30804	6/9/2008	0.00	111 N. COMMERCE		X		RAIN
ARDMORE	S30804	6/18/2008	0.00	200 BLK. "N" ST. N.E.	50	X		BLOCKAGE
ARDMORE	S30804	6/23/2008	0.00	407 7TH N.E.	150	X		BLOCKAGE
ARDMORE	S30804	6/30/2008	0.00	CHURCH ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	7/2/2008	0.00	422 ASH	100	X		BLOCKAGE
ARDMORE	S30804	7/3/2008	2.00	332 ASH ST. N.W.	<500	X		BLOCKAGE
ARDMORE	S30804	7/3/2008	0.40	E. OF MIDDLE SCHOOL	<50	X		BLOCKAGE
ARDMORE	S30804	7/3/2008	0.00	401 7TH AVE. N.E.	200	X		BROKEN PIPE
ARDMORE	S30804	7/8/2008	0.00	402 PARK ST.	100	X		BLOCKAGE
ARDMORE	S30804	7/17/2008	0.00	7TH ST N.E.	100	X		BLOCKAGE
ARDMORE	S30804	7/28/2008	0.40	111 "A" ST. N.W.	<1	X		BLOCKAGE
ARDMORE	S30804	8/5/2008	0.00	SUNSET & MCLISH	<100	X		BLOCKAGE
ARDMORE	S30804	8/6/2008	0.20	3600 SUTTON RD.	5	X		PRESSURE IN MAIN
ARDMORE	S30804	8/6/2008	0.00	ARDMORE HIGH SCHOOL	5,000	X		BUSTED PIPE
ARDMORE	S30804	8/10/2008	1.30	109 "H" N.W.	250	X		BLOCKAGE
ARDMORE	S30804	8/12/2008	1.75	111 N. COMMERCE		X		HEAVY RAIN
ARDMORE	S30804	8/13/2008	0.00	3RD & "K" N.W.	50	X		BLOCKAGE
ARDMORE	S30804	8/19/2008	0.00	11TH & "K" N.W.		X		RAIN
ARDMORE	S30804	8/25/2008	0.00	401 7TH N.W.	500	X		BLOCKAGE
ARDMORE	S30804	8/31/2008	3.40	608 COLBERT ST.	350	X		BLOCKAGE
ARDMORE	S30804	9/1/2008	2.00	403 LOCUST ST. N.W.	100	X		BLOCKAGE
ARDMORE	S30804	9/19/2008	0.40	335 6TH ST. S.W.		X		BLOCKAGE
ARDMORE	S30804	9/20/2008	0.00	704 CHERRY		X		BLOCKAGE
ARDMORE	S30804	9/26/2008		1630 3RD N.E.	<25	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	9/27/2008	3.00	1508 2ND N.E.	500	X		BLOCKAGE
ARDMORE	S30804	10/1/2008	0.00	1811 9TH ST. N.W.	<10	X		BLOCKAGE
ARDMORE	S30804	10/8/2008	0.40	543 8TH ST. N.W.	50	X		BLOCKAGE
ARDMORE	S30804	10/13/2008	1.00	721 "B" ST. N.W.	100	X		BLOCKAGE
ARDMORE	S30804	10/29/2008	0.00	2627 RIDGEWAY	500	X		BLOCKAGE
ARDMORE	S30804	11/3/2008	1.50	"A" ST. S.E. & DREW ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	11/8/2008	0.00	1219 S. ROCKFORD RD.	100	X		BLOCKAGE
ARDMORE	S30804	11/12/2008	0.00	CORNER OF 142 & MT. WASHINGTON	100	X		BLOCKAGE
ARDMORE	S30804	11/15/2008	0.00	2ND & "I" ST. N.E.	900	X		BLOCKAGE
ARDMORE	S30804	11/19/2008	0.40	13TH & "C" S.E.	10	X		BLOCKAGE
ARDMORE	S30804	11/19/2008	0.00	HWY 142 BEHIND HIGH SCHOOL	100	X		BROKEN PIPE
ARDMORE	S30804	11/21/2008	2.70	8TH & "P" N.W.	<30	X		BLOCKAGE
ARDMORE	S30804	11/21/2008	1.50	1811 9TH N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	11/21/2008	20.00	4TH & "M" N.E.	25	X		BLOCKAGE
ARDMORE	S30804	11/26/2008	0.00	501 OAK ST. N.W.	100	X		BLOCKAGE
ARDMORE	S30804	11/27/2008	0.00	517 "A" ST. N.W.	75	X		BLOCKAGE
ARDMORE	S30804	11/29/2008	0.00	406 15TH AVE. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	11/29/2008	0.00	433 "H" ST. S.W.	50	X		BLOCKAGE
ARDMORE	S30804	12/1/2008	0.00	604 "D" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	12/2/2008	0.00	ROCKFORD RD. & CHATTANOOGA	250	X		BLOCKAGE
ARDMORE	S30804	12/2/2008	0.00	2520 N. COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	12/10/2008	0.00	915 "G" ST. S.W.	<80	X		BLOCKAGE
ARDMORE	S30804	12/12/2008	0.00	110 HOLIDAY DR.	<50	X		BLOCKAGE
ARDMORE	S30804	12/14/2008	1.50	1200 N. COMMERCE	<300	X		BLOCKAGE
ARDMORE	S30804	12/16/2008	0.00	1570 CHICKASAW LAKE CLUB RD.	<100	X		BLOCKAGE
ARDMORE	S30804	12/20/2008	0.00	115 MONROE N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	1/1/2009	1.50	609 "F" ST. S.W.	<150	X		BLOCKAGE
ARDMORE	S30804	1/2/2009	0.00	110 "H" ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	1/7/2009	0.00	2000 BLK. E. BROADWAY	<100	X		BLOCKAGE
ARDMORE	S30804	1/9/2009	0.00	322 HOLIDAY DR.	500	X		BLOCKAGE
ARDMORE	S30804	1/12/2009	1.00	904 MAXWELL N.W.	50	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	1/12/2009	0.00	108 FREEMAN ST.	100	X		BLOCKAGE
ARDMORE	S30804	1/13/2009	0.00	415 4TH ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	1/14/2009	0.20	421 "K" S.W.	20	X		BLOCKAGE
ARDMORE	S30804	1/16/2009	0.00	2520 N. COMMERCE	20	X		BLOCKAGE
ARDMORE	S30804	1/22/2009	0.00	22 11TH N.W.	50	X		BLOCKAGE
ARDMORE	S30804	1/22/2009	0.00	800 N. COMMERCE	20	X		BLOCKAGE
ARDMORE	S30804	1/23/2009	0.00	1310 6TH N.E.	<30	X		BLOCKAGE
ARDMORE	S30804	1/23/2009	0.00	902 "D" ST. S.E.	20	X		BLOCKAGE
ARDMORE	S30804	1/28/2009	0.60	922 3RD ST. N.W.	75	X		BLOCKAGE
ARDMORE	S30804	2/3/2009	0.00	402 PARK ST. S.E.	100	X		BLOCKAGE
ARDMORE	S30804	2/9/2009	0.00	108 FREEMAN ST.	50	X		BLOCKAGE
ARDMORE	S30804	2/9/2009	0.00	1505 W. MAIN	<150	X		BLOCKAGE
ARDMORE	S30804	2/9/2009	0.00	3RD & "O" N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	2/12/2009	0.00	"P" ST. & WHITE ST. S.E.	100	X		BLOCKAGE
ARDMORE	S30804	2/17/2009	0.00	4TH & "M" N.E.	100	X		BLOCKAGE
ARDMORE	S30804	2/19/2009	0.00	2015 W. BROADWAY	200	X		BLOCKAGE
ARDMORE	S30804	2/25/2009	0.60	1207 "B" ST. N.W.	25	X		BLOCKAGE
ARDMORE	S30804	2/25/2009	0.50	1037 15TH N.W.	100	X		BLOCKAGE
ARDMORE	S30804	3/5/2009	0.00	11TH & CRUCE N.W.	200	X		BLOCKAGE
ARDMORE	S30804	3/6/2009	0.00	402 PARK ST. S.E.	<10	X		BLOCKAGE
ARDMORE	S30804	3/9/2009	0.00	1219 ROCKFORD RD.	100	X		BLOCKAGE
ARDMORE	S30804	3/13/2009	0.00	2009 WILDWOOD N.W.	200	X		BLOCKAGE
ARDMORE	S30804	3/17/2009	0.00	1109 S. COMMERCE	<50	X		BLOCKAGE
ARDMORE	S30804	3/18/2009	0.00	300 ASH N.W.	200	X		BLOCKAGE
ARDMORE	S30804	3/20/2009	0.00	300 BLK. "E" ST. N.W.	2,000	X		BLOCKAGE
ARDMORE	S30804	3/20/2009	0.00	914 CHERRY ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	3/24/2009	0.80	5TH & "A" ST. S.E.	<40	X		BLOCKAGE
ARDMORE	S30804	3/25/2009	0.00	HOLT & MONROE ST. N.W.	200	X		BLOCKAGE
ARDMORE	S30804	3/27/2009	0.00	1506 2ND ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	3/27/2009	0.60	421 "K" ST. S.W.	<25	X		BROKEN PIPE
ARDMORE	S30804	3/28/2009	16.00	2214 REMINGTON CT.	2,000	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	3/31/2009	0.20	3RD & N. WASHINGTON	100	X		BLOCKAGE
ARDMORE	S30804	4/1/2009	0.40	100 BLK. OF "H" ST. N.W.	60	X		BLOCKAGE
ARDMORE	S30804	4/4/2009	0.00	501 NORTHWEST BLVD.	100	X		BLOCKAGE
ARDMORE	S30804	4/13/2009	0.00	110 "H" ST. N.W.	200	X		BLOCKAGE
ARDMORE	S30804	4/20/2009	0.00	25 13TH ST. N.E.	200	X		BLOCKAGE
ARDMORE	S30804	4/20/2009	0.00	6TH & "B" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	4/24/2009	0.40	2520 N. COMMERCE	50	X		BLOCKAGE
ARDMORE	S30804	4/24/2009	0.00	915 10TH N.W.	<500	X		BLOCKAGE
ARDMORE	S30804	4/24/2009	0.00	118 1ST ST. N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	4/26/2009	0.00	617 "E" ST. S.E.	25	X		BLOCKAGE
ARDMORE	S30804	4/28/2009	0.00	413 LOCUST N.W.	100	X		BLOCKAGE
ARDMORE	S30804	4/29/2009	0.00	"B" ST. & MONROE N.W.	2,000	X		RAIN
ARDMORE	S30804	4/29/2009	0.00	1104 MELODY LN.	2,000	X		RAIN
ARDMORE	S30804	4/29/2009	0.00	2ND & 'K" ST. N.W.	2,000	X		RAIN
ARDMORE	S30804	4/29/2009	0.00	111 N. COMMERCE	2,000	X		RAIN
ARDMORE	S30804	4/29/2009	0.00	15 FREEMAN	100	X		BLOCKAGE
ARDMORE	S30804	4/30/2009	0.00	3RD ST. & "K" N.W.	2,000	X		RAIN
ARDMORE	S30804	4/30/2009	0.00	"F" ST. & BIXBY S.W.	300	X		BLOCKAGE
ARDMORE	S30804	4/30/2009	0.00	2701 RIDGEWAY	200	X		BLOCKAGE
ARDMORE	S30804	4/30/2009	36.00	3600 SUTTON	5,000	X		RAINS
ARDMORE	S30804	5/3/2009	0.00	701 ROSEWOOD	200	X		BLOCKAGE
ARDMORE	S30804	5/3/2009	0.00	412 LOCUST	200	X		BLOCKAGE
ARDMORE	S30804	5/4/2009	0.00	1712 SAM NOBLE PARKWAY	200	X		BLOCKAGE
ARDMORE	S30804	5/5/2009	0.00	8TH & BIRCH N.W.	100	X		BLOCKAGE
ARDMORE	S30804	5/5/2009		VETERANS BLVD. & MT. WASHINGTON	200	X		RAINS
ARDMORE	S30804	5/5/2009	0.00	CAMPBELL & MT. WASHINGTON	>200	X		RAINS
ARDMORE	S30804	5/5/2009	0.00	111 N. COMMERCE	>2,000	X		RAINS
ARDMORE	S30804	5/7/2009	0.00		180,000			
ARDMORE	S30804	5/8/2009	0.80	1527 3RD N.E.	100	X		BLOCKAGE
ARDMORE	S30804	5/8/2009	0.10	2520 N. COMMERCE	100	X		BLOCKAGE
ARDMORE	S30804	5/8/2009	16.40	3600 SUTTON RD.	5,000	X		RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	5/9/2009	1.30	1204 S. ROCKFORD RD.	100	X		BLOCKAGE
ARDMORE	S30804	5/10/2009	0.00	200 BLK. "N" ST. N.E.		X		BLOCKAGE
ARDMORE	S30804	5/10/2009	0.90	200 BLK. "N" ST N.E.	200	X		BLOCKAGE
ARDMORE	S30804	5/11/2009	1.60	2ND & "K" ST. N.W.	>500	X		RAIN
ARDMORE	S30804	5/11/2009	46.50	3600 SUTTON RD.	5,000	X		RAIN
ARDMORE	S30804	5/11/2009	1.30	111 N. COMMERCE	>1,000	X		RAIN
ARDMORE	S30804	5/11/2009	0.10	29 N. COMMERCE	>200	X		RAIN
ARDMORE	S30804	5/11/2009	1.50	1100 MELODY	>1,000	X		RAIN
ARDMORE	S30804	5/11/2009	2.00	10TH & "E" ST. S.E.	>200	X		RAIN
ARDMORE	S30804	5/11/2009	1.30	9TH & "E" ST. S.E.	>200	X		RAIN
ARDMORE	S30804	5/11/2009	0.40	#25 13TH N.E.	>100	X		RAIN
ARDMORE	S30804	5/11/2009	2.40	"B" ST. & MONROE ST. N.E.	>500	X		RAIN
ARDMORE	S30804	5/11/2009	2.00	MT. WASHINGTON & FREEMAN	>200	X		RAIN
ARDMORE	S30804	5/11/2009	1.00	13TH & N. WASHINGTON	>200	X		RAIN
ARDMORE	S30804	5/11/2009	1.70	3RD ST. & "K" ST. N.W.	500	X		RAIN
ARDMORE	S30804	5/11/2009	0.20	3RD & "I" N.E.	>200	X		RAIN
ARDMORE	S30804	5/11/2009	2.40	1300 BLK. 1ST ST. N.W.	200	X		RAIN
ARDMORE	S30804	5/14/2009	31.00	3600 SUTTON RD.	>5,000	X		RAINS
ARDMORE	S30804	5/14/2009	4.30	111 N. COMMERCE	>100	X		RAIN
ARDMORE	S30804	5/14/2009	0.60	"A" ST. & 5TH ST. N.E.	>100	X		BLOCKAGE
ARDMORE	S30804	5/14/2009	1.00	402 1ST ST N.E.	100	X		BLOCKAGE
ARDMORE	S30804	5/16/2009	28.50	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	5/19/2009	0.40	BIRCH & 13TH N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	5/20/2009	0.40	118 1ST N.E.	>200	X		BLOCKAGE
ARDMORE	S30804	6/1/2009	1.40	11TH & "K" ST. N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	6/5/2009	7.90	2402 AUGUSTA	<500	X		BLOCKAGE
ARDMORE	S30804	6/15/2009	0.70	5TH & "A" ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	6/18/2009	0.40	905 BIXBY	<50	X		BLOCKAGE
ARDMORE	S30804	6/20/2009	1.60	11TH & "H" ST. N.W.	<250	X		BLOCKAGE
ARDMORE	S30804	6/26/2009	0.30	1112 BAILEY S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	6/27/2009	0.70	300 BLK. SUNSET S.W.	<50	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	7/8/2009	1.50	1131 MELODY	<50	X		BLOCKAGE
ARDMORE	S30804	7/8/2009	1.30	100 BLK. "O" ST. S.W.	<50	X		BLOCKAGE
ARDMORE	S30804	7/9/2009	0.80	436 WHEELER S.W.	<50	X		BLOCKAGE
ARDMORE	S30804	7/10/2009	0.40	228 11TH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	7/17/2009	0.50	813 MYALL RD.	<10	X		LINE BLOCKAGE
ARDMORE	S30804	7/21/2009	2.25	2702 CROSSROADS DR.	>500	X		LINE BLOCKAGE
ARDMORE	S30804	7/24/2009	0.00	115 MONROE N.E.		X		
ARDMORE	S30804	7/24/2009	0.10	115 MONROE NE	>500	X		LINE BLOCKAGE
ARDMORE	S30804	7/27/2009	0.40	510 N. COMMERCE	<150	X		BLOCKAGE
ARDMORE	S30804	7/27/2009	0.90	510 N. COMMERCE	<150	X		LINE BLOCKAGE
ARDMORE	S30804	7/29/2009	0.00	338 ASH N.W.	>500	X		BLOCKAGE
ARDMORE	S30804	7/29/2009	1.10	"E" ST. & MYALL S.E.	<200	X		RAINS
ARDMORE	S30804	8/1/2009	2.50	2004 CLOVERLEAF	>100	X		BLOCKAGE
ARDMORE	S30804	8/3/2009	0.60	7TH & "F" ST. N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	8/3/2009	0.90	1902 KNOX RD.	>500	X		BLOCKAGE
ARDMORE	S30804	8/10/2009	0.60	2015 W. BROADWAY	60	X		BLOCKAGE
ARDMORE	S30804	8/11/2009	5.40	115 MONROE ST. N.E.	>500	X		BLOCKAGE
ARDMORE	S30804	8/11/2009	3.00	1219 S. ROCKFORD RD.	<200	X		BLOCKAGE
ARDMORE	S30804	8/12/2009	1.60	1620 OLIVE	<100	X		BLOCKAGE
ARDMORE	S30804	8/13/2009	0.40	300 BLK. OF 7TH N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	8/18/2009	0.50	1811 9TH N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	8/24/2009	0.40	402 PARK ST. S.E.	>500	X		BLOCKAGE
ARDMORE	S30804	8/25/2009	0.70	1109 S. COMMERCE	<30	X		BLOCKAGE
ARDMORE	S30804	8/27/2009	0.40	409 LOCUST N.W.	>100	X		BLOCKAGE
ARDMORE	S30804	8/29/2009	1.50	608 COLBERT ST.	<60	X		BLOCKAGE
ARDMORE	S30804	9/8/2009	0.60	515 RAILHEAD LOOP	<200	X		BLOCKAGE
ARDMORE	S30804	9/11/2009	0.70	1410 W. MAIN	<100	X		BLOCKAGE
ARDMORE	S30804	9/15/2009	5.30	700 BLK. VETERANS BLVD.	25	X		BROKEN PIPE
ARDMORE	S30804	9/20/2009	2.50	N. OF BURGER KING ON 2605 W. BROADWAY	>2,000	X		BLOCKAGE
ARDMORE	S30804	9/28/2009	0.40	9TH & "M" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	9/29/2009	0.30	4TH & "N" ST. N.W.	<25	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	10/8/2009	0.00			X		
ARDMORE	S30804	10/10/2009	1.30	401 7TH ST. N.E.	>100	X		BLOCKAGE
ARDMORE	S30804	10/10/2009	0.00	401 "7" ST. N.E.		X		
ARDMORE	S30804	10/13/2009	1.40	407 LOCUST N.W.	>100	X		BLOCKAGE
ARDMORE	S30804	10/16/2009	0.70	13TH & N. WASHINGTON	<200	X		BLOCKAGE
ARDMORE	S30804	10/16/2009	0.50	507 OAK ST. N.W.	>25	X		BLOCKAGE
ARDMORE	S30804	10/21/2009	0.30	422 ASH N.W.	>25	X		BLOCKAGE
ARDMORE	S30804	10/22/2009	21.00	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	10/29/2009	5.40	CAMPBELL & MT. WASHINGTON	>100	X		RAINS
ARDMORE	S30804	10/29/2009	3.70	MONROE & "B" ST. N.E.	>200	X		RAINS
ARDMORE	S30804	10/29/2009	21.60	412 LOCUST N.W.	>200	X		RAINS
ARDMORE	S30804	10/29/2009	5.40	2ND & "K" ST. N.W.	>100	X		RAINS
ARDMORE	S30804	10/31/2009	0.80	HARRIS & MAXWELL N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	11/6/2009	0.50	402 PARK ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	11/16/2009	0.00	MT WASHINGTON RD. & HWY 142	>100	X		BLOCKAGE
ARDMORE	S30804	11/18/2009	1.90	2605 W. BROADWAY	>300	X		BLOCKAGE
ARDMORE	S30804	11/23/2009	0.40	3RD & "K" ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	12/1/2009	2.60	2702 CROSSROADS DR.	<500	X		BLOCKAGE
ARDMORE	S30804	12/9/2009	0.40	525 7TH W.	<25	X		BLOCKAGE
ARDMORE	S30804	12/11/2009	0.50	1201 "L' ST. N.E.	>50	X		BLOCKAGE
ARDMORE	S30804	12/14/2009	1.40	700 BLK. VETERANS BLVD.	<100	X		BLOCKAGE
ARDMORE	S30804	12/16/2009	0.30	403 LOCUST ST.	<200	X		BLOCKAGE
ARDMORE	S30804	12/18/2009	1.00	220 HOLIDAY DR.	200	X		LINE BLOCKAGE
ARDMORE	S30804	12/28/2009	0.70	"H" ST. N.E. & 4TH N.E.	<1,000	X		BLOCKAGE
ARDMORE	S30804	12/30/2009	0.70	1220 S. ROCKFORD	<50	X		BLOCKAGE
ARDMORE	S30804	12/30/2009	0.00	3600 SUTTON RD.	>3,000	X		SNOW & RAIN
ARDMORE	S30804	12/31/2009	0.30	1710 WILDWOOD	<200	X		BLOCKAGE
ARDMORE	S30804	1/4/2010	0.70	402 PARK ST. S.E.	<25	X		BLOCKAGE
ARDMORE	S30804	1/4/2010	0.70	402 PARK ST	200	X		BLOCKAGE
ARDMORE	S30804	1/5/2010	0.60	300 ASH N.W.	>200	X		BLOCKAGE
ARDMORE	S30804	1/10/2010	2.00	513 "D" ST. S.E.	<50	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	1/11/2010	3.90	300 VETERANS BLVD.	500	X		BLOCKAGE
ARDMORE	S30804	1/11/2010	0.60	300 BLK. OF SUNSET	<50	X		BLOCKAGE
ARDMORE	S30804	1/14/2010	2.10	UNIT BLOCK OF STANLEY ST. EAST	<500	X		BLOCKAGE
ARDMORE	S30804	1/17/2010	1.20	1503 W. MAIN	<200	X		BLOCKAGE
ARDMORE	S30804	1/29/2010	32.60	3600 SUTTON RD.	>2,000	X		WEATHER
ARDMORE	S30804	1/30/2010	0.50	800 N. COMMERCE	25	X		BLOCKAGE
ARDMORE	S30804	1/30/2010	1.40	606 "D" ST. N.W.	,100	X		BLOCKAGE
ARDMORE	S30804	2/4/2010	0.40	926 ELM ST.	>200	X		BLOCKAGE
ARDMORE	S30804	2/8/2010	22.00	3600 SUTTON RD.	>2,000	X		RAIN
ARDMORE	S30804	2/8/2010	0.00	3600 SUTTON RD.		X		
ARDMORE	S30804	2/10/2010	0.40	1816 MYALL RD.	500	X		BLOCKAGE
ARDMORE	S30804	2/13/2010	4.50	3RD & "S" S.E.	500	X		BLOCKAGE
ARDMORE	S30804	2/13/2010	3.00	ASH & PINE N.W.	500	X		SNOW MELT
ARDMORE	S30804	2/13/2010	23.00	3600 SUTTON RD.	>2,000	X		RAIN & SNOW MELT
ARDMORE	S30804	2/17/2010	3.40	218 "S" ST. S.E.	<200	X		BLOCKAGE
ARDMORE	S30804	2/18/2010	0.20	100 S. WASHINGTON	150	X		BLOCKAGE
ARDMORE	S30804	2/24/2010	0.40	300 ASH N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	2/27/2010	2.10	300 ASH N.W.	>100	X		BLOCKAGE
ARDMORE	S30804	3/3/2010	1.60	1605 RED OAK	>500	X		BLOCKAGE
ARDMORE	S30804	3/3/2010	0.40	600 BLK. VETERANS BLVD.	<200	X		BLOCKAGE
ARDMORE	S30804	3/3/2010	0.40	1811 9TH AVE. N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	3/4/2010	0.80	3600 SUTTON RD.	>2,000	X		RAINS
ARDMORE	S30804	3/4/2010	0.70	1201 "L" ST. N.E.	100	X		BLOCKAGE
ARDMORE	S30804	3/5/2010	1.10	721 ROFF N.E.	25	X		BLOCKAGE
ARDMORE	S30804	3/6/2010	1.60	CAMPBELL & MT. WASHINGTON	<500	X		BLOCKAGE
ARDMORE	S30804	3/8/2010	35.00	3600 SUTTON RD.	>,2000	X		RAINS
ARDMORE	S30804	3/9/2010	0.30	511 VETERANS BLVD.	>100	X		BLOCKAGE
ARDMORE	S30804	3/9/2010	9.50	1025 6TH N.W.	150	X		BLOCKAGE
ARDMORE	S30804	3/11/2010	0.10	402 PARK ST.	<100	X		BLOCKAGE
ARDMORE	S30804	3/12/2010	0.40	511 VETERANS BLVD.	<100	X		BLOCKAGE
ARDMORE	S30804	3/15/2010	0.60	ASH & PINE	<500	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	3/15/2010	0.20	1318 S. COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	3/15/2010	0.10	6TH & "C" ST. S.W	<200	X		BLOCKAGE
ARDMORE	S30804	3/19/2010	1.40	2ND & "I" ST. N.E.	<500	X		BLOCKAGE
ARDMORE	S30804	3/19/2010	0.30	1815 SHENANDOAH	<200	X		BLOCKAGE
ARDMORE	S30804	3/19/2010	0.40	25 N. ROCKFORD RD.	>500	X		BLOCKAGE
ARDMORE	S30804	3/23/2010	0.60	800 ISABEL	<100	X		BLOCKAGE
ARDMORE	S30804	3/26/2010	0.40	1206 OAKRIDGE	<25	X		BLOCKAGE
ARDMORE	S30804	3/29/2010	0.80	402 PARK ST.	<200	X		BLOCKAGE
ARDMORE	S30804	3/31/2010	0.30	116 "I" ST. N.E.	500	X		BLOCKAGE
ARDMORE	S30804	3/31/2010	0.40	111 8TH AVE. N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	4/5/2010	0.40	402 PARK ST.	<100	X		BLOCKAGE
ARDMORE	S30804	4/5/2010	0.20	MELODY & MYALL RD.	>500	X		BLOCKAGE
ARDMORE	S30804	4/8/2010	0.40	1712 SAM NOBLE PKWY	>300	X		BLOCKAGE
ARDMORE	S30804	4/14/2010	3.00	307 "Q" ST. S.W.	<100	X		BLOCKAGE
ARDMORE	S30804	4/16/2010	1.80	110 "H" ST. N.W.	<500	X		BLOCKAGE
ARDMORE	S30804	4/18/2010	33.00	3600 SUTTON RD.	>2,000	X		RAINS
ARDMORE	S30804	4/18/2010	1.10	1811 9TH N.W.	>100	X		BLOCKAGE
ARDMORE	S30804	4/19/2010	3.50	2212 HEDGES RD.	>1,000	X		BLOCKAGE
ARDMORE	S30804	4/23/2010	0.90	934 S. LAKE MURRAY DR.	<1,000	X		BLOCKAGE
ARDMORE	S30804	5/13/2010	0.20	2300 S. VETERANS BLVD.	>2,000	X		BLOCKAGE
ARDMORE	S30804	5/14/2010	7.50	"B" ST. & MONROE N.E.	>200	X		RAIN
ARDMORE	S30804	5/14/2010	6.30	131 "K" ST. N.W.	>500	X		RAINS
ARDMORE	S30804	5/15/2010	2.60	3600 SUTTON RD.	>2,000	X		RAIN
ARDMORE	S30804	5/25/2010	0.60	MONROE & REFINERY RD.	>500	X		BLOCKAGE
ARDMORE	S30804	6/8/2010	6.20	100 S. WASHINGTON	>200	X		BLOCKAGE
ARDMORE	S30804	6/21/2010	1.80	419 8TH AVE. S.E	<100	X		BLOCKAGE
ARDMORE	S30804	7/16/2010	0.00	PLAINVIEW RD. & MYALL	>500	X		CHECK VALVES BROKEN
ARDMORE	S30804	7/20/2010	0.80	608 COLBERT ST. S.E.	>100	X		BLOCKAGE
ARDMORE	S30804	7/27/2010	0.40	1201 "L" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	8/6/2010	1.40	1902 KNOX RD.	<500	X		BLOCKAGE
ARDMORE	S30804	8/7/2010	1.00	2ND & "I" ST N.E.	<500	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	8/19/2010	0.20	819 BAILEY ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	8/20/2010	1.60	515 1ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	8/23/2010	1.40	402 PARK ST. S.E.	>100	X		BLOCKAGE
ARDMORE	S30804	9/7/2010	0.90	402 PARK ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	9/8/2010	2.80	3600 SUTTON RD.	>2,000	X		RAINS
ARDMORE	S30804	9/9/2010	0.40	1410 W. MAIN	<100	X		BLOCKAGE
ARDMORE	S30804	9/17/2010	0.40	405 PARK ST. S.E.	>100	X		BLOCKAGE
ARDMORE	S30804	9/29/2010	0.50	111 8TH AVE. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	10/4/2010	0.30	402 PARK ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	10/14/2010	0.10	8TH & BIRCH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	10/21/2010	0.50	111 8TH N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	10/29/2010	1.00	2605 W. BROADWAY	<500	X		BLOCKAGE
ARDMORE	S30804	11/1/2010	0.40	338 ASH N.W.	100	X		BLOCKAGE
ARDMORE	S30804	11/14/2010	0.30	800 ISABEL S.W.	<100	X		BLOCKAGE
ARDMORE	S30804	11/14/2010	0.50	425 COTTONWOOD	<50	X		BLOCKAGE
ARDMORE	S30804	11/22/2010	1.10	MONROE & "B" N.W.	<300	X		BLOCKAGE
ARDMORE	S30804	11/22/2010	0.60	4TH & "H" ST. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	11/22/2010	0.00	2605 W. BROADWAY	>2,000	X		BLOCKAGE
ARDMORE	S30804	11/22/2010	1.80	419 8TH S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	11/23/2010		MONROE &"B" ST. N.W.		X		BLOCKAGE
ARDMORE	S30804	11/23/2010	1.10	525 "G" ST. S.W.	<100	X		BLOCKAGE
ARDMORE	S30804	12/5/2010	5.30	601 DOUGLASS BLVD.	>500	X		BLOCKAGE
ARDMORE	S30804	12/6/2010	0.40	432 "H" ST. S.W.	<50	X		BLOCKAGE
ARDMORE	S30804	12/6/2010	0.20	916 "B" ST. S.E.	<25	X		BLOCKAGE
ARDMORE	S30804	12/8/2010	1.30	#19 15TH ST. N.E.	50	X		BLOCKAGE
ARDMORE	S30804	12/9/2010	1.40	955 "E" ST. S.E.	>200	X		BLOCKAGE
ARDMORE	S30804	12/9/2010	1.10	#15 MONROE AVE.	>500	X		BLOCKAGE
ARDMORE	S30804	12/10/2010	2.00	419 8TH ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	12/11/2010	4.60	419 8TH ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	12/13/2010	0.50	2407 CIMMARON	<100	X		BLOCKAGE
ARDMORE	S30804	12/15/2010	0.40	1503 W. MAIN	<200	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	12/16/2010	2.00	"B" ST. & MONROE ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	12/18/2010	1.00	300 ASH N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	12/18/2010	0.60	228 COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	12/19/2010	1.00	922 3RD N.W.("K" ST. & 3RD N.W.)	<100	X		BLOCKAGE
ARDMORE	S30804	12/20/2010	1.40	821 WOOD N' CREEK	<25	X		BLOCKAGE
ARDMORE	S30804	12/25/2010	2.00	606 "D" ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	12/29/2010	0.40	1211 N. COMMERCE	<50	X		BLOCKAGE
ARDMORE	S30804	12/31/2010	0.60	1201 "L" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	1/4/2011	0.20	4TH & "N" N.E.	<10	X		BLOCKAGE
ARDMORE	S30804	1/11/2011	0.40	611 VETERANS BLVD.	<50	X		BLOCKAGE
ARDMORE	S30804	1/15/2011	1.00	1416 "B" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	1/17/2011	3.00	1219 S. ROCKFORD RD.	<300	X		BLOCKAGE
ARDMORE	S30804	1/19/2011	0.90	402 PARK ST.	<50	X		BLOCKAGE
ARDMORE	S30804	1/19/2011	1.10	317 VETERANS BLVD.	<100	X		BLOCKAGE
ARDMORE	S30804	1/21/2011	0.30	1030 S. COMMERCE	<200	X		BLOCKAGE
ARDMORE	S30804	1/24/2011	0.50	900 BLK. MYALL	<50	X		BLOCKAGE
ARDMORE	S30804	1/25/2011	0.60	1410 W. MAIN	<100	X		BLOCKAGE
ARDMORE	S30804	1/27/2011	0.40	320 "E" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	2/4/2011	1.00	509 "F" ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	2/6/2011	29.70	3600 SUTTON RD.	>3,000	X		WEATHER
ARDMORE	S30804	2/6/2011	4.00	402 PARK ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	2/12/2011	1.70	4TH & "H" ST. N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	2/14/2011	0.10	111 8TH ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	2/14/2011	0.40	109 "H" ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	2/15/2011	0.50	2701 RIDGEWAY	<300	X		BLOCKAGE
ARDMORE	S30804	2/17/2011	0.80	1570 CHICKASAW CLUB LAKE RD.	<100	X		BLOCKAGE
ARDMORE	S30804	2/22/2011	0.60	2702 CROSSROADS DR.	<300	X		BLOCKAGE
ARDMORE	S30804	2/23/2011	0.40	810 S. COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	2/24/2011	0.40	2605 W. BROADWAY	<1,000	X		BLOCKAGE
ARDMORE	S30804	2/25/2011	0.50	910 S. LAKE MURRAY DR.	<2,000	X		BLOCKAGE
ARDMORE	S30804	2/28/2011	1.40	845 DOUGLAS BLVD.	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	3/4/2011	0.80	412 LOCUST	<100	X		BLOCKAGE
ARDMORE	S30804	3/4/2011	2.00	1650 SAM NOBLE PARKWAY	<50	X		BLOCKAGE
ARDMORE	S30804	3/4/2011	0.50	MT. WASHINGTON & FREEMAN	<50	X		BLOCKAGE
ARDMORE	S30804	3/4/2011	0.50	2902 MT. WASHINGTON	<200	X		BLOCKAGE
ARDMORE	S30804	3/5/2011	15.00	#9 TURNER ST.	<100	X		BLOCKAGE
ARDMORE	S30804	3/6/2011	4.50	421 "L" ST. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	3/10/2011	0.50	2407 CIMMARON DR.	<50	X		BLOCKAGE
ARDMORE	S30804	3/12/2011	1.00	608 COLBERT ST. S.E.	100	X		BLOCKAGE
ARDMORE	S30804	3/14/2011	2.50	2215 REMINGTON CT.	<100	X		BLOCKAGE
ARDMORE	S30804	3/18/2011	0.50	216 "I" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	3/19/2011	1.40	300 SUNSET DR.	<100	X		BLOCKAGE
ARDMORE	S30804	3/21/2011	4.40	1401 MONROE	<200	X		BLOCKAGE
ARDMORE	S30804	3/22/2011	2.20	515 1ST. AVE S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	3/28/2011	0.50	MCLAIN RD. & SPRINGDALE LOOP EAST	<50	X		BLOCKAGE
ARDMORE	S30804	3/29/2011	0.60	910 S. LAKE MURRAY DR.	<25	X		BLOCKAGE
ARDMORE	S30804	4/3/2011	1.90	112 FREEMAN	<750	X		BLOCKAGE
ARDMORE	S30804	4/3/2011	0.60	338 ASH ST.	<500	X		BLOCKAGE
ARDMORE	S30804	4/12/2011	1.00	1022 EAST SPRINGDALE LOOP	<100	X		BLOCKAGE
ARDMORE	S30804	4/14/2011	0.20	800 ISABEL S.W.	<500	X		BLOCKAGE
ARDMORE	S30804	4/16/2011	1.20	1633 OAKLEAF CIR.	<50	X		BLOCKAGE
ARDMORE	S30804	4/17/2011	1.60	711 ROCKFORD RD.	100	X		BLOCKAGE
ARDMORE	S30804	4/18/2011	0.30	300 ASH ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	4/20/2011	0.50	1211 N. COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	4/22/2011	1.50	HOLLINGSWORTH & CREEKSIDE EAST	<50	X		BLOCKAGE
ARDMORE	S30804	4/23/2011	1.70	2020 W. BROADWAY - TIFFANY PLAZA	<10	X		BLOCKAGE
ARDMORE	S30804	4/24/2011	1.20	2025 W. BROADWAY	<500	X		BLOCKAGE
ARDMORE	S30804	4/26/2011	0.20	1200 BLK. HALL ST. N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	4/27/2011	0.40	1416 "B" ST. N.W.	<10	X		BLOCKAGE
ARDMORE	S30804	4/29/2011	2.00	402 PARK ST. S.E.	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	5/6/2011	0.60	403 LOCUST N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	5/10/2011	0.40	604 "D" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	5/16/2011	2.70	2423 VETERANS BLVD.	<2,000	X		BLOCKAGE
ARDMORE	S30804	5/18/2011	3.00	2215 RIDGEWAY	<100	X		BLOCKAGE
ARDMORE	S30804	5/21/2011	17.00	3600 SUTTON RD.	>3,000	X		RAIN
ARDMORE	S30804	5/27/2011	0.60	518 "D" ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	5/29/2011	1.10	711 S. ROCKFORD RD.	<200	X		BLOCKAGE
ARDMORE	S30804	6/1/2011	2.50	1000 E. SPRINGDALE LOOP	<600	X		BLOCKAGE
ARDMORE	S30804	6/2/2011	0.40	1124 MELODY	<200	X		BLOCKAGE
ARDMORE	S30804	7/9/2011	3.30	1219 S. ROCKFORD RD.	<300	X		BLOCKAGE
ARDMORE	S30804	7/18/2011	2.00	244 E. WOOD LN.	<100	X		AIR RELEASE VALVE LEAK
ARDMORE	S30804	7/19/2011	23.70	244 E. WOOD LN.	<500	X		BROKEN PIPE
ARDMORE	S30804	7/23/2011	0.00	2000 BLK. OF HWY 142	>5,000	X		BLOCKAGE
ARDMORE	S30804	8/8/2011	0.40	1720 VETERANS BLVD.	<700	X		BLOCKAGE
ARDMORE	S30804	8/19/2011	3.00	INDIAN HILLS RD. & WOODS LANE	2,000	X		BLOCKAGE
ARDMORE	S30804	8/21/2011	0.30	409 LOCUST N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	9/12/2011	0.30	"K" ST. & 3RD AVE. N.W.	<150	X		BLOCKAGE
ARDMORE	S30804	9/16/2011	0.20	3RD & "K" ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	9/18/2011	1.50	4TH & "N" ST. S.W.	<100	X		BLOCKAGE
ARDMORE	S30804	9/23/2011	0.50	511 VETERAN'S BLVD.	<100	X		BROKEN PIPE
ARDMORE	S30804	9/26/2011	0.40	4TH & "N" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	9/28/2011	0.40	8TH & BIRCH ST. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	9/28/2011	0.50	2810 MT. WASHINGTON RD.	<500	X		BLOCKAGE
ARDMORE	S30804	9/30/2011	3.00	INDIAN HILLS RD. & E. WOODS LANE	2,000	X		POWER FAILURE
ARDMORE	S30804	10/11/2011	0.60	2902 MT. WASHINGTON RD.	<500	X		BLOCKAGE
ARDMORE	S30804	10/12/2011	0.40	2605 W. BROADWAY	<20	X		BLOCKAGE
ARDMORE	S30804	10/17/2011	1.20	1219 S. ROCKFORD RD.	<200	X		BLOCKAGE
ARDMORE	S30804	10/19/2011	2.00	1219 S. ROCKFORD RD.	<200	X		BLOCKAGE
ARDMORE	S30804	10/29/2011	3.20	300 BLK. OF NORTHWEST AVE.	<200	X		BLOCKAGE
ARDMORE	S30804	11/4/2011	0.40	#25 S. ROCKFORD RD.	<300	X		BLOCKAGE
ARDMORE	S30804	11/9/2011	0.40	1000 BLK. SUNSET S.W.	<200	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	11/10/2011	1.40	701 VETERANS BLVD.	<500	X		BLOCKAGE
ARDMORE	S30804	11/11/2011	1.90	701 VETERANS BLVD.	<100	X		BROKEN PIPE
ARDMORE	S30804	11/15/2011	0.60	10TH & "C" ST N.W.	<25	X		BLOCKAGE
ARDMORE	S30804	11/15/2011	0.40	1211 N. COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	11/16/2011	0.40	402 PARK ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	11/22/2011	2.00	2230 HEDGES RD.	<500	X		BLOCKAGE
ARDMORE	S30804	11/28/2011	0.60	1201 "L" ST. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	12/12/2011	0.60	115 MONROE ST. N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	12/13/2011	2.00	2015 W. BROADWAY	<50	X		BLOCKAGE
ARDMORE	S30804	12/15/2011	0.20	1201 "L" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	12/17/2011	1.30	1555 3RD N.E.	<75	X		BLOCKAGE
ARDMORE	S30804	12/17/2011	1.20	845 "C" ST. S.E.	<75	X		BLOCKAGE
ARDMORE	S30804	12/19/2011	0.60	2902 MT. WASHINGTON RD.	<20	X		BLOCKAGE
ARDMORE	S30804	12/20/2011	11.50	3600 SUTTON RD.	<500	X		BLOCKAGE
ARDMORE	S30804	12/20/2011	17.00	701 VETERANS BLVD.	<25	X		BROKEN PIPE
ARDMORE	S30804	12/21/2011	1.60	215 4TH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	1/1/2012	7.60	MT. WASHINGTON & HWY 142	<2,000	X		BLOCKAGE
ARDMORE	S30804	1/8/2012	1.40	421 PINE	<100	X		BLOCKAGE
ARDMORE	S30804	1/9/2012	1.00	2205 W. BROADWAY	<200	X		BLOCKAGE
ARDMORE	S30804	1/10/2012	2.00	608 COLBERT ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	1/10/2012	2.10	419 8TH ST. S.E.	<200	X		BLOCKAGE
ARDMORE	S30804	1/13/2012	10.00	2302 KNOX RD.	>2,000	X		BLOCKAGE
ARDMORE	S30804	1/14/2012	1.70	"D" ST. S.E. & LAKE MURRAY DR.	<100	X		BLOCKAGE
ARDMORE	S30804	1/17/2012	0.50	"D" ST. S.E. & LAKE MURRAY DR.	<100	X		BLOCKAGE
ARDMORE	S30804	1/18/2012	0.60	6TH ST. & FRISCO LN.	<300	X		BLOCKAGE
ARDMORE	S30804	1/19/2012	0.40	8TH & CARTER	100	X		BLOCKAGE
ARDMORE	S30804	1/23/2012	1.40	118 "I" ST. N.E.	<250	X		BLOCKAGE
ARDMORE	S30804	1/25/2012	0.40	608 COLBERT S.E.	<200	X		BLOCKAGE
ARDMORE	S30804	1/26/2012	14.90	3600 SUTTON	>3,000	X		RAINS
ARDMORE	S30804	1/26/2012	0.40	910 S. LAKE MURRAY DR.	<300	X		RAINS
ARDMORE	S30804	1/27/2012	0.30	6TH & "I" N.W.	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	2/9/2012	0.40	511 VETERANS BLVD.	<200	X		BLOCKAGE
ARDMORE	S30804	2/14/2012	0.50	1203 SAM NOBLE PARKWAY	<200	X		BLOCKAGE
ARDMORE	S30804	2/16/2012	0.40	610 N. COMMERCE	<300	X		BLOCKAGE
ARDMORE	S30804	2/21/2012	0.40	"D" ST. & LAKE MURRAY DR. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	2/24/2012	0.90	320 N. COMMERCE	<100	X		BLOCKAGE
ARDMORE	S30804	2/27/2012	1.40	1411 W. MAIN	<100	X		BLOCKAGE
ARDMORE	S30804	2/28/2012	0.80	1402 ROSEDALE	<100	X		BLOCKAGE
ARDMORE	S30804	3/1/2012	0.80	2025 W. BROADWAY	<1,500	X		BLOCKAGE
ARDMORE	S30804	3/6/2012	0.20	PINE & ASH N.W.	<300	X		BLOCKAGE
ARDMORE	S30804	3/9/2012	1.30	610 CARTER S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	3/12/2012	22.00	3600 SUTTON RD.	>2,000	X		RAIN
ARDMORE	S30804	3/13/2012	0.40	511 VETERANS BLVD.	<100	X		BLOCKAGE
ARDMORE	S30804	3/20/2012	71.30	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	3/20/2012	6.20	CAMPBELL & MT. WASHINGTON	>100	X		RAIN
ARDMORE	S30804	3/20/2012	4.70	2025 W. BROADWAY	100	X		BLOCKAGE
ARDMORE	S30804	3/20/2012	6.30	2200 BLK. HEDGES RD.	>1,000	X		RAIN
ARDMORE	S30804	3/24/2012	11.70	2300 "P" ST. N.E.	>2,000	X		BLOCKAGE
ARDMORE	S30804	3/30/2012	1.20	300 BLK. VETERANS BLVD.	<1,000	X		BLOCKAGE
ARDMORE	S30804	4/4/2012	10.00	3600 SUTTON RD.	>3,000	X		BLOCKAGE
ARDMORE	S30804	4/8/2012	43.40	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	5/19/2012	1.80	2627 RIDGEWAY	<600	X		BLOCKAGE
ARDMORE	S30804	5/25/2012	1.00	1505 N. COMMERCE	<200	X		BLOCKAGE
ARDMORE	S30804	6/4/2012	0.20	1650 SAM NOBLE PARKWAY	<1,000	X		BLOCKAGE
ARDMORE	S30804	6/8/2012	4.20	2300 PST N.E. (HWY 142)	<6,000	X		BLOCKAGE
ARDMORE	S30804	6/17/2012	3.50	511 VETERANS BLVD.	<2,000	X		BLOCKAGE
ARDMORE	S30804	6/18/2012	1.10	2800 BLK. OF "P" ST. N.E. (HWY 142)	<300	X		BLOCKAGE
ARDMORE	S30804	7/6/2012	4.00	'F" ST. & MOORE S.W.	<1,000	X		BLOCKAGE
ARDMORE	S30804	7/13/2012	1.20	"F" ST. & MOORE	<30	X		BLOCKAGE
ARDMORE	S30804	7/18/2012	0.00	317 VETERANS BLVD.	<400	X		BLOCKAGE
ARDMORE	S30804	8/2/2012	5.40	2ND & "I" ST. N.E.	<500	X		BLOCKAGE
ARDMORE	S30804	8/3/2012	2.60	MYALL RD. & S. COMMERCE	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	8/5/2012	3.70	6TH & CARTER S.E.	<500	X		BROKEN PIPE
ARDMORE	S30804	8/13/2012	0.40	1201 "L" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	8/16/2012	2.40	9TH & CARTER S.E.	<200	X		BLOCKAGE
ARDMORE	S30804	8/24/2012	0.50	9TH & CARTER S.E.	<250	X		BLOCKAGE
ARDMORE	S30804	9/1/2012	1.00	1219 S. ROCKFORD RD.	<5	X		BLOCKAGE
ARDMORE	S30804	9/4/2012	9.70	600 BLK. N. ROCKFORD RD.	>5,000	X		AIR RELIEF VALVE BROKE
ARDMORE	S30804	9/5/2012	8.20	600 BLK. OF ROCKFORD RD.	>30,000	X		VALVE LEAKING
ARDMORE	S30804	9/10/2012	2.90	1722 WILDWOOD RD.	>1,000	X		BLOCKAGE
ARDMORE	S30804	9/26/2012	11.00	1610 MCLAINE RD.	>1,000	X		BROKEN PIPE
ARDMORE	S30804	9/27/2012	1.20	2902 MT. WASHINGTON RD.	>1,000	X		BLOCKAGE
ARDMORE	S30804	10/2/2012	0.20	701 VETERANS BLVD.	<500	X		BROKEN PIPE
ARDMORE	S30804	10/8/2012	2.00	500 BLK. E. MAIN	<1,000	X		BLOCKAGE
ARDMORE	S30804	10/12/2012	1.50	300 MONROE AVE. N.E.	<1,000	X		BLOCKAGE
ARDMORE	S30804	10/18/2012	0.30	800 ISABEL S.W.	<200	X		BLOCKAGE
ARDMORE	S30804	10/22/2012	0.10	701 VETERANS BLVD.	<20	X		BROKEN PIPE
ARDMORE	S30804	10/22/2012	0.60	711 "N" ST. S.W.	>50	X		BLOCKAGE
ARDMORE	S30804	10/28/2012	1.30	500 BLK. MAPLE ST. N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	11/1/2012	1.30	1920 RED OAK	<50	X		BLOCKAGE
ARDMORE	S30804	11/2/2012	1.40	111 8TH AVE. N.W.	<20	X		BLOCKAGE
ARDMORE	S30804	11/5/2012	76.30	1610 MCLAINE RD.	<50	X		BROKEN PIPE
ARDMORE	S30804	11/14/2012	1.00	ELM & ROBINSON	<100	X		BLOCKAGE
ARDMORE	S30804	11/17/2012	0.50	3024 ASH N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	11/21/2012	0.40	317 E. VETERANS BLVD.	200	X		BLOCKAGE
ARDMORE	S30804	11/25/2012	1.00	2000 BLK. HARRIS N.W.	100	X		BLOCKAGE
ARDMORE	S30804	11/28/2012	2.60	1014 "A" ST. N.E.	200	X		BLOCKAGE
ARDMORE	S30804	11/30/2012	0.70	1210 "L" ST. N.E.	<300	X		BLOCKAGE
ARDMORE	S30804	12/1/2012	1.60	904 ASH N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	12/3/2012	1.30	434 WHEELER S.W.	<50	X		BLOCKAGE
ARDMORE	S30804	12/18/2012	3.40	1039 "K" N.E.	<300	X		BLOCKAGE
ARDMORE	S30804	12/18/2012	1.40	2627 RIDGEWAY	<1,000	X		BLOCKAGE
ARDMORE	S30804	12/26/2012	1.60	12TH & CRUCE N.W.	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	12/26/2012	1.20	2226 RIDGEWAY S.W.	<500	X		BLOCKAGE
ARDMORE	S30804	1/8/2013	0.60	1201 "L" ST. N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	1/11/2013	8.20	3600 SUTTON RD.	3,000	X		RAIN
ARDMORE	S30804	1/24/2013	0.50	410 RAILWAY EXPRESS	<1,000	X		BROKEN AIR RELEASE VALVE
ARDMORE	S30804	1/28/2013	1.50	219 "K" ST. S.E.	<100	X		BROKEN PIPE
ARDMORE	S30804	2/1/2013	1.10	N. MEADOW DR. & N. COMMERCE	<200	X		BLOCKAGE
ARDMORE	S30804	2/5/2013	0.70	GRAND & "E" ST. N.W.	<500	X		BLOCKAGE
ARDMORE	S30804	2/12/2013	1.10	1020 6TH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	2/13/2013	0.80	511 VETERANS BLVD.	<100	X		BLOCKAGE
ARDMORE	S30804	2/15/2013	1.50	LAKE MURRAY DR. & "D" ST. S.E.	<50	X		BLOCKAGE
ARDMORE	S30804	2/20/2013	5.80	"N" ST. & 1ST N.W.	<2,000	X		BLOCKAGE
ARDMORE	S30804	2/26/2013	0.60	E. BROADWAY & "E" ST. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	2/26/2013	2.40	2810 MT. WASHINGTON	<1,500	X		BLOCKAGE
ARDMORE	S30804	3/1/2013	0.50	1902 KNOX RD.	<200	X		BLOCKAGE
ARDMORE	S30804	3/6/2013	2.00	S. WASHINGTON & STANLEY	<1,500	X		BLOCKAGE
ARDMORE	S30804	3/14/2013	1.00	19 SUNSET S.W.	<50	X		BLOCKAGE
ARDMORE	S30804	3/18/2013	2.00	111 8TH AVE. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	3/18/2013	2.00	9TH & CARTER S.E.	<1,000	X		BLOCKAGE
ARDMORE	S30804	3/19/2013	3.50	2602 12TH N.W.	<1,500	X		BLOCKAGE
ARDMORE	S30804	3/19/2013	0.50	536 E. MAIN	<200	X		BLOCKAGE
ARDMORE	S30804	3/25/2013	0.80	ANDERSON & "D" ST. S.E.	<200	X		BLOCKAGE
ARDMORE	S30804	3/25/2013	5.20	1903 CHOCTAW	<50	X		BLOCKAGE
ARDMORE	S30804	3/26/2013	0.70	2ND & "I" ST. N.E.	<500	X		BLOCKAGE
ARDMORE	S30804	3/31/2013	2.00	422 ASH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	4/11/2013	3.50	955 "E" ST. S.E.	<1,500	X		BLOCKAGE
ARDMORE	S30804	4/16/2013	2.60	700 W. BROADWAY	<50	X		BLOCKAGE
ARDMORE	S30804	4/16/2013	1.40	1206 OAKRIDGE	<200	X		BLOCKAGE
ARDMORE	S30804	4/24/2013	1.40	1120 "G" ST. S.W.	<2,000	X		BLOCKAGE
ARDMORE	S30804	5/2/2013	0.40	ASH & PINE N.W.	<200	X		BLOCKAGE
ARDMORE	S30804	5/6/2013	1.00	ANDERSON & "D" S.E.	<1,000	X		BLOCKAGE
ARDMORE	S30804	5/13/2013	4.60	407 ANDERSON ST.	<1,000	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	5/17/2013	0.30	1201 "L" ST. N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	5/20/2013	1.30	CAMPBELL & MT. WASHINGTON	<1,000	X		RAIN
ARDMORE	S30804	5/21/2013	10.20	3600 SUTTON RD.	>2,000	X		RAINS
ARDMORE	S30804	5/24/2013	5.30	3600 SUTTON RD.	>2,000	X		RAIN
ARDMORE	S30804	5/30/2013	27.70	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	6/1/2013	16.60	3600 SUTTON RD.	>2,000	X		RAIN
ARDMORE	S30804	6/3/2013	0.40	118 "I" ST. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	6/4/2013	0.60	1820 N. ROCKFORD RD.	<1,000	X		AIR RELEASE VALVE
ARDMORE	S30804	6/4/2013	4.80	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	6/6/2013	0.30	10TH & "E" ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	6/8/2013	3.50	508 OAK ST.N.W.	>500	X		BLOCKAGE
ARDMORE	S30804	6/9/2013	3.00	1650 SAM NOBLE PKWY	<500	X		BLOCKAGE
ARDMORE	S30804	6/12/2013	0.30	610 N. COMMERCE ST.	>200	X		BLOCKAGE
ARDMORE	S30804	6/17/2013	12.00	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	6/18/2013	1.40	1720 VETERANS BLVD.	<1,000	X		BLOCKAGE
ARDMORE	S30804	6/18/2013	1.30	508 N.W. OAK ST.	<100	X		BLOCKAGE
ARDMORE	S30804	6/24/2013	2.50	2900 MYALL RD.	<300	X		BLOCKAGE
ARDMORE	S30804	7/13/2013	1.80	HOLT & MONROE N.W.	<1000	X		BLOCKAGE
ARDMORE	S30804	7/24/2013	0.40	924 3RD AVE. N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	7/27/2013	6.60	3600 SUTTON RD.	75,000	X		RAINFALL
ARDMORE	S30804	8/4/2013	2.80	120 "P" N.E.	<50	X		BLOCKAGE
ARDMORE	S30804	8/15/2013	0.40	900 3RD AVE. N.W.	<500	X		BLOCKAGE
ARDMORE	S30804	8/19/2013	1.00	206 "I" ST. N.E.	>1,000	X		BLOCKAGE
ARDMORE	S30804	8/29/2013	0.50	400 BLK. N. ROCKFORD RD.	1,500	X		VALVE MALFUNCTION/BLOCKAGE
ARDMORE	S30804	9/30/2013	0.90	10TH & "E" S.E.	<800	X		BLOCKAGE
ARDMORE	S30804	10/1/2013	0.30	823 ISABEL	<200	X		BLOCKAGE
ARDMORE	S30804	10/3/2013	0.40	1902 KNOX RD.	<200	X		BLOCKAGE
ARDMORE	S30804	10/5/2013	1.20	"E" ST. & 10TH ST. S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	10/5/2013	1.20	"E" ST. & 10TH S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	10/14/2013	2.20	1315 S. LAKE MURRAY DR.	<500	X		BLOCKAGE & RAIN
ARDMORE	S30804	10/15/2013	24.00	3600 SUTTON RD.	>5,000	X		RAIN & FLOODING

