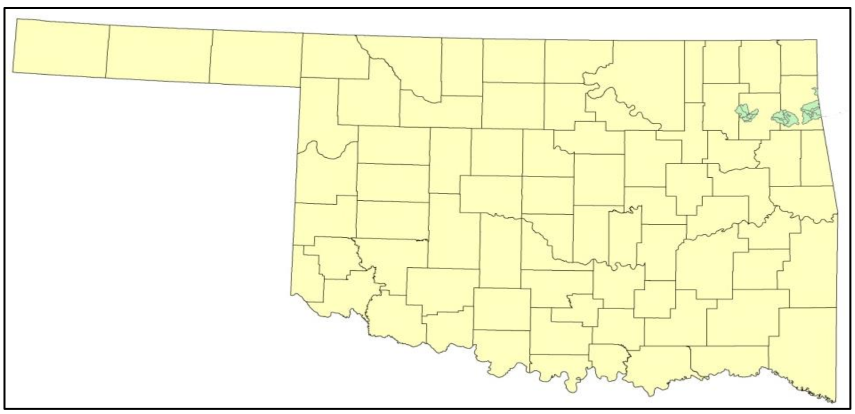
FINAL

2014 BACTERIAL AND TURBIDITY TOTAL MAXIMUM DAILY LOADS FOR OKLAHOMA STREAMS IN THE LOWER NEOSHO WATERSHED AREA (OK121600)

Oklahoma Waterbody Identification Numbers

Saline Creek	OK121600020030_10
Little Saline Creek	OK121600020070_00
Honey Creek	OK121600030445_10
Spavinaw Creek	OK121600050150_00
Beaty Creek	OK121600050160_00
Cloud Creek	OK121600050180_00
Pryor Creek	OK121610000050_10
Pryor Creek	OK121610000090_00



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OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

APRIL 2014

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ACRONYMS AND ABBREVIATIONS

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

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

EXECUTIVE SUMMARY

ES - 1 OVERVIEW

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli),* Enterococci] and turbidity for certain waterbodies in the Lower Neosho River basin. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water. Elevated turbidity levels caused by excessive sediment loading and stream bank erosion impact aquatic communities. Data assessment and total maximum daily load (TMDL) calculations are conducted in accordance with requirements of Section 303(d) of the Clean Water Act (CWA), Water Quality Planning and Management Regulations (40 CFR Part 130), U.S. Environmental Protection Agency (EPA) guidance, and Oklahoma Department of Environmental Quality (DEQ) guidance and procedures. DEQ is required to submit all TMDLs to EPA for review. Approved 303(d) listed waterbody-pollutant pairs or surrogates TMDLs will receive notification of the approval or disapproval action. Once the EPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (EPA 2003).

The purpose of this TMDL report is to establish pollutant load allocations for indicator bacteria and turbidity in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and 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 the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. MOS can be implicit and/or explicit. The implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria or turbidity within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process.

ES - 2 PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

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

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

Table ES-2 summarizes water quality data collected during primary contact recreation season from the water quality monitoring (WQM) stations between 2000 and 2010 for each bacterial indicator. The data summary in Table ES-2 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. This data collected during the primary contact recreation season includes the data used to support the decision to place specific waterbodies within the Study Area on the DEQ 2010 303(d) list (DEQ 2010). It also includes the new date collected after the data cutoff date for the 2010 303(d) list.

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

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

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

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

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

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

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

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK121600020030_10	**Saline Creek**	28	2012	1	X		N		
OK121600020070_00	**Little Saline Creek**	11	2012	1	X		N		
OK121600030445_10	**Honey Creek**	5	2018	3	X	X	N		
OK121600050150_00	**Spavinaw Creek**	15	2015	2	X		N		
OK121600050160_00	**Beaty Creek**	12	2015	2	X		N		
OK121600050180_00	**Cloud Creek**	13	2021	4	X		N		
OK121610000050_10	**Pryor Creek**	5	2018	3	X	X	N		
OK121610000090_00	**Pryor Creek**	2	2021	4		X	N	X	N

ENT = Enterococci; N = Not attaining; X = Criterion exceeded Source: 2010 Integrated Report, DEQ 2010.

Table ES - 2 Summary of Indicator Bacterial Samples from Primary Body Contact Recreation Season, 2000-2010

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Concentration (count/100 ml)	Notes
OK121600020030_10	Saline Creek	ENT	89	63	TMDL Required
OK121600020070_00	Little Saline Creek	ENT	126	94	TMDL Required
OK121600030445_10	Honey Creek	EC	134	72	Delist: Geomean below criterion
		ENT	137	126	TMDL Required
OK121600050150_00	Spavinaw Creek	ENT	109	52	TMDL Required
OK121600050160_00	Beaty Creek	ENT	169	99	TMDL Required
OK121600050180_00	Cloud Creek	ENT	74	80	TMDL Required
OK121610000050_10	Pryor Creek	EC	27	131	TMDL Required
		ENT	27	190	TMDL Required
OK121610000090_00	Pryor Creek	EC	1	428	Delist: this segment is SBCR

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

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

ES-2.2 Chapter 46: Implementation of OWQS for PBCR

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

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

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

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

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

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

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

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

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

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

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

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

ES-2.3 Chapter 45: Criteria for Turbidity

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

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

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

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

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

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

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

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

Assessment of Fish and Wildlife Propagation support

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

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

785:46-15-4. Default protocols

(b). Short term average numerical parameters.

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

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

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

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

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

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

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 nephelometric turbidity units (NTU). However, as described above, because turbidity cannot be expressed as a mass load, TSS is used as a surrogate in this TMDL. Since there is no numeric criterion in the Oklahoma WQS for TSS, a regression method to convert the turbidity criterion to TSS based on a relationship between turbidity and TSS was used to establish TSS goals as surrogates. Table ES-4 provides the results of the waterbody specific regression analysis.

Table ES - 3 Summary of Turbidity and TSS Samples Collected During Base Flow Conditions, 1999-2011

Waterbody ID	Waterbody Name	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)	Assessment Results
OK121610000090_00	Pryor Creek	15	5	33%	42	TMDL Required

Table ES - 4 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK121610000090_00	Pryor Creek	0.569	10.7%	46	15%

After re-evaluating bacterial and turbidity/TSS data for the streams listed in Table ES-1, bacterial impairments for *E. coli* on Honey Creek and Pryor Creek (OK121610000090_00) are recommended for delisting. Therefore no bacterial TMDL is required for Pryor Creek (OK121610000090_00). Table ES-5 shows the bacterial and turbidity TMDLs that will be developed in this report.

Table ES - 5 Stream Segments and Pollutants for TMDL Development

Waterbody ID	HUC 8 codes	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Turbidity
OK121600020030_10	11070209	Saline Creek	28	2012	1	x		
OK121600020070_00	11070209	Little Saline Creek	11	2012	1	x		
OK121600030445_10	11070206	Honey Creek	5	2018	3	x		
OK121600050150_00	11070209	Spavinaw Creek	15	2015	2	x		
OK121600050160_00	11070209	Beaty Creek	12	2015	2	x		
OK121600050180_00	11070209	Cloud Creek	13	2021	4	x		
OK121610000050_10	11070209	Pryor Creek	5	2018	3	x	x	
OK121610000090_00	11070209	Pryor Creek	2	2021	4			x

ES - 3 Pollutant Source Assessment

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Bacteria originate from warm-blooded animals and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated sanitary wastewater and are required to monitor fecal coliform under their current permits will be required to monitor *E. coli* when their permits come up for renewal. These facilities are also required to monitor TSS in accordance with their permits.

Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from land activities that contribute bacteria or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. Sediment loading of streams can originate from natural erosion processes, including the weathering of soil, rocks, and uncultivated land; geological abrasion; and other natural phenomena. There is insufficient data available to quantify contributions of TSS from these natural processes.

TSS or sediment loading can also occur under non-runoff conditions as a result of anthropogenic activities in riparian corridors which cause erosive conditions. Given the lack of data to establish the background conditions for TSS/turbidity, separating background loading from nonpoint sources whether it is from natural or anthropogenic processes is not feasible in this TMDL development. Table ES-6 summarizes the point and nonpoint sources that contribute bacteria or TSS to each respective waterbody.

Table ES - 6 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal NPDES Facility	Industrial NPDES Facility	MS4	NPDES No Discharge Facility	CAFO	Mines	Construction Stormwater Permit	Multi-Sector General Permit	Nonpoint Source
Saline Creek	OK121600020030_10									Bacteria
Little Saline Creek	OK121600020070_00									Bacteria
Honey Creek	OK121600030445_10									Bacteria
Spavinaw Creek	OK121600050150_00									Bacteria
Beaty Creek	OK121600050160_00									Bacteria
Cloud Creek	OK121600050180_00									Bacteria
Pryor Creek	OK121610000050_10									Bacteria
Pryor Creek	OK121610000090_00									Turbidity

Facility present in watershed and potential as contributing pollutant source.
Facility present in watershed, but not recognized as pollutant source.
No facility present in watershed.

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 segment. Plotting future monitoring information on the LDC will show trends of improvement to sources that will identify areas for revision to the segment restoration plan. The low cost of the LDC method allows the development of TMDL plans on more segments and the evaluation of the implementation of WLAs and BMPs on more segments. The technical approach for using LDCs for TMDL development includes the following steps:

- Prepare flow duration curves for gaged and ungaged WQM stations.
- Estimate existing loading in the waterbody using ambient bacteria water quality data.
- Estimate loading in the waterbody using measured TSS water quality data and turbidity-converted data.
- 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 facility (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 an LDC:

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

- 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.
- 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.
- 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.
- 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 5-1

unit conversion factor = 5.39377

ES-4.3 LDC Summary

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

ES - 5 TMDL Calculations

A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the lack of knowledge concerning the relationship between pollutant loading and water quality.

This definition can be expressed by the following equation:

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

ES-5.1 Bacterial PRG

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

Table ES-7 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area. The PRGs for the waterbodies requiring bacterial TMDLs range from 4% for *E. coli* and 37% to 83% for Enterococci.

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

Waterbody Name	Waterbody ID	Required Reduction Rate	
		EC	ENT
Saline Creek	OK121600020030_10	-	48%
Little Saline Creek	OK121600020070_00	-	65%
Honey Creek	OK121600030445_10	-	74%
Spavinaw Creek	OK121600050150_00	-	37%
Beaty Creek	OK121600050160_00	-	67%
Cloud Creek	OK121600050180_00	-	59%
Pryor Creek	OK121610000050_10	4%	83%

ES-5.2 TSS PRG

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

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

Waterbody ID	Waterbody Name	Required Reduction Rate
OK121610000090_00	Pryor Creek	56%

ES-5.3 MOS

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 include an MOS and account for seasonal variability. The MOS, which can be implicit or explicit, is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained.

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

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

ES-5.4 PBCR Season

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

ES - 6 Reasonable Assurance

Reasonable assurance is required by the EPA rules for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent WLA based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurances" that nonpoint source (NPS) load reductions will actually occur must be demonstrated. In this report, all point source discharges either already have or will be given discharge limitations less than or equal to the water quality standard numerical criteria. This ensures that the impairments of the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

ES - 7 Public Participation

The public had a 45-day opportunity to review the draft TMDL report and submit written comments. One public comment was received, and the response to that public comment can be found in Appendix F. No changes were made to this final TMDL report or its 208 Factsheet as a result of that comment. There was no request for a public meeting. The written comment that was received during the public notice period became a part of the record of this TMDL report. The final TMDL was submitted to EPA for final approval.

SECTION 1 INTRODUCTION

1.1 TMDL Program Background

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

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli),* Enterococci] and turbidity for selected waterbodies in the Lower Neosho River basin. (All future references to bacteria in this document imply these two fecal pathogen indicator bacterial groups unless specifically stated otherwise.) 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 received notification of the approval or disapproval action. Once the EPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (EPA 2003).

The purpose of this TMDL report is to establish pollutant load allocations for indicator bacteria and turbidity in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and 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 the National Pollutant Discharge Elimination System (NPDES). The LA is the fraction of the total pollutant load apportioned to nonpoint sources. MOS can be implicit and/or explicit. An implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

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

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

Table 1-1 Lower Neosho Watershed Waterbodies and Waterbody ID Numbers

Waterbody Name	Waterbody Identification Number
Saline Creek	OK121600020030_10
Little Saline Creek	OK121600020070_00
Honey Creek	OK121600030445_10
Spavinaw Creek	OK121600050150_00
Beaty Creek	OK121600050160_00
Cloud Creek	OK121600050180_00
Pryor Creek	OK121610000050_10
Pryor Creek	OK121610000090_00

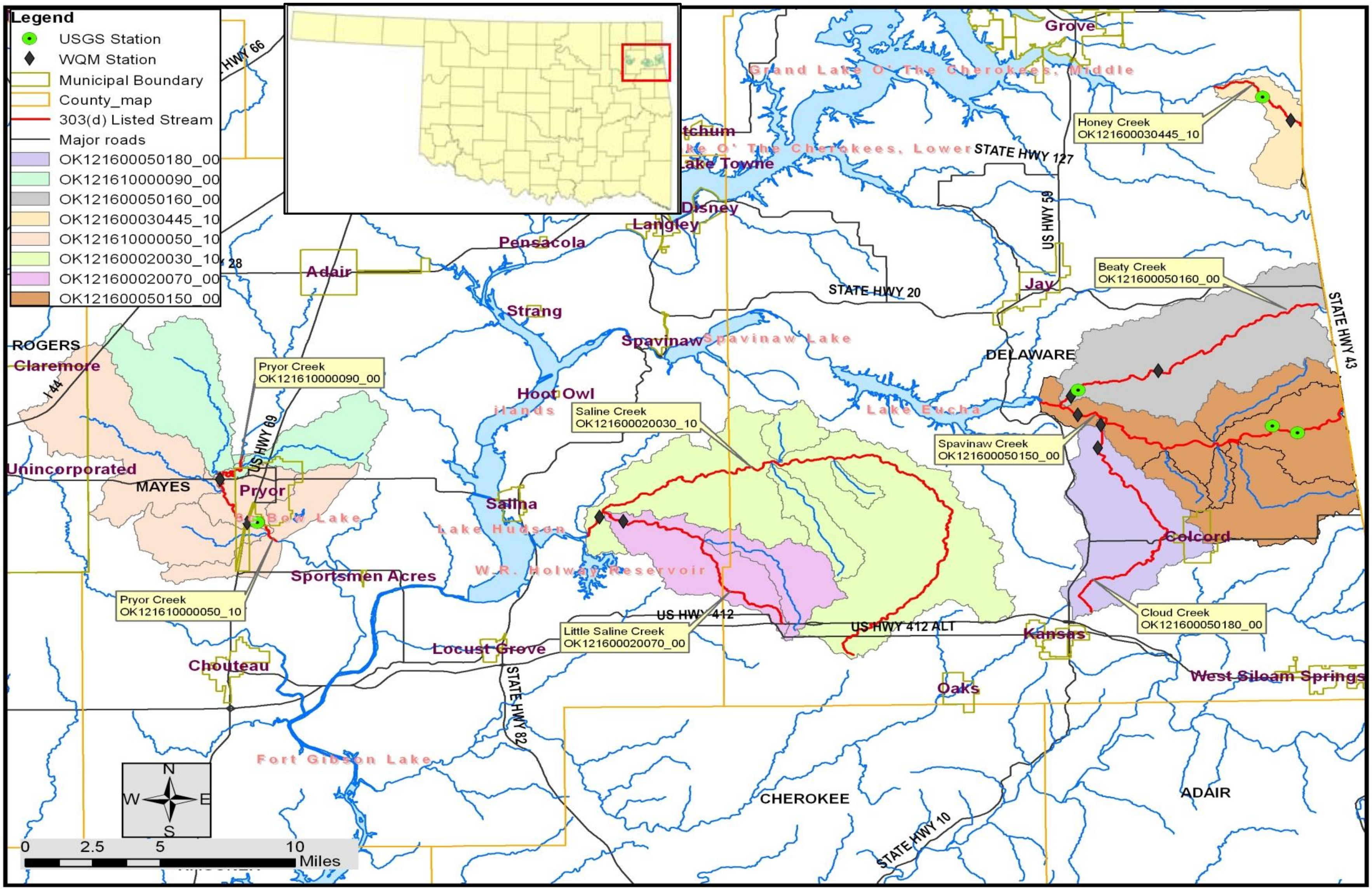
Figure 1-1 shows these Oklahoma waterbodies and their contributing watersheds. These maps also display locations of the water quality monitoring (WQM) stations used as the basis for placement of these waterbodies on the Oklahoma 303(d) list. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

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

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

Station ID	Waterbody Name	WBID
OK121600-02-0030D	Saline Creek	OK121600020030_10
OK121600-02-0070F	Little Saline Creek	OK121600020070_00
OK121600-03-0445Y	Honey Creek: Upper	OK121600030445_10
OK121600-03-0445L	Honey Creek: Lower	
OK121600-05-0150G	Spavinaw Creek	OK121600050150_00
OK121600-05-0160G	Beaty Creek: Lower	OK121600050160_00
OK121600-05-0160F	Beaty Creek: Upper	
OK121600-05-0180C	Cloud Creek: Downstream	OK121600050180_00
OK121600-05-0180G	Cloud Creek: Upstream	
OK121610-00-0050D	Pryor Creek: HWY 20	OK121610000050_10
OK121610-00-0050M	Pryor Creek: HWY 69	
OK121610-00-0090N	Pryor Creek	OK121610000090_00

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



1.2 WATERSHED DESCRIPTION

1.2.1 General

The Lower Neosho River basin is located in the northeastern portion of Oklahoma. The majority of the waterbodies addressed in this report are located in Delaware and Mayes Counties with a very small portion located in Rogers County. These counties are part of the Ozark Highlands and Central Irregular Plains Level III ecoregions (Woods, A.J, Omerik, J.M., et al 2005). The watersheds in the Study Area are located in the Ozark Uplift and Cherokee Platform 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, except for Mayes County, which is densely populated compared to the others (U.S. Census Bureau 2010). Table 1-4 lists the towns and cities located in each watershed.

Table 1-3 County Population and Density

County Name	Population (2010 Census)	Population Density (per square mile)
Delaware	41,633	56
Mayes	87,706	130
Rogers	41,389	63

Table 1-4 Towns and Cities by Watershed

Waterbody Name	Waterbody ID	Municipalities
Saline Creek	OK121600020030_10	Spavinaw Hoot Owl Oaks
Little Saline Creek	OK121600020070_00	Salina Locust Grove
Honey Creek	OK121600030445_10	Grove Jay
Spavinaw Creek	OK121600050150_00	Jay Colcord
Beaty Creek	OK121600050160_00	Jay Colcord
Cloud Creek	OK121600050180_00	Colcord Siloam Springs, Kansas
Pryor Creek	OK121610000050_10	Pryor Creek Sportsmen Acres Chouteau
Pryor Creek	OK121610000090_00	Pryor Creek Adair Hoot Owl Salina

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 62 and 71 inches (Oklahoma Climatological Survey 2005).

Table 1-5 Average Annual Precipitation by Watershed

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Saline Creek	OK121600020030_10	62
Little Saline Creek	OK121600020070_00	63
Honey Creek	OK121600030445_10	67
Spavinaw Creek	OK121600050150_00	65
Beaty Creek	OK121600050160_00	66
Cloud Creek	OK121600050180_00	65
Pryor Creek	OK121610000050_10	71
Pryor Creek	OK121610000090_00	71

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) 2001 National Land Cover Dataset (USGS 2007). 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 most dominant land use category throughout the Lower Neosho River Study Area is pasture/hay. Three of the watersheds in the Study Area have a significant percentage of land use classified as deciduous forest including Saline Creek (OK121600020030_10), Little Saline Creek (OK121600020070_00) and Cloud Creek (OK121600050180_00). The watersheds targeted for TMDL development in this Study Area range in size from 5,070 acres (Honey Creek, OK121600030445_10) to 52,610 acres (Saline Creek, OK121600020030_10).

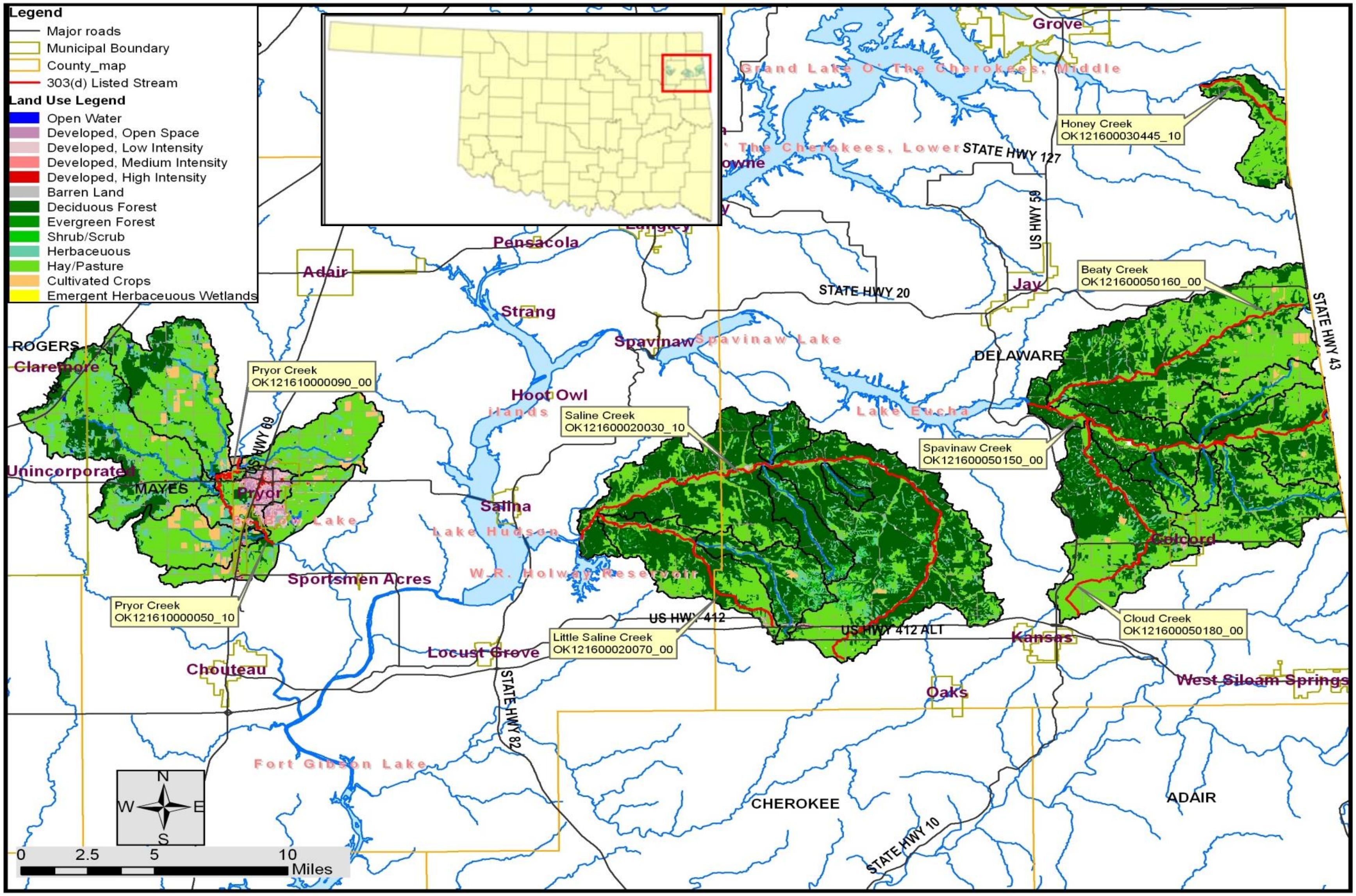
1.3 Stream Flow Conditions

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

Table 1-6 Land Use Summaries by Watershed

Landuse Category	Watershed							
	Saline Creek	Little Saline Creek	Honey Creek	Spavinaw Creek	Beaty Creek	Cloud Creek	Pryor Creek	Pryor Creek
Waterbody ID	OK121600020030_10	OK121600020070_00	OK121600030445_10	OK121600050150_00	OK121600050160_00	OK121600050180_00	OK121610000050_10	OK121610000090_00
Open Water	696	29	121	150	83	13	631	85
Medium Intensity Residential	157	46	22	150	56	64	1,114	92
High Intensity Residential	5	0	2	8	1	4	269	12
Bare Rock/Sand/Clay	34	0	2	43	12	4	0	0
Deciduous Forest	32,516	7,928	1,220	12,935	8,975	6,786	8,848	2,837
Evergreen Forest	493	201	1	201	147	555	5	0
Mixed Forest	64	12	3	48	39	135	0	0
Shrubland	732	327	0	4	4	149	0	0
Grasslands/Herbaceous	3,070	842	16	357	305	790	7,120	2,165
Pasture/Hay	12,656	5,395	3,460	18,624	15,230	6,660	27,664	11,478
Cultivated Crops	50	67	7	190	354	94	2,677	1,262
Urban/Recreational Grasses	2,028	425	211	1,502	1,005	727	3,122	947
Woody Wetlands	108	0	5	28	17	1	0	0
Emergent Herbaceous Wetlands	0	0	0	0	0	0	3	2
Total (Acres)	**52,610**	**15,272**	**5,070**	**34,240**	**26,228**	**15,981**	**51,453**	**18,878**
Open Water	1.32%	0.19%	2.38%	0.44%	0.32%	0.08%	1.23%	0.45%
Medium Intensity Residential	0.30%	0.30%	0.43%	0.44%	0.21%	0.40%	2.17%	0.49%
High Intensity Residential	0.01%	0.00%	0.04%	0.02%	0.00%	0.02%	0.52%	0.06%
Bare Rock/Sand/Clay	0.06%	0.00%	0.03%	0.12%	0.05%	0.03%	0.00%	0.00%
Deciduous Forest	61.81%	51.91%	24.06%	37.78%	34.22%	42.46%	17.20%	15.03%
Evergreen Forest	0.94%	1.32%	0.02%	0.59%	0.56%	3.47%	0.01%	0.00%
Mixed Forest	0.12%	0.08%	0.06%	0.14%	0.15%	0.85%	0.00%	0.00%
Shrubland	1.39%	2.14%	0.00%	0.01%	0.02%	0.93%	0.00%	0.00%
Grasslands/Herbaceous	5.84%	5.51%	0.33%	1.04%	1.16%	4.94%	13.84%	11.47%
Pasture/Hay	24.06%	35.33%	68.25%	54.39%	58.07%	41.67%	53.77%	60.80%
Cultivated Crops	0.09%	0.44%	0.15%	0.56%	1.35%	0.59%	5.20%	6.68%
Urban/Recreational Grasses	3.85%	2.78%	4.15%	4.39%	3.83%	4.55%	6.07%	5.01%
Woody Wetlands	0.21%	0.00%	0.10%	0.08%	0.07%	0.01%	0.00%	0.00%
Emergent Herbaceous Wetlands	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
Total Percentage:	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 1-2 Land Use Map



SECTION 2
PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Oklahoma Water Quality Standards

Title 785 of the Oklahoma Administrative Code contains Oklahoma Water Quality Standards (OWQS) and implementation procedures (OWRB 2011). The Oklahoma Water Resources Board (OWRB) has statutory authority and responsibility concerning establishment of State WQS, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules …*which establish classifications of uses of waters of the State, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the State. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2011). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in Appendix C. Table 2-1, an excerpt from the 2010 Integrated Report (DEQ 2010), lists beneficial uses designated for each bacterial and/or turbidity impaired stream segment in the Study Area. The beneficial uses include:

- AES – Aesthetics
- AG – Agriculture Water Supply
- Fish and Wildlife Propogation
  - CWAC – Cool Water Aquatic Community
  - WWAC – Warm Water Aquatic Community
- FISH – Fish Consumption
- PBCR – Primary Body Contact Recreation
- SBCR – Secondary Body Contact Recreation
- PPWS – Public & Private Water Supply
- HQW – High Quality Waters
- SWS – Sensitive Public & Private Water Supply

Table 2-1 Designated Beneficial Uses for Each Stream Segment in This Report

Waterbody Name	Waterbody ID #	AES	AG	CWAC	WWAC	FISH	PBCR	SBCR	PPWS	Other
Saline Creek	OK121600020030_10	F	F	F		F	N		F	
Little Saline Creek	OK121600020070_00	F	I	F		X	N		I	
Honey Creek	OK121600030445_10	I	I	F		X	N		X	HQW
Spavinaw Creek	OK121600050150_00	F	I	F		X	N		I	SWS
Beaty Creek	OK121600050160_00	F	I	F		X	N		I	HQW
Cloud Creek	OK121600050180_00	I	I	F		X	N		X	SWS
Pryor Creek	OK121610000050_10	I	F		N	X	N		I	
Pryor Creek	OK121610000090_00	F	F		N	X		N		

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

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 Chapter 45 of the Oklahoma WQSs.

