Introduction

In November 2013 the City of Norman received notification from the Oklahoma Department of Environmental Quality (ODEQ) that a Total Maximum Daily Load (TMDL) completed for Lake Thunderbird had been approved by EPA (EPA approval date was 11-13-2013). The ODEQ letter required that Norman, as a Phase 2 MS4 Permittee, "incorporate all Total Maximum Daily Load (TMDL) requirements applicable to the storm water discharges into the City's Storm Water Management Program (SWMP)" and that the SWMP be modified within 24 months from the date of EPA approval (of the TMDL). The SWMP is to be modified in accordance with "Appendix E" of the Lake Thunderbird TMDL, which is titled "*MS4 Stormwater Permitting Requirements and Presumptive Best Management Practices (BMP) Approach.*"

This document provides the requirements of Appendix E compiled into two documents, a TMDL Compliance Plan and a Monitoring Plan. The Compliance Plan outlines the steps Norman will take to meet the TMDL requirements and the Monitoring Plan provides the framework for assessing progress towards meeting the goals of the Compliance Plan.

Approach

To achieve the WLA allocated to the City of Norman MS4 program, and meet the requirements of the TMDL, reductions of sediment, nitrogen and phosphorus are required. A watershed assessment was completed using a combination of GIS land use analysis, watershed modeling and unified stream assessments to help identify watershed issues, sources of pollution and to prioritize problem sub-watersheds. All this information was analyzed first from an overall watershed perspective (all of the Lake Thunderbird Watershed), then the focus was narrowed to examine just the Norman portion of the watershed.

The WLA and reduction requirements allotted to the City of Norman and the other MS4's on an average basis, are provided in the Table ES-1.

Table ES-1. WLA and Required Pollutant Reductions for the MS4's on an Average Annual Basis[1].

Pollutant	LTA Annual Load (lb)	Moore WLA (lb/Year)	Norman WLA (lb/Year)	OKC WLA (lb/Year)	LTA 35% Reduction	Moore Required Reduction (lb/Year)	Norman Required Reduction (lb/Year)	OKC Required Reduction (lb/Year)
TN	259,120	67,604	105,255	86,287	90,692	23,046	35,881	29,415
TP	50,900	14,715	19,866	16,319	17,815	5,011	6,765	5,557
TSS	25,336,800	5,493,018	10,689,596	9,151,652	8,867,880	1,872,570	3,644,083	3,119,798

[1]These average values can be converted to maximum daily load (MDL) values (for comparative purposes) using the same procedure presented in Section 5.5 of the TMDL report (Dynamic Solutions, 2013).

The TMDL Compliance Plan is largely based on the HSPF modeling completed for the TMDL by Dynamic Solutions using data from 2008 to 2009. Load reductions required to meet Norman's WLA were determined by applying various BMPs to the base HSPF model outputs for different land uses in each of Norman's sub-watersheds. HSPF modeling was used to address mostly structural BMPs applied to urban\suburban and rural land. In addition to the HSPF modeling, the Watershed Treatment Model developed by the Center for Watershed Protection (Caraco, 2013) was also used to determine potential reductions from non-structural BMPs.

Watershed Assessment

An assessment of the Lake Thunderbird Watershed was completed to supplement the information from the TMDL report and the HSPF modeling. The focus of the assessment was to better pin-point which sub-watersheds have potentially been contributing the most sediment and nutrients to Lake Thunderbird and the most probable major sources of those non-point source (NPS) pollutants within each sub-watershed. The assessment utilized GIS resources and field based unified stream assessment (USA) methodologies. The last sections of this assessment focus on specific findings for the City of Norman MS4 portion of the Lake Thunderbird Watershed. This narrower focus was accomplished by utilizing the watershed delineations found in the City's Storm Water Master Plan and grouping them into 6 sub-watersheds to create watershed sizes that were logical and manageable (Figure ES-1). The sub-watersheds depicted in the Figure are those that Norman has complete control over.

Priority Sub-Watershed Ranking

A priority matrix was developed to aid in determining which sub-watersheds were contributing the most sediment and nutrients to Lake Thunderbird and most in need of being addressed.

Scores were assigned to sub-watersheds based on a ranking of the top five sub-watersheds with the greatest apparent impacts (highest sediment load from bank erosion, worst buffer impacts, highest % urban area, highest sediment load predicted by HSPF, etc.).