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	10/24/2013	0.60	823 ISABEL	50	X		BLOCKAGE
ARDMORE	S30804	11/10/2013	0.40	422 ASH	<200	X		BLOCKAGE
ARDMORE	S30804	11/11/2013	2.40	REFINERY & MONROE ST. N.E.	>1,000	X		BLOCKAGE
ARDMORE	S30804	11/11/2013	1.50	2605 W. BROADWAY	>1,000	X		BLOCKAGE
ARDMORE	S30804	11/17/2013	1.40	228 S. COMMERCE	<50	X		BLOCKAGE
ARDMORE	S30804	11/18/2013	1.40	"I" ST. & 2ND AVE. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	11/18/2013	1.80	348 BEAUMONT ST.	<100	X		BLOCKAGE
ARDMORE	S30804	11/20/2013	0.50	338 ASH ST.	<100	X		BLOCKAGE
ARDMORE	S30804	12/3/2013	0.50	1321 S. COMMERCE	200	X		BLOCKAGE
ARDMORE	S30804	12/3/2013	0.90	402 PARK - UNIT 41B	200	X		BLOCKAGE
ARDMORE	S30804	12/12/2013	2.70	608 MOORE ST. S.W.	50	X		BLOCKAGE
ARDMORE	S30804	12/13/2013	1.60	1740 WINCHESTER ST.	<50	X		BLOCKAGE
ARDMORE	S30804	12/16/2013	1.80	402 PARK ST.	<1,000	X		BLOCKAGE
ARDMORE	S30804	12/18/2013	0.40	1742 WINCHESTER	<20	X		BLOCKAGE
ARDMORE	S30804	12/19/2013	2.40	402 PARK	<500	X		BLOCKAGE
ARDMORE	S30804	12/21/2013	0.90	709 COTTONWOOD ST.	<100	X		BLOCKAGE
ARDMORE	S30804	12/21/2013	26.60	3600 SUTTON RD.	>5,000	X		RAIN
ARDMORE	S30804	12/26/2013	1.00	1101 HARRIS N.W.	200	X		BLOCKAGE
ARDMORE	S30804	12/27/2013	0.50	621 INTERSTATE DR.	<100	X		BLOCKAGE
ARDMORE	S30804	12/27/2013	0.70	1902 KNOX RD.	<500	X		BLOCKAGE
ARDMORE	S30804	12/29/2013	0.60	9TH & "E" ST. S.E.	<500	X		BLOCKAGE
ARDMORE	S30804	1/3/2014	0.30	338 ASH ST.	<200	X		BLOCKAGE
ARDMORE	S30804	1/4/2014	0.70	3600 SUTTON RD.	>1,000	X		BLOCKAGE
ARDMORE	S30804	1/4/2014	2.90	402 PARK ST. UNIT 4313	<200	X		BLOCKAGE
ARDMORE	S30804	1/4/2014	6.30	13TH & WASHINGTON ST. N.W.	<2,000	X		BLOCKAGE
ARDMORE	S30804	1/7/2014	0.70	"P" ST. & 8TH N.E.	<200	X		BLOCKAGE
ARDMORE	S30804	1/13/2014	1.10	701 ROSEWOOD	<200	X		BLOCKAGE
ARDMORE	S30804	1/14/2014	0.30	1515 EASLEY DR.	<50	X		BLOCKAGE
ARDMORE	S30804	1/15/2014	0.30	511 VETERANS BLVD.	<100	X		BLOCKAGE
ARDMORE	S30804	1/16/2014	0.70	323 ASH N.W.	<75	X		BLOCKAGE
ARDMORE	S30804	1/17/2014	0.40	100 S. WASHINGTON	<100	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ARDMORE	S30804	1/17/2014	1.50	#2 WEST MAIN ST.	450	X		BLOCKAGE
ARDMORE	S30804	1/20/2014	1.80	2015 W. BROADWAY (TIFFANY PLAZA)	<100	X		BLOCKAGE
ARDMORE	S30804	1/24/2014	1.30	1309 1ST. ST. S.W.	<20	X		BLOCKAGE
ARDMORE	S30804	1/24/2014	0.20	514 MAXWELL ST.	<100	X		BLOCKAGE
ARDMORE	S30804	1/24/2014	0.50	524 LAKE MURRAY DR.	<100	X		BLOCKAGE
ARDMORE	S30804	1/27/2014	0.70	"I" & 2ND N.E.	<300	X		BLOCKAGE
ARDMORE	S30804	2/11/2014	1.60	3130 MT. WASHINGTON RD.	<1,000	X		BLOCKAGE
ARDMORE	S30804	2/11/2014	0.60	15TH & N. WASHINGTON ST.	<100	X		BLOCKAGE
ARDMORE	S30804	2/13/2014	1.80	907 ASH N.W.	<100	X		BLOCKAGE
ARDMORE	S30804	2/14/2014	0.60	534 CHOCTAW	<100	X		BLOCKAGE
ARDMORE	S30804	2/14/2014	1.60	1000 BLK. 8TH AVE. N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	2/15/2014	2.80	#19 15TH AVE N.E.	<100	X		BLOCKAGE
ARDMORE	S30804	2/16/2014	0.70	520 "A" ST. N.W.	<50	X		BLOCKAGE
ARDMORE	S30804	2/16/2014	1.50	701 ROSEWOOD	<200	X		BLOCKAGE
ARDMORE	S30804	2/17/2014	2.40	1009 ROCKFORD CT.	<200	X		BLOCKAGE
ARDMORE	S30804	2/17/2014	4.10	GRAND AVE. & "E' N.W.	<1,000	X		BLOCKAGE
ARDMORE	S30804	2/18/2014	56.50	GRAND & "E" ST. N.W.	<1,500	X		LINE COLLAPSED
ARDMORE	S30804	2/19/2014	1.40	402 PARK ST.	<200	X		BLOCKAGE
ARDMORE	S30804	2/23/2014	4.00	1219 S. ROCKFORD RD.	<200	X		BLOCKAGE
ARDMORE	S30804	2/25/2014	1.60	308 10TH S.E.	<100	X		BLOCKAGE
ARDMORE	S30804	3/6/2014	2.60	2214 REMINGTON CT.	<300	X		BLOCKAGE
ARDMORE	S30804	3/8/2014	2.00	1610 4TH N.W.	<30	X		BLOCKAGE
ARDMORE	S30804	3/10/2014	1.00	1219 S. ROCKFORD RD.	<200	X		BLOCKAGE
ARDMORE	S30804	3/12/2014	1.60	2214 REMINGTON CT.	<200	X		BLOCKAGE
ARDMORE	S30804	3/14/2014	0.80	2423 VETERANS BLVD.	<3,000	X		BLOCKAGE
ARDMORE	S30804	3/15/2014	1.00	914 S. COMMERCE	>200	X		BLOCKAGE
ARDMORE	S30804	3/17/2014	0.50	1219 S. ROCKFORD RD.	<300	X		BLOCKAGE
FALCONHEAD	S11104	9/28/2003	0.00	300 YDS S.W. OF LIFT STATION	500	X		LEAKING
GOLDEN OAKS	S10919	6/13/1993	168.00	NE CORNER OF EAST LAGOON		X		EXCESSIVE RAINS
GOLDEN OAKS	S10919		0.00					