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

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

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

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

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

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 2013a). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

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

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

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

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

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

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

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

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

Table 2-2 summarizes the PBCR and WWAC use attainment status and the bacterial and turbidity impairment status for streams in the Study Area. The TMDL priority shown in Table 2-2 is directly related to the TMDL target date. The TMDLs established in this report, which are a necessary step in the process of restoring water quality, only address bacterial and/or turbidity impairments that affect the PBCR and WWAC beneficial uses.

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

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK121600020030_10	Saline Creek	28	2012	1	X		N		
OK121600020070_00	Little Saline Creek	11	2012	1	X		N		
OK121600030445_10	Honey Creek	5	2018	3	X	X	N		
OK121600050150_00	Spavinaw Creek	15	2015	2	X		N		
OK121600050160_00	Beaty Creek	12	2015	2	X		N		
OK121600050180_00	Cloud Creek	13	2021	4	X		N		
OK121610000050_10	Pryor Creek	5	2018	3	X	X	N		
OK121610000090_00	Pryor Creek	2	2021	4		X	N	X	N

ENT = Enterococci; N = Not attaining; X = Criterion exceeded Source: 2010 Integrated Report, DEQ 2010

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

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

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

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

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

Each waterbody on the 2010 303(d) list has been assigned a potential date of TMDL development based on the priority level for the corresponding HUC 11 watershed. Priority 1 watersheds are targeted for TMDL development within the next two years.

Compliance with the Oklahoma WQS is based on meeting requirements for both *E. coli* and Enterococci bacterial indicators in addition to the minimum sample requirements for assessment. Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2011).

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.

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

2.1.3 Chapter 45: Criteria for Turbidity

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

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

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

ii. Lakes: 25 NTU; and

iii. Other surface waters: 50 NTUs.

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

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

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

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

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

Assessment of Fish and Wildlife Propagation support

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

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

785:46-15-4. Default protocols

(b). Short term average numerical parameters.

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

(2) A beneficial use shall be deemed to be fully supported for a given parameter whose criterion is based upon a short term average if 10%

or less of the samples for that parameter exceeds the applicable screening level prescribed in this Subchapter.

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

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

2.2 Problem Identification

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

2.2.1 Bacterial Data Summary

Table 2-3 summarizes water quality data collected during primary contact recreation season from the WQM stations between 2000 and 2010 for each indicator bacteria. The data summary in Table 2-3 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. This data collected during the primary contact recreation season was used to support the decision to place specific waterbodies within the Study Area on the DEQ 2010 303(d) list (DEQ 2010). Water quality data from the primary contact recreation season are provided in Appendix A. For the data collected between 2000 and 2010, evidence of nonsupport of the PBCR use based on elevated Enterococci concentrations was observed in all, except Pryor Creek (OK121610000090_00). Evidence of nonsupport of the PBCR use based on *E.coli* and Enterococci concentrations was observed in Pryor Creek (OK121610000050_10). Honey Creek (OK121600030445_10) and Pryor Creek (OK121610000090_00) were both listed on the DEQ 2010 303(d) list (DEQ 2010) as nonsupport for *E. coli*., however, detailed review of the data indicated that these segments were not impaired for *E. coli* therefore no TMDLs are required and delisting is recommended. Seven of the eight waterbodies for which water quality data was assessed will have TMDLs developed for bacteria resulting in a total of eight bacterial TMDLs for waterbody/pollutant combinations.

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.

For the waterbody assessed in this report for turbidity, Table 2-4 summarizes water quality data collected from the WQM station between 1999 and 2001. 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 the waterbody identified in Table 2-4 indicate nonsupport of the Fish and Wildlife Propagation use based on turbidity levels observed in the waterbody which will be targeted for TMDL development. Table 2-6 summarizes water quality data collected from the WQM station between 1999 and 2001 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. Water quality data for turbidity and TSS are provided in Appendix A.

2.3 Water Quality Target

The Code of Federal Regulations (40 CFR §130.7(c)(1)) states that, "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." The water quality targets for *E. coli* and Enterococci are geometric mean standards of 126 cfu/100ml and 33 cfu/100ml, respectively.

The TMDL for bacteria will incorporate an explicit 10% margin of safety.

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

TMDLs for turbidity in streams designated as WWAC must take into account that no more than 10% of the samples may exceed the numeric criterion of 50 NTU. However, as described above, because turbidity cannot be expressed as a mass load, TSS is used as a surrogate for TMDL development. Since there is no numeric criterion in the Oklahoma WQS for TSS, a specific method must be developed to convert the turbidity criterion to TSS based on a relationship between turbidity and TSS. The method for deriving the relationship between turbidity and TSS and for calculating a waterbody 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, 2000-2010

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Concentration (count/100 ml)	Notes
OK121600020030_10	Saline Creek	ENT	89	63	TMDL Required
OK121600020070_00	Little Saline Creek	ENT	126	94	TMDL Required
OK121600030445_10	Honey Creek	EC	134	72	Delist: Geomean below criterion
		ENT	137	126	TMDL Required
OK121600050150_00	Spavinaw Creek	ENT	109	52	TMDL Required
OK121600050160_00	Beaty Creek	ENT	169	99	TMDL Required
OK121600050180_00	Cloud Creek	ENT	74	80	TMDL Required
OK121610000050_10	Pryor Creek	EC	27	131	TMDL Required
		ENT	27	190	TMDL Required
OK121610000090_00	Pryor Creek	EC	1	428	Delist: insufficient samples

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

Table 2-4 Summary of All Turbidity Samples, 1999-2001

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)
OK121610000090_00	Pryor Creek	OK121610-00-0090N	20	8	40%	83

Table 2-5 Summary of Turbidity Samples Collected Excluding High Flow Conditions, 1999-2001

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
OK121610000090_00	Pryor Creek	OK121610-00-0090N	15	5	33%	42	TMDL Required

TMDLs will be developed for waterbodies highlighted in green for bacteria and tan for turbidity.

Table 2-6 Summary of All TSS Samples, 1999-2001

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK121610000090_00	Pryor Creek	OK121610-00-0090N	20	100

Table 2-7 Summary of TSS Samples Collected Excluding High Flow Conditions, 1999-2001

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK121610000090_00	Pryor Creek	OK121610-00-0090N	15	36

SECTION 3 POLLUTANT SOURCE ASSESSMENT

3.1 OVERVIEW

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Pathogen indicator bacteria originate from the digestive tract of warm-blooded animals, and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are currently required to monitor for fecal coliform and TSS in accordance with their permits. The discharges with bacterial limits will be required to monitor for *E. coli* when their permits come to renew. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from land activities that contribute bacteria or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources.

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

The following nonpoint sources of *E. coli* 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 2010 Integrated Water Quality Assessment Report (DEQ 2010) listed potential sources of turbidity as clean sediment, grazing in riparian corridors of streams and creeks, highway/road/bridge runoff (non-construction related), non-irrigated crop production, petroleum/natural gas activities, rangeland grazing, as well as other unknown sources. The following discussion describes what is known regarding point and nonpoint sources of bacteria in the impaired watersheds.

3.2 NPDES-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. NPDES-permitted facilities classified as point sources that may contribute bacterial or TSS loading includes:

- Continuous Point Source Dischargers
  - NPDES municipal wastewater treatment facilities (WWTF)
  - NPDES Industrial WWTF Discharges
- NPDES municipal separate storm sewer system (MS4) discharges
  - Phase 1 MS4
  - Phase 2 MS4
- NPDES multi-sector general permits
- NPDES construction stormwater discharges
- Rock, Sand, and Gravel Quarries
- No-discharge WWTF
- Sanitary sewer overflow (SSO)
- NPDES Concentrated Animal Feeding Operation (CAFO)

Five watersheds in the Study Area [Little Saline Creek, Honey Creek, Spavinaw Creek, Beaty Creek, and Pryor Creek (OK121610000090_00)] have no NPDES permitted facilities within their contributing watershed. There is at least one NPDES-permitted facility in each of the remaining three watersheds in the Study Area [Saline Creek, Cloud Creek, and Pryor Creek (OK121610000050_10)].

3.2.1 Continuous Point Source Discharger

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.

3.2.1.1 Municipal NPDES WWTF

In this Study Area there was one NPDES-permitted facility, the City of Pryor Creek, which is a municipal continuous point source facility that discharges wastewater into Pryor Creek (OK121610000050_10). The facility is listed in Table 3-1 and displayed in Figure 3-1. The City of Pryor Creek's WWTF discharges TSS and has specific permit limits for TSS which is listed in Table 3-1. However, because municipal WWTFs designated with a Standard Industrial

Code number 4952 discharge organic TSS, this facility is not considered a potential source of turbidity within its respective watershed. Pryor Creek's WWTF reported 52 daily maximum bacterial concentration violations from 1990 through 2012. They will be given a WLA for bacteria. Available discharge monitoring report (DMR) data for bacteria and TSS are provided in Appendix D.

3.2.1.2 Industrial NPDES WWTFs

There were no industrial NPDES Industrial point source dischargers in this Study Area.

3.2.2 Stormwater Permits

Stormwater runoff from MS4 areas, which is regulated under the EPA NPDES Program, can also contain high fecal coliform bacterial concentrations. Stormwater runoff from MS4 areas, facilities under multi-sector general permits, and NPDES construction stormwater discharges, which are regulated under the EPA NPDES Program, can contain TSS. 40 C.F.R. § 130.2(h) requires 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 and stormwater discharges from MS4 areas or construction sites do not contribute to the violation of Oklahoma's turbidity standard. Therefore, TSS WLAs for NPDES-regulated stormwater discharges are essentially considered unnecessary in this TMDL report and will not be included in the TMDL calculations.

3.2.2.1 NPDES Municipal Separate Storm Sewer System

3.2.2.1.1 Phase I MS4

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

Table 3-1 Point Source Discharger in the Study Area

OPDES Permit No.	Name	Receiving Water	Receiving Waterbody Name	Facility Type	SIC Code	County	Design Flow (mgd)	Facility ID	Expiration Date	Avg./Max. FC cfu/100mL	Avg./Max. TSS mg/L	Outfall
OK0040479	City of Pryor Creek	OK121610000050_10	Pryor Creek	Sanitary Services	4952	Mayes	1.67	S-21623	9/30/17	200/400	15/30	001A

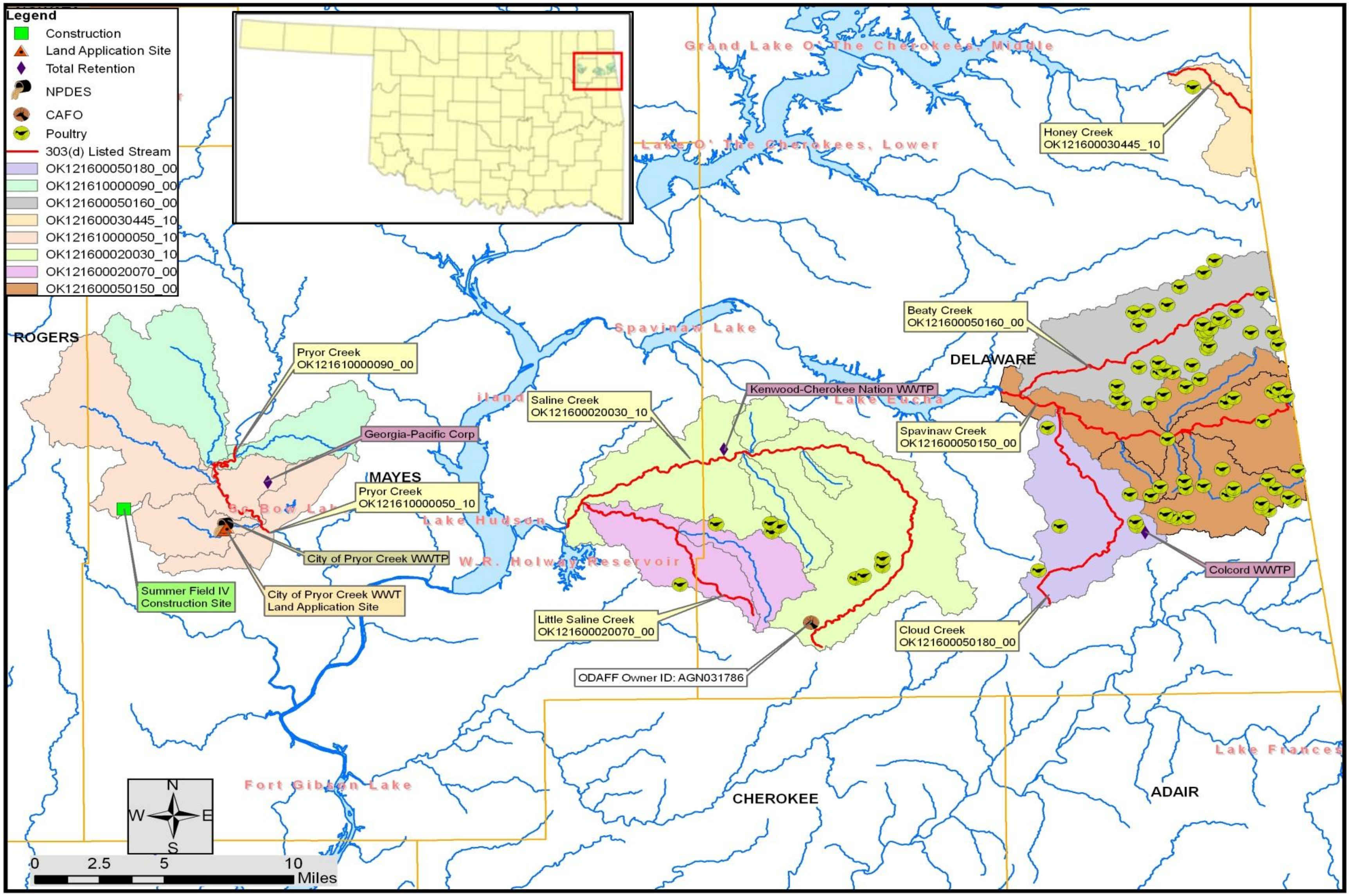
Table 3-2 NPDES No-Discharge Facilities in the Study Area

Facility	Facility ID	County	Facility Type	Type	Waterbody ID	Waterbody Name
Colcord WWTF	S-21618	Delaware	Lagoon (total retention)	Municipal	OK121600050180_00	Cloud creek
Kenwood - Cherokee Nation WWTF	S-21643	Delaware	Lagoon (total retention)	Municipal	OK121600020030_10	Saline Creek

Table 3-3 Sanitary Sewer Overflow Summary (1990 – 2012)

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
City of Pryor Creek	OK0040479	OK121610000050_10	S-21623	52	10/3/1990	1/19/2012	NA	40,000
Colcord WWTF	OK0032174	OK121600050180_00	S-21618	1	3/21/1994	3/21/1994	NA	NA
Kenwood-Cherokee Nation WWTF	OK0032468	OK121600020030_10	S-21643	1	4/13/1993	4/13/1993	NA	3,000

Figure 3-1 Location of the NPDES-Permitted Facility in the Study Area



3.2.2.1.2 Phase II MS4

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

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

The small MS4 General Permit for communities in Oklahoma became effective on February 8, 2005. DEQ provides information on the current status of the MS4 program on its website at: www.deq.state.ok.us/WQDnew/stormwater/ms4/. There are no Phase 2 MS4s within this Study Area.

3.2.2.2 Multi-Sector General Permits

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

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

If the TMDL shows that a TSS limit more stringent than 45 mg/L is required, additional TSS limitations and monitoring requirements will be required. These additional requirements will be implemented under the multi-sector general permit. There are currently no facilities within the Study Area with a multi-sector general permit.

3.2.2.3 Construction Activities

A general stormwater permit (OKR10) is required by the DEQ for any stormwater discharges associated with construction activities that result in land disturbance of equal to or greater than one (1) acre, or less than one (1) acre if they are part of a larger common plan of development or sale that totals at least one (1) acre. The permit also authorizes any stormwater discharges from support activities (e.g. concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, and borrow areas) that are directly related to a construction site that is required to have permit coverage, and is not a commercial operation serving unrelated different sites (DEQ 2007). Stormwater discharges occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply and are not considered potential contributors to turbidity impairment. The permit for the construction project that was active during the time period that samples were taken is summarized in Table 3-4.

Table 3-4 Construction Permits Summary

Company Name	County	Permit ID	Date Issued	Waterbody ID	Receiving Water (Permit)	Estimated Acres
Summerfield Place IV	Mayes	OKR108864	03/14/2008	OK121610000050_10	Pryor Creek	12

3.2.2.4 Rock, Sand and Gravel Quarries

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

3.2.3 No-Discharge Facilities

Certain municipal 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 two municipal no-discharge facilities in the Study Area which are listed in Table 3-2. These no-discharge facilities could be contributing to the elevated levels of instream indicator bacterial loading.

3.2.4 Sanitary sewer overflow (SSO)

Sanitary sewer overflow (SSO) from wastewater collection systems, although infrequent, can be a major source of indicator bacterial loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of sewer pipes by grease, tree roots, and other debris that clog sewer lines, by sewer line breaks and leaks, cross connections with storm sewers, and inflow and infiltration of groundwater into sanitary sewers. SSOs are permit violations that must be addressed by the responsible NPDES permittee. The reporting of SSOs has been strongly encouraged by EPA, primarily through enforcement and fines. While not all sewer overflows are reported, DEQ has some data on SSOs available. Between 1990 and 2012, 54 SSO overflows were reported ranging from 1 gallon to over 40,000 gallons. Table 3-3 summarizes the SSO occurrences by NPDES facility. Historical data of reported SSOs are provided in Appendix E.

3.2.5 Concentrated Animal Feeding Operations

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

3.2.5.1 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 2005). The CAFO Act is designed to protect water quality through the use of best management practices (BMP) such as dikes, berms, terraces, ditches, or other similar structures used to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event (ODAFF 2005). CAFOs are considered no-discharge facilities for the purpose of the TMDL calculations in this report.

CAFOs are designated by EPA as significant sources of pollution (ODAFF 2009), 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. CAFOs are not considered a source of TSS loading. The location of the only CAFO in the Study Area is shown in Figure 3-1 and is listed in Table 3-5.

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

Table 3-5 NPDES-Permitted CAFO in Study Area

ODAFF Owner ID	EPA Facility	ODAFF ID	ODAFF License Number	Max # of Swine units at Facility	Max # of Dairy Cattle units at Facility	Total # of Animal Units at Facility	County	Waterbody ID and Waterbody Name
AGN031786	OKG010224	88	1373	40	420	460	Delaware	OK121600020030_10 Saline Creek

3.2.5.2 PFO

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

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

Per data provided by ODAFF in May 2011, there are 69 PFOs located in the watershed as shown in Table 3-6. These PFOs are small animal feeding oerations and are not required to get NPDES permits; they are required only to register with ODAFF. They generate dry litter and do not have any significant impact on the watershed.

Table 3-6 Registered PFOs in Study Area

Company Name	Poultry ID	Type	Total Birds	County	Waterbody Name	Waterbody ID
Simmons Foods	1343	Broilers	310000	Delaware	Saline Creek	OK121600020030_10
Simmons Foods	1372	Broilers	223000			
Simmons Foods	1381	Broilers	167250			
Simmons Foods	1418	Layers	30000			
Simmons Foods	1704	Broilers	280000			
Simmons Foods	229	Broilers	60000	Mayes	Little Saline Creek	OK121600020070_00
Cobb-Vantress	1698	Breeders	20000	Delaware		
Simmons Foods	1429	Broilers	230000	Delaware	Honey Creek	OK121600030445_10
Cobb-Vantress	62	Pullets	23400	Delaware	Spavinaw Creek	OK121600050150_00
Simmons Foods	147	Broilers	40000			
Georges Inc.	350	Broilers	100000			
Simmons Foods	458	Broilers	80000			
Simmons Foods	460	Broilers	60000			
Cobb-Vantress	485	Layers	20000			
Tyson Foods	486	Broilers	40000			
Simmons Foods	513	Layers	16000			
Simmons Foods	593	Layers	19000			

Company Name	Poultry ID	Type	Total Birds	County	Waterbody Name	Waterbody ID
Cobb-Vantress	674	Pullets	21000	Delaware	Spavinaw Creek	OK121600050150_00
Simmons Foods	781	Broilers	50000			
Moark Productions	809	Layers	15000			
Simmons Foods	1096	Layers	36000			
Cobb-Vantress	1256	Layers	21500			
Moark Productions	1260	Breeders	24000			
Simmons Foods	1272	Broilers	114800			
Moark Productions	1284	Breeders	23000			
Simmons Foods	1368	Broilers	130000			
Tyson Foods	1384	Broilers	232000			
Tyson Foods	1385	Broilers	232000			
Simmons Foods	1390	Broilers	80000			
Tyson Foods	1432	Broilers	232000			
Tyson Foods	1433	Broilers	232000			
Tyson Foods	1434	Broilers	232000			
Tyson Foods	1435	Broilers	232000			
Simmons Foods	1474	Broilers	45000			
Cobb-Vantress	1520	Breeders	19000			
Cobb-Vantress	1611	Breeders	22000			
Cobb-Vantress	1640	Pullets	27200			
Simmons Foods	1682	Pullets	52000			
Simmons Foods	1683	Broilers	200000			
Simmons Foods	11	Broilers	60000	Delaware	Beaty Creek	OK121600050160_00
Simmons Foods	12	Broilers	60000			
Simmons Foods	60	Broilers	40000			
Moark Productions	73	Layers	28000			
Moark Productions	79	Layers	30000			
Moark Productions	252	Layers	22000			
Moark Productions	323	Layers	10000			
Simmons Foods	395	Broilers	40000			
Simmon & Tyson Foods	403	Pullets	40000			
Simmons Foods	750	Broilers	200000			
Simmons Foods	754	Broilers	200000			
Simmons Foods	756	Broilers	200000			
Simmons Foods	780	Broilers	60000			
Simmons Foods	1221	Broilers	86000			
Moark Productions	1247	Layers	44000			
Tyson Foods	1265	Breeders	26400			
Moark Productions	1266	Layers	85000			
Tyson Foods	1420	Breeders	28000			
Moark Productions	1460	Breeders	12000			
Moark Productions	1545	Pullets	80000			
Tyson Foods	1565	Layer	13200			
Moark Productions	1570	Layers	26000			
Cobb-Vantress	1604	Pullets	64000			
Simmons Foods	1676	Layers	40000			
Simmons Foods	1708	Broilers	200000			
Moark Productions	1711	Layers	26000			
Simmons Foods	1715	Broilers & Pullets	240000			
Simmons Foods	552	Broilers	45000	Delaware	Cloud Creek	OK121600050180_00
Tyson Foods	655	Broilers	72000			
Simmons Foods	810	Broilers	140000			
Simmons Foods	1373	Breeders	19500			

3.2.6 Section 404 permits

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

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

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

3.3 NONPOINT SOURCES

Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. The relatively homogeneous land use/land cover categories throughout the Study Area associated with rural agricultural, forest and range management activities has an influence on the origin and pathways of pollutant sources to surface water. Bacteria originate from warm-blooded animals in rural, suburban, and urban areas. These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state's water quality standards. A study under EPA's National Urban Runoff Project indicated that the average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000/100 mL in stormwater runoff (EPA 1983). Runoff from urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria. Water quality data collected from streams draining many of the non-permitted communities show a high level of fecal coliform bacteria.

Various potential nonpoint sources of TSS as indicated in the 2010 Integrated Report include sediments originating from grazing in riparian corridors of streams and creeks, highway/road/bridge runoff, non-irrigated crop production, rangeland grazing and other sources of sediment loading (DEQ 2010). Elevated turbidity measurements can be caused by stream bank erosion processes, stormwater runoff events and other channel disturbances. The following section provides general information on nonpoint sources contributing bacterial 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. By using Oklahoma Department of Wildlife and Conservation (ODWC) county data, the population of deer can be roughly estimated from the actual number of deer harvested and harvest rate estimates. Because harvest success varies from year to year based on weather and other factors, the average harvest from 2005 to 2009 was combined with an estimated annual harvest rate of 20% to predict deer population by county. Using the estimated deer population by county and the percentage of the watershed area within each county, a wild deer population can be calculated for each watershed.

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

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

Waterbody ID	Waterbody Name	Watershed Area (acres)	Wild Deer Population	Estimated Wild Deer per acre	Fecal Production (x 10^9 cfu/day) of Deer Population
OK121600020030_10	Saline Creek	52,609	947	0.018	474
OK121600020070_00	Little Saline Creek	15,272	272	0.018	136
OK121600030445_10	Honey Creek	5,069	21	0.004	11
OK121600050150_00	Spavinaw Creek	34,240	385	0.011	192
OK121600050160_00	Beaty Creek	26,231	388	0.015	194
OK121600050180_00	Cloud Creek	15,981	292	0.018	146
OK121610000050_10	Pryor Creek	51,454	871	0.017	436

3.3.2 Non-Permitted Agricultural Activities and Domesticated Animals

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

- Processed commercially raised farm animal manure is often applied to fields as fertilizer, and can contribute to fecal bacterial loading to waterbodies if washed into streams by runoff.

- Animals grazing in pastures deposit manure containing fecal bacteria onto land surfaces. These bacteria may be washed into waterbodies by runoff.
- Animals often have direct access to waterbodies and can provide a concentrated source of fecal bacterial loading directly into streams or can cause unstable stream banks which can contribute TSS.

Table 3-11 provides estimated numbers of selected commercially raised farm animals by watershed based on the 2007 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2007). The estimated populations were derived by using the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and commercially raised farm animals are not evenly distributed across counties or constant with time, these are rough estimates only. Cattle are clearly the most abundant species of commercially raised farm animals in the Study Area and often have direct access to the waterbodies and their tributaries.

Detailed information is not available to describe or quantify the relationship between in-stream concentrations of bacteria and land application or direct deposition of manure from commercially raised farm animal. Nor is sufficient information available to describe or quantify the contributions of sediment loading caused by commercially raised farm animal responsible for destabilizing stream banks or erosion in pasture fields. The estimated acreage by watershed where manure was applied in 2007 is shown in Table 3-11. These estimates are also based on the county level reports from the 2007 USDA county agricultural census, and thus, represent approximations of the commercially raised farm animal populations in each watershed. 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 despite lack of specific data. Table 3-8 gives the daily fecal coliform production rates by animal species:

Table 3-8 Daily Fecal Coliform Production Rates by Livestock 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 3-8, 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 3-12. 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 is transported to streams by runoff from urban and suburban areas, can be a potential source of bacterial loading. On average 37.2% of the nation's households own dogs and 32.4% own cats and in these households the average number of dogs is 1.7 and 2.2 cats per household (American Veterinary Medical Association 2007). Using the U.S. Census data at the block level (U.S. Census Bureau 2010), dog and cat populations can be estimated for each watershed. Table 3-9 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-9 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK121600020030_10	Saline Creek	1,633	2,114
OK121600020070_00	Little Saline Creek	559	724
OK121600030445_10	Honey Creek	238	309
OK121600050150_00	Spavinaw Creek	1,460	1,889
OK121600050160_00	Beaty Creek	910	1,178
OK121600050180_00	Cloud Creek	558	722
OK121610000050_10	Pryor Creek	7,127	9,223

Table 3-10 provides an estimate of the fecal coliform production from pets. These estimates are based on estimated fecal coliform production rates from Table 3-8.

Table 3-10 Estimated Fecal Coliform Daily Production by Pets ($x10^9$ counts/day)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK121600020030_10	Saline Creek	5,390	1,141	12,209
OK121600020070_00	Little Saline Creek	1,846	391	4,188
OK121600030445_10	Honey Creek	787	167	1,793
OK121600050150_00	Spavinaw Creek	4,817	1,020	10,914
OK121600050160_00	Beaty Creek	3,004	636	6,806
OK121600050180_00	Cloud Creek	1,840	390	4,176
OK121610000050_10	Pryor Creek	23,518	4,980	53,265

3.3.1 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

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

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

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state's minimum design criteria (Hall 2002). The 1990 American Housing Survey for Oklahoma conducted by the U.S. Census Bureau estimates that, nationwide, 10% of occupied homes with OSWD systems experience malfunctions during the year (U.S. Department of Commerce, Bureau of the Census 1990). A study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12% of the OSWD systems in east Texas and 8% in the Texas Panhandle were chronically malfunctioning. Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002).

Some studies, however, found that lot sizes in this range or even larger could still cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-13 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 3-11 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Goats	Sheep	Hogs & Pigs	Ducks & Geese	Acres of Manure Application
OK121600020030_10	Saline Creek	7,971	384	313	1	104	18	27	1,739
OK121600020070_00	Little Saline Creek	2,416	131	94	0	29	10	8	539
OK121600030445_10	Honey Creek	879	30	11	0	11	0	1	159
OK121600050150_00	Spavinaw Creek	5,805	208	137	1	83	0	11	1,299
OK121600050160_00	Beaty Creek	4,112	157	128	0	59	0	11	995
OK121600050180_00	Cloud Creek	2,307	94	91	0	33	0	8	606
OK121610000050_10	Pryor Creek	8,916	589	368	1	85	80	43	1,487

Table 3-12 Fecal Coliform Production Estimates for Commercially Raised Farm Animals ($x10^9$ number/day)

Waterbody ID	Waterbody Name	Cattle & Calves	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks &Geese	Total
OK121600020030_10	Saline Creek	829,033	38,796	131	13	1,252	189	694	870,109
OK121600020070_00	Little Saline Creek	251,276	13,263	40	4	352	106	215	265,256
OK121600030445_10	Honey Creek	91,386	2,987	5	1	134	0	23	94,534
OK121600050150_00	Spavinaw Creek	603,677	21,008	58	6	996	0	285	626,030
OK121600050160_00	Beaty Creek	427,700	15,867	54	6	704	0	270	444,599
OK121600050180_00	Cloud Creek	239,884	9,531	38	4	393	0	195	250,047
OK121610000050_10	Pryor Creek	927,280	59,509	155	16	1,015	860	1,099	989,934

Table 3-13 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks / Mile^2
OK121600020030_10	Saline Creek	243	682	36	961	8.3
OK121600020070_00	Little Saline Creek	73	248	8	329	10.4
OK121600030445_10	Honey Creek	37	101	2	140	12.8
OK121600050150_00	Spavinaw Creek	236	607	15	859	11.3
OK121600050160_00	Beaty Creek	244	280	11	535	6.8
OK121600050180_00	Cloud Creek	36	283	9	328	11.3
OK121610000050_10	Pryor Creek	3,174	1007	11	4192	34.1

The average of number of people per household was calculated to be 2.29 for counties in the Study Area (U.S. Census Bureau 2010). Approximately 70 gallons of wastewater were estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per 100 mL of effluent based on reported concentrations from a number of publications (Metcalf and Eddy 1991; Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the watersheds was summarized below in Table 3-14.

Table 3-14 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)
OK121600020030_10	Saline Creek	52,609	682	82	538
OK121600020070_00	Little Saline Creek	15,272	248	30	196
OK121600030445_10	Honey Creek	5,069	101	12	80
OK121600050150_00	Spavinaw Creek	34,240	607	73	479
OK121600050160_00	Beaty Creek	26,231	280	34	221
OK121600050180_00	Cloud Creek	15,981	283	34	223
OK121610000050_10	Pryor Creek	51,454	1,007	121	794

3.4 Summary of Sources of Impairments

3.4.1 Bacteria

There are no continuous, permitted point sources of bacteria in the Saline Creek, Little Saline Creek, Honey Creek, Spavinaw Creek, Beaty Creek, or Cloud 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. Only Pryor Creek (OK121610000050_10) has a continuous point source discharger that may contribute bacteria. However, available data suggests that the proportion of bacteria from that point source is minor. There is 1 CAFO and 2 PFOs (1 with 60,000 broilers and 1 with 20,000 breeders) which could possibly contribute bacterial loading to the Little Saline Creek watershed. But PFOs 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 PFO Rules. Therefore the various nonpoint sources are considered to be the major source of bacterial loading in each watershed that requires a TMDL.

All the stream segments in Table 3-15 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 3-15 Percentage Contribution of Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces

Waterbody ID	Waterbody Name	All Livestock	Pets	Deer	Estimated Loads from Septic Tanks
OK121600020030_10	Saline Creek	98.50%	1.38%	0.05%	0.06%
OK121600020070_00	Little Saline Creek	98.32%	1.55%	0.05%	0.07%
OK121600030445_10	Honey Creek	98.05%	1.86%	0.01%	0.08%
OK121600050150_00	Spavinaw Creek	98.18%	1.71%	0.03%	0.08%
OK121600050160_00	Beaty Creek	98.40%	1.51%	0.04%	0.05%
OK121600050180_00	Cloud Creek	98.21%	1.64%	0.06%	0.09%
OK121610000050_10	Pryor Creek	94.78%	5.10%	0.01%	0.08%

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

3.4.2 Turbidity

Pryor Creek (OK121610000090_00) is the only stream segment in this report which requires a turbidity TMDL. Pryor Creek subwatershed has no industrial permitted source of TSS that will necessitate a WLA. Therefore nonsupport of WWAC use is caused by nonpoint sources of TSS. Sediment loading of streams can originate from natural erosion processes, including the weathering of soil, rocks, and uncultivated land; geological abrasion; and other natural phenomena. There is insufficient data available to quantify contributions of TSS from these natural processes. TSS or sediment loading can also occur under non-runoff conditions as a result of anthropogenic activities in riparian corridors which cause erosive conditions. Given the lack of data to establish the background conditions for TSS/turbidity, separating background loading from nonpoint sources whether it is from natural or anthropogenic processes is not feasible in this TMDL development.

SECTION 4
TECHNICAL APPROACH AND METHODS

The objective of a TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. A TMDL is expressed as the sum of three elements as described in the following mathematical equation:

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

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

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

4.1 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 1998 to 2011 at stations within the Study Area. Prior to developing the regression the following steps were taken to refine the dataset:

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

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

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

- LOC minimizes fitted residuals in both the X and Y directions;
- It provides a unique best-fit line regardless of which parameter is used as the independent variable; and
- 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:

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

where $m1$ is the slope of the LOC line

m is the TSS on turbidity OLS slope

m' is the turbidity on TSS OLS slope

r is the TSS-turbidity correlation coefficient

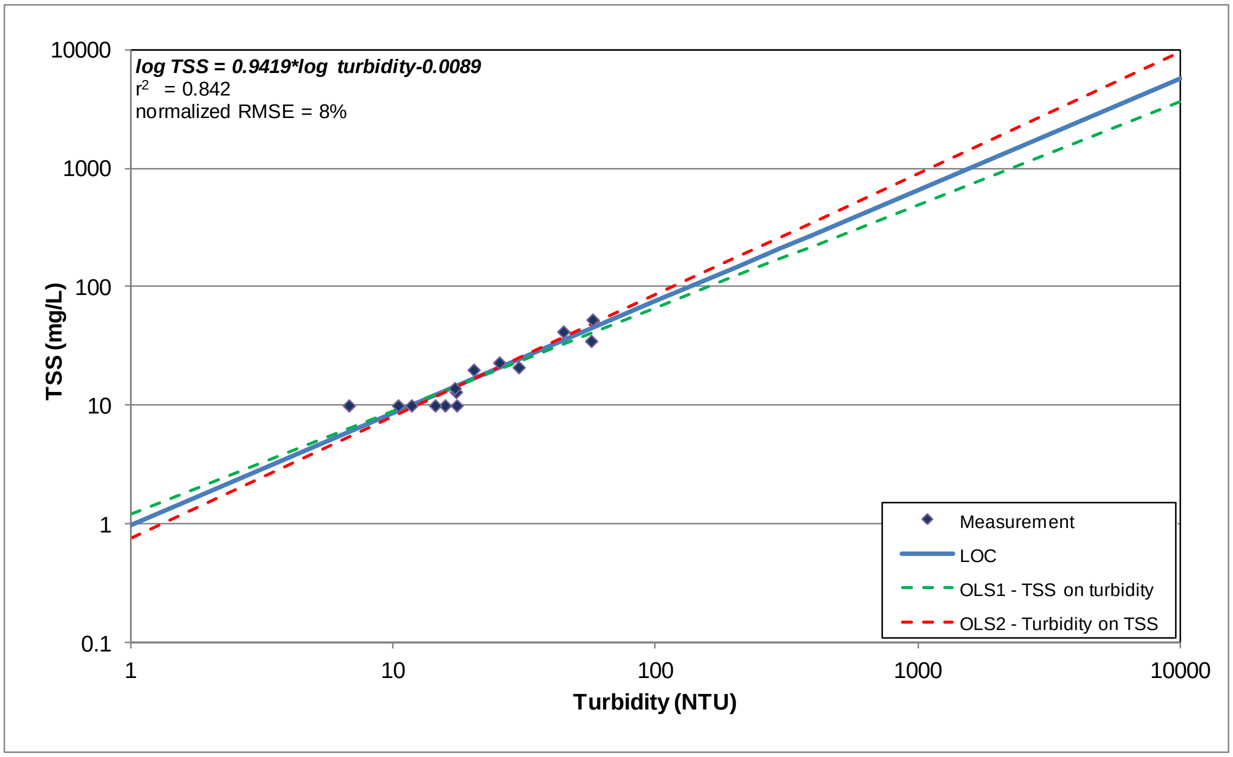
s_y is the standard deviation of the TSS measurements

s_x is the standard deviation of the turbidity measurements.

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

The NRMSE and R-square (r^2) were used as the primary measures of goodness-of-fit. As shown in Figure 4-1, the LOC yields a NRMSE value of 8 which means the root mean square error (RMSE) is 8% of the average of the measured TSS values. The R-square (r^2) value indicates the fraction of the total variance in TSS or turbidity observations that is explained by the LOC. The regression equation can be used to convert the turbidity standard of 50 NTUs to TSS goals.

Figure 4-1 Linear Regression for TSS-Turbidity for Euchee Creek (OK620900010290_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 regressions presented in Section 5 were calculated using the dataset with outliers removed.

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

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

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

4.2 Using Load Duration Curves to Develop TMDLs

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

- Prepare flow duration curves for gaged and ungaged WQM stations.
- Estimate existing loading in the waterbody using ambient bacterial water quality data.
- Estimate loading in the waterbody using measured TSS water quality data and turbidity-converted data.
- 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 Development of Flow Duration Curves

Flow duration curves (FDC) serve as the foundation of LDCs and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many WQM stations throughout Oklahoma do not have long-term flow data and therefore, flow frequencies must be estimated. Nine of the eleven waterbodies in the Study Area do not have USGS gage stations. The default approach used to develop flow frequencies necessary to establish flow duration curves considers watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. A detailed explanation of the methods for estimating flow for ungaged streams is provided in Appendix B.

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 (USGS 2009) to support the Oklahoma TMDL Toolbox.

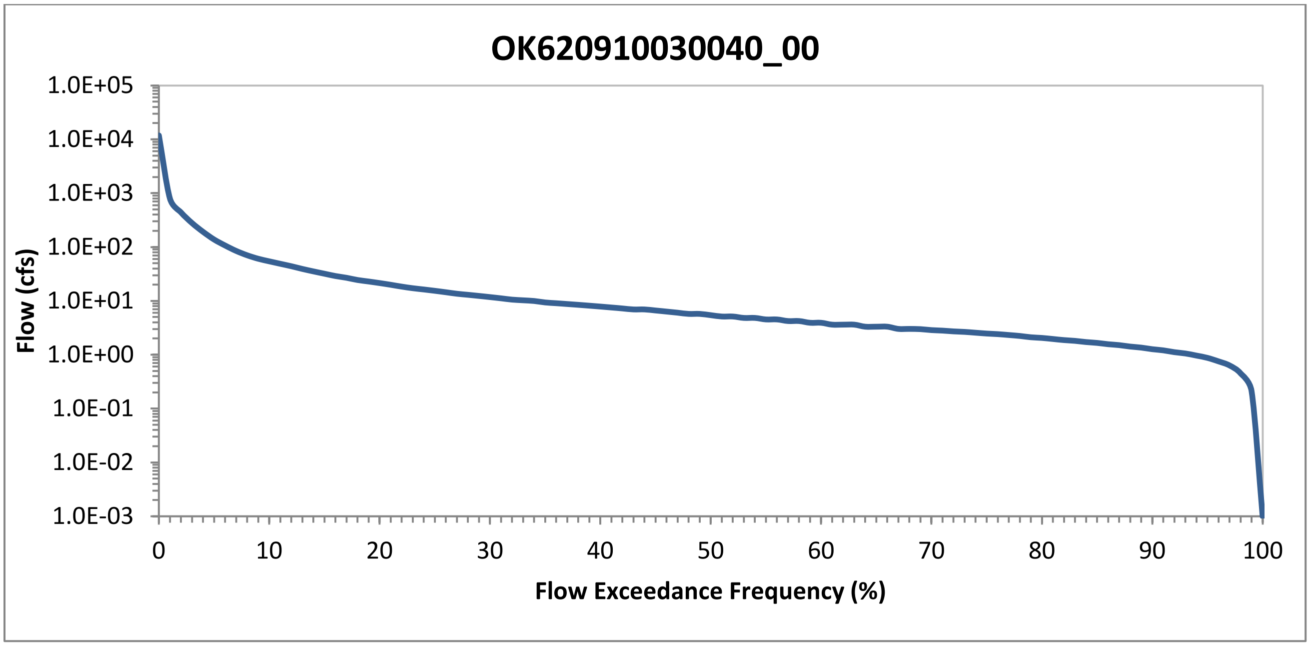
The USGS National Water Information System serves as the primary source of flow measurements for the Oklahoma TMDL Toolbox. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream gages in adjacent states, were retrieved for use in the Oklahoma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

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

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

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

Figure 4-2 Flow Duration Curve for Otter Creek (OK31620910030040_00)



4.4 Estimate Existing Loads

4.4.1 Bacterial FDC

Existing in-stream loads can be estimated using FDCs. 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.

4.4.2 TSS FDC

For 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); or multiplying the flow by the bacterial indicator concentration to calculate daily loads.

4.5 Development of TMDLs Using Load Duration Curves

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

4.5.1 Step 1: Generate LDCs

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

For turbidity, the curve represents the water quality target for TSS from Table 5-1 expressed in terms of a load obtained through multiplication of the TSS goal by the continuum of flows historically observed at the site.

The following are the basic steps in developing a LDC:

- Obtain daily flow data for the site of interest from the USGS.
- Sort the flow data and calculate flow exceedance percentiles.
- Obtain the water quality data from the primary contact recreation season (May 1 through September 30).
- Obtain available turbidity and TSS water quality data.
- 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 bacterial and TSS goal for turbidity).
- 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).
- 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).

4.5.1.1 Bacterial LDC

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

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

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

unit conversion factor = 24,465,525

4.5.1.2 Turbidity LDC

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

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

where: WQ $_{goal}$ ***= waterbody specific TSS concentration derived from regression analysis results presented in Table 5-1***

unit conversion factor = 5.39377

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

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

4.5.2 Step 2: Define MOS

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

4.5.3 Step 3: Calculate WLA

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

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

4.5.3.1 WLA for WWTF

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

4.5.3.1.1 WLA for Bacteria

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

Where:

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

flow = permitted flow (mgd)

unit conversion factor = 37,854,120

4.5.3.1.2 WLA for TSS

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

Where:

WQ goal =Waterbody specific water quality goal provided in Table 5-1, or monthlyTSS limit in the current permit, whichever is smaller(mg/L)

flow = permitted flow or average monthly flow (mgd)

unit conversion factor = 8.3445

4.5.4 Step 4: Calculate LA and WLA for MS4s

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

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

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

4.5.4.1 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.

4.5.4.2 Turbidity WLA for MS4s

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

4.5.5 Step 5: Estimate Percent Load Reduction

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

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

4.5.5.1 WLA Load Reduction

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

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

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

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

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

4.5.5.2 LA Load Reduction

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

SECTION 5
TMDL CALCULATIONS

5.1 Surrogate TMDL Target for Turbidity

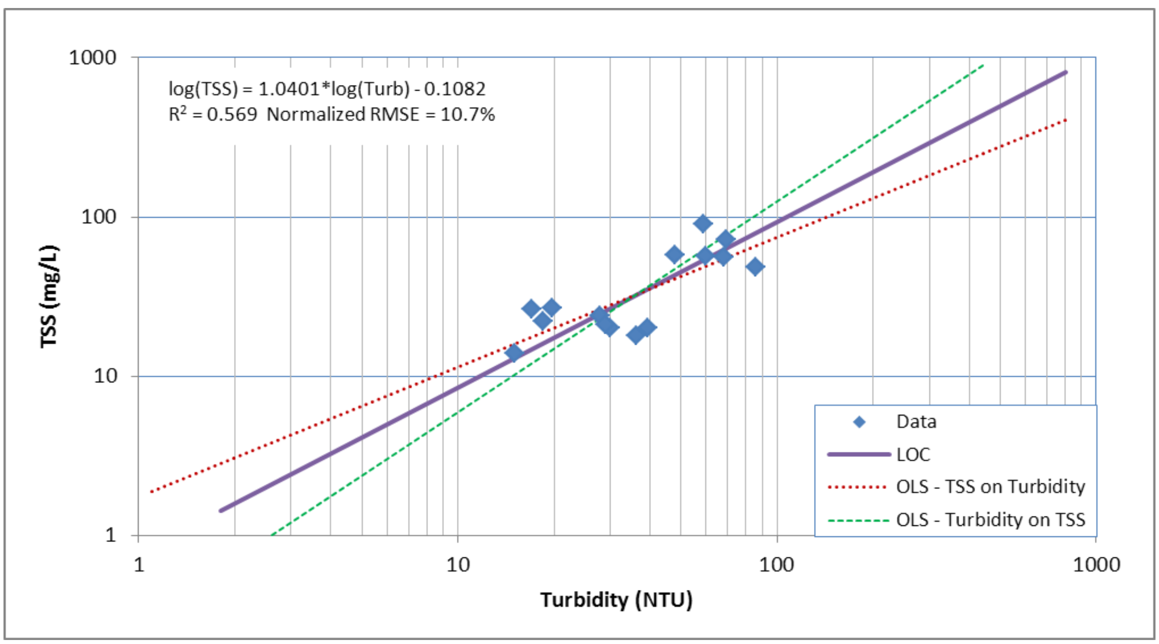
Using the line of organic correlation (LOC) method described in Section 4.1, correlations between TSS and turbidity were developed for establishing the statistics of the regressions and the resulting TSS goal is provided in Table 5-1. The regression analysis for Pryor Creek (OK121610000090_00) using the LOC method is displayed in Figure 5-1.

Table 5-1 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK121610000090_00	Pryor Creek	0.569	10.7%	46	15%

[a] Calculated using the regression equation and the turbidity standard (50 NTU)
[b] Based on the goodness-of-fit of the turbidity-TSS regression (NRMSE)

Figure 5-1 Linear Regression for TSS-Turbidity for Pryor Creek (OK121610000090_00)

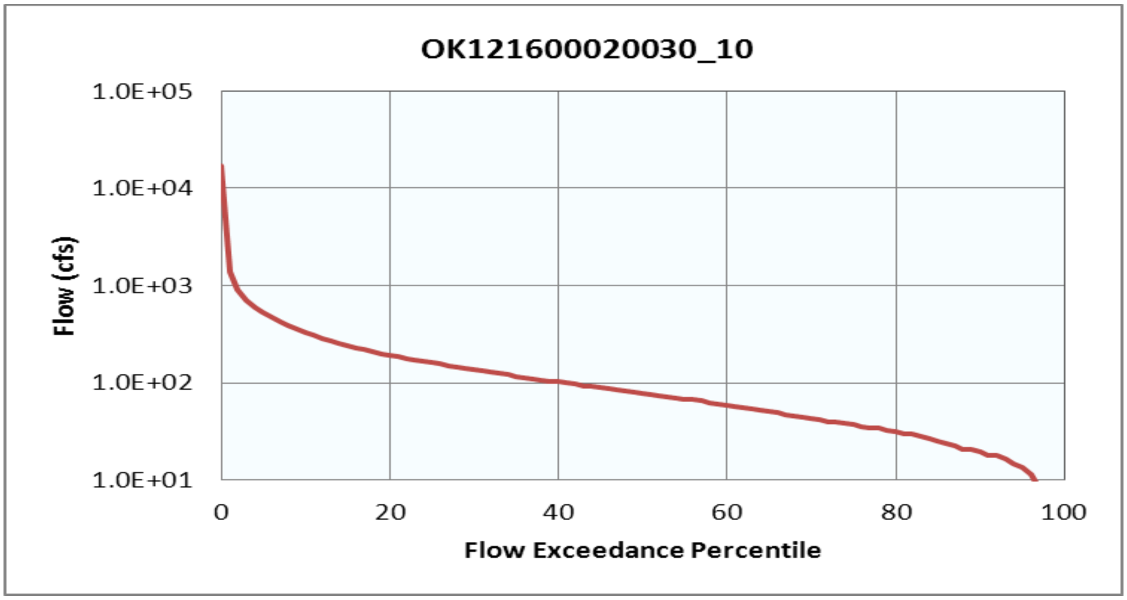


5.2 Flow Duration Curve

A flow duration curve for each stream segment in this study was developed by following the same procedures described in Section 4.3. These LDCs are shown in Figures 5-2 through 5-9.

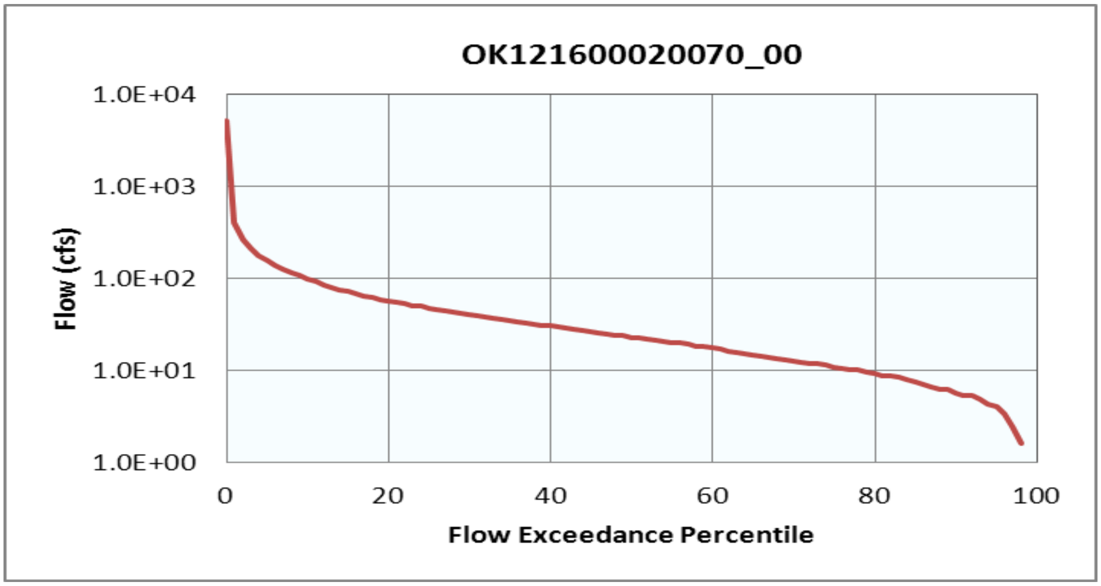
No flow gage exists on Saline Creek, segment OK121600020030_10. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07191220 located in an adjacent watershed (Spavinaw Creek, near Sycamore, OK). The flow duration curve was based on measured flows from 1959 to 2012.

Figure 5-2 Flow Duration Curve for Saline Creek (OK121600020030_10)



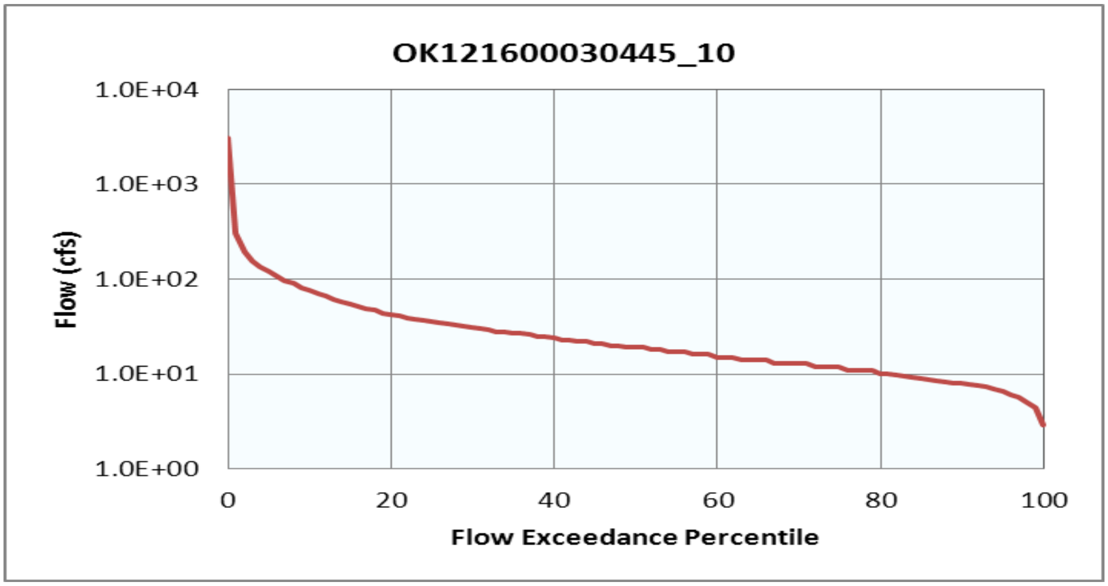
No flow gage exists on Little Saline Creek, segment OK121600020070_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07191220 located in an adjacent watershed (Spavinaw Creek, near Sycamore, OK). The flow duration curve was based on measured flows from 1959 to 2012.

Figure 5-3 Flow Duration Curve for Little Saline Creek (OK121600020070_00)



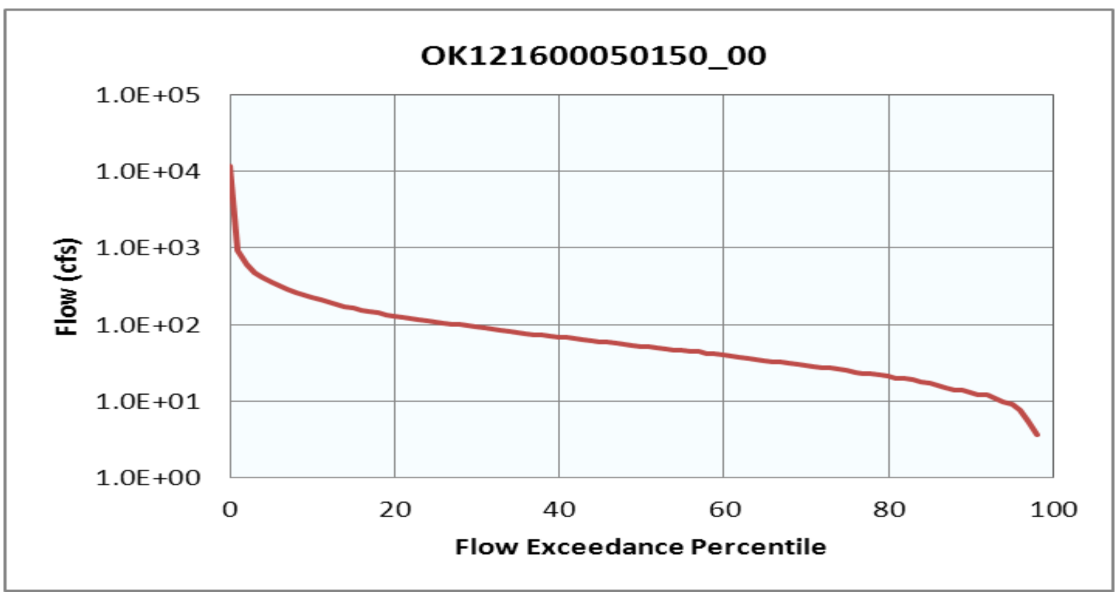
Flows for Honey Creek (OK121600030445_10), were based on measured flows at USGS gage station 07189542 (South West City, MO). The flow duration curve was based on measured flows from 1997 to 2012.