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
HOMEOWNERS ASSOC.								
LONE GROVE - E	S11003		0.00	110 CODY ST.	2	X		TAMPERING
LONE GROVE - E	S11003	7/23/2008	0.70	SOUTH LAGOON	100	X		SHUT DOWN L.S. FOR REPAIR
LONE GROVE - E	S11003	1/15/2009	23.00	SUNSET L.S. S. LAGOON	6			POWER OUTAGE
LONE GROVE - E	S11003	6/16/2011	0.00	EAST LAGOON		X		PIPE BROKEN BY ROAD CREW
MARIETTA	S10901		0.00					
MARIETTA	S10901		0.00	E. OF I-35 N.E. OF PLANT		X		OBSTRUCTION
MARIETTA	S10901	1/13/1992	0.00	SW Seminole, South outfall line to sewage treatment plant.	0	x		?
MARIETTA	S10901	1/13/1992	11.00	700 W SEMINOLE BEHIND AND WEST OF LIVESTOCK AUCTION		X		RAIN OVERLOAD DUE TO I/I
MARIETTA	S10901	9/3/1992		WWTP		X	X	PLANT BROKEN DOWN
MARIETTA	S10901	12/13/1992	14.00	SW PART OF MARIETTA INTO DALES CREEK	2000	X		RAINFALL I/I
MARIETTA	S10901	2/28/1993	48.00	700 WEST SEMINOLE	0	X		EXCESSIVE RAINFALL
MARIETTA	S10901	2/28/1993	48.00	BEHIND LIVESTOCK BARN	0	X		EXCESSIVE RAIN
MARIETTA	S10901	1/19/1995	1.00	AT PLANT	1000	R		CLARIFIER STOPPDE UP
MARIETTA	S10901	6/13/1999	10.00	TREATMENT PLANT	60,000		X	SLUDGE RETURN TUBE PLUGGED
MARIETTA	S10901	6/23/2001	0.50		500	X		LINE STOPPAGE
MARIETTA	S10901	12/19/2001	1.00	N. CENTRAL PORTION OF TOWN	>500	X		LINE STOPPAGE
MARIETTA	S10901	2/11/2002	1.00	2ND ST N.W. & MILL ST	100	X		LINE COLLAPSED
MARIETTA	S10901	3/4/2002	0.50	NEAR BIG FIVE DAYCARE	200	X		HAND TOWELS
MARIETTA	S10901	3/18/2002	0.00	S.W. PART OF MARIETTA			X	I&I
MARIETTA	S10901	4/30/2002	0.50	CITY PARK N.W. OF TOWN	300	X		RAGS
MARIETTA	S10901	11/20/2002	6.00	S. OF HARPER'S WESTERN WEAR	2,000	X		GREASE
MARIETTA	S10901	11/20/2002	0.20	CITY PARK	100	X		TOWELS
MARIETTA	S10901	5/27/2007	5.50	7TH & W. SEMINOLE ST.	50,000	X		MAIN BREAK
MARIETTA	S10901	7/10/2007	8.00	S.W. MARIETTA	30,000	X		PIPE BUSTED
MARIETTA	S10901	7/20/2007	7.70	506 S.W. 7TH	30,000	X		BUSTED PIPE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
MARIETTA	S10901	7/29/2007	4.00	PLANT	6,000		X	PLUGGED TUBE
MARIETTA	S10901	12/30/2007	12.00	N. OF INDIAN TRAIL RD.	50,000	X		GREASE
MARIETTA	S10901	3/3/2008	0.50	N. OF STONEBRIAR APTS/ N. OF INDIAN TRAIL RD.	50,000	X		GREASE
MARIETTA	S10901	8/25/2008	0.40	N. OF HWY 32 E. OF CARL'S JR.	100	X		GREASE
MARIETTA	S10901	9/28/2009	2.00	HWY 77	2,500	X		GREASE
MARIETTA	S10901	10/20/2009	2.00	204 EAST MAIN	300	X		STOPPED MAIN
FORT SILL	S11304	2/28/1990		HEADWORKS OF PLANT-BYPASS VIA PIPELINE DIRECT TO THE STREAM				EXCESSIVE RAINFALL
FORT SILL	S11304	4/18/1990		EAST CACHE CREEK EFFLUENT LINE	0			EXCESSIVE RAINWATER
FORT SILL	S11304	5/3/1990		FORT SILL WASTEWATER TREATMENT PLANT				EXCESSIVE RAINFALL CAUSED INFLOW AND INFILTRATION
FORT SILL	S11304	7/12/1990		E CACHE CR				RAIN
FORT SILL	S11304	7/25/1990		E CACHE CR				RAIN
FORT SILL	S11304	9/21/1990		WWTP				RAIN
FORT SILL	S11304	4/24/1991		PLANT				RAIN
FORT SILL	S11304	9/4/1991	2.0	WWTP Plant		x		Excessive Rain
FORT SILL	S11304	9/18/1991	10	INFLUENT STRUCTURE AT WASTEWATER TREATMENT PLANT	0	X		VERY HEAVY RAINFALL
FORT SILL	S11304	8/31/1991	2.0	Overflow weir of influent channel at Ft. Sill WWTP		X		Heavy Rainfall
FORT SILL	S11304	9/4/1991	2.0	Overflow weir of influent channel		X		Heavy rainfall
FORT SILL	S11304	9/14/1991	3.0	WWTP inflow weir		X		Heavy rainfall
FORT SILL	S11304	9/13/1991	5.0	Influent weir WWTP		X		Heavy rainfall
FORT SILL	S11304	9/18/1991	10	WWTP Infulent weir		X		Heavy rainfall
FORT SILL	S11304	10/28/1991	5.0	At the headworks	0	x		Due to rainfall
FORT SILL	S11304	12/12/1991	3.0	BUILDING 5925				HEAVY RAINFALL
FORT SILL	S11304	9/18/1991	10	WWTP Infulent weir		X		Heavy rainfall
FORT SILL	S11304	12/20/1991	83	WWTP FORT SILL ARMY BASE		X	X	TREATMENT PLANT PARTICALLY FLOODED DUE TO HEAVY RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
FORT SILL	S11304	12/12/1991	3.0	OVERFLOW WEIR OF INFLUENT CHANNEL		X		EXCESSIVE RAINFALL
FORT SILL	S11304	4/16/1992	6.0	sewage plant	0	X		Heavy rain.
FORT SILL	S11304	4/17/1992	12	sewage plant	0	X		Heavy rain.
FORT SILL	S11304	5/11/1992	2.0	Headworks of the wastewater treatment plant	0	x		excessive rain
FORT SILL	S11304	5/28/1992	15	Bypass to the plant outfall	4	X		Rain
FORT SILL	S11304	6/20/1992	5.0	INFLUENT TO THE WWTP	0	X		HEAVY RAINFALL; ELECTRICAL STORM; 90 MPH WIND.
FORT SILL	S11304	6/28/1992	2.0	INFLUENT TO WWTP	0	X		HEAVY RAIN.
FORT SILL	S11304	6/9/1992	21	INFLUENT CHANNEL AT WWTP	4	X		HEAVY RAIN.
FORT SILL	S11304	6/8/1992	3.0	WWTP		X		HYDRUALIC OVERLOAD OF HOLDING BASIN
FORT SILL	S11304	6/5/1992	3.0	WWTP		X		HYDRUALIC OVERLOAD OF HOLDING BASIN
FORT SILL	S11304	6/6/1992	4.0	WWTP		X		HYDRUALIC OVERLOAD OF HOLDING BASIN
FORT SILL	S11304	7/27/1992	2.0	headworks of the plant	0	x		rainfall
FORT SILL	S11304	8/26/1992	2.0	headworks of plant	0	x		heavy rain fall
FORT SILL	S11304	9/10/1992	4.0	HEADWORKS OF PLANT	300000	X		TO BEGIN CONSTRUCTION ON A UNIT IN PLANT
FORT SILL	S11304	9/22/1992	5.0	PLANT COMPLEX	250000	X		RERUOTE FLOW DUE TO CONSTRUCTION PROBLEMS
FORT SILL	S11304	10/13/1992	3.0	headwaters of sewage plant	40	x		MCA Construction project - working on pumps
FORT SILL	S11304	10/28/1992	0.0	AT PLANT	18	Y		CONSTRUCTION & EXCESSIVE RAINFALL - TRIED TO REACH US ON 29T
FORT SILL	S11304	11/19/1992	7.0	HEADWORKS AT PLANT	700000	X		RAIN STORM
FORT SILL	S11304	6/5/1992	3.0	Plant		X		Excessive Rain
FORT SILL	S11304	6/6/1992	4.0	Plant		X		Excessive Rain
FORT SILL	S11304	6/8/1992		Plant		X		Excessive Rain
FORT SILL	S11304	11/21/1992	8.0	Plant OVERFLOW WEIR AT HEADWORKS	800000	X		Excessive Rain
FORT SILL	S11304	12/9/1992	2.0	HEADWORKS OF PLANT	170000	X		HEAVY RAINFALL