Figure 5-4 Flow Duration Curve for Honey Creek (OK121600030445_10)



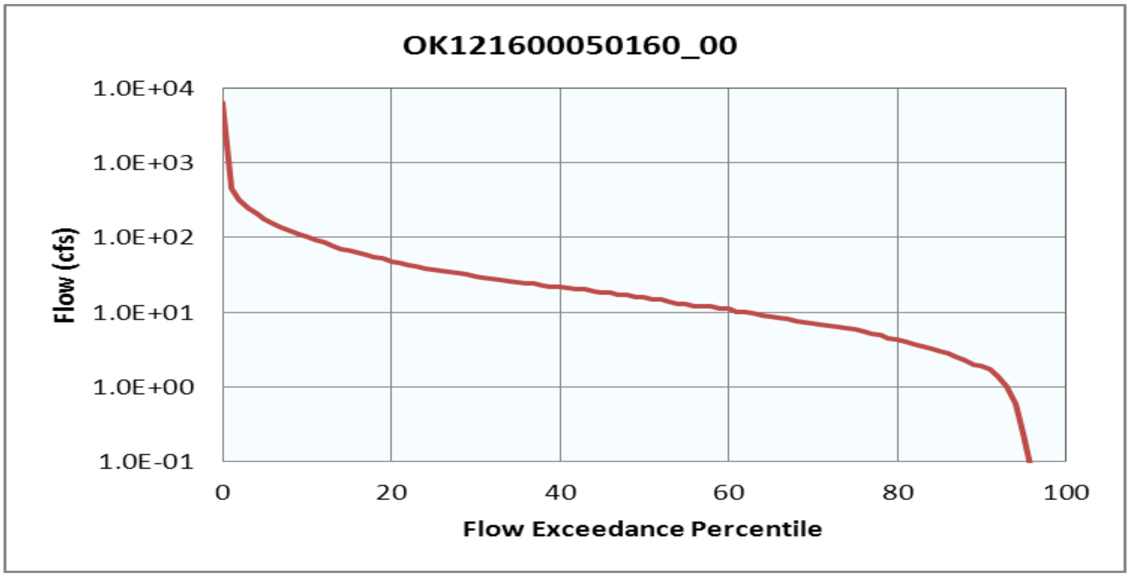
Flows for Spavinaw Creek (OK121600050150_00), were based on measured flows at USGS gage stations 07191200 and 07191220 near Sycamore, Oklahoma. The flow duration curve was based on measured flows from 1959 to 2012.

Figure 5-5 Flow Duration Curve for Spavinaw Creek (OK121600050150_00)



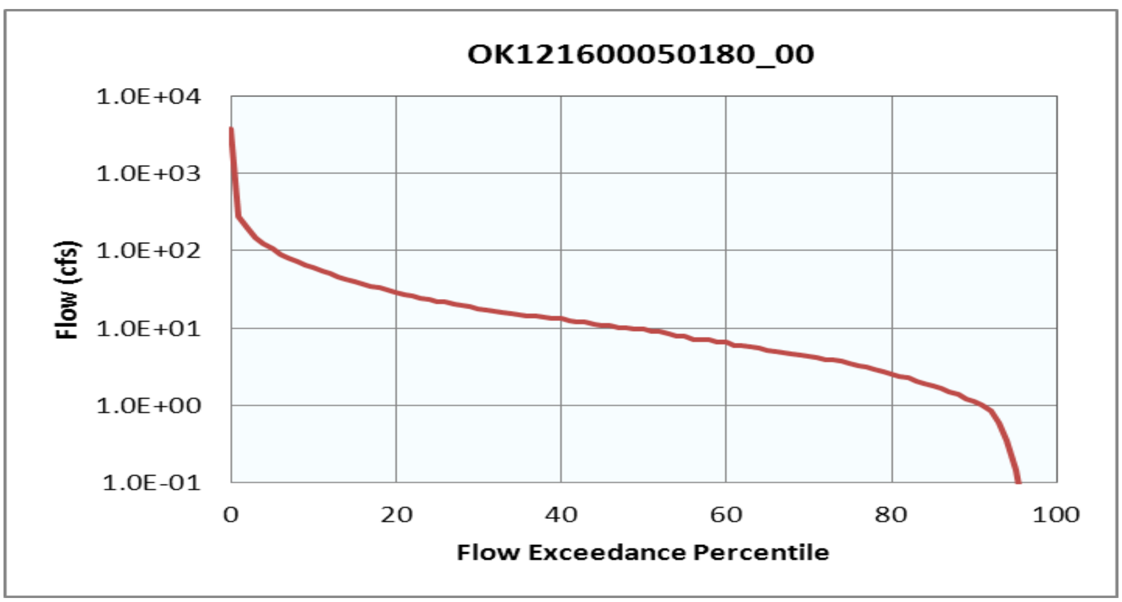
Flows for Beaty Creek (OK121600050160_00), were based on measured flows at USGS gage station 07191222 near Jay, Oklahoma. The flow duration curve was based on measured flows from 1998 to 2012.

Figure 5-6 Flow Duration Curve for Beaty Creek (OK121600050160_00)



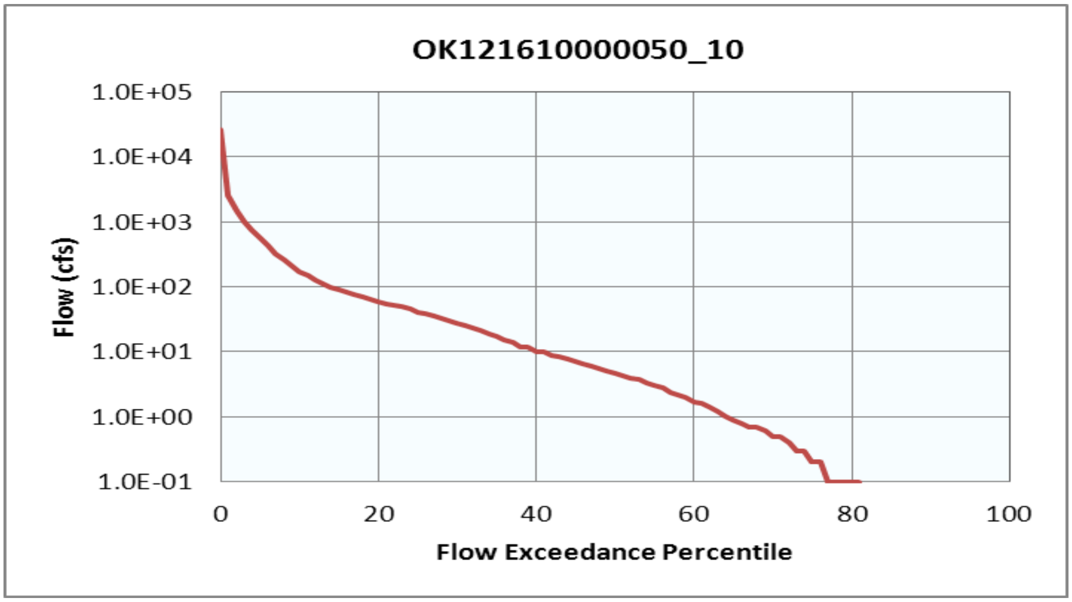
No flow gage exists on Cloud Creek, segment OK121600050180_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07191222 located in an adjacent watershed (Beaty Creek, near Jay, OK). The flow duration curve was based on measured flows from 1998 to 2012.

Figure 5-7 Flow Duration Curve for Cloud Creek (OK121600050180_00)



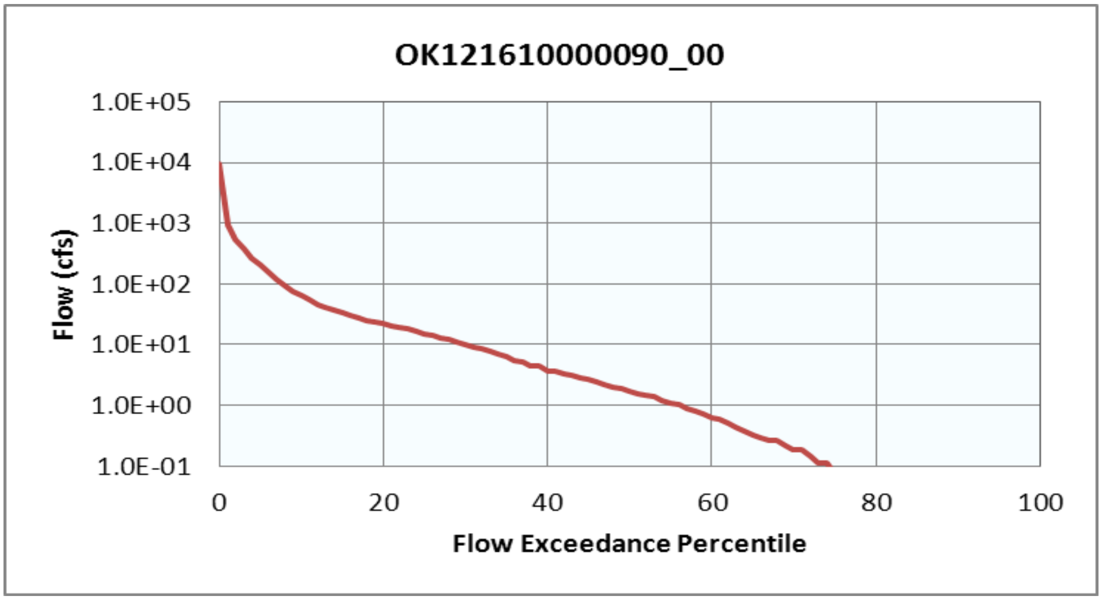
Flows for Pryor Creek (OK121610000050_10) were estimated using the watershed area ratio method based on measured flows at USGS gage station 07192000 located near Pryor Creek, Oklahoma. The flow duration curve was based on measured flows from 1947 to 1963.

Figure 5-8 Flow Duration Curve for Pryor Creek (OK121610000050_10)



No flow gage exists on Pryor Creek, segment OK121610000090_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07192000 located in an adjacent watershed (Pryor Creek in Pryor Creek, OK). The flow duration curve was based on measured flows from 1947 to 1963.

Figure 5-9 Flow Duration Curve for Pryor Creek (OK121610000090_00)



5.3 ESTIMATED LOADING AND CRITICAL CONDITIONS

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

5.3.1 Bacterial LDC

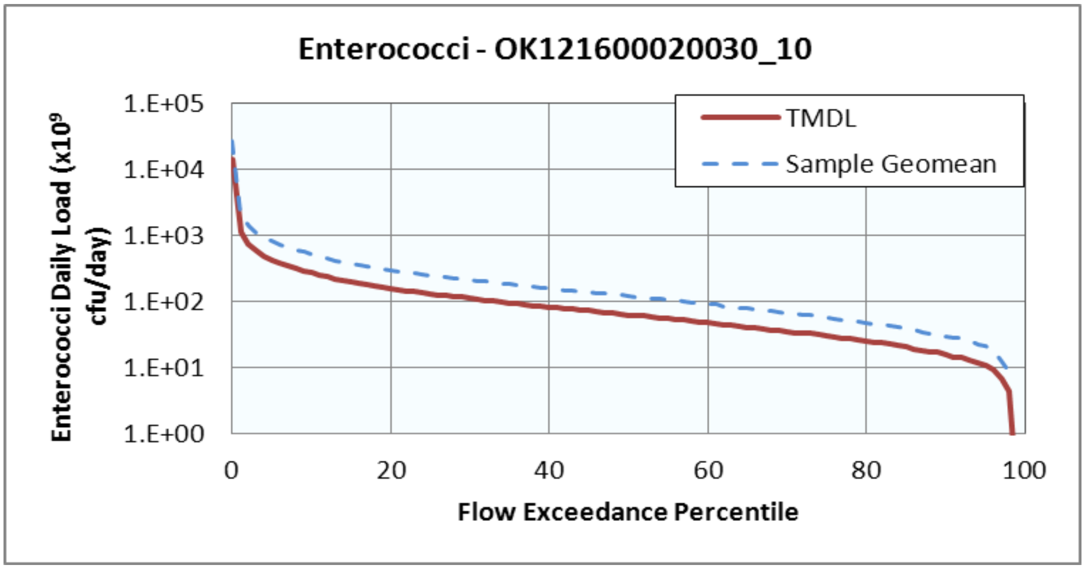
To calculate the allowable bacterial load, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525*) and the geometric mean water quality criterion for each bacterial indicator. This calculation produces the maximum bacterial load in the stream over the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

To estimate existing loading, the geometric mean of all bacterial observations (concentrations) for the primary contact recreation season (May 1st through September 30th) from 2005 to 2010 are paired with the flows measured or estimated in that waterbody. Pollutant loads are then calculated by multiplying the measured bacterial concentration by the flow rate and the unit conversion factor of *24,465,756*.

The bacterial LDCs developed for each impaired waterbody (representing the primary contact recreation season from 2002 through 2010) are shown in Figures 5-10 through 5-18. Each waterbody had an LDC for either *E. coli*, Enterococci or both. This is because for the PBCR use to be supported, criteria for each bacterial indicator must be met in each impaired waterbody.

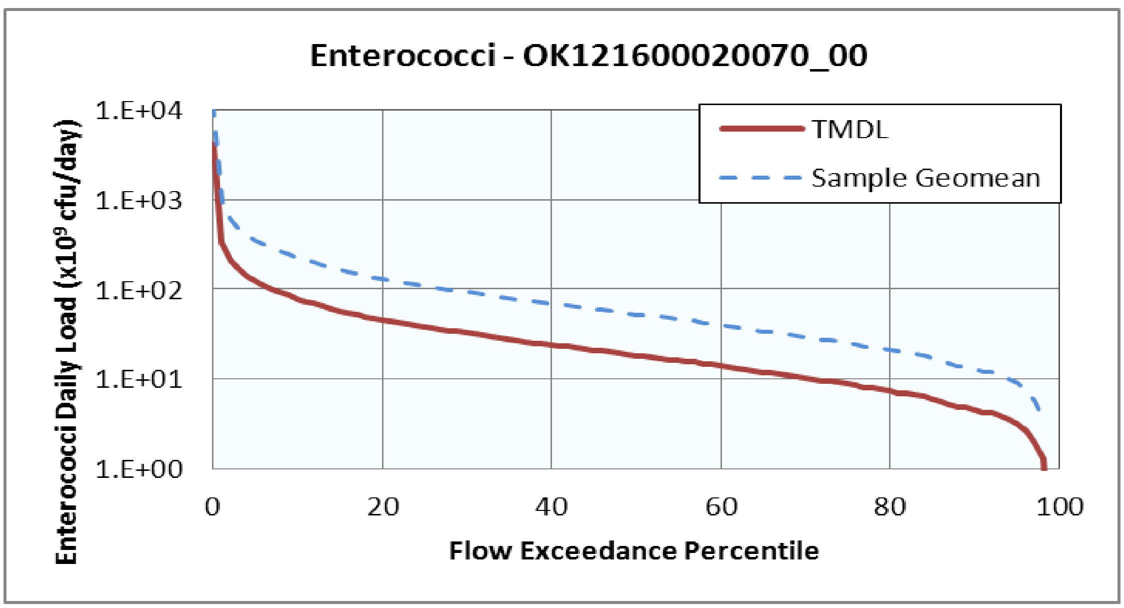
The LDC for Saline Creek (Figure 5-10) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM station OK121600-02-0030D.

Figure 5-10 Load Duration Curve for Enterococci in Saline Creek (OK121600020030_10)



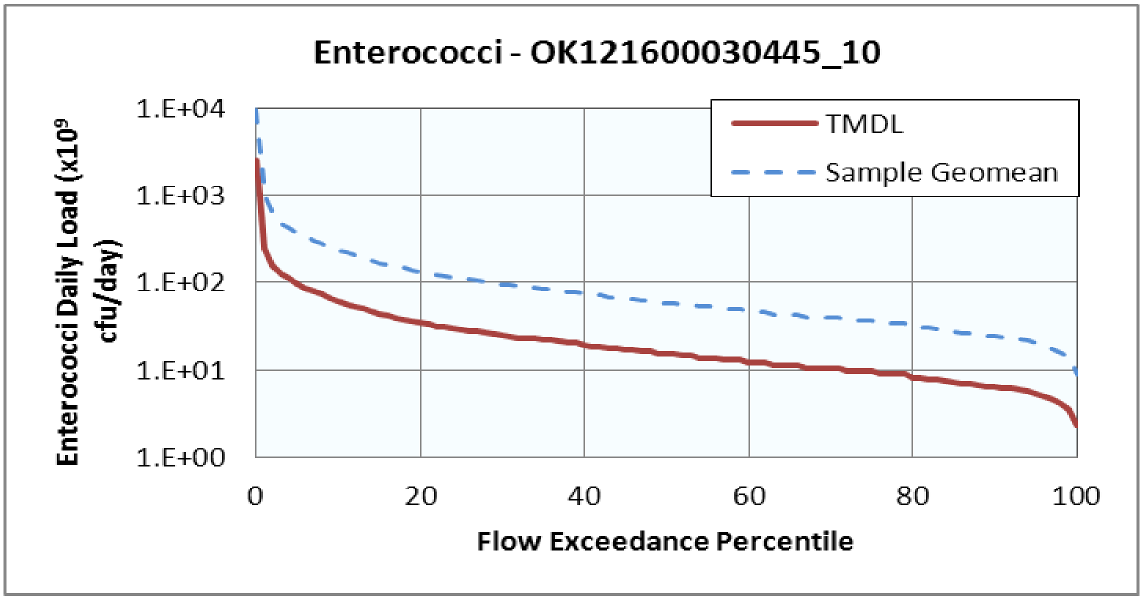
The LDC for Little Saline Creek (Figure 5-11) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM station OK121600-02-0070F.

Figure 5-11 Load Duration Curve for Enterococci in Little Saline Creek (OK121600020070_00)



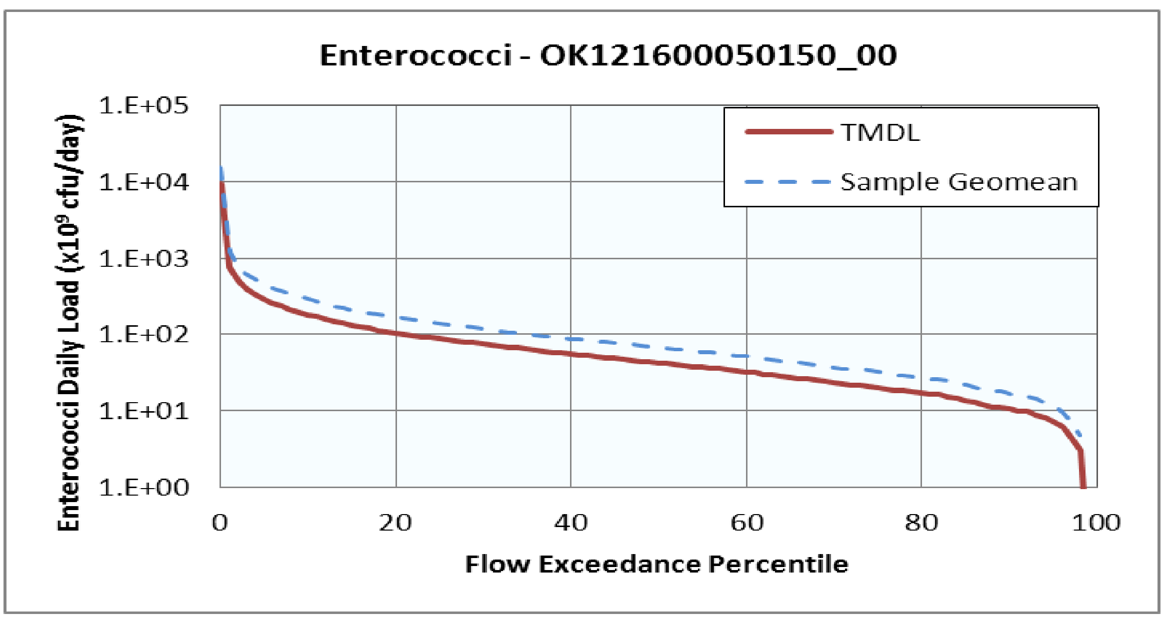
The LDC for Honey Creek (Figure 5-12) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK121600-03-0445Y and OK121600-03-0445L.

Figure 5-12 Load Duration Curve for Enterococci in Honey Creek (OK121600030445_10)



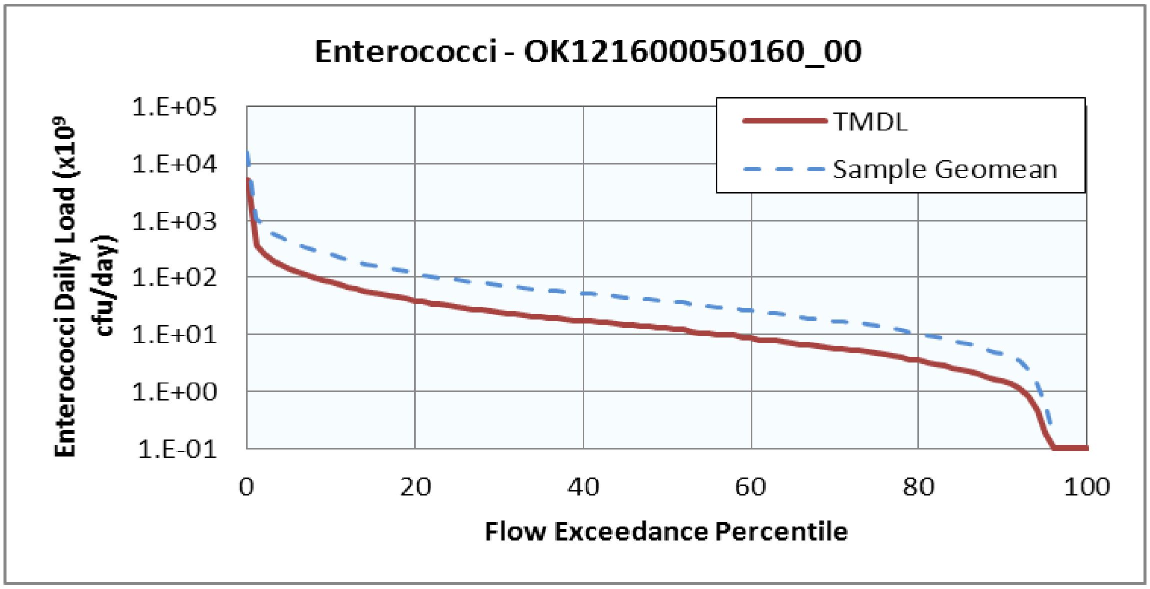
The LDC for Spavinaw Creek (Figure 5-13) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM station OK121600-05-0150G.

Figure 5-13 Load Duration Curve for Enterococci in Spavinaw Creek (OK121600050150_00)



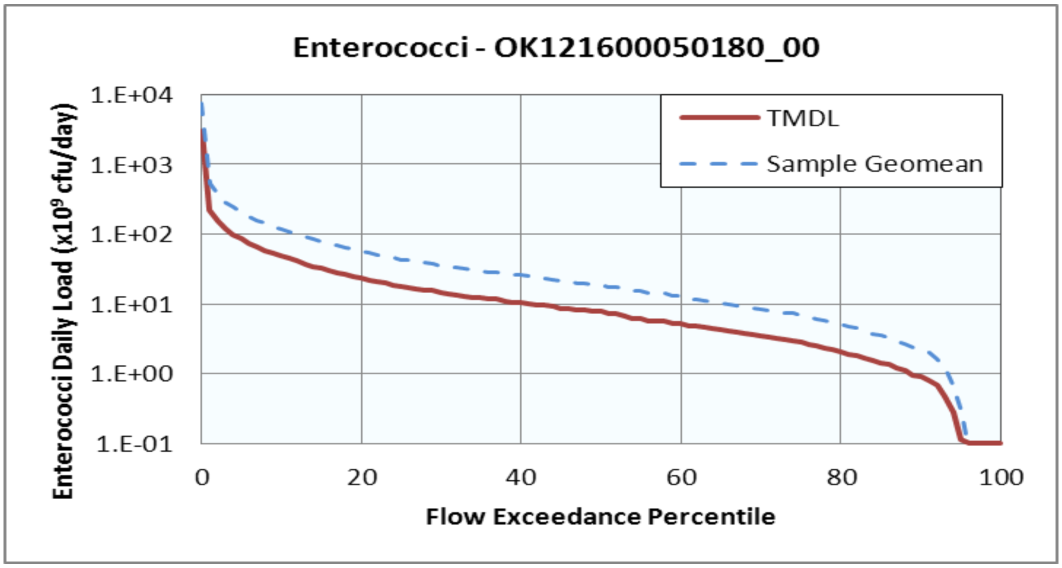
The LDC for Beaty Creek (Figure 5-14) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK121600-05-0160F and OK121600-05-0160G.

Figure 5-14 Load Duration Curve for Enterococci in Beaty Creek (OK121600050160_00)



The LDC for Cloud Creek (Figure 5-15) is based on Enterococci bacterial measurements collected during primary contact recreation season at WQM stations OK121600-05-0180C and OK121600-05-0180G.

Figure 5-15 Load Duration Curve for Enterococci in Cloud Creek (OK121600050180_00)



The LDCs for Pryor Creek (Figure 5-16 and Figure 5-17) for *E. coli* and Enterococci measurements during primary contact recreation season at WQM stations OK121610-00-0050D and OK121610-00-0050M. The atypical configuration of the LDC for Pryor Creek is the result of several different characteristics. The intermittent naturalized flow of the creek and the discharge of a large WWTF results in Pryor Creek being an effluent dominated stream. The horizontal LDC reflects the influence of the continuous discharge using the permitted design flow (1.67 mgd) of the City of Pryor Creek WWTF.

Figure 5-16 Load Duration Curve for *E. coli* in Pryor Creek (OK121610000050_10)

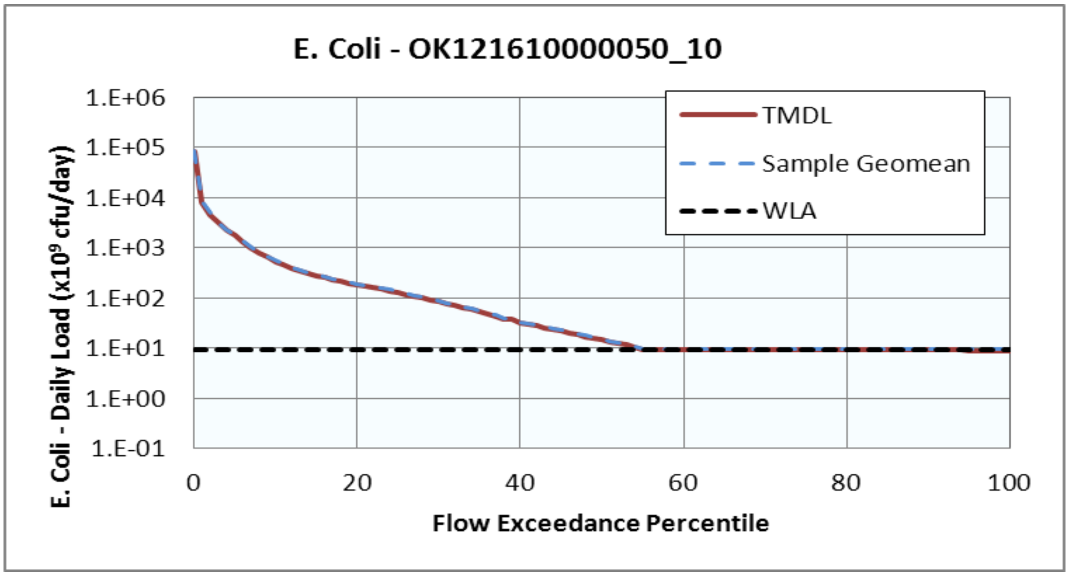
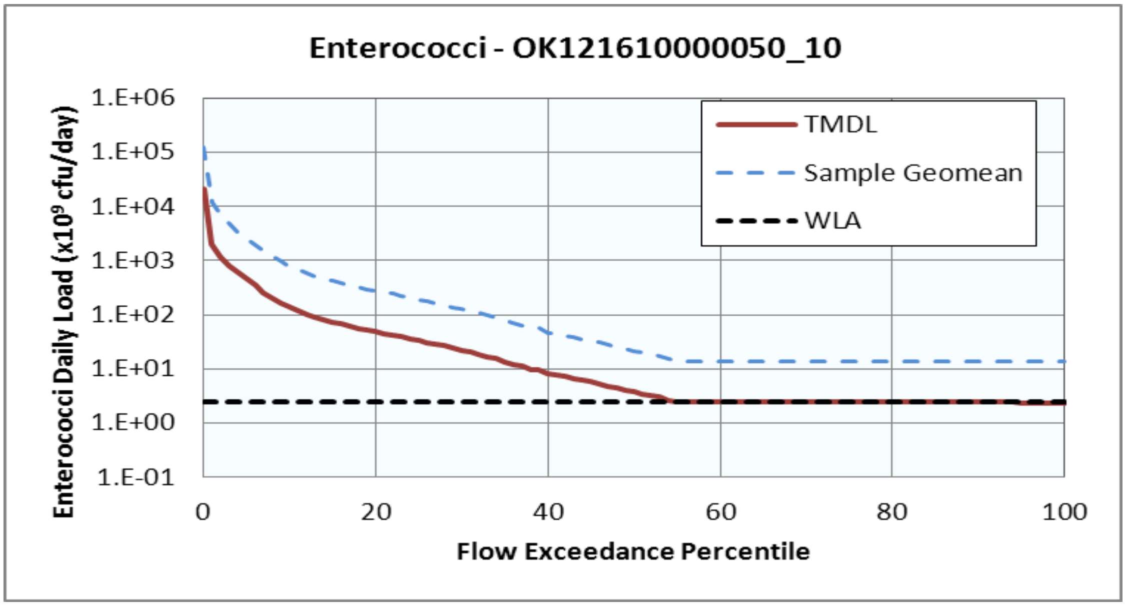


Figure 5-17 Load Duration Curve for Enterococci in Pryor Creek (OK121610000050_10)



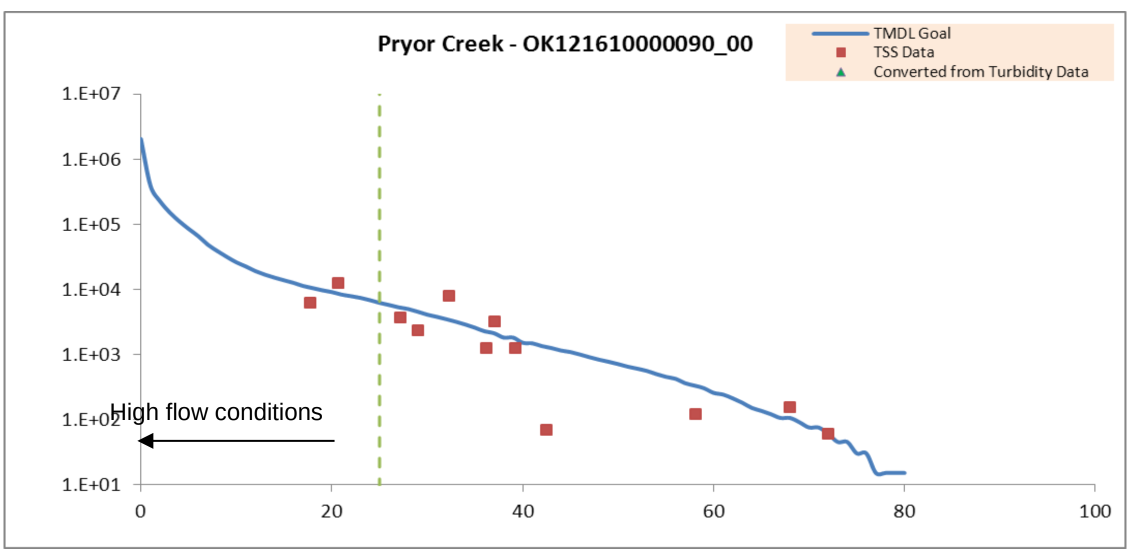
5.3.2 TSS LDC

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

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

Figure 5-18 shows the TSS LDC developed for Pryor Creek (OK121610000090_00). Data in the figure indicate that 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 for 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 5-18 Load Duration Curve for Total Suspended Solids in Pryor Creek (OK121610000090_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. PRGs are calculated through an iterative process of taking a series of percent reduction values, applying each value uniformly to the concentrations of samples and verifying if the geometric mean of the reduced values of all samples is less than the WQS geometric mean. Table 5-2 represents the percent reductions necessary to meet the TMDL water quality target for each bacterial indicator in each of the impaired waterbodies in the Study Area. The PRGs range from 4% to 83%.

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

Waterbody Name	Waterbody ID	Required Reduction Rate	
		EC	ENT
Saline Creek	OK121600020030_10	-	48%
Little Saline Creek	OK121600020070_00	-	65%
Honey Creek	OK121600030445_10	-	74%
Spavinaw Creek	OK121600050150_00	-	37%
Beaty Creek	OK121600050160_00	-	67%
Cloud Creek	OK121600050180_00	-	59%
Pryor Creek	OK121610000050_10	4%	83%

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 PRG for Pryor Creek is 56% and is found in Table 5-3.

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

Waterbody ID	Waterbody Name	Required Reduction Rate
OK121610000090_00	Pryor Creek	56%

5.4 Wasteload Allocation

5.4.1 Indicator Bacteria

For bacterial TMDLs, NPDES-permitted facilities are allocated a daily wasteload calculated as their permitted flow rate multiplied by the in-stream geometric mean water quality criterion. In other words, the facilities are required to meet in-stream criteria in their discharge.

Table 5-4 shows the WLA for Pryor Creek WWTF. Since the Pryor Creek WWTF is discharging to a bacterially-impaired waterbody, the WLA was derived from the following equation:

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

<u>Where:</u>

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

flow (mgd) = permitted flow

unit conversion factor = 37,854,120

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

Table 5-4 also indicates that the Pryor Creek WWTF has 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 bacteria levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacterial limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacterial load from existing discharges will be considered consistent with the TMDL provided that the NPDES permit requires in-stream criteria to be met.

Table 5-4 Bacterial Wasteload Allocations for Pryor Creek WWTF

Waterbody ID & Waterbody Name	NPDES Permit No.	Name	Dis-infection?	Design Flow (mg/d)	EC Wasteload Allocation (cfu/day)	ENT Wasteload Allocation (cfu/day)
OK121610000050_10 Pryor Creek	OK0040479	City of Pryor Creek Municipal Utilities Authority	Yes	1.67	7.97E+09	2.09E+09

Permitted stormwater discharges are considered point sources; however, there are no areas designated as MS4s within the watersheds of the Study Area impaired for contact recreation, so the WLA for MS4 is zero. Otherwise, WLA for each MS4 facility would have been derived as follows:

WLA_{MS4}= (TMDL-MOS-WLA)*% watershed covered by MS4

<u>Where:</u> TMDL = total maximum daily load at a given flow, as calculated using LDCs

MOS = explicit margin of safety

WLA = waste load allocation for permitted WWTFs as defined previously

5.4.2 Total Suspended Solids

NPDES-permitted facilities discharging inorganic TSS are allocated a daily wasteload calculated by using the average of self-reported monthly flow multiplied by the water quality target. In other words, the facilities are required to meet 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. There are no NPDES-permitted facilities discharging inorganic TSS within the Study Area. The WLA for each facility is derived as follows:

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

<u>Where:</u>

WQ goal = waterbody-specific water quality goal as summarized in Table5-1, or monthly TSS limit in the current permit, whichever is smaller

flow (mgd) = average monthly flow

unit conversion factor = 8.3445

No TSS WLAs are needed for MS4s in the Study Area. By definition, any stormwater discharge occurs during periods of rainfall and elevated flow conditions. Oklahoma's Water Quality Standards specify that the criteria for turbidity "apply only to seasonal base flow conditions" and go on to say "Elevated turbidity levels may be expected during, and for several days after, a runoff event" [OAC 785:45-5-12(f)(7)]. To accommodate the potential for future growth in those watersheds with no WLA for TSS, 1% of TSS loading is reserved as part of the WLA.

5.4.3 Section 404 Permits

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

- Include TSS limits in the permit and establish a monitoring requirement to ensure compliance with turbidity standards and TSS TMDLs or

- Submit to the DEQ a BMP turbidity reduction plan which should include all practicable turbidity control techniques. The turbidity reduction plan must be approved first before a Section 401 Certification can be issued.

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

5.5 Load Allocation

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

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

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

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

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. Similarly, the turbidity TMDLs established in this report adheres to the seasonal application of the Oklahoma WQS for turbidity, which applies to seasonal base flow conditions only. Seasonal variation was also accounted for in these TMDLs by using five years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.7 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained. EPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for the lack of knowledge, then the MOS is considered explicit. 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 the waterbody. The explicit MOS for Pryor Creek (OK121610000050_10) was 15%, this is shown in Table 5-5.

Table 5-5 Explicit Margin of Safety for Total Suspended Solids TMDLs

Waterbody ID	Waterbody Name	NRMSE	Margin of Safety
OK121610000050_10	Pryor Creek	10.7%	15%

5.8 TMDL Calculations

The TMDLs for the 303(d)-listed waterbodies covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the lack of knowledge concerning the relationship between pollutant loading and water quality.

This definition can be expressed by the following equation:

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

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

The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5^{th} flow interval percentile. Tables 5-6 through 5-13 summarize the allocations for indicator bacteria. The bacterial TMDLs calculated in these tables apply to the recreation season (May 1 through September 30) only. Table 5-14 presents the allocations for total suspended solids.

Table 5-6 Enterococci TMDL Calculations for Saline Creek (OK121600020030_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	17303	1.40E+13	0	0	1.26E+13	1.40E+12
5	524	4.23E+11	0	0	3.80E+11	4.23E+10
10	331	2.67E+11	0	0	2.41E+11	2.67E+10
15	241	1.95E+11	0	0	1.75E+11	1.95E+10
20	192	1.55E+11	0	0	1.40E+11	1.55E+10
25	161	1.30E+11	0	0	1.17E+11	1.30E+10
30	138	1.11E+11	0	0	9.99E+10	1.11E+10
35	117	9.43E+10	0	0	8.49E+10	9.43E+09
40	102	8.24E+10	0	0	7.41E+10	8.24E+09
45	89	7.16E+10	0	0	6.45E+10	7.16E+09
50	77	6.21E+10	0	0	5.59E+10	6.21E+09
55	68	5.49E+10	0	0	4.94E+10	5.49E+09
60	59	4.78E+10	0	0	4.30E+10	4.78E+09
65	50	4.06E+10	0	0	3.65E+10	4.06E+09
70	43	3.46E+10	0	0	3.12E+10	3.46E+09
75	37	2.99E+10	0	0	2.69E+10	2.99E+09
80	31	2.51E+10	0	0	2.26E+10	2.51E+09
85	25	2.03E+10	0	0	1.83E+10	2.03E+09
90	19	1.55E+10	0	0	1.40E+10	1.55E+09
95	13	1.09E+10	0	0	9.78E+09	1.09E+09
100	0	0.00E+00	0	0	0.00E+00	0.00E+00

Table 5-7 Enterococci TMDL Calculations for Little Saline Creek (OK121600020070_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	5104	4.12E+12	0	0	3.71E+12	4.12E+11
5	154	1.25E+11	0	0	1.12E+11	1.25E+10
10	98	7.89E+10	0	0	7.10E+10	7.89E+09
15	71	5.74E+10	0	0	5.17E+10	5.74E+09
20	57	4.58E+10	0	0	4.12E+10	4.58E+09
25	48	3.84E+10	0	0	3.46E+10	3.84E+09
30	41	3.28E+10	0	0	2.95E+10	3.28E+09
35	34	2.78E+10	0	0	2.50E+10	2.78E+09
40	30	2.43E+10	0	0	2.19E+10	2.43E+09
45	26	2.11E+10	0	0	1.90E+10	2.11E+09
50	23	1.83E+10	0	0	1.65E+10	1.83E+09
55	20	1.62E+10	0	0	1.46E+10	1.62E+09
60	17	1.41E+10	0	0	1.27E+10	1.41E+09
65	15	1.20E+10	0	0	1.08E+10	1.20E+09
70	13	1.02E+10	0	0	9.19E+09	1.02E+09
75	11	8.81E+09	0	0	7.93E+09	8.81E+08
80	9	7.40E+09	0	0	6.66E+09	7.40E+08
85	7	5.99E+09	0	0	5.39E+09	5.99E+08
90	6	4.58E+09	0	0	4.12E+09	4.58E+08
95	4	3.21E+09	0	0	2.88E+09	3.21E+08
100	0	0.00E+00	0	0	0.00E+00	0.00E+00

Table 5-8 Enterococci TMDL Calculations for Honey Creek (OK121600030445_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3090	2.49E+12	0	0	2.25E+12	2.49E+11
5	119	9.62E+10	0	0	8.65E+10	9.62E+09
10	76	6.15E+10	0	0	5.54E+10	6.15E+09
15	54	4.36E+10	0	0	3.92E+10	4.36E+09
20	42	3.42E+10	0	0	3.08E+10	3.42E+09
25	36	2.91E+10	0	0	2.62E+10	2.91E+09
30	31	2.50E+10	0	0	2.25E+10	2.50E+09
35	27	2.18E+10	0	0	1.96E+10	2.18E+09
40	24	1.94E+10	0	0	1.74E+10	1.94E+09
45	21	1.70E+10	0	0	1.53E+10	1.70E+09
50	19	1.53E+10	0	0	1.38E+10	1.53E+09
55	17	1.37E+10	0	0	1.24E+10	1.37E+09
60	15	1.21E+10	0	0	1.09E+10	1.21E+09
65	14	1.13E+10	0	0	1.02E+10	1.13E+09
70	13	1.05E+10	0	0	9.45E+09	1.05E+09
75	12	9.69E+09	0	0	8.72E+09	9.69E+08
80	10	8.07E+09	0	0	7.27E+09	8.07E+08
85	9	7.19E+09	0	0	6.47E+09	7.19E+08
90	8	6.38E+09	0	0	5.74E+09	6.38E+08
95	7	5.33E+09	0	0	4.80E+09	5.33E+08
100	3	2.34E+09	0	0	2.11E+09	2.34E+08

Table 5-9 Enterococci TMDL Calculations for Spavinaw Creek (OK121600050150_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	11700	9.45E+12	0	0	8.50E+12	9.45E+11
5	354	2.86E+11	0	0	2.57E+11	2.86E+10
10	224	1.81E+11	0	0	1.63E+11	1.81E+10
15	163	1.32E+11	0	0	1.18E+11	1.32E+10
20	130	1.05E+11	0	0	9.45E+10	1.05E+10
25	109	8.80E+10	0	0	7.92E+10	8.80E+09
30	93	7.51E+10	0	0	6.76E+10	7.51E+09
35	79	6.38E+10	0	0	5.74E+10	6.38E+09
40	69	5.57E+10	0	0	5.01E+10	5.57E+09
45	60	4.84E+10	0	0	4.36E+10	4.84E+09
50	52	4.20E+10	0	0	3.78E+10	4.20E+09
55	46	3.71E+10	0	0	3.34E+10	3.71E+09
60	40	3.23E+10	0	0	2.91E+10	3.23E+09
65	34	2.75E+10	0	0	2.47E+10	2.75E+09
70	29	2.34E+10	0	0	2.11E+10	2.34E+09
75	25	2.02E+10	0	0	1.82E+10	2.02E+09
80	21	1.70E+10	0	0	1.53E+10	1.70E+09
85	17	1.37E+10	0	0	1.24E+10	1.37E+09
90	13	1.05E+10	0	0	9.45E+09	1.05E+09
95	9	7.35E+09	0	0	6.61E+09	7.35E+08
100	0	0.00E+00	0	0	0.00E+00	0.00E+00

Table 5-10 Enterococci TMDL Calculations for Beaty Creek (OK121600050160_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	6320	5.10E+12	0	0	4.59E+12	5.10E+11
5	177	1.43E+11	0	0	1.29E+11	1.43E+10
10	102	8.24E+10	0	0	7.41E+10	8.24E+09
15	67	5.41E+10	0	0	4.87E+10	5.41E+09
20	48	3.88E+10	0	0	3.49E+10	3.88E+09
25	37	2.99E+10	0	0	2.69E+10	2.99E+09
30	30	2.42E+10	0	0	2.18E+10	2.42E+09
35	25	2.02E+10	0	0	1.82E+10	2.02E+09
40	22	1.78E+10	0	0	1.60E+10	1.78E+09
45	18	1.45E+10	0	0	1.31E+10	1.45E+09
50	16	1.29E+10	0	0	1.16E+10	1.29E+09
55	13	1.05E+10	0	0	9.45E+09	1.05E+09
60	11	8.88E+09	0	0	7.99E+09	8.88E+08
65	9	7.02E+09	0	0	6.32E+09	7.02E+08
70	7	5.73E+09	0	0	5.16E+09	5.73E+08
75	6	4.76E+09	0	0	4.29E+09	4.76E+08
80	4	3.47E+09	0	0	3.12E+09	3.47E+08
85	3	2.42E+09	0	0	2.18E+09	2.42E+08
90	2	1.53E+09	0	0	1.38E+09	1.53E+08
95	0	1.94E+08	0	0	1.74E+08	1.94E+07
100	0	0.00E+00	0	0	0.00E+00	0.00E+00

Table 5-11 Enterococci TMDL Calculations for Cloud Creek (OK121600050180_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3774	3.05E+12	0	0	2.74E+12	3.05E+11
5	106	8.53E+10	0	0	7.68E+10	8.53E+09
10	61	4.92E+10	0	0	4.43E+10	4.92E+09
15	40	3.23E+10	0	0	2.91E+10	3.23E+09
20	29	2.31E+10	0	0	2.08E+10	2.31E+09
25	22	1.78E+10	0	0	1.61E+10	1.78E+09
30	18	1.45E+10	0	0	1.30E+10	1.45E+09
35	15	1.21E+10	0	0	1.08E+10	1.21E+09
40	13	1.06E+10	0	0	9.54E+09	1.06E+09
45	11	8.68E+09	0	0	7.81E+09	8.68E+08
50	10	7.71E+09	0	0	6.94E+09	7.71E+08
55	7.8	6.27E+09	0	0	5.64E+09	6.27E+08
60	6.6	5.30E+09	0	0	4.77E+09	5.30E+08
65	5.2	4.19E+09	0	0	3.77E+09	4.19E+08
70	4.2	3.42E+09	0	0	3.08E+09	3.42E+08
75	3.5	2.84E+09	0	0	2.56E+09	2.84E+08
80	2.6	2.07E+09	0	0	1.87E+09	2.07E+08
85	1.8	1.45E+09	0	0	1.30E+09	1.45E+08
90	1.1	9.16E+08	0	0	8.24E+08	9.16E+07
95	0.14	1.16E+08	0	0	1.04E+08	1.16E+07
100	0.00	0.00E+00	0	0	0.00E+00	0.00E+00

Table 5-12 *E. coli* TMDL Calculations for Pryor Creek (OK121610000050_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	26600	8.20E+13	7.97E+09	0	7.38E+13	8.20E+12
5	561	1.73E+12	7.97E+09	0	1.55E+12	1.73E+11
10	172	5.30E+11	7.97E+09	0	4.69E+11	5.30E+10
15	91	2.81E+11	7.97E+09	0	2.45E+11	2.81E+10
20	60	1.85E+11	7.97E+09	0	1.58E+11	1.85E+10
25	41	1.26E+11	7.97E+09	0	1.06E+11	1.26E+10
30	27	8.32E+10	7.97E+09	0	6.69E+10	8.32E+09
35	17	5.24E+10	7.97E+09	0	3.92E+10	5.24E+09
40	10	3.08E+10	7.97E+09	0	1.98E+10	3.08E+09
45	7	2.22E+10	7.97E+09	0	1.20E+10	2.22E+09
50	5	1.45E+10	7.97E+09	0	5.07E+09	1.45E+09
55	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
60	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
65	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
70	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
75	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
80	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
85	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
90	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
95	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08
100	3	9.25E+09	7.97E+09	0	3.54E+08	9.25E+08

Table 5-13 Enterococci TMDL Calculations for Pryor Creek (OK121610000050_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	26600	2.15E+13	2.09E+09	0	1.93E+13	2.15E+12
5	561	4.53E+11	2.09E+09	0	4.06E+11	4.53E+10
10	172	1.39E+11	2.09E+09	0	1.23E+11	1.39E+10
15	91	7.35E+10	2.09E+09	0	6.40E+10	7.35E+09
20	60	4.84E+10	2.09E+09	0	4.15E+10	4.84E+09
25	41	3.31E+10	2.09E+09	0	2.77E+10	3.31E+09
30	27	2.18E+10	2.09E+09	0	1.75E+10	2.18E+09
35	17	1.37E+10	2.09E+09	0	1.03E+10	1.37E+09
40	10	8.07E+09	2.09E+09	0	5.18E+09	8.07E+08
45	7	5.81E+09	2.09E+09	0	3.14E+09	5.81E+08
50	5	3.79E+09	2.09E+09	0	1.33E+09	3.79E+08
55	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
60	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
65	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
70	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
75	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
80	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
85	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
90	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
95	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08
100	3	2.42E+09	2.09E+09	0	9.27E+07	2.42E+08

Table 5-14 Total Suspended Solids TMDL Calculations for Pryor Creek (OK121610000090_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)			LA (lb/day)	MOS (lb/day)
			WWTF	MS4	Future growth		
0	9741	N/A	0	0	N/A	N/A	N/A
5	407	N/A	0	0	N/A	N/A	N/A
10	125	N/A	0	0	N/A	N/A	N/A
15	66	N/A	0	0	N/A	N/A	N/A
20	44	N/A	0	0	N/A	N/A	N/A
25	30	1.63E+04	0	0	1.63E+02	1.37E+04	2.45E+03
30	20	1.08E+04	0	0	1.08E+02	9.04E+03	1.61E+03
35	12	6.77E+03	0	0	6.77E+01	5.69E+03	1.02E+03
40	7	3.98E+03	0	0	3.98E+01	3.35E+03	5.98E+02
45	5	2.87E+03	0	0	2.87E+01	2.41E+03	4.30E+02
50	3	1.87E+03	0	0	1.87E+01	1.57E+03	2.81E+02
55	2	1.20E+03	0	0	1.20E+01	1.00E+03	1.79E+02
60	1	6.77E+02	0	0	6.77E+00	5.69E+02	1.02E+02
65	1	3.59E+02	0	0	3.59E+00	3.01E+02	5.38E+01
70	0	1.99E+02	0	0	1.99E+00	1.67E+02	2.99E+01
75	0	7.97E+01	0	0	7.97E-01	6.69E+01	1.20E+01
80	0	3.98E+01	0	0	3.98E-01	3.35E+01	5.98E+00
85	0	0.00E+00	0	0	0.00E+00	0.00E+00	0.00E+00
90	0	0.00E+00	0	0	0.00E+00	0.00E+00	0.00E+00
95	0	0.00E+00	0	0	0.00E+00	0.00E+00	0.00E+00
100	0	0.00E+00	0	0	0.00E+00	0.00E+00	0.00E+00

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

Table 5-15 provides a partial list of the State partner agencies DEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

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

Agency	Web Link
Oklahoma Conservation Commission	http://www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	http://www.wildlifedepartment.com/wildlifemgmt/endangeredspecies.htm
Oklahoma Department of Agriculture, Food, and Forestry	http://www.ok.gov/~okag/aems
Oklahoma Water Resources Board	http://www.owrb.state.ok.us/quality/index.php

5.9.1 Point Sources

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

5.9.2 Nonpoint Sources

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

The reduction rates called for in this TMDL report are as high as 83%. The DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of both bacterial and TSS loading. The high reduction rates are not uncommon for pathogen- or TSS-impaired waters. Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of a waterbody should be reviewed. For example, the Kansas Department of Environmental Quality has proposed to exclude certain high flow conditions during which pathogen standards will not apply, although that exclusion was not approved by the EPA. Additionally, EPA has been conducting new epidemiology studies and may develop new recommendations for pathogen criteria in the near future.

Revisions to the current pathogen provisions of Oklahoma's WQSs should be considered. There are three basic approaches 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 do swim in this segment of the river, 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 discharging discharge limitations less than or equal to the water quality standards numerical criteria. This ensures that the impairments to the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

SECTION 6
PUBLIC PARTICIPATION

The draft TMDL report was preliminarily reviewed by EPA before being sent out for public notice. The public notice and draft 208 Factsheet was sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who have requested copies of all TMDL public notices. The public notice, draft 208 Factsheet, and draft TMDL report was also posted at the following DEQ website: http://www.deq.state.ok.us/wqdnew/index.htm.

The public comment period lasted 45 days and was open from February 14, 2014 to March 31, 2014. During that time, the public had the opportunity to review the draft TMDL report and make written comments. One comment was received. The response to that comment is in Appendix F. The comment and response are part of the record of this TMDL report. As a result of the public comment, no changes were made to the final TMDL report or 208 Factsheet. There were no requests for a public meeting.

After EPA's final approval, the 208 Factsheet and each TMDL was adopted into Oklahoma's Water Quality Management Plan (WQMP). These TMDLs provide a mathematical solution to meet ambient water quality criteria 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 criteria. The updates to the WQMP are also useful when the water quality criteria change and the loading scenario is reviewed to ensure that the in-stream criterion is predicted to be met.