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
FORT SILL	S11304	12/9/1992	5.0	HEADWORKS WEIR	512000	X		HEAVY RAINFALL
FORT SILL	S11304	12/13/1992	16	HEADWORKS	2700000	X		HEAVY RAINFALL
FORT SILL	S11304	12/14/1992	20	HEADWORKS	2900000	X		RAINS
FORT SILL	S11304	12/15/1992	5.0	HEADWORKS AT WWTP	650	X		INFLOW/INFILTRATON FROM HEAVY RAINS
FORT SILL	S11304	1/19/1993	3.0	SEWER PLANT	332			RAINFALL
FORT SILL	S11304	2/14/1993	35	HEADWORKS	2000000	X		HEAVY RAINFALL
FORT SILL	S11304	3/1/1993	7.0	HEADWORKS	1000000	X		RAIN OVERLOAD
FORT SILL	S11304	3/19/1993	45	HEADWORK PLANT	5	X		EXCESSIVE RAINFALL
FORT SILL	S11304	4/14/1993	21	WWTP HEADWORKS	1240000	X		HEAVY RAINFALL I/I
FORT SILL	S11304	4/20/1993	30	HEADWORKS OF THE SEWER PLANT	5	X		DUE TO CONSTRUCTION
FORT SILL	S11304	4/21/1993	30	HEADWORKS OF THE SEWER PLANT	5250	X		DUE TO CONSTRUCTION
FORT SILL	S11304	5/3/1993	7.0	HEADWORKS	500000	X		HEAVY RAINFALL
FORT SILL	S11304	5/2/1993	14	HEADWORKS	1500000	X		HEAVY RAINFALL
FORT SILL	S11304	5/8/1993	3.0	HEADWORKS	1300000	X		EXCESSIVE RAIN
FORT SILL	S11304	5/9/1993	54	WWTP HEADWORKS	7500000	X		HEAVY RAINS
FORT SILL	S11304	5/23/1993	5.0	HEADWORKS TO CREEK	30000	X		RAINFALL OVERLOAD
FORT SILL	S11304	5/30/1993	2.0	WWTP	100	X		RAINFALL.
FORT SILL	S11304	6/9/1993	10	WWTP	1	X		PLANNED.
FORT SILL	S11304	7/14/1993	1.0	HEADWORKS OF PLANT	0	X		HEAVY RAINFALL
FORT SILL	S11304	9/14/1993	3.0	HEADWORKS	20000	X	X	RAINFALL
FORT SILL	S11304	9/19/1993	3.0	HEAD WORKS	150000	X	X	EXCESSIVE RAINFALL
FORT SILL	S11304	9/25/1993	5.0	HEADWORKS	400000	X	X	RAINFALL
FORT SILL	S11304	9/22/1993	3.0	HEADWORKS OF FACILITY	140		X	DUE TO CONSTRUCTION
FORT SILL	S11304	10/19/1993	4.0	HEADWORKS	300000	X	X	HEAVY RAINFALL
FORT SILL	S11304	10/30/1993	1.0	BLD 5795 A & B	100	X		LINE BLOCKAGE
FORT SILL	S11304	11/23/1993	4.0	FORT SILL WASTEWATER PLANT	28	X		DUE TO CONSTRUCTION - HEADWORKS
FORT SILL	S11304	2/21/1994	10	HEADWORKS OF PLANT	1000000	X	X	
FORT SILL	S11304	2/23/1994	1.0	INFULLENT PUMP FAILED	1000	X		PUMP FAILURE
FORT SILL	S11304	3/1/1994	6.0	HEADWORKS	500000	X	X	RAINFALL