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APPENDIX A: Ambient Water Quality Data

Appendix Table A-1 Bacterial Data (2000 – 2010)

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Saline Creek	OK121600-02-0030D	06/20/06	5	10
Saline Creek	OK121600-02-0030D	08/08/06	20	115
Saline Creek	OK121600-02-0030D	09/12/06	20	95
Saline Creek	OK121600-02-0030D	05/08/07	120	750
Saline Creek	OK121600-02-0030D	05/09/07	200	460
Saline Creek	OK121600-02-0030D	05/15/07	80	80
Saline Creek	OK121600-02-0030D	05/23/07	20	25
Saline Creek	OK121600-02-0030D	05/30/07	40	35
Saline Creek	OK121600-02-0030D	06/06/07	60	80
Saline Creek	OK121600-02-0030D	06/12/07	600	940
Saline Creek	OK121600-02-0030D	06/13/07	305	370
Saline Creek	OK121600-02-0030D	06/20/07	60	115
Saline Creek	OK121600-02-0030D	06/26/07	80	110
Saline Creek	OK121600-02-0030D	07/03/07	50	155
Saline Creek	OK121600-02-0030D	07/10/07	160	530
Saline Creek	OK121600-02-0030D	07/17/07	30	60
Saline Creek	OK121600-02-0030D	07/17/07	20	60
Saline Creek	OK121600-02-0030D	07/24/07	20	70
Saline Creek	OK121600-02-0030D	07/31/07	20	95
Saline Creek	OK121600-02-0030D	08/08/07	30	145
Saline Creek	OK121600-02-0030D	08/15/07	15	135
Saline Creek	OK121600-02-0030D	08/21/07	10	60
Saline Creek	OK121600-02-0030D	08/21/07	60	290
Saline Creek	OK121600-02-0030D	08/28/07	5	140
Saline Creek	OK121600-02-0030D	09/05/07	1000.001	1000.001
Saline Creek	OK121600-02-0030D	09/19/07	15	15
Saline Creek	OK121600-02-0030D	09/25/07	30	145
Saline Creek	OK121600-02-0030D	05/06/08	5	15
Saline Creek	OK121600-02-0030D	05/13/08	35	5
Saline Creek	OK121600-02-0030D	05/20/08	45	10
Saline Creek	OK121600-02-0030D	05/28/08	45	30
Saline Creek	OK121600-02-0030D	06/03/08	5	10
Saline Creek	OK121600-02-0030D	06/09/08	1820	2000
Saline Creek	OK121600-02-0030D	06/10/08	360	560
Saline Creek	OK121600-02-0030D	06/16/08	2000.001	2000.001
Saline Creek	OK121600-02-0030D	06/23/08	250	980
Saline Creek	OK121600-02-0030D	07/01/08	10	20
Saline Creek	OK121600-02-0030D	07/07/08	25	5
Saline Creek	OK121600-02-0030D	07/15/08	25	45
Saline Creek	OK121600-02-0030D	07/22/08	15	75

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Saline Creek	OK121600-02-0030D	07/30/08	15	10
Saline Creek	OK121600-02-0030D	08/05/08	50	160
Saline Creek	OK121600-02-0030D	08/12/08	40	190
Saline Creek	OK121600-02-0030D	08/20/08	30	40
Saline Creek	OK121600-02-0030D	08/26/08	5	5
Saline Creek	OK121600-02-0030D	09/03/08	110	350
Saline Creek	OK121600-02-0030D	09/09/08	65	110
Saline Creek	OK121600-02-0030D	09/16/08	65	160
Saline Creek	OK121600-02-0030D	09/23/08	25	140
Saline Creek	OK121600-02-0030D	09/30/08	20	40
Saline Creek	OK121600-02-0030D	05/05/09	70	350
Saline Creek	OK121600-02-0030D	05/11/09	20	30
Saline Creek	OK121600-02-0030D	05/19/09	70	50
Saline Creek	OK121600-02-0030D	05/26/09	1	20
Saline Creek	OK121600-02-0030D	06/02/09	10	10
Saline Creek	OK121600-02-0030D	06/09/09	5	5
Saline Creek	OK121600-02-0030D	06/23/09	5	10
Saline Creek	OK121600-02-0030D	06/29/09	40	40
Saline Creek	OK121600-02-0030D	07/07/09	5	20
Saline Creek	OK121600-02-0030D	07/14/09	5	10
Saline Creek	OK121600-02-0030D	07/21/09	25	65
Saline Creek	OK121600-02-0030D	07/28/09	17	27
Saline Creek	OK121600-02-0030D	08/03/09	5	15
Saline Creek	OK121600-02-0030D	08/11/09	5	60
Saline Creek	OK121600-02-0030D	08/25/09	5	5
Saline Creek	OK121600-02-0030D	09/01/09	5	15
Saline Creek	OK121600-02-0030D	09/09/09	115	330
Saline Creek	OK121600-02-0030D	09/15/09	30	50
Saline Creek	OK121600-02-0030D	09/22/09	140	295
Saline Creek	OK121600-02-0030D	09/29/09	5	5
Saline Creek	OK121600-02-0030D	05/04/10	10	30
Saline Creek	OK121600-02-0030D	05/10/10	25	20
Saline Creek	OK121600-02-0030D	05/16/10	100	70
Saline Creek	OK121600-02-0030D	05/24/10	20	40
Saline Creek	OK121600-02-0030D	06/01/10	5	5
Saline Creek	OK121600-02-0030D	06/08/10	5	30
Saline Creek	OK121600-02-0030D	06/14/10	70	350
Saline Creek	OK121600-02-0030D	06/21/10	5	25
Saline Creek	OK121600-02-0030D	06/28/10	15	70
Saline Creek	OK121600-02-0030D	07/12/10	60	310
Saline Creek	OK121600-02-0030D	07/19/10	5	60
Saline Creek	OK121600-02-0030D	07/26/10	10	85

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Saline Creek	OK121600-02-0030D	08/03/10	5	65
Saline Creek	OK121600-02-0030D	08/09/10	5	55
Saline Creek	OK121600-02-0030D	08/16/10	25	250
Saline Creek	OK121600-02-0030D	08/23/10	5	110
Saline Creek	OK121600-02-0030D	08/31/10	50	85
Saline Creek	OK121600-02-0030D	09/20/10	5	80
Saline Creek	OK121600-02-0030D	09/27/10	5	15
Saline Creek	OK121600-02-0030D	06/20/06	5	10
Saline Creek	OK121600-02-0030D	08/08/06	20	115
Saline Creek	OK121600-02-0030D	09/12/06	20	95
Saline Creek	OK121600-02-0030D	05/08/07	120	750
Saline Creek	OK121600-02-0030D	05/09/07	200	460
Saline Creek	OK121600-02-0030D	05/15/07	80	80
Saline Creek	OK121600-02-0030D	05/23/07	20	25
Saline Creek	OK121600-02-0030D	05/30/07	40	35
Saline Creek	OK121600-02-0030D	06/06/07	60	80
Saline Creek	OK121600-02-0030D	06/12/07	600	940
Saline Creek	OK121600-02-0030D	06/13/07	305	370
Saline Creek	OK121600-02-0030D	06/20/07	60	115
Saline Creek	OK121600-02-0030D	06/26/07	80	110
Saline Creek	OK121600-02-0030D	07/03/07	50	155
Saline Creek	OK121600-02-0030D	07/10/07	160	530
Saline Creek	OK121600-02-0030D	07/17/07	30	60
Saline Creek	OK121600-02-0030D	07/17/07	20	60
Saline Creek	OK121600-02-0030D	07/24/07	20	70
Saline Creek	OK121600-02-0030D	07/31/07	20	95
Saline Creek	OK121600-02-0030D	08/08/07	30	145
Saline Creek	OK121600-02-0030D	08/15/07	15	135
Saline Creek	OK121600-02-0030D	08/21/07	10	60
Saline Creek	OK121600-02-0030D	08/21/07	60	290
Saline Creek	OK121600-02-0030D	08/28/07	5	140
Saline Creek	OK121600-02-0030D	09/05/07	1000.001	1000.001
Saline Creek	OK121600-02-0030D	09/19/07	15	15
Saline Creek	OK121600-02-0030D	09/25/07	30	145
Saline Creek	OK121600-02-0030D	05/06/08	5	15
Saline Creek	OK121600-02-0030D	05/13/08	35	5
Saline Creek	OK121600-02-0030D	05/20/08	45	10
Saline Creek	OK121600-02-0030D	05/28/08	45	30
Saline Creek	OK121600-02-0030D	06/03/08	5	10
Saline Creek	OK121600-02-0030D	06/09/08	1820	2000
Saline Creek	OK121600-02-0030D	06/10/08	360	560
Saline Creek	OK121600-02-0030D	06/16/08	2000.001	2000.001

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Saline Creek	OK121600-02-0030D	06/23/08	250	980
Saline Creek	OK121600-02-0030D	07/01/08	10	20
Saline Creek	OK121600-02-0030D	07/07/08	25	5
Saline Creek	OK121600-02-0030D	07/15/08	25	45
Saline Creek	OK121600-02-0030D	07/22/08	15	75
Saline Creek	OK121600-02-0030D	07/30/08	15	10
Saline Creek	OK121600-02-0030D	08/05/08	50	160
Saline Creek	OK121600-02-0030D	08/12/08	40	190
Saline Creek	OK121600-02-0030D	08/20/08	30	40
Saline Creek	OK121600-02-0030D	08/26/08	5	5
Saline Creek	OK121600-02-0030D	09/03/08	110	350
Saline Creek	OK121600-02-0030D	09/09/08	65	110
Saline Creek	OK121600-02-0030D	09/16/08	65	160
Saline Creek	OK121600-02-0030D	09/23/08	25	140
Saline Creek	OK121600-02-0030D	09/30/08	20	40
Saline Creek	OK121600-02-0030D	05/05/09	70	350
Saline Creek	OK121600-02-0030D	05/11/09	20	30
Saline Creek	OK121600-02-0030D	05/19/09	70	50
Saline Creek	OK121600-02-0030D	05/26/09	1	20
Saline Creek	OK121600-02-0030D	06/02/09	10	10
Saline Creek	OK121600-02-0030D	06/09/09	5	5
Saline Creek	OK121600-02-0030D	06/23/09	5	10
Saline Creek	OK121600-02-0030D	06/29/09	40	40
Saline Creek	OK121600-02-0030D	07/07/09	5	20
Saline Creek	OK121600-02-0030D	07/14/09	5	10
Saline Creek	OK121600-02-0030D	07/21/09	25	65
Saline Creek	OK121600-02-0030D	07/28/09	17	27
Saline Creek	OK121600-02-0030D	08/03/09	5	15
Saline Creek	OK121600-02-0030D	08/11/09	5	60
Saline Creek	OK121600-02-0030D	08/25/09	5	5
Saline Creek	OK121600-02-0030D	09/01/09	5	15
Saline Creek	OK121600-02-0030D	09/09/09	115	330
Saline Creek	OK121600-02-0030D	09/15/09	30	50
Saline Creek	OK121600-02-0030D	09/22/09	140	295
Saline Creek	OK121600-02-0030D	09/29/09	5	5
Saline Creek	OK121600-02-0030D	05/04/10	10	30
Saline Creek	OK121600-02-0030D	05/10/10	25	20
Saline Creek	OK121600-02-0030D	05/16/10	100	70
Saline Creek	OK121600-02-0030D	05/24/10	20	40
Saline Creek	OK121600-02-0030D	06/01/10	5	5
Saline Creek	OK121600-02-0030D	06/08/10	5	30
Saline Creek	OK121600-02-0030D	06/14/10	70	350

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Saline Creek	OK121600-02-0030D	06/21/10	5	25
Saline Creek	OK121600-02-0030D	06/28/10	15	70
Saline Creek	OK121600-02-0030D	07/12/10	60	310
Saline Creek	OK121600-02-0030D	07/19/10	5	60
Saline Creek	OK121600-02-0030D	07/26/10	10	85
Saline Creek	OK121600-02-0030D	08/03/10	5	65
Saline Creek	OK121600-02-0030D	08/09/10	5	55
Saline Creek	OK121600-02-0030D	08/16/10	25	250
Saline Creek	OK121600-02-0030D	08/23/10	5	110
Saline Creek	OK121600-02-0030D	08/31/10	50	85
Saline Creek	OK121600-02-0030D	09/20/10	5	80
Saline Creek	OK121600-02-0030D	09/27/10	5	15
Little Saline Creek	OK121600-02-0070F	05/03/06	25	140
Little Saline Creek	OK121600-02-0070F	05/08/06	10	95
Little Saline Creek	OK121600-02-0070F	05/16/06	67	110
Little Saline Creek	OK121600-02-0070F	05/22/06	194	98
Little Saline Creek	OK121600-02-0070F	05/30/06	65	48
Little Saline Creek	OK121600-02-0070F	06/05/06	130	105
Little Saline Creek	OK121600-02-0070F	06/12/06	110	145
Little Saline Creek	OK121600-02-0070F	06/19/06	90	125
Little Saline Creek	OK121600-02-0070F	06/26/06	40	95
Little Saline Creek	OK121600-02-0070F	07/05/06	45	60
Little Saline Creek	OK121600-02-0070F	07/11/06	105	250
Little Saline Creek	OK121600-02-0070F	07/17/06	40	145
Little Saline Creek	OK121600-02-0070F	07/24/06	5	70
Little Saline Creek	OK121600-02-0070F	07/31/06	60	45
Little Saline Creek	OK121600-02-0070F	08/07/06	20	410
Little Saline Creek	OK121600-02-0070F	08/14/06	5	60
Little Saline Creek	OK121600-02-0070F	08/22/06	90	165
Little Saline Creek	OK121600-02-0070F	08/28/06	335	420
Little Saline Creek	OK121600-02-0070F	09/05/06	75	155
Little Saline Creek	OK121600-02-0070F	09/12/06	15	70
Little Saline Creek	OK121600-02-0070F	09/18/06	35	140
Little Saline Creek	OK121600-02-0070F	09/26/06	95	190
Little Saline Creek	OK121600-02-0070F	05/09/07	280	880
Little Saline Creek	OK121600-02-0070F	05/15/07	70	110
Little Saline Creek	OK121600-02-0070F	05/21/07	55	70
Little Saline Creek	OK121600-02-0070F	05/29/07	70	145
Little Saline Creek	OK121600-02-0070F	06/04/07	60	170
Little Saline Creek	OK121600-02-0070F	06/13/07	285	400
Little Saline Creek	OK121600-02-0070F	06/18/07	430	500
Little Saline Creek	OK121600-02-0070F	06/25/07	80	155

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Little Saline Creek	OK121600-02-0070F	07/09/07	345	205
Little Saline Creek	OK121600-02-0070F	07/16/07	30	270
Little Saline Creek	OK121600-02-0070F	07/24/07	110	245
Little Saline Creek	OK121600-02-0070F	07/31/07	270	365
Little Saline Creek	OK121600-02-0070F	08/06/07	10	500
Little Saline Creek	OK121600-02-0070F	08/14/07	40	451
Little Saline Creek	OK121600-02-0070F	08/21/07	80	300
Little Saline Creek	OK121600-02-0070F	08/28/07	95	295
Little Saline Creek	OK121600-02-0070F	09/11/07	120	300
Little Saline Creek	OK121600-02-0070F	09/17/07	50	80
Little Saline Creek	OK121600-02-0070F	09/25/07	90	95
Little Saline Creek	OK121600-02-0070F	05/06/08	10	10
Little Saline Creek	OK121600-02-0070F	05/13/08	15	25
Little Saline Creek	OK121600-02-0070F	05/20/08	45	5
Little Saline Creek	OK121600-02-0070F	05/28/08	50	100
Little Saline Creek	OK121600-02-0070F	06/03/08	35	100
Little Saline Creek	OK121600-02-0070F	06/10/08	340	390
Little Saline Creek	OK121600-02-0070F	06/18/08	140	250
Little Saline Creek	OK121600-02-0070F	06/23/08	670	620
Little Saline Creek	OK121600-02-0070F	07/01/08	20	50
Little Saline Creek	OK121600-02-0070F	07/07/08	25	70
Little Saline Creek	OK121600-02-0070F	07/15/08	60	70
Little Saline Creek	OK121600-02-0070F	07/22/08	330	175
Little Saline Creek	OK121600-02-0070F	07/30/08	55	30
Little Saline Creek	OK121600-02-0070F	08/05/08	70	130
Little Saline Creek	OK121600-02-0070F	08/12/08	75	120
Little Saline Creek	OK121600-02-0070F	08/20/08	10	65
Little Saline Creek	OK121600-02-0070F	08/26/08	215	5
Little Saline Creek	OK121600-02-0070F	09/03/08	155	360
Little Saline Creek	OK121600-02-0070F	09/09/08	25	70
Little Saline Creek	OK121600-02-0070F	09/16/08	55	335
Little Saline Creek	OK121600-02-0070F	09/23/08	30	130
Little Saline Creek	OK121600-02-0070F	09/30/08	45	65
Little Saline Creek	OK121600-02-0070F	05/05/09	210	420
Little Saline Creek	OK121600-02-0070F	05/11/09	10	70
Little Saline Creek	OK121600-02-0070F	05/19/09	1	20
Little Saline Creek	OK121600-02-0070F	05/26/09	1	10
Little Saline Creek	OK121600-02-0070F	06/02/09	40	30
Little Saline Creek	OK121600-02-0070F	06/09/09	35	50
Little Saline Creek	OK121600-02-0070F	06/22/09	10	55
Little Saline Creek	OK121600-02-0070F	06/29/09	20	35
Little Saline Creek	OK121600-02-0070F	07/07/09	15	70

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Little Saline Creek	OK121600-02-0070F	07/14/09	70	5
Little Saline Creek	OK121600-02-0070F	07/21/09	30	40
Little Saline Creek	OK121600-02-0070F	07/28/09	3	87
Little Saline Creek	OK121600-02-0070F	08/04/09	10	45
Little Saline Creek	OK121600-02-0070F	08/11/09	35	170
Little Saline Creek	OK121600-02-0070F	08/18/09	55	90
Little Saline Creek	OK121600-02-0070F	08/25/09	20	25
Little Saline Creek	OK121600-02-0070F	09/01/09	10	35
Little Saline Creek	OK121600-02-0070F	09/09/09	1000	1000
Little Saline Creek	OK121600-02-0070F	09/15/09	60	120
Little Saline Creek	OK121600-02-0070F	09/22/09	100	280
Little Saline Creek	OK121600-02-0070F	09/29/09	5	5
Little Saline Creek	OK121600-02-0070F	05/04/10	50	30
Little Saline Creek	OK121600-02-0070F	05/10/10	10	40
Little Saline Creek	OK121600-02-0070F	05/16/10	70	100
Little Saline Creek	OK121600-02-0070F	05/24/10	20	25
Little Saline Creek	OK121600-02-0070F	06/01/10	20	40
Little Saline Creek	OK121600-02-0070F	06/08/10	30	10
Little Saline Creek	OK121600-02-0070F	06/14/10	60	45
Little Saline Creek	OK121600-02-0070F	06/21/10	40	95
Little Saline Creek	OK121600-02-0070F	06/28/10	145	185
Little Saline Creek	OK121600-02-0070F	07/06/10	50	110
Little Saline Creek	OK121600-02-0070F	07/12/10	70	460
Little Saline Creek	OK121600-02-0070F	07/19/10	30	175
Little Saline Creek	OK121600-02-0070F	07/26/10	15	155
Little Saline Creek	OK121600-02-0070F	08/03/10	30	250
Little Saline Creek	OK121600-02-0070F	08/09/10	20	150
Little Saline Creek	OK121600-02-0070F	08/16/10	15	240
Little Saline Creek	OK121600-02-0070F	08/23/10	25	145
Little Saline Creek	OK121600-02-0070F	08/31/10	30	5000
Little Saline Creek	OK121600-02-0070F	09/20/10	30	80
Little Saline Creek	OK121600-02-0070F	09/27/10	5	30
Little Saline Creek	OK121600-02-0070F	05/03/06	25	140
Little Saline Creek	OK121600-02-0070F	05/08/06	10	95
Little Saline Creek	OK121600-02-0070F	05/16/06	67	110
Little Saline Creek	OK121600-02-0070F	05/22/06	194	98
Little Saline Creek	OK121600-02-0070F	05/30/06	65	48
Little Saline Creek	OK121600-02-0070F	06/05/06	130	105
Little Saline Creek	OK121600-02-0070F	06/12/06	110	145
Little Saline Creek	OK121600-02-0070F	06/19/06	90	125
Little Saline Creek	OK121600-02-0070F	06/26/06	40	95
Little Saline Creek	OK121600-02-0070F	07/05/06	45	60

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Little Saline Creek	OK121600-02-0070F	07/11/06	105	250
Little Saline Creek	OK121600-02-0070F	07/17/06	40	145
Little Saline Creek	OK121600-02-0070F	07/24/06	5	70
Little Saline Creek	OK121600-02-0070F	07/31/06	60	45
Little Saline Creek	OK121600-02-0070F	08/07/06	20	410
Little Saline Creek	OK121600-02-0070F	08/14/06	5	60
Little Saline Creek	OK121600-02-0070F	08/22/06	90	165
Little Saline Creek	OK121600-02-0070F	08/28/06	335	420
Little Saline Creek	OK121600-02-0070F	09/05/06	75	155
Little Saline Creek	OK121600-02-0070F	09/12/06	15	70
Little Saline Creek	OK121600-02-0070F	09/18/06	35	140
Little Saline Creek	OK121600-02-0070F	09/26/06	95	190
Little Saline Creek	OK121600-02-0070F	05/09/07	280	880
Little Saline Creek	OK121600-02-0070F	05/15/07	70	110
Little Saline Creek	OK121600-02-0070F	05/21/07	55	70
Little Saline Creek	OK121600-02-0070F	05/29/07	70	145
Little Saline Creek	OK121600-02-0070F	06/04/07	60	170
Little Saline Creek	OK121600-02-0070F	06/13/07	285	400
Little Saline Creek	OK121600-02-0070F	06/18/07	430	500
Little Saline Creek	OK121600-02-0070F	06/25/07	80	155
Little Saline Creek	OK121600-02-0070F	07/09/07	345	205
Little Saline Creek	OK121600-02-0070F	07/16/07	30	270
Little Saline Creek	OK121600-02-0070F	07/24/07	110	245
Little Saline Creek	OK121600-02-0070F	07/31/07	270	365
Little Saline Creek	OK121600-02-0070F	08/06/07	10	500
Little Saline Creek	OK121600-02-0070F	08/14/07	40	451
Little Saline Creek	OK121600-02-0070F	08/21/07	80	300
Little Saline Creek	OK121600-02-0070F	08/28/07	95	295
Little Saline Creek	OK121600-02-0070F	09/11/07	120	300
Little Saline Creek	OK121600-02-0070F	09/17/07	50	80
Little Saline Creek	OK121600-02-0070F	09/25/07	90	95
Little Saline Creek	OK121600-02-0070F	05/06/08	10	10
Little Saline Creek	OK121600-02-0070F	05/13/08	15	25
Little Saline Creek	OK121600-02-0070F	05/20/08	45	5
Little Saline Creek	OK121600-02-0070F	05/28/08	50	100
Little Saline Creek	OK121600-02-0070F	06/03/08	35	100
Little Saline Creek	OK121600-02-0070F	06/10/08	340	390
Little Saline Creek	OK121600-02-0070F	06/18/08	140	250
Little Saline Creek	OK121600-02-0070F	06/23/08	670	620
Little Saline Creek	OK121600-02-0070F	07/01/08	20	50
Little Saline Creek	OK121600-02-0070F	07/07/08	25	70
Little Saline Creek	OK121600-02-0070F	07/15/08	60	70

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Little Saline Creek	OK121600-02-0070F	07/22/08	330	175
Little Saline Creek	OK121600-02-0070F	07/30/08	55	30
Little Saline Creek	OK121600-02-0070F	08/05/08	70	130
Little Saline Creek	OK121600-02-0070F	08/12/08	75	120
Little Saline Creek	OK121600-02-0070F	08/20/08	10	65
Little Saline Creek	OK121600-02-0070F	08/26/08	215	5
Little Saline Creek	OK121600-02-0070F	09/03/08	155	360
Little Saline Creek	OK121600-02-0070F	09/09/08	25	70
Little Saline Creek	OK121600-02-0070F	09/16/08	55	335
Little Saline Creek	OK121600-02-0070F	09/23/08	30	130
Little Saline Creek	OK121600-02-0070F	09/30/08	45	65
Little Saline Creek	OK121600-02-0070F	05/05/09	210	420
Little Saline Creek	OK121600-02-0070F	05/11/09	10	70
Little Saline Creek	OK121600-02-0070F	05/19/09	1	20
Little Saline Creek	OK121600-02-0070F	05/26/09	1	10
Little Saline Creek	OK121600-02-0070F	06/02/09	40	30
Little Saline Creek	OK121600-02-0070F	06/09/09	35	50
Little Saline Creek	OK121600-02-0070F	06/22/09	10	55
Little Saline Creek	OK121600-02-0070F	06/29/09	20	35
Little Saline Creek	OK121600-02-0070F	07/07/09	15	70
Little Saline Creek	OK121600-02-0070F	07/14/09	70	5
Little Saline Creek	OK121600-02-0070F	07/21/09	30	40
Little Saline Creek	OK121600-02-0070F	07/28/09	3	87
Little Saline Creek	OK121600-02-0070F	08/04/09	10	45
Little Saline Creek	OK121600-02-0070F	08/11/09	35	170
Little Saline Creek	OK121600-02-0070F	08/18/09	55	90
Little Saline Creek	OK121600-02-0070F	08/25/09	20	25
Little Saline Creek	OK121600-02-0070F	09/01/09	10	35
Little Saline Creek	OK121600-02-0070F	09/09/09	1000	1000
Little Saline Creek	OK121600-02-0070F	09/15/09	60	120
Little Saline Creek	OK121600-02-0070F	09/22/09	100	280
Little Saline Creek	OK121600-02-0070F	09/29/09	5	5
Little Saline Creek	OK121600-02-0070F	05/04/10	50	30
Little Saline Creek	OK121600-02-0070F	05/10/10	10	40
Little Saline Creek	OK121600-02-0070F	05/16/10	70	100
Little Saline Creek	OK121600-02-0070F	05/24/10	20	25
Little Saline Creek	OK121600-02-0070F	06/01/10	20	40
Little Saline Creek	OK121600-02-0070F	06/08/10	30	10
Little Saline Creek	OK121600-02-0070F	06/14/10	60	45
Little Saline Creek	OK121600-02-0070F	06/21/10	40	95
Little Saline Creek	OK121600-02-0070F	06/28/10	145	185
Little Saline Creek	OK121600-02-0070F	07/06/10	50	110

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Little Saline Creek	OK121600-02-0070F	07/12/10	70	460
Little Saline Creek	OK121600-02-0070F	07/19/10	30	175
Little Saline Creek	OK121600-02-0070F	07/26/10	15	155
Little Saline Creek	OK121600-02-0070F	08/03/10	30	250
Little Saline Creek	OK121600-02-0070F	08/09/10	20	150
Little Saline Creek	OK121600-02-0070F	08/16/10	15	240
Little Saline Creek	OK121600-02-0070F	08/23/10	25	145
Little Saline Creek	OK121600-02-0070F	08/31/10	30	5000
Little Saline Creek	OK121600-02-0070F	09/20/10	30	80
Little Saline Creek	OK121600-02-0070F	09/27/10	5	30
Honey Creek: Upper	OK121600-03-0445Y	5/9/2007	220	860
Honey Creek: Lower	OK121600-03-0445L	5/9/2007	200	700
Honey Creek: Lower	OK121600-03-0445L	5/15/2007	100	210
Honey Creek: Upper	OK121600-03-0445Y	5/15/2007	110	180
Honey Creek: Upper	OK121600-03-0445Y	5/23/2007	640	110
Honey Creek: Lower	OK121600-03-0445L	5/23/2007	35	55
Honey Creek: Upper	OK121600-03-0445Y	5/30/2007	120	220
Honey Creek: Lower	OK121600-03-0445L	5/30/2007	55	70
Honey Creek: Upper	OK121600-03-0445Y	6/6/2007	770	230
Honey Creek: Lower	OK121600-03-0445L	6/6/2007	75	115
Honey Creek: Lower	OK121600-03-0445L	6/13/2007	355	480
Honey Creek: Upper	OK121600-03-0445Y	6/13/2007	160	420
Honey Creek: Lower	OK121600-03-0445L	6/20/2007	115	140
Honey Creek: Upper	OK121600-03-0445Y	6/20/2007	80	120
Honey Creek: Upper	OK121600-03-0445Y	6/26/2007	170	410
Honey Creek: Lower	OK121600-03-0445L	6/26/2007	90	160
Honey Creek: Upper	OK121600-03-0445Y	7/3/2007	160	170
Honey Creek: Lower	OK121600-03-0445L	7/3/2007	55	150
Honey Creek: Lower	OK121600-03-0445L	7/10/2007	1000	1000
Honey Creek: Upper	OK121600-03-0445Y	7/10/2007	1000	1000
Honey Creek: Lower	OK121600-03-0445L	7/17/2007	80	360
Honey Creek: Upper	OK121600-03-0445Y	7/17/2007	60	150
Honey Creek: Upper	OK121600-03-0445Y	7/24/2007	380	70
Honey Creek: Lower	OK121600-03-0445L	7/24/2007	280	50
Honey Creek: Lower	OK121600-03-0445L	7/31/2007	610	1000
Honey Creek: Upper	OK121600-03-0445Y	7/31/2007	460	550
Honey Creek: Lower	OK121600-03-0445L	8/8/2007	65	490
Honey Creek: Upper	OK121600-03-0445Y	8/8/2007	235	405
Honey Creek: Lower	OK121600-03-0445L	8/15/2007	90	480
Honey Creek: Upper	OK121600-03-0445Y	8/15/2007	720	360
Honey Creek: Upper	OK121600-03-0445Y	8/21/2007	290	670
Honey Creek: Lower	OK121600-03-0445L	8/21/2007	30	540

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Honey Creek: Upper	OK121600-03-0445Y	8/28/2007	215	485
Honey Creek: Lower	OK121600-03-0445L	8/28/2007	70	305
Honey Creek: Upper	OK121600-03-0445Y	9/5/2007	710	1000
Honey Creek: Lower	OK121600-03-0445L	9/11/2007	50	600
Honey Creek: Upper	OK121600-03-0445Y	9/11/2007	60	440
Honey Creek: Lower	OK121600-03-0445L	9/19/2007	50	140
Honey Creek: Upper	OK121600-03-0445Y	9/19/2007	245	45
Honey Creek: Lower	OK121600-03-0445L	9/25/2007	475	500
Honey Creek: Upper	OK121600-03-0445Y	9/25/2007	210	480
Honey Creek: Lower	OK121600-03-0445L	5/7/2008	1000	1000
Honey Creek: Upper	OK121600-03-0445Y	5/7/2008	650	390
Honey Creek: Upper	OK121600-03-0445Y	5/14/2008	50	5
Honey Creek: Lower	OK121600-03-0445L	5/14/2008	35	5
Honey Creek: Lower	OK121600-03-0445L	5/19/2008	35	10
Honey Creek: Upper	OK121600-03-0445Y	5/19/2008	15	5
Honey Creek: Upper	OK121600-03-0445Y	5/27/2008	140	460
Honey Creek: Lower	OK121600-03-0445L	5/27/2008	130	280
Honey Creek: Lower	OK121600-03-0445L	6/3/2008	45	65
Honey Creek: Upper	OK121600-03-0445Y	6/3/2008	195	55
Honey Creek: Lower	OK121600-03-0445L	6/10/2008	560	1000
Honey Creek: Upper	OK121600-03-0445Y	6/10/2008	370	1000
Honey Creek: Upper	OK121600-03-0445Y	6/17/2008	200	440
Honey Creek: Lower	OK121600-03-0445L	6/17/2008	360	340
Honey Creek: Lower	OK121600-03-0445L	6/24/2008	30	70
Honey Creek: Upper	OK121600-03-0445Y	6/24/2008	50	40
Honey Creek: Upper	OK121600-03-0445Y	7/1/2008	60	60
Honey Creek: Lower	OK121600-03-0445L	7/1/2008	30	60
Honey Creek: Upper	OK121600-03-0445Y	7/8/2008	105	100
Honey Creek: Lower	OK121600-03-0445L	7/8/2008	25	65
Honey Creek: Upper	OK121600-03-0445Y	7/15/2008	40	125
Honey Creek: Lower	OK121600-03-0445L	7/15/2008	30	50
Honey Creek: Upper	OK121600-03-0445Y	7/22/2008	185	180
Honey Creek: Lower	OK121600-03-0445L	7/22/2008	20	130
Honey Creek: Upper	OK121600-03-0445Y	7/29/2008	490	140
Honey Creek: Lower	OK121600-03-0445L	7/29/2008	25	10
Honey Creek: Lower	OK121600-03-0445L	8/5/2008	30	115
Honey Creek: Upper	OK121600-03-0445Y	8/5/2008	295	110
Honey Creek: Lower	OK121600-03-0445L	8/12/2008	40	65
Honey Creek: Upper	OK121600-03-0445Y	8/12/2008	10	60
Honey Creek: Lower	OK121600-03-0445L	8/26/2008	25	15
Honey Creek: Upper	OK121600-03-0445Y	8/26/2008	85	5
Honey Creek: Upper	OK121600-03-0445Y	9/3/2008	100	580

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Honey Creek: Lower	OK121600-03-0445L	9/3/2008	130	530
Honey Creek: Lower	OK121600-03-0445L	9/9/2008	25	85
Honey Creek: Upper	OK121600-03-0445Y	9/9/2008	50	35
Honey Creek: Upper	OK121600-03-0445Y	9/30/2008	15	150
Honey Creek: Lower	OK121600-03-0445L	9/30/2008	25	105
Honey Creek: Upper	OK121600-03-0445Y	5/5/2009	260	210
Honey Creek: Lower	OK121600-03-0445L	5/5/2009	130	130
Honey Creek: Lower	OK121600-03-0445L	5/11/2009	60	110
Honey Creek: Upper	OK121600-03-0445Y	5/11/2009	80	80
Honey Creek: Lower	OK121600-03-0445L	5/18/2009	350	40
Honey Creek: Upper	OK121600-03-0445Y	5/18/2009	50	40
Honey Creek: Lower	OK121600-03-0445L	5/27/2009	1	100
Honey Creek: Upper	OK121600-03-0445Y	5/27/2009	1	45
Honey Creek: Upper	OK121600-03-0445Y	6/1/2009	20	20
Honey Creek: Lower	OK121600-03-0445L	6/1/2009	10	10
Honey Creek: Lower	OK121600-03-0445L	6/8/2009	5	75
Honey Creek: Upper	OK121600-03-0445Y	6/8/2009	15	70
Honey Creek: Lower	OK121600-03-0445L	6/16/2009		1000
Honey Creek: Upper	OK121600-03-0445Y	6/16/2009		500
Honey Creek: Upper	OK121600-03-0445Y	6/22/2009	20	50
Honey Creek: Upper	OK121600-03-0445Y	6/30/2009	235	95
Honey Creek: Lower	OK121600-03-0445L	6/30/2009	10	20
Honey Creek: Lower	OK121600-03-0445L	7/15/2009	40	140
Honey Creek: Upper	OK121600-03-0445Y	7/15/2009	255	75
Honey Creek: Lower	OK121600-03-0445L	7/20/2009	30	65
Honey Creek: Upper	OK121600-03-0445Y	7/20/2009	15	25
Honey Creek: Lower	OK121600-03-0445L	7/27/2009	10	250
Honey Creek: Upper	OK121600-03-0445Y	7/27/2009	15	220
Honey Creek: Lower	OK121600-03-0445L	8/3/2009	13	207
Honey Creek: Upper	OK121600-03-0445Y	8/3/2009		127
Honey Creek: Lower	OK121600-03-0445L	8/10/2009	15	70
Honey Creek: Upper	OK121600-03-0445Y	8/10/2009	25	20
Honey Creek: Lower	OK121600-03-0445L	8/17/2009	80	330
Honey Creek: Upper	OK121600-03-0445Y	8/17/2009	15	170
Honey Creek: Lower	OK121600-03-0445L	8/24/2009	15	80
Honey Creek: Upper	OK121600-03-0445Y	8/24/2009	15	45
Honey Creek: Upper	OK121600-03-0445Y	8/31/2009	5	105
Honey Creek: Lower	OK121600-03-0445L	8/31/2009	5	15
Honey Creek: Upper	OK121600-03-0445Y	9/8/2009	30	130
Honey Creek: Lower	OK121600-03-0445L	9/8/2009	5	10
Honey Creek: Upper	OK121600-03-0445Y	9/14/2009	980	1000
Honey Creek: Lower	OK121600-03-0445L	9/14/2009	900	1000

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Honey Creek: Upper	OK121600-03-0445Y	9/21/2009	15	60
Honey Creek: Lower	OK121600-03-0445L	9/21/2009	35	45
Honey Creek: Upper	OK121600-03-0445Y	9/28/2009	10	55
Honey Creek: Lower	OK121600-03-0445L	9/28/2009	5	50
Honey Creek: Lower	OK121600-03-0445L	5/4/2010	30	10
Honey Creek: Upper	OK121600-03-0445Y	5/4/2010	30	10
Honey Creek: Upper	OK121600-03-0445Y	5/11/2010	65	35
Honey Creek: Lower	OK121600-03-0445L	5/11/2010	40	25
Honey Creek: Upper	OK121600-03-0445Y	5/16/2010	8100	10000
Honey Creek: Lower	OK121600-03-0445L	5/16/2010	7400	10000
Honey Creek: Lower	OK121600-03-0445L	5/25/2010	55	100
Honey Creek: Upper	OK121600-03-0445Y	5/25/2010	70	45
Honey Creek: Upper	OK121600-03-0445Y	6/2/2010	55	10
Honey Creek: Lower	OK121600-03-0445L	6/7/2010	160	180
Honey Creek: Upper	OK121600-03-0445Y	6/7/2010	110	180
Honey Creek: Upper	OK121600-03-0445Y	6/15/2010	190	730
Honey Creek: Lower	OK121600-03-0445L	6/15/2010	45	430
Honey Creek: Upper	OK121600-03-0445Y	6/22/2010	115	85
Honey Creek: Lower	OK121600-03-0445L	6/22/2010	10	60
Honey Creek: Upper	OK121600-03-0445Y	6/29/2010	120	115
Honey Creek: Lower	OK121600-03-0445L	6/29/2010	10	70
Spavinaw Creek	OK121600-05-0150G	5/2/2006	25	165
Spavinaw Creek	OK121600-05-0150G	5/9/2006	50	130
Spavinaw Creek	OK121600-05-0150G	5/15/2006	15	55
Spavinaw Creek	OK121600-05-0150G	5/22/2006	2	10
Spavinaw Creek	OK121600-05-0150G	5/31/2006	15	25
Spavinaw Creek	OK121600-05-0150G	6/6/2006	100	255
Spavinaw Creek	OK121600-05-0150G	6/13/2006	20	35
Spavinaw Creek	OK121600-05-0150G	6/20/2006	5	15
Spavinaw Creek	OK121600-05-0150G	7/5/2006	35	80
Spavinaw Creek	OK121600-05-0150G	7/11/2006	5	100
Spavinaw Creek	OK121600-05-0150G	7/17/2006	5	25
Spavinaw Creek	OK121600-05-0150G	7/24/2006	10	25
Spavinaw Creek	OK121600-05-0150G	7/31/2006	10	20
Spavinaw Creek	OK121600-05-0150G	8/7/2006	25	55
Spavinaw Creek	OK121600-05-0150G	8/14/2006	20	50
Spavinaw Creek	OK121600-05-0150G	8/21/2006	25	60
Spavinaw Creek	OK121600-05-0150G	9/5/2006	30	120
Spavinaw Creek	OK121600-05-0150G	9/11/2006	35	100
Spavinaw Creek	OK121600-05-0150G	9/19/2006	10	30
Spavinaw Creek	OK121600-05-0150G	9/25/2006	15	45
Spavinaw Creek	OK121600-05-0150G	5/1/2007	20	40

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Spavinaw Creek	OK121600-05-0150G	5/8/2007	280	690
Spavinaw Creek	OK121600-05-0150G	5/22/2007	20	10
Spavinaw Creek	OK121600-05-0150G	5/24/2007	40	120
Spavinaw Creek	OK121600-05-0150G	5/29/2007	30	30
Spavinaw Creek	OK121600-05-0150G	6/5/2007	30	25
Spavinaw Creek	OK121600-05-0150G	6/12/2007	205	345
Spavinaw Creek	OK121600-05-0150G	6/19/2007	165	65
Spavinaw Creek	OK121600-05-0150G	6/25/2007	50	35
Spavinaw Creek	OK121600-05-0150G	7/9/2007	10	95
Spavinaw Creek	OK121600-05-0150G	7/17/2007	20	270
Spavinaw Creek	OK121600-05-0150G	7/23/2007	50	190
Spavinaw Creek	OK121600-05-0150G	7/30/2007	10	120
Spavinaw Creek	OK121600-05-0150G	8/7/2007	5	190
Spavinaw Creek	OK121600-05-0150G	8/13/2007	5	165
Spavinaw Creek	OK121600-05-0150G	8/20/2007	10	190
Spavinaw Creek	OK121600-05-0150G	8/27/2007	10	115
Spavinaw Creek	OK121600-05-0150G	9/4/2007	10	120
Spavinaw Creek	OK121600-05-0150G	9/10/2007	90	900
Spavinaw Creek	OK121600-05-0150G	9/18/2007	5	40
Spavinaw Creek	OK121600-05-0150G	9/24/2007	35	35
Spavinaw Creek	OK121600-05-0150G	5/5/2008	5	10
Spavinaw Creek	OK121600-05-0150G	5/12/2008	5	5
Spavinaw Creek	OK121600-05-0150G	5/19/2008	15	5
Spavinaw Creek	OK121600-05-0150G	5/28/2008	15	25
Spavinaw Creek	OK121600-05-0150G	6/4/2008	60	50
Spavinaw Creek	OK121600-05-0150G	6/10/2008	240	350
Spavinaw Creek	OK121600-05-0150G	6/10/2008	410	800
Spavinaw Creek	OK121600-05-0150G	6/18/2008	120	190
Spavinaw Creek	OK121600-05-0150G	6/24/2008	10	40
Spavinaw Creek	OK121600-05-0150G	6/30/2008	10	10
Spavinaw Creek	OK121600-05-0150G	7/7/2008	15	25
Spavinaw Creek	OK121600-05-0150G	7/14/2008	100	225
Spavinaw Creek	OK121600-05-0150G	7/21/2008	5	185
Spavinaw Creek	OK121600-05-0150G	7/29/2008	5	110
Spavinaw Creek	OK121600-05-0150G	8/4/2008	30	170
Spavinaw Creek	OK121600-05-0150G	8/11/2008	40	440
Spavinaw Creek	OK121600-05-0150G	8/18/2008	10	85
Spavinaw Creek	OK121600-05-0150G	8/26/2008	5	45
Spavinaw Creek	OK121600-05-0150G	9/2/2008	10	15
Spavinaw Creek	OK121600-05-0150G	9/8/2008	10	60
Spavinaw Creek	OK121600-05-0150G	9/15/2008	270	680
Spavinaw Creek	OK121600-05-0150G	9/23/2008	20	40

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Spavinaw Creek	OK121600-05-0150G	9/29/2008	10	35
Spavinaw Creek	OK121600-05-0150G	5/6/2009	50	70
Spavinaw Creek	OK121600-05-0150G	5/12/2009	40	10
Spavinaw Creek	OK121600-05-0150G	5/19/2009	60	30
Spavinaw Creek	OK121600-05-0150G	5/26/2009	1	100
Spavinaw Creek	OK121600-05-0150G	6/2/2009	10	10
Spavinaw Creek	OK121600-05-0150G	6/9/2009	15	10
Spavinaw Creek	OK121600-05-0150G	6/23/2009	5	15
Spavinaw Creek	OK121600-05-0150G	6/29/2009	5	25
Spavinaw Creek	OK121600-05-0150G	7/7/2009	40	0.89
Spavinaw Creek	OK121600-05-0150G	7/14/2009	5	15
Spavinaw Creek	OK121600-05-0150G	7/21/2009	5	40
Spavinaw Creek	OK121600-05-0150G	7/28/2009	7	133
Spavinaw Creek	OK121600-05-0150G	8/4/2009	5	25
Spavinaw Creek	OK121600-05-0150G	8/11/2009	10	50
Spavinaw Creek	OK121600-05-0150G	8/18/2009	20	90
Spavinaw Creek	OK121600-05-0150G	8/24/2009	5	30
Spavinaw Creek	OK121600-05-0150G	9/1/2009	5	5
Spavinaw Creek	OK121600-05-0150G	9/9/2009	70	345
Spavinaw Creek	OK121600-05-0150G	9/15/2009	20	20
Spavinaw Creek	OK121600-05-0150G	9/21/2009	10	35
Spavinaw Creek	OK121600-05-0150G	9/22/2009	750	1000
Spavinaw Creek	OK121600-05-0150G	9/29/2009	5	20
Spavinaw Creek	OK121600-05-0150G	5/5/2010	5	5
Spavinaw Creek	OK121600-05-0150G	5/10/2010	5	5
Spavinaw Creek	OK121600-05-0150G	5/16/2010	1500	2000
Spavinaw Creek	OK121600-05-0150G	5/24/2010	5	15
Spavinaw Creek	OK121600-05-0150G	6/1/2010	20	25
Spavinaw Creek	OK121600-05-0150G	6/8/2010	5	15
Spavinaw Creek	OK121600-05-0150G	6/14/2010	10	35
Spavinaw Creek	OK121600-05-0150G	6/21/2010	5	15
Spavinaw Creek	OK121600-05-0150G	6/28/2010	15	45
Spavinaw Creek	OK121600-05-0150G	7/7/2010	15	25
Spavinaw Creek	OK121600-05-0150G	7/12/2010	10	90
Spavinaw Creek	OK121600-05-0150G	7/20/2010	5	50
Spavinaw Creek	OK121600-05-0150G	8/4/2010	5	110
Spavinaw Creek	OK121600-05-0150G	8/10/2010	15	55
Spavinaw Creek	OK121600-05-0150G	8/17/2010	25	290
Spavinaw Creek	OK121600-05-0150G	8/24/2010	10	120
Spavinaw Creek	OK121600-05-0150G	8/30/2010	20	115
Spavinaw Creek	OK121600-05-0150G	9/21/2010	10	15
Spavinaw Creek	OK121600-05-0150G	9/28/2010	5	10

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Beaty Creek: Lower	OK121600-05-0160G	5/3/2006	20	125
Upper Beaty Creek	OK121600-05-0160F	5/3/2006	45	190
Beaty Creek: Lower	OK121600-05-0160G	5/8/2006	15	20
Upper Beaty Creek	OK121600-05-0160F	5/8/2006	70	160
Beaty Creek: Lower	OK121600-05-0160G	5/16/2006	13	53
Upper Beaty Creek	OK121600-05-0160F	5/16/2006	20	97
Beaty Creek: Lower	OK121600-05-0160G	5/22/2006	16	40
Upper Beaty Creek	OK121600-05-0160F	5/22/2006	24	64
Beaty Creek: Lower	OK121600-05-0160G	5/30/2006	4	4
Upper Beaty Creek	OK121600-05-0160F	5/30/2006	10	62
Beaty Creek: Lower	OK121600-05-0160G	6/5/2006	55	5
Beaty Creek: Lower	OK121600-05-0160G	6/12/2006	55	85
Upper Beaty Creek	OK121600-05-0160F	6/12/2006	80	155
Beaty Creek: Lower	OK121600-05-0160G	6/19/2006	5	65
Upper Beaty Creek	OK121600-05-0160F	6/19/2006	145	170
Beaty Creek: Lower	OK121600-05-0160G	6/26/2006	10	60
Upper Beaty Creek	OK121600-05-0160F	6/26/2006	20	45
Beaty Creek: Lower	OK121600-05-0160G	6/27/2006	5	10
Beaty Creek: Lower	OK121600-05-0160G	7/5/2006	10	55
Upper Beaty Creek	OK121600-05-0160F	7/5/2006	55	215
Beaty Creek: Lower	OK121600-05-0160G	7/11/2006	5	80
Upper Beaty Creek	OK121600-05-0160F	7/11/2006	10	105
Beaty Creek: Lower	OK121600-05-0160G	7/17/2006	5	90
Upper Beaty Creek	OK121600-05-0160F	7/17/2006	10	70
Upper Beaty Creek	OK121600-05-0160F	7/24/2006	5	35
Beaty Creek: Lower	OK121600-05-0160G	7/24/2006	5	205
Beaty Creek: Lower	OK121600-05-0160G	7/31/2006	5	40
Upper Beaty Creek	OK121600-05-0160F	7/31/2006	10	20
Upper Beaty Creek	OK121600-05-0160F	8/7/2006	25	115
Beaty Creek: Lower	OK121600-05-0160G	8/7/2006	225	145
Beaty Creek: Lower	OK121600-05-0160G	8/14/2006	10	40
Upper Beaty Creek	OK121600-05-0160F	8/14/2006	60	215
Beaty Creek: Lower	OK121600-05-0160G	8/22/2006	5	210
Upper Beaty Creek	OK121600-05-0160F	8/22/2006	10	30
Beaty Creek: Lower	OK121600-05-0160G	8/28/2006	105	265
Upper Beaty Creek	OK121600-05-0160F	8/28/2006	500	500
Beaty Creek: Lower	OK121600-05-0160G	9/5/2006	45	80
Upper Beaty Creek	OK121600-05-0160F	9/5/2006	50	350
Beaty Creek: Lower	OK121600-05-0160G	9/12/2006	45	90
Upper Beaty Creek	OK121600-05-0160F	9/12/2006	310	270
Beaty Creek: Lower	OK121600-05-0160G	9/18/2006	20	65
Upper Beaty Creek	OK121600-05-0160F	9/18/2006	205	175

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Beaty Creek: Lower	OK121600-05-0160G	9/26/2006	5	30
Upper Beaty Creek	OK121600-05-0160F	5/1/2007	5	85
Beaty Creek: Lower	OK121600-05-0160G	5/1/2007	5	30
Beaty Creek: Lower	OK121600-05-0160G	5/8/2007	710	1000
Upper Beaty Creek	OK121600-05-0160F	5/8/2007	800	1000
Beaty Creek: Lower	OK121600-05-0160G	5/14/2007	70	215
Upper Beaty Creek	OK121600-05-0160F	5/14/2007	75	275
Beaty Creek: Lower	OK121600-05-0160G	5/21/2007	5	50
Upper Beaty Creek	OK121600-05-0160F	5/21/2007	40	75
Beaty Creek: Lower	OK121600-05-0160G	5/29/2007	5	50
Upper Beaty Creek	OK121600-05-0160F	5/29/2007	40	110
Upper Beaty Creek	OK121600-05-0160F	6/4/2007	15	80
Beaty Creek: Lower	OK121600-05-0160G	6/4/2007	25	55
Beaty Creek: Lower	OK121600-05-0160G	6/12/2007	325	490
Upper Beaty Creek	OK121600-05-0160F	6/14/2007	470	780
Upper Beaty Creek	OK121600-05-0160F	6/18/2007	155	290
Beaty Creek: Lower	OK121600-05-0160G	6/18/2007	240	355
Beaty Creek: Lower	OK121600-05-0160G	6/25/2007	75	85
Upper Beaty Creek	OK121600-05-0160F	6/25/2007	270	185
Upper Beaty Creek	OK121600-05-0160F	7/9/2007	25	285
Beaty Creek: Lower	OK121600-05-0160G	7/9/2007	30	280
Upper Beaty Creek	OK121600-05-0160F	7/16/2007	10	580
Beaty Creek: Lower	OK121600-05-0160G	7/16/2007	50	350
Upper Beaty Creek	OK121600-05-0160F	7/23/2007	40	240
Beaty Creek: Lower	OK121600-05-0160G	7/23/2007	80	430
Beaty Creek: Lower	OK121600-05-0160G	7/30/2007	30	190
Upper Beaty Creek	OK121600-05-0160F	7/30/2007	40	420
Beaty Creek: Lower	OK121600-05-0160G	8/6/2007	10	265
Upper Beaty Creek	OK121600-05-0160F	8/6/2007	15	495
Beaty Creek: Lower	OK121600-05-0160G	8/13/2007	5	180
Upper Beaty Creek	OK121600-05-0160F	8/13/2007	45	500
Beaty Creek: Lower	OK121600-05-0160G	8/20/2007	30	250
Upper Beaty Creek	OK121600-05-0160F	8/20/2007	130	1000
Beaty Creek: Lower	OK121600-05-0160G	8/27/2007	10	370
Upper Beaty Creek	OK121600-05-0160F	8/27/2007	55	425
Upper Beaty Creek	OK121600-05-0160F	9/4/2007	5	85
Beaty Creek: Lower	OK121600-05-0160G	9/4/2007	5	100
Beaty Creek: Lower	OK121600-05-0160G	9/10/2007	30	220
Upper Beaty Creek	OK121600-05-0160F	9/10/2007	60	630
Upper Beaty Creek	OK121600-05-0160F	9/17/2007	10	120

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Beaty Creek: Lower	OK121600-05-0160G	9/17/2007	10	35
Upper Beaty Creek	OK121600-05-0160F	9/24/2007	5	180
Beaty Creek: Lower	OK121600-05-0160G	9/24/2007	15	50
Beaty Creek: Lower	OK121600-05-0160G	5/5/2008	5	5
Upper Beaty Creek	OK121600-05-0160F	5/5/2008	10	10
Upper Beaty Creek	OK121600-05-0160F	5/13/2008	20	55
Beaty Creek: Lower	OK121600-05-0160G	5/13/2008	25	10
Beaty Creek: Lower	OK121600-05-0160G	5/20/2008	5	5
Upper Beaty Creek	OK121600-05-0160F	5/20/2008	30	5
Beaty Creek: Lower	OK121600-05-0160G	5/28/2008	5	25
Upper Beaty Creek	OK121600-05-0160F	5/28/2008	15	25
Beaty Creek: Lower	OK121600-05-0160G	6/4/2008	25	5
Upper Beaty Creek	OK121600-05-0160F	6/4/2008	75	20
Beaty Creek: Lower	OK121600-05-0160G	6/9/2008	10000	10000
Upper Beaty Creek	OK121600-05-0160F	6/10/2008	350	610
Beaty Creek: Lower	OK121600-05-0160G	6/16/2008	4400	9900
Upper Beaty Creek	OK121600-05-0160F	6/16/2008	6200	9700
Beaty Creek: Lower	OK121600-05-0160G	6/23/2008	50	130
Upper Beaty Creek	OK121600-05-0160F	6/24/2008	60	10
Upper Beaty Creek	OK121600-05-0160F	7/1/2008	10	10
Beaty Creek: Lower	OK121600-05-0160G	7/1/2008	10	10
Upper Beaty Creek	OK121600-05-0160F	7/7/2008	10	35
Beaty Creek: Lower	OK121600-05-0160G	7/7/2008	15	10
Beaty Creek: Lower	OK121600-05-0160G	7/15/2008	15	60
Upper Beaty Creek	OK121600-05-0160F	7/15/2008	25	70
Beaty Creek: Lower	OK121600-05-0160G	7/21/2008	10	125
Upper Beaty Creek	OK121600-05-0160F	7/22/2008	15	120
Beaty Creek: Lower	OK121600-05-0160G	7/29/2008	15	30
Upper Beaty Creek	OK121600-05-0160F	7/30/2008	30	55
Beaty Creek: Lower	OK121600-05-0160G	8/4/2008	5	105
Upper Beaty Creek	OK121600-05-0160F	8/5/2008	20	395
Beaty Creek: Lower	OK121600-05-0160G	8/12/2008	5	45
Upper Beaty Creek	OK121600-05-0160F	8/12/2008	65	130
Beaty Creek: Lower	OK121600-05-0160G	8/18/2008	5	55
Upper Beaty Creek	OK121600-05-0160F	8/20/2008	15	70
Beaty Creek: Lower	OK121600-05-0160G	8/26/2008	15	30
Upper Beaty Creek	OK121600-05-0160F	8/28/2008	20	35
Beaty Creek: Lower	OK121600-05-0160G	9/2/2008	10	65
Upper Beaty Creek	OK121600-05-0160F	9/3/2008	50	430
Beaty Creek: Lower	OK121600-05-0160G	9/8/2008	5	20

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Upper Beaty Creek	OK121600-05-0160F	9/9/2008	20	75
Beaty Creek: Lower	OK121600-05-0160G	9/15/2008	160	410
Upper Beaty Creek	OK121600-05-0160F	9/16/2008	135	450
Beaty Creek: Lower	OK121600-05-0160G	9/23/2008	10	20
Upper Beaty Creek	OK121600-05-0160F	9/23/2008	20	90
Beaty Creek: Lower	OK121600-05-0160G	9/29/2008	5	25
Upper Beaty Creek	OK121600-05-0160F	9/30/2008	115	70
Upper Beaty Creek	OK121600-05-0160F	5/6/2009	250	100
Upper Beaty Creek	OK121600-05-0160F	5/12/2009	70	140
Upper Beaty Creek	OK121600-05-0160F	5/18/2009	290	10
Upper Beaty Creek	OK121600-05-0160F	5/27/2009	1	25
Upper Beaty Creek	OK121600-05-0160F	6/1/2009	10	10
Upper Beaty Creek	OK121600-05-0160F	6/8/2009	5	40
Upper Beaty Creek	OK121600-05-0160F	6/16/2009	5	120
Upper Beaty Creek	OK121600-05-0160F	6/22/2009	5	55
Upper Beaty Creek	OK121600-05-0160F	6/29/2009	5	55
Upper Beaty Creek	OK121600-05-0160F	7/15/2009	5	200
Upper Beaty Creek	OK121600-05-0160F	7/20/2009	5	110
Upper Beaty Creek	OK121600-05-0160F	7/27/2009	20	235
Upper Beaty Creek	OK121600-05-0160F	8/18/2009	35	255
Upper Beaty Creek	OK121600-05-0160F	8/25/2009	5	5
Upper Beaty Creek	OK121600-05-0160F	8/31/2009	5	45
Upper Beaty Creek	OK121600-05-0160F	9/8/2009	45	45
Upper Beaty Creek	OK121600-05-0160F	9/14/2009	30	350
Upper Beaty Creek	OK121600-05-0160F	9/21/2009	35	40
Upper Beaty Creek	OK121600-05-0160F	9/22/2009	1000	1000
Upper Beaty Creek	OK121600-05-0160F	9/28/2009	15	25
Upper Beaty Creek	OK121600-05-0160F	5/5/2010	65	15
Upper Beaty Creek	OK121600-05-0160F	5/10/2010	55	55
Upper Beaty Creek	OK121600-05-0160F	5/16/2010	7200	10000
Upper Beaty Creek	OK121600-05-0160F	5/24/2010	30	70
Upper Beaty Creek	OK121600-05-0160F	6/2/2010	30	25
Upper Beaty Creek	OK121600-05-0160F	6/7/2010	45	155
Upper Beaty Creek	OK121600-05-0160F	6/15/2010	80	355
Upper Beaty Creek	OK121600-05-0160F	6/22/2010	15	40
Upper Beaty Creek	OK121600-05-0160F	6/29/2010	65	85
Upper Beaty Creek	OK121600-05-0160F	7/7/2010	5	205
Upper Beaty Creek	OK121600-05-0160F	7/12/2010	10	270
Upper Beaty Creek	OK121600-05-0160F	7/20/2010	5	380
Upper Beaty Creek	OK121600-05-0160F	7/27/2010	10	215