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
FORT SILL	S11304	3/8/1994	7.0	HEADWORKS OF PLANT	600000	X	X	RAIN OVERLOAD
FORT SILL	S11304	4/7/1994	0.0	AREA 6900 FT SILL	0	X		LINE STOPPAGE
FORT SILL	S11304	5/6/1994	0.0	BLD 2454 NW CORNER	2500	X		DEBRIS BLOCKAGE
FORT SILL	S11304	5/12/1994	4.0	HEAD WORKS BYPASS LINE	600000	X		HAVY RAINFALL
FORT SILL	S11304	8/30/1994	5.0	WHITE WOLF LIFT STATION	0	X		DEBIRS BUILD UP
FORT SILL	S11304	4/16/1995	1.0	PLANT HEADWORKS	250	X	X	RAIN HYDROLIC OVERLOAD TO HEADWORKS
FORT SILL	S11304	4/17/1995	1.0	PLANT HEADWORKS	250	X		RAIN HYDROLIC OVERLOAD TO HEADWORKS
FORT SILL	S11304	6/5/1995	3.0	HEWADWORKS	350000	X		RAIN I/I
FORT SILL	S11304	9/17/1995	1.0	HEAD WORKS OF PLANT	10000	X		LIGHTING HIT CONTROL PANEL
FORT SILL	S11304	5/21/1996	1.0	5900 AREA TOWARD END OF FRANCIS ST	1000	X		STOPPAGE
FORT SILL	S11304	6/20/1996	1.0	QUINETTE CROSSING	500	X		MOTOR STARTERS BURNED OUT
FORT SILL	S11304	12/1/1996	55	L.S. 5900 AREA	2	X		PUMPS PLUGGED
FORT SILL	S11304	12/1/1996	24	QUINETTE CROSSING L.S.	500	X		ELECTRICAL BURNOUT
FORT SILL	S11304	12/3/1996	24	MH AT MARTHA SONGBIRD WILDERNESS AREA	10	X		VANDALIZED
FORT SILL	S11304	12/11/1996	1.0	L.S. 5900 SECTION	200	X		DEBRIS
FT. SILL	S11304	12/8/1996	11	LIFT STATION 5900 AREA	2	X		CLOGGED PUMPS
FT. SILL	S11304	11/18/1997	8	BLDG. 3443	2,000	X		PLUGGED LINE
FORT SILL	S11304	3/18/1998		CENTRAL WASH FACILITY	5 MILL			RAINS
FORT SILL	S11304	3/16/1998	8	WWTP			X	OVERFLOW
FORT SILL	S11304	11/2/1998	1	TRANSFER LINE BETWEEN DIGESTER #2 & 3	2,500			LINE BREAK
FORT SILL	S11304	2/9/1999	1.5	WHITE WOLF CROSSING	250			LINE BREAK
FORT SILL	S11304	3/31/1999	1.7	SECONDARY TREATMENT	110,250			
FORT SILL	S11304	4/9/1999	2.5	TERTIARY TREATMENT	157,500		X	
FORT SILL	S11304	4/14/1999	2.4	TERTIARY TREATMENT	294,000			CONSTRUCTION
FORT SILL	S11304	10/14/1999	4.5	BLDG. 2243	1,500			
LAWTON	S11304	10/23/1999	1.4	7201 N.W. CACHE	>500	X		DEBRIS
LAWTON	S11304	10/24/1999	5.5	901 N.W. CHERYL	>500	X		PRIVATE SERVICE RISER

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
FT. SILL	S11304	3/29/2000		CENTRAL WASH WEST FACILITY	>6 MILLN			RAIN
FORT SILL	S11304	6/27/2000	24	MH S34C04		X		RAIN
FREDERICK	S11309	6/11/1995	0.0	#3 LAGOON	0	X	X	RAIN I/I
GRANDFIELD	S11311	6/5/1995	48	#4 CELL AT LAGOONS	0	X		RAIN I/I
GRANDFIELD	S11311	6/9/1995	48	LAGOON #4	0	X		RAIN I/I
GRANDFIELD	S11311	3/16/1998		#4 LAGOON				RAIN
GRANDFIELD SEWER LAGOON	S11311	1/16/2001	666	1/2 N, 1/2 W OF GRANDFIELD #4 LAGOON	44593920		X	OVER 20" OF RAIN, SNOW & ICE
GRANDFIELD SEWER LAGOON	S11311	1/16/2001	120	#4 LAGOON	1592640		X	OVER 20" RAIN, SNOW & ICE
GRANDFIELD SEWER LAGOON	S11311	1/21/2001	240	#4 LAGOON	1592640		X	OVER 20" OF RAIN, SNOW & ICE
GRANDFIELD	S11311			LAGOONS				RAIN
DAVIDSON	S11401	6/6/1995	0.0	LAGOONS	0	X		RAIN I/I FROM FLOODING
FREDERICK	S11402	2/25/1991						
FREDERICK	S11402	6/1/1995		EAST OF FREDERICK	350000	X		RAINI/I
FREDERICK	S11402	6/11/1995	0.0	#3 LAGOON	0	X	X	RAIN I/I
DEVOL	S11403	10/11/1997		BLOCK 73, TOWN OF DEVOL		X		COLLAPSED SEWER LINE
DEVOL	S11403	2/17/1998		SEWER LAGOON	10,000	X		POWER FAILURE
DEVOL	S11403	11/17/1998						BROKEN LINE
DEVOL	S11403	1/2/2001		SEWER LAGOONS #3 CELL	5,000		X	NO WEIR BOX
DEVOL	S11403	12/25/2000		L.S.	5,000	X		LOSS OF POWER
DEVOL	S11403	12/22/2000		3RD CELL	5,000	X		NO OUTLET
DEVOL	S11403	11/11/2000	4	WW TREATMENT POND	70,000		X	DIKE OVERFLOWING
DEVOL	S11403	2/16/2001		3RD LAGOON CELL	6,000		X	NO WIER BOX
DEVOL	S11403	2/24/2001		LAGOON	8,000		X	RAIN
DEVOL	S11403	3/1/2001	96	#3 LAGOON CELL	5000		X	NO WIER BOX

APPENDIX I: STORMWATER PERMITTING REQUIREMENTS AND PRESUMPTIVE BEST MANAGEMENT PRACTICES (BMP) APPROACH

Stormwater Permitting Requirements and Presumptive Best Management practices (BMPs) Approach

A. Background

The National Pollutant Discharge Elimination System (NPDES) permitting program for stormwater discharges was established under the Clean Water Act as the result of a 1987 amendment. The Act specifies the level of control to be incorporated into the NPDES stormwater permitting program depending on the source (industrial versus municipal stormwater). These programs contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or stormwater pollution prevention plan (SWPPP) to implement any requirements of the total maximum daily load (TMDL) allocation. [See 40 CFR §130.]

Stormwater discharges are highly variable both in terms of flow and pollutant concentration, and the relationships between discharges and water quality can be complex. For municipal stormwater discharges in particular, the current use of system-wide permits and a variety of jurisdiction-wide BMPs, including educational and programmatic BMPs, does not easily lend itself to the existing methodologies for deriving numeric water quality-based effluent limitations. These methodologies were designed primarily for process wastewater discharges which occur at predictable rates with predictable pollutant loadings under low flow conditions in receiving waters.

EPA has recognized these problems and developed permitting guidance for stormwater permits. [See "Interim Permitting Approach for Water Quality-Based Effluent Limitations in Stormwater Permits" (EPA-833-D-96-00, Date published: 09/01/1996)] Due to the nature of stormwater discharges, and the typical lack of information on which to base numeric water quality-based effluent limitations (expressed as concentration and mass), EPA recommends an interim permitting approach for OPDES stormwater permits which is based on BMPs. "The interim permitting approach uses best management practices (BMPs) in first-round stormwater permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards." (*ibid.*)

A monitoring component is also included in the recommended BMP approach. "Each storm water permit should include a coordinated and cost-effective monitoring program to gather necessary information to determine the extent to which the permit provides for attainment of applicable water quality standards and to determine the appropriate conditions or limitations for subsequent permits." (*ibid.*)

This approach was further elaborated in a guidance memo issued in 2002. [See Memorandum from Robert Wayland, Director of OWOW and James Hanlon, Director of OWM to Regional Water Division Directors: "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit requirements Based on Those WLAs " (Date published: 11/22/2002)] "The policy outlined in this memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and non-structural BMPs) that address stormwater discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments (i.e., more stringent controls or specific BMPs) as necessary to protect water quality. …… If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the stormwater component of the TMDL, EPA recommends that the TMDL reflect this." This BMP-based approach to stormwater sources in TMDLs is also recognized and described in the most recent EPA guidance. [See "TMDLs to Stormwater Permits Handbook" (DRAFT), EPA, November 2008] This TMDL adopts the EPA recommended approach and relies on appropriate BMPs for implementation. No numeric effluent limitations are required or anticipated for municipal stormwater discharge permits.

B. Specific SWMP/SWPPP Requirements

As noted in Section 3 of this report, Oklahoma Pollutant Discharge Elimination System (OPDES)-permitted facilities and non-point sources (e.g., wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal system, and domestic pets) could contribute to exceedances of the water quality criteria. In particular, stormwater runoff from the Phase I and II Municipal Separate Storm Sewer Systems (MS4s) is likely to contain elevated bacterial concentrations. Permits for these discharges must comply with the provisions of this TMDL. **Table Appendix I-1** provides a list of Phase I and II MS4s that are affected by this bacterial TMDL report.

Agricultural activities and other nonpoint sources of bacteria are unregulated. Voluntary measures and incentives should be used and encouraged wherever possible and such sources should strive to attain the reduction goals established in this TMDL.

Table Appendix I-1 MS4 Permits affected by this TMDL Report

Entity	Permit No.	MS4 Phase	Date Issued
Fort Sill Army Base	OKR040040	Phase 2 MS4	9/29/2005

The provisions of this appendix apply only to OPDES/NPDES regulated stormwater discharges. Regulated CAFOs within the watershed operate under NPDES permits issued and overseen 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, as the responsible permitting agency, for follow up.

To ensure compliance with the TMDL requirements under the permit, stormwater permittees must develop strategies designed to achieve progress toward meeting the reduction goals established in the TMDL. Relying primarily upon a Best Management Practices (BMP) approach, permittees should take advantage of existing information on BMP performance and select a suite of BMPs appropriate to the local community that are expected to result in progress toward meeting the reduction goals established in the TMDL. The permittee should provide guidance on BMP installation and maintenance, as well as a monitoring and/or inspection schedule.

Table Appendix I-2 provides a summary description of some BMPs with reported effectiveness in reducing bacteria. Permittees may choose different BMPs to meet the permit requirements, as long as the permittees demonstrate that these practices will result in progress toward attaining water quality standards.

As noted above, when a BMP approach is selected a coordinated monitoring program is necessary to establish the effectiveness of the selected BMPs and demonstrate progress toward attaining water quality standards. The monitoring results should be used to refine bacterial controls in the future.

After EPA approval of the final TMDL, existing MS4 permittees will be notified of the TMDL provisions and schedule. Industrial stormwater permittees are not expected to be a significant source of bacteria. But if any are identified, similar actions will be required.

Compliance with the following provisions will constitute compliance with the requirements of this TMDL.

1. **Develop a Bacterial Reduction Plan**

   The permittee shall adopt its WLAs specified in the TMDL as measurable goals within its permit. The permittee shall submit an approvable TMDL compliance Plan to the DEQ within 24 months of EPA approval of this TMDL. Unless disapproved by the Director within 60 days of submission, the plan shall be approved and then implemented by the permittee. This plan shall, at a minimum, include the following:

   A. An evaluation to identify potential significant sources of bacteria entering your MS4. Such an evaluation should include an enhanced plan for illicit discharge screening and remediation. Following the evaluation and using guidelines outlined below, the permittee shall develop (or modify an existing program as necessary) and implement a program to reduce the discharge of bacteria in municipal stormwater contributed by all significant sources identified in the evaluation.

B. Selecting a General Strategy for the plan: An MS4 should demonstrate, in the TMDL Compliance Plan that it understands the TMDL requirements and that it has a strategy for meeting the WLAs. There are several ways for an MS4 to meet a TMDL waste load allocation (WLA) using BMPs and other approaches, including but not limited to:

a. Retrofitting developed areas and other suitable sites with structural stormwater BMPs (e.g. infiltration BMPs in built out areas).

b. Implementing BMPs that prevent additional stormwater bacterial pollution associated with new development and re-development; (e.g. promoting wet and dry detention pond development and biofiltration practices, developing wetland treatment systems, and installing hydrodynamic and manufactured devices).

c. Implementing non-structural BMPs designed for source control (e.g. manure management, source controls, and riparian buffer protection requirements) by considering ordinances or other regulatory mechanisms to require bacterial pollution control, as well as enforcement procedures for noncompliance.

d. Implementing non-structural BMPs designed to treat existing loads (e.g. livestock riparian access control).

e. Developing and implementing water quality trading: water quality trading among the MS4 permittees may be considered as a tool to achieve the overall WLA of the TMDLs. As the authorization and enforcement agency of Oklahoma's MS4 permits, the DEQ reserves the authority for the final approval of any trades or trading programs that may be considered in the study watershed.

C. Determining a schedule for achieving the WLA: This schedule can be general in nature, discussing groups of activities to be implemented within permit cycles or based on funding cycles. Specific activities need not be included in this section of the TMDL Compliance Plan. For example:

"MS4 X" will achieve necessary pollutant reductions within four permit cycles. During the first permit cycle, "MS4 X" will evaluate its existing stormwater program in relation to the TMDL compliance plan, determine if the program requires modification, outline a process for develop the TMDL compliance plan, and implement BMPs if opportunities arise. In the second permit cycle, "MS4 X" will modify its stormwater program as necessary, implement non-structural BMPs, develop a system to evaluate the effectiveness of these BMPs and implement structural BMPs if opportunities arise. In the third permit cycle, "MS4 X" will evaluate the effectiveness of non-structural BMPs, determine if structural BMPs (through retrofits) are needed, identify where and which structural BMPs will achieve the needed pollutant load reductions, and implement structural BMPs if opportunities arise. In the fourth permit cycle, "MS4 X" will implement structural BMPs as needed.

D. Implementing and Tracking BMPs

BMP Summary Sheets should be prepared for both structural and non-structural BMPs. For BMPs for which pollutant reductions can be calculated or modeled, BMP sheets should include any information used to make the calculations, BMP efficiencies, and maintenance information for the BMP (e.g. to ensure the efficiency used in the calculation is valid into the future or determine if it needs to be adjusted). Include references to support the calculations or modeling.

BMP Sheets can be prepared for ordinances, resources, or other tools needed for implementation of BMPs. Load reductions may be difficult to quantify with these BMPs, but these tools may be needed to implement BMPs that reduce loading.

a. Educational programs directed at reducing bacterial pollution. Implement a public education program to reduce the discharge of bacteria in municipal stormwater contributed (if applicable) by pets, recreational and exhibition livestock, and zoos.

2. Develop or Participate In a Bacterial Monitoring Program

As noted above, when a BMP approach is selected a coordinated monitoring program is necessary to establish the effectiveness of the selected BMPs and demonstrate progress toward achieving the reduction goals of the TMDL and eventually attaining water quality standards in the study watershed. The monitoring results should also be used to refine bacterial controls in the future. The permittee may participate in a coordinated regional monitoring program or develop its own individual program. Specific requirements for an effective monitoring and tracking program are as follows.

E. Within 24 months of EPA approval of this TMDL, the permittee shall prepare and submit to the DEQ either a TMDL monitoring plan or a commitment to participate in a coordinated regional monitoring program. Unless disapproved by the Director within 60 days of submission, the plan shall be approved and then implemented by the permittee. The plan or program shall include:

a. Evaluation of any existing stormwater monitoring program in relation to TMDL reduction goals.

b. A detailed description of the goals, monitoring, and sampling and analytical methods.

c. A map that identifies discharge points, stormwater drainage areas contributing to discharge points, and within each such drainage area, mapping the conveyance system.

d. A list and map of the selected TMDL monitoring sites, which may include sites on receiving waterbodies.

e. Consideration of methods for evaluating pollutant loading in stormwater discharges from residential and agricultural areas, such as monitoring requirement for on-site wastewater treatment facilities and animal feeding operations.

f. The frequency of sample collection to occur at each station or site: at a minimum, sample collection shall include at least one representative sample of a stormwater discharge from at least 50% of the major discharge points discharging directly to surface waters of the state within the portion of the TMDL watershed in the MS4 area. A major discharge point is a pipe or open conveyance measuring 36 inches or more at its widest cross section. If there isn't any major discharge point within the portion of the TMDL watershed in the MS4 area, the location of all outfalls in the TMDL watershed shall be identified and monitored properly to comply with the permit requirements and to address the TMDL.

g. The parameters to be measured, as appropriate for and relevant to the TMDL: at a minimum, the samples shall be analyzed for subjected bacteria in WLA. In this TMDL, the samples shall be analyzed for both *E. coli* and Enterococci.

B. The monitoring program shall be fully implemented within three years of EPA approval of this TMDL.

With the obtained monitoring and tracking data, periodically evaluate the effectiveness of individual BMPs if possible and the effectiveness of the overall TMDL compliance plan to ensure progress toward attainment of the WLA. If progress cannot be shown, the MS4 permittee must revise its TMDL compliance plan to further its load reduction efforts.

3. **Annal Reporting**

The permittee shall include a TMDL implementation report as part of their annual report. The TMDL implementation report shall include the status and actions taken by the permittee to implement the Bacterial Reduction Plan and monitoring program. The TMDL implementation report shall document relevant actions taken by the permittee that affect MS4 stormwater discharges to the waterbody segments that are the subject of the TMDL. This TMDL implementation report also shall identify the status of any applicable TMDL implementation schedule milestones.

Table Appendix I-2 Some BMPs Applicable to Bacteria

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Animal waste management: A planned system designed to manage liquid and solid waste from livestock and poultry. It improves water quality by storing and spreading waste at the proper time, rate and location.	X		75%[1]	
Artificial wetland/rock reed microbial filter: A long shallow hydroponic plant/rock filter system that treats polluted waste and wastewater. It combines horizontal and vertical flow of water through the filter, which is filled with aquatic and semi-aquatic plants and microorganisms and provides a high surface area of support media, such as rocks or crushed stone.	X	X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Compost facility: Treating organic agricultural wastes in order to reduce the pollution potential to surface and ground water. The composting facility must be constructed, operated and maintained without polluting air and/or water resources.	X	X		Permit may be needed
Conservation landscaping: The placement of vegetation in and around stormwater management BMPs. Its purpose is to help stabilize disturbed areas, enhance the pollutant removal capabilities of stormwater BMP, and improve the overall aesthetics of a stormwater BMP.		X		
Diversions: Establishing a channel with a supporting ridge on the lower side constructed along the general land slope which improves water quality by directing nutrient and sediment laden water to sites where it can be used or disposed of safely.	X	X		
Drain Inlet Inserts: A proprietary BMP that is generally easily installed in a drain inlet or catch basin to treat stormwater runoff. Three basic types of inlet insert are available, the tray type, bag type and basket type. The tray type allows flow to pass through filter media residing in a tray located around the perimeter of the inlet.	X	X	5%[2]	
Dry detention pond/basin: Detention ponds/basins that have been designed to temporarily detain stormwater runoff. These ponds fill with stormwater and release it over a period of a few days. They can also be used to provide flood control by including additional flood detention storage.	X	X	40%[2] 51%[3] 88% [4]	
Earthen embankments: A raised impounding structure made from compacted soil. It is appropriate for use with infiltration, detention, extended-detention or retention facilities.	X	X		
Drip irrigation: An irrigation method that supplies a slow, even application of low-pressure water through polyethylene tubing running from supply line directly to a plant's base. Water soaks into the soil gradually, reducing runoff and evaporation (i.e., salinity). Transmission of nutrients and pathogens spread by splashing water and wet foliage created by overhead sprinkler irrigation is greatly reduced. Weed growth is minimized, thereby reducing herbicide applications. Vegetable farming and virtually every type of landscape situation can benefit from the use of drip irrigation.	X	X		
Fencing: A constructed barrier to livestock, wildlife or people. Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.	X		75%[1]	
Filtration (e.g., sand filters): Intermittent sand filters capture, pre-treat to remove sediments, store while awaiting treatment, and treat to remove pollutants (by percolation through sand media) the most polluted stormwater from a site. Intermittent sand filter BMPs may be constructed in underground vaults, in paved trenches within or at the perimeter of impervious surfaces, or in either earthen or concrete open basins.	X	X	30%[1] 55%[2] 37%[4]	
Infiltration Basin: A vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil strata. While flooding and channel erosion control may be achieved within an infiltration basin, they are primarily used for water quality enhancement.		X	50%[1]	

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Infiltration Trench: A shallow, excavated trench backfilled with a coarse stone aggregate to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into the surrounding soils from the bottom and sides of the trench. The trench can be either an open surface trench or an underground facility.		X	50%[1]	
Irrigation water management: The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner. An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, etc.) must be available and capable of applying water to meet the intended purpose(s).	X	X		
Lagoon pump out: A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout in order to biologically treat waste (such as manure and wastewater) and thereby reduce pollution potential by serving as a treatment component of a waste management system.	X	X		
Land-use conversion: BMPs that involve a change in land use in order to retire land contributing detrimentally to the environment. Some examples of BMPs with associated land use changes are: Conservation Reserve Program (CRP) - cropland to pasture; Forest conservation - pervious urban to forest; Forest/grass buffers - cropland to forest/pasture; Tree planting - cropland/pasture to forest; and Conservation tillage – conventional tillage to conservation tillage.	X	X		
Limit livestock access: Excluding livestock from areas where grazing or trampling will cause erosion of stream banks and lowering of water quality by livestock activity in or adjacent to the water. Limitation is generally accomplished by permanent or temporary fencing. In addition, installation of an alternative water source away from the stream has been shown to reduce livestock access.	X			
Litter control: Litter includes larger items and particulates deposited on street surfaces, such as paper, vegetation residues, animal feces, bottles and broken glass, plastics and fallen leaves. Litter-control programs can reduce the amount of deposition of pollutants by as much as 50%, and may be an effective measure of controlling pollution by storm runoff.		X		
Livestock water crossing facility: Providing a controlled crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment.	X		100%[1]	
Manufactured BMP systems: Structural measures which are specifically designed and sized by the manufacturer to intercept stormwater runoff and prevent the transfer of pollutants downstream. They are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible.	X	X		
Onsite treatment system installation: Conventional onsite wastewater treatment and disposal system (onsite system) consists of three major components: a septic tank, a distribution box, and a subsurface soil absorption field (consisting of individual trenches). This system relies on gravity to carry household waste to the septic tank, move effluent from the septic tank to the distribution box, and distribute effluent from the distribution box throughout the subsurface soil absorption field. All of these		X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
components are essential for a conventional onsite system to function in an acceptable manner.				
Porous pavement: An alternative to conventional pavement, it is made from asphalt (in which fine filler fractions are missing) or modular or poured-in concrete pavements. Its use allows rainfall to percolate through it to the sub-base, providing storage and enhancing soil infiltration that can be used to reduce runoff and combined sewer overflows. The water stored in the sub-base then gradually infiltrates the subsoil.		X	50%[1]	
Proper site selection for animal feeding facility: Establishing or relocating confined feeding facilities away from environmentally vulnerable areas such as sinkholes, streams, and rivers in order to reduce or eliminate the amount of pollutant runoff reaching these areas.	X			
Raingarden/bio-retention basin: Rain gardens are landscaped gardens of trees, shrubs, and plants located in commercial or residential areas in order to treat stormwater runoff through temporary collection of the water before infiltration. They are slightly depressed areas into which stormwater runoff is channeled by pipes, curb openings, or gravity.		X	40%[1]	
Range and pasture management: Systems of practices to protect the vegetative cover on improved pasture and native rangelands. It includes practices such as seeding or reseeding, brush management (mechanical, chemical, physical, or biological), proper stocking rates and proper grazing use, and deferred rotational systems.	X		50%[1]	
Wet retention ponds/basins: A stormwater facility that includes a permanent pool of water and, therefore, is normally wet even during non-rainfall periods. Inflows from stormwater runoff may be temporarily stored above this permanent pool.	X	X	32%[1] 70%[4]	
Riparian buffer zones: A protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural non-point sources.	X	X	43–57%[1]	Forested buffer w/o incentive payment
Septic system pump-out: A typical septic system consists of a tank that receives waste from a residence or business, and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.		X	5%[1]	
Sewer line maintenance (e.g., sewer flushing): Sewer flushing during dry weather is designed to periodically remove solids that have deposited on the bottom of the sewer and the biological slime that grows on the walls of combined sewers during periods of low-flow. Flushing is especially necessary in sewer systems that have low grades which has resulted in velocities during low-flow periods that fall below those needed for self-cleaning.		X		
Stream bank protection and stabilization (e.g., riprap, gabions): Stabilizing shoreline areas that are being eroded by landscaping,	X	X	40-75%[1]	40 % w/o fencing;

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
constructing bulkheads, riprap revetments, gabion systems, or establishing vegetation.				75 % w/fencing
Street sweeping: The practice of passing over an impervious surface, usually a street or a parking lot, with a vacuum or a rotating brush for the purpose of collecting and disposing of accumulated debris, litter, sand and sediments. In areas with defined wet and dry seasons, sweeping prior to the wet season is likely to be beneficial; following snowmelt and heavy leaf fall are also opportune times.		X		
Terrace: An earth embankment, or a combination ridge and channel, constructed across the field slope. Terraces can be used when there is a need to conserve water, excessive runoff is a problem, and the soils and topography are such that terraces can be constructed and farmed with reasonable effort.	X	X		
Vegetated filter strip: A densely vegetated strip of land engineered to accept runoff from upstream development as overland sheet flow. It may adopt any naturally vegetated form, from grassy meadow to small forest. The purpose of a vegetated filter strip is to enhance the quality of stormwater runoff through filtration, sediment deposition, infiltration and absorption.	X	X	<30% [3]	
Waste system/storage (e.g., lagoons, litter shed): Waste treatment lagoons biologically treat liquid waste to reduce the nutrient and BOD content. Lagoons must be emptied and their contents disposed of properly.	X	X	80–100%[1]	
Water treatment (e.g., disinfection, flocculation, carbon filter system): Physical, chemical and/or biological processes used to treat concentrated discharges. Physical-chemical processes that have been demonstrated to effectively treat discharge include sedimentation, vortex separation, screening (e.g., fine-mesh screening), and sand-peat filters. Chemical additives used to enhance separation of particles from liquid include chemical coagulants such as lime, alum, ferric chloride, and various polyelectrolytes. Biological processes that have been demonstrated to effectively treat discharges include contact stabilization, biodiscs, oxidation ponds, aerated lagoons, and facultative lagoons.	X	X		
Wetland development/enhancement: The construction of a wetland for the treatment of animal waste runoff or stormwater runoff. Wetlands improve water quality by removing nutrients from animal waste or sediments and nutrients from stormwater runoff.	X	X	30%[1] 78%[4]	Including creation and restoration

4. Evaluating Progress

Compliance with this TMDL and progress toward achieving the wasteload allocations and load reduction goals will be evaluated at each renewal of the MS4 permit for the entity, generally every five years. Consideration will be given to:

- Water quality data and results from the pollutant monitoring and tracking program

- The status of achieving milestones and accomplishing items in the current compliance plan
- Any revisions that have been made to or proposed for the compliance plan
- Any proposed enhancements to the compliance plan for the next permit term

If sufficient progress is not demonstrated, an updated compliance plan and implementation schedule will be required to be submitted within 6 months. Noncompliance may subject the permittee to enforcement action.

Sources

[1] BMP Efficiencies Chesapeake Bay Watershed Model (PhaseIV) August 1999; Draft FC and Nitrate TMDL IP for Dry River (2001); EPA (1998); EPA (1999b); Novotny (1994); Storm Water Best Management Practice Categories and Pollutant Removal Efficiencies (2003); USDA (2003); DCR (1999); DEQ/DCR (2001).

[2] Barrett, M.E.,Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices, Texas Natural Resource Conservation Commission Report RG-348, June (1999).

[3] The Expected Pollutant Removal (Percent) Data Adapted from US EPA, 1993C.

[4] National Pollutant Removal Performance Database, Version 3, September, 2007

APPENDIX J: RESPONSE TO COMMENTS

Scott A. Thompson
Executive Director

Mary Fallin
Governor

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Response to the EPA Comment Received for the Draft Bacterial TMDL Report for the Red River Area

Comment #1: Table ES-1 & Table 2-2: Explain the "not attaining" for the DU of PBCR when there are no data (enterococci or *E. coli*) indicating the criteria are exceeded.

DEQ Response 1: All waterbodies not attaining Water Quality Standards (WQS) exceeded the criteria. An explanation was added in a footnote for clarity as, "impaired for enterococci, but TMDL was done in 2007." Data were presented in Appendix A and assessment results were in Table ES-2 and Table 2-3.

Comment #2-1: Table ES-2: Is "Assessment Results" the best descriptive field header as the column seems populated with actions, not assessment results?

DEQ Response 2-1: The column heading in Table ES-2, ES-3, 2-3, and 2-5 was changed to "Assessment Results/Recommended Actions" from "Assessment Results" and assessment results were added in the column.

Comment #2-2: What constitutes insufficient data? Explain the implications of "insufficient data."

DEQ Response 2-2: OAC Chapter 46 requires a minimum number of samples to assess the beneficial use. An explanation was added as Section ES-2.5 and Section 2.1.6, "OAC Chapter 46: Minimum number of samples." Oklahoma Administrative Code [OAC 785:46-15-3(D)(1)] states that "Except when (f) of this Section or any of subsection (e), (h), (i), (j), (k), (l), or (m) of 785:46-15-5applies, **a minimum of 10 samples shall be required to assess beneficial use support** due to field parameters including but not limited to DO, pH and temperature, and due to routine water quality constituents including but not limited to coliform bacteria, dissolved solids and salts. Analyses may be aggregated to meet the 10 sample minimum requirements in non-wadable stream reaches that are 25 miles or less in length, and in wadable stream reaches that are 10 miles or less in length, if water quality conditions are similar at all sites. Provided, **a minimum of 10 samples shall not be necessary if the existing samples already assure exceedance of the applicable percentage of a prescribed screening level."**

Comment #2-3: What action is to be taken on those waterbody/parameter pairs that do not have the "Assessment Results" field populated?

DEQ Response 2-3: Assessment Results and Recommended Actions were added as "Meeting WQS / No action."

Comment #2-4: It seems as though several streams are being delisted due to insufficient data-if these streams were listed, they need to stay on the list until a TMDL is completed & approved by EPA, sufficient data indicate they are no longer impaired, or an adequate explanation of the assessment methodology leading to delisting is explained & the TMDL report recommends these waters for delisting.

DEQ Response 2-4: Column heading was changed to recommended action. If the number of samples is insufficient and the waterbody is on the 303(d) list, the waterbody is recommended for delisting in the next Integrated Report cycle. The impairments will remain on the State's 303(d) list until the delistings are approved by EPA. Delisting justifications will be submitted to EPA along with the subsequent draft 303(d) list.

Comment #2-5: Why is the outcome for insufficient data for Dry Creek (delist) different from the insufficient data outcome for Blue Beaver Creek (TMDL required)?

DEQ Response 2-5: Please see Response 2-2 ("a minimum of 10 samples shall not be necessary if the existing samples already assure exceedance of the applicable percentage of a prescribed screening level"). When additional samples to meet the minimum number of samples were assumed to be **non-detects**, Blue Beaver Creek exceeded WQS with the existing samples (See below table).

Sample	#1	#2	#3	#4	#5	#6	7	8	9	10	Geometric Mean
Enterococci for Blue Beaver Creek	210	6,000	120	218	165	40	**5**	**5**	**5**	**5**	51.7 (**Existing samples indicated a "not attained"/TMDL**)
Enterococci for Dry Creek	8,000	400	106	185	**5**	**5**	**5**	**5**	**5**	**5**	31.6 (Insufficient data/Delist)

WQS for Enterococci = 33/100mL

Detection limit for Entrococci = 10/100mL (**Non-detect = half the detection limit**)

Comment #2-6: Why is Red River included in this table if no further action is to be taken as it already has a TMDL for enterococci and the "Assessment Results" field for *E. coli* indicator is left blank?