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Upper Beaty Creek	OK121600-05-0160F	8/4/2010	5	675
Upper Beaty Creek	OK121600-05-0160F	8/10/2010	5	420
Upper Beaty Creek	OK121600-05-0160F	8/17/2010	10	200
Upper Beaty Creek	OK121600-05-0160F	8/25/2010	5	650
Upper Beaty Creek	OK121600-05-0160F	8/30/2010	5	215
Upper Beaty Creek	OK121600-05-0160F	9/21/2010	40	70
Upper Beaty Creek	OK121600-05-0160F	9/28/2010	5	25
Cloud Creek: Downstream	OK121600-05-0180C	5/2/2006	30	260
Cloud Creek: Upstream	OK121600-05-0180G	5/2/2006	45	345
Cloud Creek: Downstream	OK121600-05-0180C	5/9/2006	10	90
Cloud Creek: Upstream	OK121600-05-0180G	5/9/2006	10	150
Cloud Creek: Downstream	OK121600-05-0180C	5/15/2006	5	20
Cloud Creek: Upstream	OK121600-05-0180G	5/16/2006	3	33
Cloud Creek: Upstream	OK121600-05-0180G	5/22/2006	18	24
Cloud Creek: Upstream	OK121600-05-0180G	5/31/2006	5	75
Cloud Creek: Upstream	OK121600-05-0180G	6/6/2006	80	220
Cloud Creek: Upstream	OK121600-05-0180G	6/13/2006	5	25
Cloud Creek: Upstream	OK121600-05-0180G	6/20/2006	10	75
Cloud Creek: Upstream	OK121600-05-0180G	6/27/2006	10	105
Cloud Creek: Upstream	OK121600-05-0180G	7/5/2006	25	125
Cloud Creek: Upstream	OK121600-05-0180G	7/11/2006	500	185
Cloud Creek: Upstream	OK121600-05-0180G	7/17/2006	75	175
Cloud Creek: Upstream	OK121600-05-0180G	7/24/2006	15	105
Cloud Creek: Upstream	OK121600-05-0180G	7/31/2006	65	90
Cloud Creek: Upstream	OK121600-05-0180G	8/7/2006	60	140
Cloud Creek: Upstream	OK121600-05-0180G	8/14/2006	45	70
Cloud Creek: Upstream	OK121600-05-0180G	8/21/2006	105	55
Cloud Creek: Upstream	OK121600-05-0180G	9/5/2006	5	135
Cloud Creek: Upstream	OK121600-05-0180G	9/11/2006	40	140
Cloud Creek: Upstream	OK121600-05-0180G	9/19/2006	25	105
Cloud Creek: Upstream	OK121600-05-0180G	9/25/2006	25	50
Cloud Creek: Upstream	OK121600-05-0180G	5/1/2007	95	45
Cloud Creek: Downstream	OK121600-05-0180C	5/4/2007	130	290
Cloud Creek: Downstream	OK121600-05-0180C	5/14/2007	340	50
Cloud Creek: Upstream	OK121600-05-0180G	5/22/2007	5	15
Cloud Creek: Upstream	OK121600-05-0180G	5/29/2007	15	40
Cloud Creek: Upstream	OK121600-05-0180G	6/5/2007	25	50
Cloud Creek: Downstream	OK121600-05-0180C	6/12/2007	290	500
Cloud Creek: Downstream	OK121600-05-0180C	6/18/2007	35	70
Cloud Creek: Downstream	OK121600-05-0180C	6/25/2007	80	100

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Cloud Creek: Upstream	OK121600-05-0180G	7/9/2007	25	145
Cloud Creek: Upstream	OK121600-05-0180G	7/17/2007	20	310
Cloud Creek: Upstream	OK121600-05-0180G	7/23/2007	80	430
Cloud Creek: Upstream	OK121600-05-0180G	7/30/2007	50	380
Cloud Creek: Upstream	OK121600-05-0180G	8/7/2007	10	350
Cloud Creek: Upstream	OK121600-05-0180G	8/13/2007	15	140
Cloud Creek: Upstream	OK121600-05-0180G	8/20/2007	30	420
Cloud Creek: Upstream	OK121600-05-0180G	8/27/2007	5	205
Cloud Creek: Upstream	OK121600-05-0180G	9/4/2007	5	180
Cloud Creek: Upstream	OK121600-05-0180G	9/10/2007	80	980
Cloud Creek: Upstream	OK121600-05-0180G	9/18/2007	5	130
Cloud Creek: Upstream	OK121600-05-0180G	9/24/2007	5	95
Cloud Creek: Downstream	OK121600-05-0180C	5/5/2008	5	10
Cloud Creek: Downstream	OK121600-05-0180C	5/12/2008	5	5
Cloud Creek: Downstream	OK121600-05-0180C	5/19/2008	5	5
Cloud Creek: Downstream	OK121600-05-0180C	5/28/2008	5	20
Cloud Creek: Downstream	OK121600-05-0180C	6/4/2008	85	20
Cloud Creek: Downstream	OK121600-05-0180C	6/9/2008	480	1720
Cloud Creek: Downstream	OK121600-05-0180C	6/16/2008	1060	1980
Cloud Creek: Downstream	OK121600-05-0180C	6/24/2008	10	60
Cloud Creek: Downstream	OK121600-05-0180C	6/30/2008	10	30
Cloud Creek: Downstream	OK121600-05-0180C	7/7/2008	5	5
Cloud Creek: Downstream	OK121600-05-0180C	7/14/2008	10	55
Cloud Creek: Downstream	OK121600-05-0180C	7/21/2008	5	85
Cloud Creek: Downstream	OK121600-05-0180C	7/29/2008	5	15
Cloud Creek: Upstream	OK121600-05-0180G	8/4/2008	5	165
Cloud Creek: Downstream	OK121600-05-0180C	8/11/2008	40	480
Cloud Creek: Downstream	OK121600-05-0180C	8/18/2008	5	10
Cloud Creek: Upstream	OK121600-05-0180G	8/25/2008	5	55
Cloud Creek: Upstream	OK121600-05-0180G	9/2/2008	5	155
Cloud Creek: Downstream	OK121600-05-0180C	9/8/2008	5	50
Cloud Creek: Upstream	OK121600-05-0180G	9/15/2008	130	730
Cloud Creek: Downstream	OK121600-05-0180C	9/23/2008	5	50
Cloud Creek: Upstream	OK121600-05-0180G	9/29/2008	5	10
Cloud Creek: Upstream	OK121600-05-0180G	5/6/2009	40	70
Cloud Creek: Downstream	OK121600-05-0180C	5/12/2009	30	120
Cloud Creek: Upstream	OK121600-05-0180G	5/19/2009	10	20
Cloud Creek: Downstream	OK121600-05-0180C	5/19/2009	20	20
Cloud Creek: Downstream	OK121600-05-0180C	5/26/2009	1	15
Cloud Creek: Upstream	OK121600-05-0180G	6/2/2009	10	20

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Cloud Creek: Upstream	OK121600-05-0180G	6/9/2009	45	55
Pryor Creek: HWY 20	OK121610-00-0050D	5/29/2002	800	1240
Pryor Creek: HWY 69	OK121610-00-0050M	7/9/2002	70	190
Pryor Creek: HWY 20	OK121610-00-0050D	7/9/2002	120	100
Pryor Creek: HWY 20	OK121610-00-0050D	8/6/2002	10	80
Pryor Creek: HWY 69	OK121610-00-0050M	8/6/2002	30	10
Pryor Creek: HWY 20	OK121610-00-0050D	9/17/2002	20	60
Pryor Creek: HWY 69	OK121610-00-0050M	9/17/2002	80	20
Pryor Creek: HWY 20	OK121610-00-0050D	5/13/2003	10	70
Pryor Creek: HWY 69	OK121610-00-0050M	5/13/2003	10	190
Pryor Creek: HWY 20	OK121610-00-0050D	6/17/2003	100	480
Pryor Creek: HWY 69	OK121610-00-0050M	6/17/2003	120	420
Pryor Creek: HWY 20	OK121610-00-0050D	6/20/2006	40	30
Pryor Creek: HWY 69	OK121610-00-0050M	6/20/2006	240	330
Pryor Creek: HWY 69	OK121610-00-0050M	8/15/2006	670	450
Pryor Creek: HWY 20	OK121610-00-0050D	8/15/2006	1000	820
Pryor Creek: HWY 69	OK121610-00-0050M	9/19/2006	400	900
Pryor Creek: HWY 20	OK121610-00-0050D	9/19/2006	520	640
Pryor Creek: HWY 20	OK121610-00-0050D	5/14/2007	120	400
Pryor Creek: HWY 69	OK121610-00-0050M	5/14/2007	140	380
Pryor Creek: HWY 69	OK121610-00-0050M	6/18/2007	180	420
Pryor Creek: HWY 20	OK121610-00-0050D	6/18/2007	220	360
Pryor Creek: HWY 69	OK121610-00-0050M	7/23/2007	190	130
Pryor Creek: HWY 20	OK121610-00-0050D	7/23/2007	260	110
Pryor Creek: HWY 20	OK121610-00-0050D	8/28/2007	220	380
Pryor Creek: HWY 69	OK121610-00-0050M	8/28/2007	270	470
Pryor Creek: HWY 69	OK121610-00-0050M	5/6/2008	300	20
Pryor Creek: HWY 20	OK121610-00-0050D	5/6/2008	480	220

EC = *E. coli* ; ENT = Enterococci
> 1000 reported as 1000.001 in data analysis
[2] Units = counts/100 mL

Appendix Table A-2 Turbidity and Total Suspended Solids Data (1999-2001)

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
Pryor Creek	OK121610-00-0090N	04/19/99	17	26.5	low
Pryor Creek	OK121610-00-0090N	05/17/99	346	670	rainfall
Pryor Creek	OK121610-00-0090N	06/14/99	36.8	40	rainfall
Pryor Creek	OK121610-00-0090N	07/13/99	3	38	low
Pryor Creek	OK121610-00-0090N	08/16/99	69.5	72	low
Pryor Creek	OK121610-00-0090N	09/27/99	59.9	56.5	low
Pryor Creek	OK121610-00-0090N	11/01/99	27.8	24	low
Pryor Creek	OK121610-00-0090N	12/07/99	58.7	90	low
Pryor Creek	OK121610-00-0090N	01/10/00	19.8	27	low
Pryor Creek	OK121610-00-0090N	02/14/00	15.1	14	low
Pryor Creek	OK121610-00-0090N	03/20/00	30.1	20	low
Pryor Creek	OK121610-00-0090N	05/01/00	563	675	rainfall
Pryor Creek	OK121610-00-0090N	06/05/00	48.1	58	low
Pryor Creek	OK121610-00-0090N	07/10/00	92.7	9.99	low
Pryor Creek	OK121610-00-0090N	08/15/00	85.5	48	low
Pryor Creek	OK121610-00-0090N	09/18/00	36.3	18	low
Pryor Creek	OK121610-00-0090N	10/24/00	39.2	20	low
Pryor Creek	OK121610-00-0090N	11/28/00	29.1	21	low
Pryor Creek	OK121610-00-0090N	01/08/01		46	low
Pryor Creek	OK121610-00-0090N	02/13/01	68	56	high
Pryor Creek	OK121610-00-0090N	03/20/01	18.5	22	high

APPENDIX B: General Method for Estimating Flow for Ungaged Streams and Estimated Flow Exceedance Percentiles

Appendix B

General Method for Estimating Flow for Ungaged Streams

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

A. In cases where a USGS flow gage occurs 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 date are available, these flow measurements will be used.

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

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

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

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

1. Watershed delineations are performed using ESRI Arc Hydro with a 30 m resolution National Elevation Dataset digital elevation model, and National Hydrography Dataset (NHD) streams. The area of each watershed will be calculated following watershed delineation.

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

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

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

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

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

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

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

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

Wurbs Modified NRCS Method

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

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

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

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

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

Thus, the runoff curve number equation can be rewritten:

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

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

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

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:

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

Where:

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.

D. 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

Appendix Table B-2 Estimated Flow Exceedance Percentiles

Stream Name	Saline Creek	Little Saline Creek	Honey Creek	Spavinaw Creek	Beaty Creek	Cloud Creek	Pryor Creek	Pryor Creek
WBID	OK121600020030_10	OK121600020070_00	OK121600030445_10	OK121600050150_00	OK121600050160_00	OK121600050180_00	OK121610000090_00	OK121610000050_10
USGS Gage Reference	07191200 & 07191220	07191200 & 07191220	07189542	07191200 & 07191220	07191222	07191222	07192000	07192000
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
0	17303	5104	3090	11700	6320	3774	9741	26600
1	1384	408	309	936	461	275	943	2576
2	899	265	196	608	321	192	546	1491
3	708	209	156	479	249	149	370	1010
4	601	177	136	407	206	123	269	736
5	524	154	119	354	177	106	206	561
6	470	139	108	318	152	91	159	435
7	426	126	97	288	136	81	118	322
8	388	114	90	262	122	73	94	256
9	359	106	82	243	111	66	76	208
10	331	98	76	224	102	61	63	172
11	309	91	71	209	93	56	54	148
12	288	85	66	195	85	51	46	126
13	269	79	62	182	78	46	41	111
14	254	75	57	172	71	42	37	100
15	241	71	54	163	67	40	33	91
16	229	68	51	155	62	37	30	83
17	219	65	49	148	58	35	27	75
18	209	62	47	141	55	33	25	69
19	200	59	44	135	52	31	23	64
20	192	57	42	130	48	29	22	60
21	185	55	41	125	46	27	20	55
22	177	52	39	120	43	26	19	52
23	172	51	38	116	41	24	18	49
24	167	49	37	113	39	23	16	45
25	161	48	36	109	37	22	15	41
26	155	46	35	105	36	21	14	38

Stream Name	Saline Creek	Little Saline Creek	Honey Creek	Spavinaw Creek	Beaty Creek	Cloud Creek	Pryor Creek	Pryor Creek
WBID	OK121600020030_10	OK121600020070_00	OK121600030445_10	OK121600050150_00	OK121600050160_00	OK121600050180_00	OK121610000090_00	OK121610000050_10
USGS Gage Reference	07191200 & 07191220	07191200 & 07191220	07189542	07191200 & 07191220	07191222	07191222	07192000	07192000
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
27	151	44	34	102	34	20	13	35
28	146	43	33	99	33	20	12	33
29	142	42	32	96	32	19	11	30
30	138	41	31	93	30	18	10	27
31	133	39	30	90	29	17	9	25
32	129	38	29	87	28	17	8	23
33	124	37	28	84	27	16	8	21
34	121	36	28	82	26	16	7	19
35	117	34	27	79	25	15	6	17
36	112	33	27	76	24	14	5	15
37	109	32	26	74	24	14	5	14
38	106	31	25	72	23	14	4	12
39	104	31	25	70	22	13	4	12
40	102	30	24	69	22	13	4	10
41	99	29	23	67	21	13	4	9.8
42	96	28	23	65	20	12	3	8.9
43	93	27	22	63	20	12	3	8.3
44	92	27	22	62	19	11	3	7.6
45	89	26	21	60	18	11	3	7.2
46	87	26	21	59	18	11	2	6.6
47	84	25	20	57	17	10	2	6.0
48	81	24	20	55	17	10	2	5.5
49	80	24	19	54	16	10	2	5.1
50	77	23	19	52	16	10	2	4.7
51	75	22	19	51	15	9	2	4.3
52	74	22	18.0	50	15	9.0	1.5	4.0
53	72	21	18.0	49	14	8.4	1.4	3.7
54	70	21	17.0	47	13	7.8	1.2	3.3
55	68	20	17.0	46	13	7.8	1.1	3.0
56	67	20	17.0	45	12	7.2	1.0	2.8

Stream Name	Saline Creek	Little Saline Creek	Honey Creek	Spavinaw Creek	Beaty Creek	Cloud Creek	Pryor Creek	Pryor Creek
WBID	OK121600020030_10	OK121600020070_00	OK121600030445_10	OK121600050150_00	OK121600050160_00	OK121600050180_00	OK121610000090_00	OK121610000050_10
USGS Gage Reference	07191200 & 07191220	07191200 & 07191220	07189542	07191200 & 07191220	07191222	07191222	07192000	07192000
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
57	65	19	16.0	44	12	7.2	0.9	2.4
58	62	18	16.0	42	12	7.2	0.8	2.2
59	61	18	16.0	41	11	6.6	0.7	2.0
60	59	17	15.0	40	11	6.6	0.6	1.7
61	58	17	15.0	39	10	6.0	0.6	1.6
62	55	16	15.0	37	10	6.0	0.5	1.4
63	53	16	14.0	36	9.6	5.7	0.4	1.2
64	52	15	14.0	35	9.2	5.5	0.4	1.0
65	50	15	14.0	34	8.7	5.2	0.3	0.9
66	49	14	14.0	33	8.4	5.0	0.3	0.8
67	47	14	13.0	32	8.0	4.8	0.3	0.7
68	46	14	13.0	31	7.7	4.6	0.3	0.7
69	44	13	13.0	30	7.4	4.4	0.2	0.6
70	43	13	13.0	29	7.1	4.2	0.2	0.5
71	41	12	13.0	28	6.9	4.1	0.2	0.5
72	40	12	12.0	27	6.6	3.9	0.1	0.4
73	40	12	12.0	27	6.4	3.8	0.1	0.3
74	38	11	12.0	26	6.2	3.7	0.1	0.3
75	37	11	12.0	25	5.9	3.5	0.1	0.2
76	35	10	11.0	24	5.5	3.3	0.1	0.2
77	34	10	11.0	23	5.2	3.1	0.0	0.1
78	34	10	11.0	23	4.9	2.9	0.0	0.1
79	33	10	11.0	22	4.5	2.7	0.0	0.1
80	31	9	10.0	21	4.3	2.6	0.0	0.1
81	30	9	10.0	20	4.0	2.4	0.0	0.1
82	30	9	9.7	20	3.8	2.3	0	0
83	28	8	9.5	19	3.5	2.1	0	0
84	27	8	9.1	18	3.2	1.91	0	0
85	25	7	8.9	17	3.0	1.79	0	0
86	24	7	8.6	16	2.8	1.67	0	0

Stream Name	Saline Creek	Little Saline Creek	Honey Creek	Spavinaw Creek	Beaty Creek	Cloud Creek	Pryor Creek	Pryor Creek
WBID	OK121600020030_10	OK121600020070_00	OK121600030445_10	OK121600050150_00	OK121600050160_00	OK121600050180_00	OK121610000090_00	OK121610000050_10
USGS Gage Reference	07191200 & 07191220	07191200 & 07191220	07189542	07191200 & 07191220	07191222	07191222	07192000	07192000
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
87	22	7	8.4	15	2.5	1.49	0	0
88	21	6	8.2	14	2.3	1.37	0	0
89	21	6	8.0	14	2.0	1.19	0	0
90	19	6	7.9	13	1.9	1.13	0	0
91	18	5	7.7	12	1.7	1.02	0	0
92	18	5	7.5	12	1.4	0.84	0	0
93	16	5	7.2	11	1.0	0.60	0	0
94	15	4	7.0	9.9	0.6	0.35	0	0
95	13	4	6.6	9.1	0.2	0.14	0	0
96	11	3	6.1	7.6	0.1	0.04	0	0
97	8	2	5.7	5.6	0.0	0.0	0	0
98	5	2	5.0	3.7	0.0	0.0	0	0
99	0	0	4.4	0.0	0.0	0.0	0	0
100	0	0	2.9	0.0	0.0	0.0	0	0

APPENDIX C: State of Oklahoma Antidegradation Policy

Appendix C
State of Oklahoma Antidegradation Policy

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

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

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

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

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

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

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

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

785:46-13-1. Applicability and scope

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

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

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

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

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

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

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

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

785:46-13-2. Definitions

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

"Specified pollutants" means

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

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

(C) Phosphorus;

(D) Total Suspended Solids (TSS); and

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

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

(a) General.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX D: NPDES Discharge Monitoring Report Data

Appendix Table D-1 NPDES Discharge Monitoring Report Data

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0040479	1	9/30/2007	2400*	84.8		
OK0040479	1	11/30/2007			8	8
OK0040479	1	12/31/2007			<5	<5
OK0040479	1	1/31/2008			5	5
OK0040479	1	2/29/2008			11	11
OK0040479	1	3/31/2008			<5	<5
OK0040479	1	5/31/2008	360	185		
OK0040479	1	6/30/2008	480*	24.3		
OK0040479	1	7/31/2008	2200*	46.9		
OK0040479	1	8/31/2008	74	39.4		
OK0040479	1	9/30/2008	17	4.1		
OK0040479	1	11/30/2008			6	6
OK0040479	1	12/31/2008			<5	<5
OK0040479	1	1/31/2009			<5	<5
OK0040479	1	2/28/2009			6	6
OK0040479	1	3/31/2009			<5	<5
OK0040479	1	5/31/2009	973*	162		
OK0040479	1	6/30/2009	16	11.3		
OK0040479	1	7/31/2009	37	21.9		
OK0040479	1	8/31/2009	450*	21.2		
OK0040479	1	9/30/2009	2	1.4		
OK0040479	1	11/30/2009			<5	<5
OK0040479	1	12/31/2009			<5	<5
OK0040479	1	1/31/2010			10	10
OK0040479	1	2/28/2010			<5	<5
OK0040479	1	3/31/2010			<5	<5
OK0040479	1	5/31/2010	14	3.7		
OK0040479	1	6/30/2010	43	40.4		
OK0040479	1	7/31/2010	91	83.6		
OK0040479	1	8/31/2010	11	6.6		
OK0040479	1	9/30/2010	32	27		
OK0040479	1	11/30/2010			5	5
OK0040479	1	12/31/2010			10	10
OK0040479	1	1/31/2011			<5	<5
OK0040479	1	2/28/2011			11	11
OK0040479	1	3/31/2011			8	8
OK0040479	1	5/31/2011	2150*	2052*		
OK0040479	1	6/30/2011	991*	55		
OK0040479	1	7/31/2011	2	2		
OK0040479	1	8/31/2011	4	3.5		
OK0040479	1	9/30/2011	1100*	81.2		
OK0040479	1	11/30/2011			<5	<5

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0040479	1	12/31/2011			<5	<5
OK0040479	1	1/31/2012			6	6
OK0040479	1	2/29/2012			<5	<5
OK0040479	1	3/31/2012			<5	<5
OK0040479	1	5/31/2012	6	5.47		
OK0040479	1	6/30/2012	5	2.2		
OK0040479	1	7/31/2012	9	5.9		
OK0040479	1	8/31/2012	5	4.5		
OK0040479	1	9/30/2012	Not Received	Not Received		

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in Table 3-1.

APPENDIX E: DEQ Sanitary Sewer Overflow Data – 1990-2012

Appendix Table E-1 DEQ Sanitary Sewer Overflow Data

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Pryor Creek	S21623	10/3/1990		SE 2ND	900			Rain
Pryor Creek	S21623	3/6/1992	1	West Ninth Street	200	x		Air relief valve stuck with plastic
Pryor Creek	S21623	3/20/1992	1	608 Meadowview Circle	15000	X		Line blockage
Pryor Creek	S21623	3/20/1992	44	1/4 Mile S of South Mill on SW 9TH ST	200	X		Check valve failure at pump station
Pryor Creek	S21623	1/26/1993		PARK AND VAN		X		Heavy rainfall I/I
Pryor Creek	S21623	1/26/1993		NE 5TH AND ADAIR		X		Heavy rainfall I/I
Pryor Creek	S21623	9/6/1994	1			X		
Pryor Creek	S21623	6/7/1996	3	1809 Southridge				Line stoppage & clean out back yard
Pryor Creek	S21623	9/25/1996	2	PARK ST. & S. VAN	0	X		Rain and I&I
Pryor Creek	S21623	11/13/1996	3	1513 LAKEVIEW CIR.	500	X		Bad seam in mh
Pryor Creek	S21623	2/10/1997						Computer failure
Pryor Creek	S21623	2/19/1997	1	WWTF	40			Pump malfunction
Pryor Creek	S21623	7/25/1997						
Pryor Creek	S21623	8/29/1997	5	LAGOONS				Malfunction
Pryor Creek	S21623	1/8/1998	1	32 PAYNE ST.	25			Blockage
Pryor Creek	S21623	3/24/1998			4000	X		Line busted
Pryor Creek	S21623	3/30/1998		FIELD N. OF FACILITY	4,000			
Pryor Creek	S21623	4/14/1998	6	S. HOGAN		X		
Pryor Creek	S21623	4/17/1998	24	S. HOGAN ST.				Broken line
Pryor Creek	S21623	3/25/1999	3	N. OF FACILITY				
Pryor Creek	S21623	5/7/1999		WEST OF L.S. IN FIELD	600			Valve malfunction
Pryor Creek	S21623	12/9/1999	4	S. ELLIOTT & S.E. SECOND ST.	200			Drainage leak
Pryor Creek	S21623	11/13/2000	3	Brookfield Terrace & Cherry Point lane				Stoppage
Pryor Creek	S21623	8/26/2002	6	1/3 OF A MILE W. OF HWY 69 & S.E. 9TH	1,000	X		Corrosion in air valve
Pryor Creek	S21623	1/27/2003	0.5	1/2 MILE W. ON S.W. 9TH	1,000	X		Line broken
Pryor Creek	S21623	3/20/2003	1	ALLEY 1132 S.E. 14	200	X		Stopped main
Pryor Creek	S21623	9/25/2003	0.4					

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Pryor Creek	S21623	8/3/2004	1					
Pryor Creek	S21623	10/15/2004	0					Main break
Pryor Creek	S21623	12/19/2005	0	S.E. 2ND & ELLIOTT				
Pryor Creek	S21623	4/27/2006	9.4	1 mile W. of State HWY 69 on S.W. 9th ST.	4,500	X		Hole in force main
Pryor Creek	S21623	5/1/2006	1	305 S.E. 15TH	30	X		Blockage
Pryor Creek	S21623	7/12/2006	0					Stopped main
Pryor Creek	S21623	1/3/2007	0					
Pryor Creek	S21623	2/7/2007	1	COUNTY RD. N. S. 430	300	X		Pipe damage
Pryor Creek	S21623	6/1/2007	0					Blockage
Pryor Creek	S21623	6/11/2007	0					Rain
Pryor Creek	S21623	6/14/2007	0	S.E. 2ND & S. ELLIOTT				Rain
Pryor Creek	S21623	6/14/2007	0	PARK & S. MANN ST.				Rain
Pryor Creek	S21623	3/18/2008	8	S.E. 2ND & ELLIOTT ST.		X		Rain
Pryor Creek	S21623	4/10/2008	0					Rain
Pryor Creek	S21623	9/15/2008	3.5	S. ELLIOTT & S.E. 2ND		X		Rain
Pryor Creek	S21623	3/8/2009	8	WWTF		X		Broken line
Pryor Creek	S21623	5/1/2009	0					Rain
Pryor Creek	S21623	9/19/2009	0					Leaking main
Pryor Creek	S21623	4/25/2011	0	VANN & PARK ST.				Rain
Pryor Creek	S21623	4/26/2011	0					Stoppage
Pryor Creek	S21623	5/20/2011	0					Blockage
Pryor Creek	S21623	9/19/2011	0					Blown force main
Pryor Creek	S21623	2/7/2012	29.5	101-A EAST SIDE OF LAGOON	40,000	X		Debris
Pryor Creek	S21623	3/20/2012	0					Rain
Pryor Creek	S21623	3/20/2012	11.5					Rain
Colcord WWTF	S21618	3/24/1994	0.00	AT LAGOONS		X		Dike seepage
Kenwood WWTF	S21643	4/27/1993	0.00	AT THE LAGOON	3000	X		Pump station went down

APPENDIX F: RESPONSE TO PUBLIC COMMENTS

Scott A. Thompson
Executive Director

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Mary Fallin
Governor

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Response to the Public Comment Received for the Draft Bacterial and Turbidity TMDL Report for the Lower Neosho River Basin

April 3, 2014

Comment sent by via email from Ray West, Ph.D. , Water Quality Specialist; City of Tulsa:

The City of Tulsa appreciates the opportunity to comment on the draft Bacterial and Turbidity TMDLs for the Lower Neosho River Basin. Three of the eight streams in this TMDL are within the Eucha/Spavinaw Watershed – a critical source water watershed for the City of Tulsa. Tulsa supplies drinking water to nearly twenty percent of the Oklahoma residents and the ramifications of TMDLs on our stream water quality is always a concern for us. As you are aware, Tulsa is experiencing ongoing problems resulting from excess animal waste runoff from Animal Feeding Operations (AFOs). We offer the following comments and recommendations for your consideration.

1) Last sentence, last par., p. 3-9: The statement "They (Poultry Feeding Operations) generate dry litter and do not have any significant impact on the watershed." is not a correct statement. The phosphorus loading in this basin is primarily via runoff from poultry litter-applied pastures.

2) 3rd paragraph, 1st bullet item, p. 5-27: The first approach, "Remove the PBCR use", should not be considered and should be omitted in this report.

Response:

The statement that PFOs generate dry litter and thus do not have significant impact on the watershed is with respect to bacteria and turbidity. This report is meant to address potential bacteria and turbidity sources, not phosphorus, and PFOs were considered to have less impact. Nevertheless, the management plans for these facilities will be reviewed to identify further actions to reduce bacterial loads. No change was made.

Removing the PBCR use is one of the three basic approaches to Water Quality Standards revisions that may be considered. Although this approach may not be feasible in this case and possibly other cases, there are situations where it may be appropriate. It is included here to identify the range of possible approaches for informational purposes. No change was made.

Thank you for your comment.