DEQ Response 2-6: All waterbodies not attaining their beneficial use for either PBCR or WWAC were assessed in this report to see if there is any change in WQ and also additional data collected after April 30, 2013 (assessment period for 2014 IR: May 2008 -April 2013) were reviewed. The TMDL process begins by determining which waters do not meet, or are not expected to meet, water quality standards after the implementation of technology-based controls. After EPA final approval of the TMDLs, they are integrated into the State's Water Quality Management Plan (CPP p147, 2012). State, Territories, and authorized Tribes are required to update their Water Quality Management Plan as needed to reflect changing water quality conditions and the results of implementation actions (EPA, 1999). Assessment result for *E. coli* in the Red River was added as "Meeting WQS/No action."

Reference

EPA; 1999, Draft Guidance for Water Quality-based Decisions; The TMDL Process (Second Edition), EPA-841-D-99-001, August 1999. Retrieved on October 23, 2015 from website: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/propguid_Guidance.cfm#Contents

DEQ; 2012. The State of Oklahoma 2012 Continuing Planning Process (CPP). Retrieved on October 23, 2015 from website: http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf

Comment #2-7: Does the 2007 TMDL need to be revised as the water is not attaining WQS?

DEQ Response 2-7: Water quality (WQ) of the Red River hasn't been changed since the 2007 TMDL. Efficacy of approved TMDLs will be assessed at a later date.

Comment #3-1: Table ES-3 & 2-3: What constitutes insufficient data?

DEQ Response 3-1: Please see Response 2-2.

Comment #3-2: Explain the implications of "insufficient data."

DEQ Response 3-2: Please see Response 2-2 & 2-4.

Comment #3-3: In the "Assessment Results" field, explain "Not listed, but TMDL required."

DEQ Response 3-3: Wording was changed to "Impaired, but not listed in 303d / TMDL".

Comment #3-4: Will this be an informational TMDL?

DEQ Response 3-4: No. The waterbody impairments will be added to the next 303(d) list if the assessment of applicable data indicates impairment.

Comment #3-5: What is the action to be taken for Hickory Creek?

DEQ Response 3-5: Please see Table ES-2 and ES-3 or Table 2-3 and 2-5. For *E. coli* and turbidity, no action will be taken because it meets WQS. Assessment Results and Recommended Actions were added as "Meeting WQS / No action." For enterococci, a TMDL will be established.

Comment #3-6: Is "Assessment Results" the best descriptive field header as the column seems populated with actions, not assessment results?

DEQ Response 3-6: Please see the Response 2-1.

Comment #3-7: From the table, it looks as though none of the 2010 TMDLs are attaining. Are they expected to attain In the near future?

DEQ Response 3-7: This question is outside of the scope of this TMDL. The wasteload allocations for point sources including MS4s will be implemented through the Oklahoma Pollutant Discharge Elimination System (OPDES) permits. The Oklahoma Conservation Commission (OCC) has responsibilities for the state's NPS program.

Comment #3-8: Do these TMDLs need to be revised?

DEQ Response 3-8: Efficacy of approved TMDLs will be assessed at a later date.

Comment #3-9. Why are these streams listed in this report if they already have an approved TMDL?

DEQ Response 3-9: Please see Response 2-6.

Comment #4-1: Table 2-1: This Table combines designated use assignments and assessment results of those designated uses, which can cause confusion to the public as assessment results were not mentioned in the text.

DEQ Response 4-1: This Table showed other beneficial uses for the study waterbodies along with WWAC and PBCR. This table is used for informational purposes. Assessment results were shown in the Table 2-3 and Table 2-5. An explanation was given in Section 2.2.

Comment #4-2: Additionally, the characters "x" and "v" in the table are not defined.

DEQ Response 4-2: Definitions for "x" and "v" were added in the Table 2-1 as X - Not assessed and V - Listed.

Comment #4-3. Where insufficient marked-does this indicate there has always been insufficient data or insufficient data for the 2014 IR POR? If the later, what was the original assessment?

DEQ Response 4-3: Collecting agencies (OWRB & OCC) assess the waterbodies based on their sample data. However, OAC 785:46-15-3(C)(2) provides the assessment period (please see below).

785:46-15-3. Data requirements

(c)Temporal coverage

(2) **Streams.** Data not older than five years old shall be utilized in assessing use support for a stream unless

(A) the data available from the preceding five year period is insufficient to satisfy the requirement of 785:46-15-3(d) or other specific minimum requirements provided in this Subchapter, **in which case data older than five years old may be utilized**, or

(b) the provisions of 785:46-15-4(b)(3) or 785:46-15-4(c)(3) apply.

If five years of stream data are not meeting data requirements, data for the one year period preceding the POR are added until data requirements are met. Therefore, insufficient data indicate there are not enough historical data available to meet data requirements. Most of our listings that have been determined to have insufficient data were originally assessed and added to the 303(d) list in error.

Comment #5: Section 2.2.1: The last paragraph indicates that 2 waterbodies were removed from TMDL development due to insufficient data. Were these waterbodies previously listed? If so, they need to stay on the list until a TMDL is completed & approved by EPA, sufficient data indicated they are no longer impaired, or an adequate explanation of the assessment methodology leading to delisting is explained & the TMDL report recommends these waters for delisting.

DEQ Response 5: These impairments will remain on the 303(d) list until delisting is approved by EPA. The delisting justifications will be provided to EPA during the next Integrated Report cycle. Due to lack of data, DEQ could not establish TMDLs for these waterbodies.

Comment #6-1: Section 3 uses fecal coliforms as the estimate of bacteria-define how fecal coliform are related to the TMDL parameters, enterococci and *E. coli*.

DEQ Response 6-1: The TMDL report (page 3-1) states, "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."

Comment #6-2: Is a ratio used to allow for better characterization of the nonpoint source contribution?

DEQ Response 6-2: No. The TMDL report (page 3-27) states, "The magnitude of loading to land surfaces may not reflect the magnitude of loading to a stream. 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 wash-off 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."

Comment #7-1: Table 3-1: Is the field heading "Waterbody ID & Waterbody Name" the best descriptor?

DEQ Response 7-1: The heading has been changed to "Receiving stream or facility" from "Waterbody ID & Waterbody Name".

Comment #7-2: Populated appear to be a mix of facilities and waters that haven't been mentioned elsewhere in the report.

DEQ Response 7-2: They were mentioned in Section 3.2.1.1 & 3.2.1.2.

In Section 3.2.1.1 (page 3-12), "There are six active permitted municipal point source facilities within the Study Area. Municipal WWTFs are designated with a Standard Industrial Code (SIC) number 4952. They discharge organic TSS with limits for $CBOD_5$ so they are not considered a potential source of turbidity."

In Section 3.2.1.2 (page 3-12), "There are five active OPDES industrial point source dischargers in this Study Area, including Pretreatment (OKP00) and General Permit (OKG95). Pretreatment facilities discharge wastewater to municipal wastewater treatment plant. Therefore, they (OKP003031, OKP003022, and OKP003058) don't discharge wastewater to "Water of U.S." and will not receive WLA. Dolese Bros Ardmore Quarry (OKG950032) is in the Hickory Creek watershed impaired for bacteria. Quarry is not considered as bacterial source. Therefore, Dolese Bros Ardmore Quarry will not receive bacteria WLA. In other hand, Dolese Bros Richard's Spur Quarry (OKG950031) is in turbidity impaired East Cache Creek (OK311300020010_10) watershed."

Comment #7-3: Are there the numbers populated in the "Ave/Max FC cfu/100mL" field limits from permits?

DEQ Response 7-3: Yes. OAC 252:690-3-86 (effective by July 1, 2011) indicated, "The fecal coliform MAL of 200 CFU/100ml, expressed as a geometric mean, and the DML of 400 CFU/100ml apply to permittees that discharge fecal coliform." However, fecal coliform is no longer used for bacterial indicators from July 1, 2011.

Comment #7-4: Are there the numbers populated in the "Ave/Max TSS mg/L" field limits from permits?

DEQ Response 7-4: Yes. OAC 252:690-3-60 states water quality constituents to protect the Fish and Wildlife Propagation beneficial use (please see below).

252:690-3-60. Receiving water characterization for the implementation of dissolved oxygen criteria to protect the Fish and Wildlife Propagation beneficial use

> (2) **Water quality constituents.** Where available, the long term average of measured values will be used to establish receiving water conditions. For seasonal analyses, values calculated from the dataset for the season shall be used. For simple models, assumed conditions estimated from similar streams in the area may be used.

Comment #7-5: What causes the difference in numbers/seasons?

DEQ Response 7-5: Please see Responses 7-3 and 7-4.

Comment #7-6: Why do the vast majority have expired permits, N/A, or a blank in the "Expiration Date" field?

DEQ Response 7-6: Expiration dates were updated in the Table 3-1.

Comment #7-7: If a permit is expired, does that mean it has been administratively continued or is it no longer discharging?

DEQ Response 7-7: Upon timely application for a permit, any prior permit remains in effect until a new one is issued.

Comment #7-8: Why is the OKTEX Baking facility listed if it is inactive?

DEQ Response 7-8: All facilities existing in sample period (2000-2014) were listed in the Table 3-1 for informational purposes.

Comment #8-1: Table 3-5: If the minimum amount field is populated, does this mean the SSO is always discharging?

DEQ Response 8-1: No. Sanitary sewer overflow (SSO) is a condition in which untreated sewage is discharged from a sanitary sewer into the environment prior to reaching sewage treatment facilities. Please see DEQ Response 8-2.

Comment #8-2: Define "minimal" in the minimum amount field.

DEQ Response 8-2: The minimal amount of overflow is near 0 gallon which is too small to measure.

Comment #9: Section 3.2.2.1.2 mentions Fort Sill as the only MS4 in a study area; however, no percentage area of the watershed covered by Fort Sill is mentioned with which to be able to check calculations.

DEQ Response 9: Coverage was added in the Section 3.2.2.1.2 as "It covers 7.6% of the East Cache Creek watershed."

Comment #10: Section 3.3.2 references Tb inputs from farm animals, but gives no estimate of contribution-literature values are available with which to better characterize nonpoint source contributions.

DEQ Response 10: It is known fact that farm animals accessing waterbodies can cause unstable stream banks. However, as mentioned in the report (page 3-21), there is not sufficient information available to describe or quantify the contributions of sediment loading caused by commercially raised farm animals responsible for destabilizing stream banks or erosion in pasture fields.

Comment #11: Section 3.3.1: Please provide the citation from where the deer harvest rate was obtained.

DEQ Response 11: The TMDL report stated that, "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." Also, in Section 7, citation was referenced as "Oklahoma Department of Wildlife Conservation (ODWC); 2009. Deer Harvest Totals. http://www.wildlifedepartment.com/hunting/deerharvesttotals.htm"

Comment #12: Table 3-8: field heading "Wild Deer Population" and "Fecal Production…" should include the word "estimated"

DEQ Response 12: The title of Table 3-8 states as "Estimated Population and Fecal Coliform Production for Deer". The title of the table indicates that the deer population and resultant fecal coliform production are estimates.

Comment #13: Table 3-15: How was the # of failing septic tanks determined? Citation?

DEQ Response 13: In the TMDL report (page 3-25), citation and calculation/equation were given. Please see bold type below.

"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 3-14 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**.**" No change was made for this comment.

Comment #14: Section 3.4.2 states: "Therefore, nonsupport of WWAC use in these watersheds is likely caused primarily by nonpoint sources." This sentence is not substantiated.

DEQ Response 14: The preceding sentence in the report explained that there are no point sources. Without point sources, nonpoint sources are the sole cause of impairment.

Comment #15: Section 4.2.3: define "censored" data & the implication of censored data.

DEQ Response 15: "Censored data" is a common terminology in statistics. Non-detects and censored data were used interchangeably in the report. Definition for non-detects was in Section 4.2.1. Term "Censored data" was added in the parenthesis as below.

"Non-detects (**censored data**) are TSS sample observations less than the detection limit (10 mg/L)."

Comment #16: Section 4.3.3.3, WLA for WWTF: over what time period is used to calculate the average of monthly flows from DMRs?

DEQ Response 16: OAC 785:46-5-2(C) states, "Regulatory effluent flows" (please see below). When the design flow for municipalities is not available, Q_e is determined as industrial dischargers.

785:46-5-2. Regulatory flow determination

> **(c)Regulatory effluent flows.** The regulatory effluent flow, Q_e, is the highest monthly averaged flow over the previous two years for industrial discharges if the permitting authority determines that sufficient data are available. For other dischargers (e.g. municipalities), Q_e is the design flow. If a significant daily or seasonal variability in effluent flow is present, a regulatory effluent flow should take this variability into account.

Comment #17: Please provide a map of the USGS gages used to estimate flow in relation to the stream segments for which they were applied.

DEQ Response 17: USGS gaging stations have been added in Figure 1-1.

Comment #18: Please provide the USGS gage drainage areas and or the watershed ratios used when estimating the flow from neighboring USGS gage. Appendix C includes the drainage area of the stream, but does not include information on how the stream flows were scaled with respect to surrogate watersheds. EPA needs this information in order to do a complete review of the document and calculations. These flow estimation calculations for each stream where flow was estimated should be documented in an appendix for clarity.

DEQ Response 18: USGS gage drainage areas were added in Table Appendix C-2.

Comment #19-1: Section 5.3.1: Further explain geometric mean calculations. Was a geometric mean calculated for each season from 2000-2013 so there would be 14 geometric means or were data from the whole timespan calculated into one geometric mean?

DEQ Response 19-1: The method of calculation is explained in Section 4.3.2.1.

"**4.3.2.1 Bacteria**

Existing in-stream loads can be calculated using LDCs. For bacteria:

- Calculate the geometric mean of all water quality observations from the period of record selected for the waterbody."

Comment #19-2: Why is the POR so long?

DEQ Response 19-2: Please see the Response 2-2. If the sample data were not meeting the minimum number of data, data collected in previous year were added until minimum data requirement was met. Data period could be found in Appendix A.

Waterbody ID	Waterbody Name	POR	
		Bacteria	TSS/Turbidity
OK311100010230_00	Bills Creek	6/20/2001	6/20/2001 - 2/12/2003
OK311100010250_00	Walnut Bayou	6/6/2006 - 7/9/**2013**	5/27/2009 - 3/10/2014
OK311100010300_00	Fleetwood Creek	5/9/2005 - 9/14/2010	5/26/2009 - 4/26/2011
OK311100020010_10	Hickory Creek	6/6/2006 - 9/14/2010	5/27/2009 - 4/26/2011
OK311200000080_00	Dry Creek	5/7/2001 - 8/20/2001	5/15/2000 - 3/25/2002
OK311300020010_10	Cache Creek, East	5/26/2009 - 9/20/2010	5/26/2009 - 4/25/2011
OK311300040060_00	Medicine Creek	5/26/2009 - 9/20/2010	5/26/2009 - 4/25/2011
OK311310010010_00	Red River	5/10/2004 - 6/18/2013	5/24/**1999** - 6/16/**2014**
OK311310020010_10	Cache Creek, West	5/26/2009 - 9/20/2010	5/26/2009 - 4/25/2011
OK311310020060_00	Blue Beaver Creek	8/28/**2000** - 9/24/2001	5/7/2001 - 3/25/2002
OK311310030040_00	Little Deep Red Creek	5/26/2009 - 9/20/2010	5/26/2009 - 4/25/2011

Comment #20: Figure 5-17, should this have the WLA_{sw} line drawn on it as well with a corresponding text description?

DEQ Response 20: In Figure 5-17, WLA = WLA_{WWTF} + WLA_{MS4}. An explanation was given in Section 5.3.1 where the graph is located. Please see the text below (page 5-8) from the report.

"The LDC for Cache Creek, East (Figure 5-17) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK311300-02-0010M. The WLA reflects the influence of the MS4 discharge at high flow and the continuous discharge of the municipal discharger with the permitted design flow (4.3 MGD), Fort Sill WWT (OK0030295), at low flow.

Separating WLA into WLA_{WWTF} and WLA_{MS4} does not help understanding of point source contribution. Separate WLA calculations can be found in Table 5-13.

Comment #21: Figure 5-24, why is there a TMDL being completed for East Cache Creek when the only violations are noted at high flow, which is not considered because the Tb standard only applies at base flows.

DEQ Response 21: The impairments of waterbody are determined from waterbody assessment based on sample data. Assessment results were shown in Table 2-5 (page 2-11). As you said, turbidity standards are applied only at base flow. TMDLs were established based on assessment results of turbidity, not TSS.

Figure 5-24 was based on estimated flow and TSS. There is 19% NRMSE to estimate TSS from turbidity. In addition to this, there is an uncertainty of using flow estimation from adjacent waterbody. TMDL reduction was calculated based on these estimations. Please don't confuse with estimated values with collected sample data.

Comment #22: 5.4.2: references using "the average of self-reported monthly flow" over what time period was the average calculated?

DEQ Response 22: Please see Response 16.

Comment #23: Table 5-5 needs to have decimal agreement with the TMDL calculation tables (Tables 5-9 through 5-20)

DEQ Response 23: Each table uses different multipliers. Table 5-5 uses 10^9 for multiplier. Please see the table below. Changes were made in Table 5-5 to coincide with the TMDL calculation tables.

Waterbody ID	Stream Name	Name	Wasteload Allocation in Table 5-5 ($x10^9$ cfu/day)		TMDL calculation	
			EC	ENT	EC	ENT
OK311100020010_10	Hickory Creek	**Lone Grove WWTF**	-	~~0.02~~ 0.0225	-	2.25E+07
OK311300020010_10	Cache Creek, East	**Fort Sill WWT**	-	~~5.4~~ 5.37	-	5.37E+09
OK311310030040_00	Little Deep Red Creek	**Fredrick POTW**	~~2.6~~ 2.62	~~0.7~~ 0.687	2.62E+09	6.87E+08

Comment #24: Table 5-9 & 5-19: these are for the same creek, different parameters; however, the flows are slightly different (decimal agreement, how many sig figs were used in the actual calculations).

DEQ Response 24: The flows used in calculation were not different in both tables. 1000th decimal values were used in TMDL calculation. However, simplified flows were shown in the tables. In order to coincide flows in both tables, flows in Table 5-9 were changed as Table 5-19.

Percentile	Flow (cfs) in Table 5-9	Flow (cfs) in Table 5-19
0	10,998	10,998
5	231	231
10	63	63
15	29	29
20	18	18
25	12	12
30	7.9	7.9
35	5.2	5.2
40	3.8	3.8
45	2.5	2.5
50	1.7	1.7
55	1.2	1.2
60	~~0.81~~ 0.8	0.8
65	~~0.52~~ 0.5	0.5
70	~~0.29~~ 0.3	0.3
75	~~0.15~~ 0.1	0.1
80	0.07	0.07
85	0.02	0.02
90	0	0
95	0	0
100	0	0

Comment #25: Table 5-9 through 5-21: double-check all calculations, many do not seem accurate.

DEQ Response 25: There was a flow conversion error for Lone Grove East WWT. Only Table 5-12 was corrected. No other miscalculation was found. An Excel spread sheet is available by request.

Comment #26: Appendix A: describe the numeric Flow Conditions-why are some flow conditions listed out in words or in terms of rainfall amount?

DEQ Response 26: Numeric flow conditions were given by sample collection agencies (OWRB and OCC), not by DEQ. If the numeric flow condition data didn't exist, rainfall data on the sample day and on the previous two days were checked. Please see page 4-1 in the report.

Comment #27: Appendix D, were any calculations done to determine the data really are log normal distribution?

DEQ Response 27: Data distribution for TSS cannot be determined due to the number of non-detects. However, turbidity distribution was positively skewed (Figure Appendix D-1). Turbidity and TSS have positive correlation. Therefore, log-normal distribution was assumed for TSS. Helsel and Hirsch (2002) also stated, "most water resources data and indeed most environmental data show positive skewness." Therefore, the log normal distribution was assumed in censored data estimation.

Helsel, D.R. and R.M. Hirsch; 2002. Statistical Methods in Water Resources. U.S. Department of the Interior, U.S. Geological Survey, September 2002.

Comment #28: Executive Summary & Section 1.1 indicate that once a waterbody reaches attainment of WQS for a parameter, that is no longer housed in category 4A. Explain the category these waters are moved to after attaining WQS with an approved TMDL.

DEQ Response 28: If the waterbody attains WQS after an approved TMDL, it can be placed in any category based on the impairment status of other parameters. This TMDL report focuses on waterbodies not supporting PBCR and WWAC. Other non-supporting beneficial uses are not addressed in this TMDL.

Comment #29: Section ES-5.3: further define "Longest period of USGS flow records"-the longest contiguous span? The longest span that covers the period of record for the document?

DEQ Response 29: To develop flow duration curve, all available consecutive USGS flow records were used. Change was made from "Longest period of USGS flow records" to "all available consecutive USGS flow records."

Comment #30: End of section ES-5 & section 5.4.3.1: explain how OPDES permits will require in-stream criteria to be met such that new dischargers or increased load from existing dischargers will be considered consistent with the TMDL.

DEQ Response 30: Permit requirements are not addressed in this report.

Comment #31: Section 5.4.3.1: will limits be included in permits for Enterococci based upon the WLA in the TMDL?

DEQ Response 31: Please see Response 30.

Comment #32: In Section 3.4.2, it is mentioned that data are insufficient to separate natural background loads from other nonpoint sources of turbidity. However, natural background for bacteria is not discussed. Please explain whether natural background sources for bacteria were characterizes; if not, please explain in the document, as appropriate.

DEQ Response 32: All sources of pollutant loading not regulated by OPDES permits are considered nonpoint sources in the report. These nonpoint sources also include anthropogenic and natural background sources. Wildlife within the watershed is a natural source of coliform bacteria.

Comment #33: Why was future growth included for the WLAs for turbidity, but not for the WLAs for bacteria?

DEQ Response 33: Point sources are required to meet bacteria WQSs at the end of pipe, whereas turbidity WQSs are designed as in-stream criteria. Therefore, future growth (such as new sources and source expansion) didn't affect bacteria WQSs in stream. However, future growth may affect or change the relationship of TSS and turbidity. As a result, 1% of TSS loading is reserved as part of the WLA.

Comment #34: Section 5.8: explain why revisions to the Oklahoma pathogen provisions should be considered. Explain why modifying the application of existing criteria may have merit/should be considered.

DEQ Response 34: Revisions to the current pathogen provisions were discussed in Section 5.9.2. Please see explanation in the text (page 5-36).

"**The reduction rates called for in this TMDL report are as high as 97.0% for bacteria and 92.8% for TSS. DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of 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."

Comment #35: Section 5.9.1: is this a general statement? Specify when the WLAs in this TMDL will be incorporated into the 208 Plan.

DEQ Response 35: Please see Section 6 (page 6-1). A 208 Plan is also referred to as a Water Quality Management Plan (WQMP).

"**After EPA's final approval, each TMDL will be adopted into the Water Quality Management Plan (WQMP).** These TMDLs provide a mathematical solution to meet ambient water quality criterion with a given set of facts. 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 are reviewed to ensure that the in-stream criterion is predicted to be met."

Comment #36: In a water impaired primarily by nonpoint sources, reasonable assurances that load reductions will be achieved are not required in order for a TMDL to be approvable. However, for such nonpoint source only waters, Oklahoma is strongly encouraged to provide assurance regarding achievement of load allocations in an associated implementation plan. As described in the August 8, 1997 Perciasepe Memorandum, such reasonable assurances "may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs." Please provide further information, if available, regarding the implementation of the non-point source loadings.

DEQ Response 36: There are no watershed management plans in the Study Area. However, some changes were made in Section 5.10 as below.

"Reasonable assurance is required by the EPA guidance for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurance" that the NPS load reductions will actually occur must be demonstrated. In this report, all point source discharges either already have or will be given discharge limitations less than or equal to the water quality standards numerical criteria. ~~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.~~ **Therefore, reasonable assurance is derived from Oklahoma Pollutant Discharge Elimination System (OPDES). The wasteload allocations for MS4s will be implemented through the OPDES MS4 permits. MS4 permits contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or stormwater pollution prevention plan (SWP3) to implement best management practices (BMPs), public education and outreach, and illicit discharge elimination.**

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

Other Comments

No comment number from 1 to 7.

Comment #8: ES page numbers are off.

DEQ Response 8: Corrected. Page number for ES-3 Pollutant Source Assessment is changed from ES-5 to ES-6.

Comment #9: ES-4: Point 3 reads "Easimate loading" please revise to "Estimated loading"

DEQ Response 9: Corrected.

Comment #10: Table ES-5/general table & graph comment: the public does not always have access to color printers or available computer time (for example at a library) to read the entire report; therefore, be sure that all tables/graphs can be easily read in a black & white copy (use symbols).

DEQ Response 10: Corrected on Table ES-5. However, without color distinction, maps in the report cannot be identified. Color identification is necessary for this report.

Comment #11: ES-5.1 heading is "Bacterial PRG" however, the paragraph ends with talking about Turbidity reductions. Move Tb discussion to the appropriate location.

DEQ Response 11: Tb discussion was removed from Section ES-5.1.

Comment #12: Section 2.1: Reference to the IR is 2013; however, in the references section, the date is 2015.

DEQ Response 12: The reference year for IR is changed to 2015 in Section 2.1.

Comment #13-1: Section 2.1.5: The second sentence could be confusing based on the information that follows indicating that priority is based on the percentile category, which then determines TMDL date. Please define the target timeframe for development of TMDLs who fall into priorities 2-4.

DEQ Response 13-1: The priority is based on percentile ranking of an overall score for each watershed. Timeframe for priorities 2-4 were added in the text as below.

"Priority 1 watersheds are targeted for TMDL development within the next two years. **Other priority watersheds are established for TMDL development within the next five years for Priority 2, eight years for Priority 3, and eleven years for Priority 4**."

Comment #13-2: Also, the reference to 2014 IR is listed as 2013; however, in the reference, it is 2015.

DEQ Response 13-2: It was corrected to 2015 in Section 2.1.5.

Comment #14-1: Section 2.2: Reference to the 303(d) list is 2015, in the references, it is 2013.

DEQ Response 14-1: Change was made in Reference from 2013 to 2015.

Comment #14-2: Also, the second paragraph begins with a period.

DEQ Response 14-2: Corrected. A period was deleted.

Comment #15: Unless great value to the public is identified by the state, it is not necessary to characterize ALL of the Tb data (including the storm flows) in such extensive detail.

DEQ Response 15: Tables 2-4 and 2-6 showed all data summary including data from storm events. They are necessary to understand these tables.

Comment #16-1: Section 3.2 for clarity, insert the italicized words into the following sentence: There is at least one *type of* OPDES-permitted facility in each of the remaining seven watersheds in the Study Area…

DEQ Response 16-1: In Section 3.2, each facility in its watershed was focused, not the type of the facility. No change was made for this comment.

Comment #16-2: Additionally, discuss further the statement that no-discharge facilities can be sources of bacterial loading.

DEQ Response 16-2: This was discussed in Section 3.2.3 No-Discharge Facilities. No change was made for this comment.

Comment #17: Section 3.2.2: Last sentence needs further explanation. Example: …;therefore, MS4 areas will receive loads…

DEQ Response 17: A sentence was added to the last paragraph as "Therefore, MS4 areas will receive WLAs for each bacterial indicator exceeding WQSs."

Comment #18-1: Section 3.2.2.2.1: The word "mined" is used to define "mine," revise for clarity.

DEQ Response 18-1: The word "mined" was changed to "excavated."

Comment #18-2: Sentence structure of the second-to-last sentence in the last paragraph needs to be revised. The last sentence refers to "dishcrarges" instead of discharges and needs further explanation.

DEQ Response 18-2: The last and the second-to-last sentence were combined as, "There are no mine dewatering MSGPs in the turbidity TMDL watersheds." Mine dewatering was explained in the text.

Comment #19: Is there a text reference to Table 3-6? Three permits mentioned in this table are expired, define the implication of expired permits.

DEQ Response 19: Text reference was added to the last sentence in Section 3.2.2.2.2. Oklahoma Department of Mines issues mine permits. Permit verification was requested and the Table 3-6 was updated. Permits LE-2108 & LE-1683 were expired. However, all sources existing in sample period (2000 -2014) were listed.

Comment #20: Table 3-7: what types of animals?

DEQ Response 20: The field heading "Total # of Animal Units at Facility" was changed to "Total # of Heifer and Cattle Units at Facility"

Comment #21-1: Section 3.2.5.3: Run-on words -- "reviewedacceptable." Also review sentence structure of that sentence.

DEQ Response 21-1: Run-on words were corrected.

Comment #21-2: Last paragraph: Is this sentence referring to groundwater recharge area?

DEQ Response 21-2: No. All groundwater is vulnerable to contamination from surface sources of pollution. However, some areas are more vulnerable than others. The boundaries of such "nutrient-vulnerable groundwater" hydrogeologic basins shall be as defined in the Oklahoma Water Resources Board publication number 99-1 entitled "Statewide Groundwater Vulnerability Map of Oklahoma".

Comment #21-3: Are there no time restriction on non-nutrient limited watershed?

DEQ Response 21-3: The last sentence was modified as "PFOs in non-nutrient limited watersheds **perform nutrient sample analysis at least once every three years and** need to have available the most recent **record** ~~nutrient sample analysis~~."

Comment #21-4: What about nutrient surplus areas?

DEQ Response 21-4: "Nutrient-limited watershed" means a watershed of a waterbody with a designated beneficial use which is adversely affected by excess nutrients as determined by Carlson's Trophic State Index (using chlorophyll-a) of 62 or greater, or is otherwise listed as "NLW" in Appendix A of OAC 785:45.

Comment #22: Double-check table references in section 3. There is a text reference to Table 3-13; but the information is contained in table 3-9.

DEQ Response 22: Corrected.

Comment #23-1: Section 4.1.: states "sum of three elements"; the public will look at the equation below and see four elements. Perhaps clarify.

DEQ Response 23-1: Parentheses on three elements were added as, "sum of three elements **(WLA, LA, and MOS)**". Clarification was given in the text as "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."

Comment #23-2: The last sentence of this section reads that the stream will attain the WQS and PRG. Is that the intent of the sentence? Or is this intent to specify that PRG will also be derived from TSS?

DEQ Response 23-2: The last sentence explains the meaning of TMDL. TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet WQSs, and an allocation of that load among the various sources of that pollutant.

Comment #24: Section 4.2.3, the second paragraph states: Before determine the relationship… Change to "determining." Also in defining "n", change to number of "observations." Remove "its" from the last paragraph.

DEQ Response 24: Corrected.

Comment #25: Section 4.3: …development tool can help *identify* whether… instead of identifying.

DEQ Response 25: Corrected.

Comment #26: Section 4.3.1: Explain the TMDL Toolbox?

DEQ Response 26: An explanation is in the text in same section … "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.**" Also, additional explanation is given in Appendix C (pages C-6 and C-7). EPA approved Bacteria and Turbidity TMDLs QAPP using Toolbox (QTRAK # 10-097) on November 30, 2009.

Comment #27: 4.3.3.3.1: put the unit conversion factor on the next line for clarity.

DEQ Response 27: It has been moved to the next line.

Comment #28: Section 4.3.3.5.2: the *E. coli* and enterococci statement appears to be an incomplete thought.

DEQ Response 28: The word "because" has been taken out from the statement.

Comment #29: Section 5.3.1: The LDC text descriptions for Hickory Creek and Little Deep Red Creek do not have WLA descriptions in keeping with the format of the other LDC descriptions.

DEQ Response 29: The WLA descriptions were added in the LDC text for both watersheds.

Comment #30: Figures 5-23, 5-24, 5-25: the x-axis label says "frequcney" instead of "frequency"

Comment #31: Figures 5-23, 5-24: the legend says "detetion" instead of "detection"

Comment #32: Figures 5-24: Title says "Eest" instead of "East"

DEQ Response 30, 31, & 32: Corrected.

Comment #33: Section 5.3.3.2: text refers to seven waterbodies included in the TMDL… only 3 waterbodies have calculated RPGs for TSS.

DEQ Response 33: Corrected to three.

Comment #34: Section 5.4.1, last paragraph: clarify the last sentence. …impaired for primary body contact recreation; therefore, the Fort Sill Army Base will receive WLAs for *E.coli* & Enterococci.

DEQ Response 34: The last paragraph was modified as the comment.

"Permitted stormwater discharges are considered point sources. The Fort Sill Army Base is the designated Phase II MS4s within the watersheds of the Study Area impaired for **primary body** contact recreation. Therefore, ~~they~~ the Fort Sill Army Base will receive WLAs for ~~MS4s~~ *E.coli* & Enterococci."

Comment #35: Section 5.4.2, last paragraph, the first sentence seems out of context. Flip it with the second sentence. Start a new paragraph with the last sentence as it is also out of context with the previous information.

DEQ Response 35: Paragraph was modified as below.

"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)].~~ **Elevated turbidity levels may be expected during, and for several days after, a runoff event. However, Oklahoma's Water Quality Standards specify that the criteria for turbidity "apply only to seasonal base flow conditions" [OAC 785:45-5-12(f)(7)]. Therefore, Oklahoma Water Quality Standard for turbidity does not apply to stormwater runoff from the watershed, including MS4. The development for future growth will affect turbidity levels in the watershed, but stormwater runoff from development sites are not covered by the WQSs**. 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."

Comment #36: 5.4.3.2 clarify the first sentence: Stormwater discharges from MS4*s*, industrial facilities, *and* construction *sites*.

DEQ Response 36: Corrected as the comment.

Comment #37-1: Section 5.7: Last sentence of the first paragraph, remove the comma after "bacterial."

DEQ Response 37-1: The comma was removed.

Comment #37-2: Second paragraph specifies that MOS range from 10-15% for TSS, but it ranges from 10% to 25%.

DEQ Response 37-2: MOS range was corrected to 10-25%.

Comment #38: Table 5-8: There isn't decimal agreement with the following tables, especially for Walnut Bayou WLA_{growth} & East Cache Creek WLA.

DEQ Response 38: Please see below Table. WLA for East Cache Creek and was WLA_{Growth} for Walnut Bayou were changed.

Stream Name	Waterbody ID	Pollutant	TMDL (lbs/day)	WLA (lbs/day)	WLA_{MS4} (lbs/day)	WLA_{Growth} (lbs/day)	LA (lbs/day)	MOS (lbs/day)
Walnut Bayou	OK311100010250_00	TSS	225	0	0	~~2~~ 2.2	166	56
Cache Creek, East	OK311300020010_10	TSS	7,759	~~14~~ 14.4	0	78	6,116	1,552
Red River	OK311310010010_00	TSS	126,125	0	0	1,261	112,252	12,613

Comment #39-1: Section 5.9.2: for clarity specify the 96% reduction rate is for bacteria.

DEQ Response 39-1: The sentence was modified for clarity. The reduction rates called for in this TMDL report are as high as 97.0% **for bacteria and 92.8% for TSS**.

Comment #39-2: The sentence "Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation" is not overly relevant.

DEQ Response 39-2: It is relevant to the content to show that such high reduction rate is not uncommon in pathogen and TSS TMDLs.

Examples of high reduction rates are shown below:

2014 Oklahoma Arkansas River TMDL: as high as 94.7% for bacteria and 92.4% for TSS.

2014 Minnesota Upper Mississippi River Bacteria TMDL: as high as 94% for bacteria

2007 Missouri Shoal Creek TMDL: as high as 99% for bacteria

Comment #39-3: Nor is the sentence: "For example, the Kansas Department of Environmental Quality has proposed…"

DEQ Response 39-3: This is the example case for another state reviewing WQSs.

Comment #39-4: With regard to "the suitability of current criteria for pathogens and the beneficial uses of a waterbody should be reviewed"-will they be reviewed? Currently be reviewed?

DEQ Response 39-4: Yes, all waterbodies are assessed every 2 years and WQSs are reviewed every 3 years. During period of assessing and reviewing, individual waterbodies are constantly monitored and evaluated.

Comment #40: Section 5.10: …or will be given ~~discharging~~ discharge limitations…"

DEQ Response 40: The word "discharging" was removed.

Comment #41: Appendix C: to which gage is the table footnote referring?

DEQ Response 41: Table footnote was deleted.

Comment #42: Appendix E: Please review for sentence structure and tense agreement.

DEQ Response 42: Two sentences were corrected for tense agreement… "All data ~~were~~ are log-transformed and censored data ~~were~~ are set as a range from one (TSS=1 mg/L; log (TSS) = 0) to detection limit (TSS=10 mg/L; log (TSS) = 1)…. . In less extreme situations, non-parametric methods perform~~ed~~ similarly or slightly worse than MLE methods."

Comment #43: General comment: when summarizing data, count, max, min, & average are all useful.

DEQ Response 43: In general, they can be useful. However, in this report, max and min have no use. For bacteria, geometric mean of all samples was used. For TSS, all samples are evaluated whether 10% of them exceed the WQSs. Therefore, counts and averages are presented in the report.