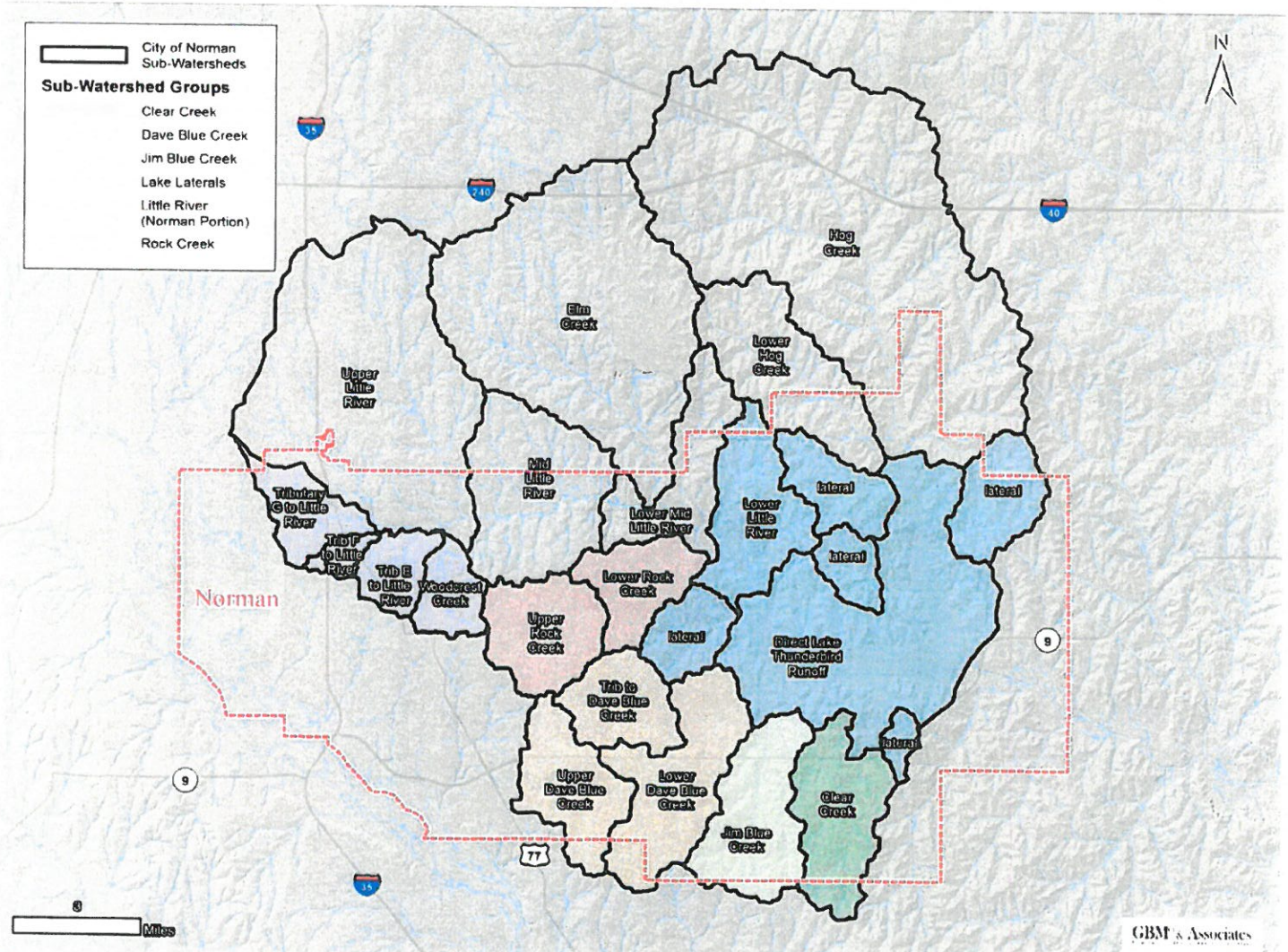

Figure ES-1. Norman MS4 Portion of the Lake Thunderbird Watershed and its Associated Sub-Watersheds.

This detailed matrix analysis aids in defining where priority areas are and what the key sources of pollution may be (Table ES-2).

Table ES-2. Total Scores and Matrix Ranking.

Severity Rank	Sub-watershed	Score
1	Little River (Norman portion)	30
2	Rock Creek	27
3	Dave Blue Creek	26
4	Jim Blue Creek	16
5	Lake Laterals	12
6	Clear Creek	10

According to the matrix ranking, the three key sub-watersheds within the Norman portion of the watershed most in need of source reductions are Little River, Rock Creek and Dave Blue Creek. These areas should be the focus of the first round of BMP implementation (Figure ES-2).

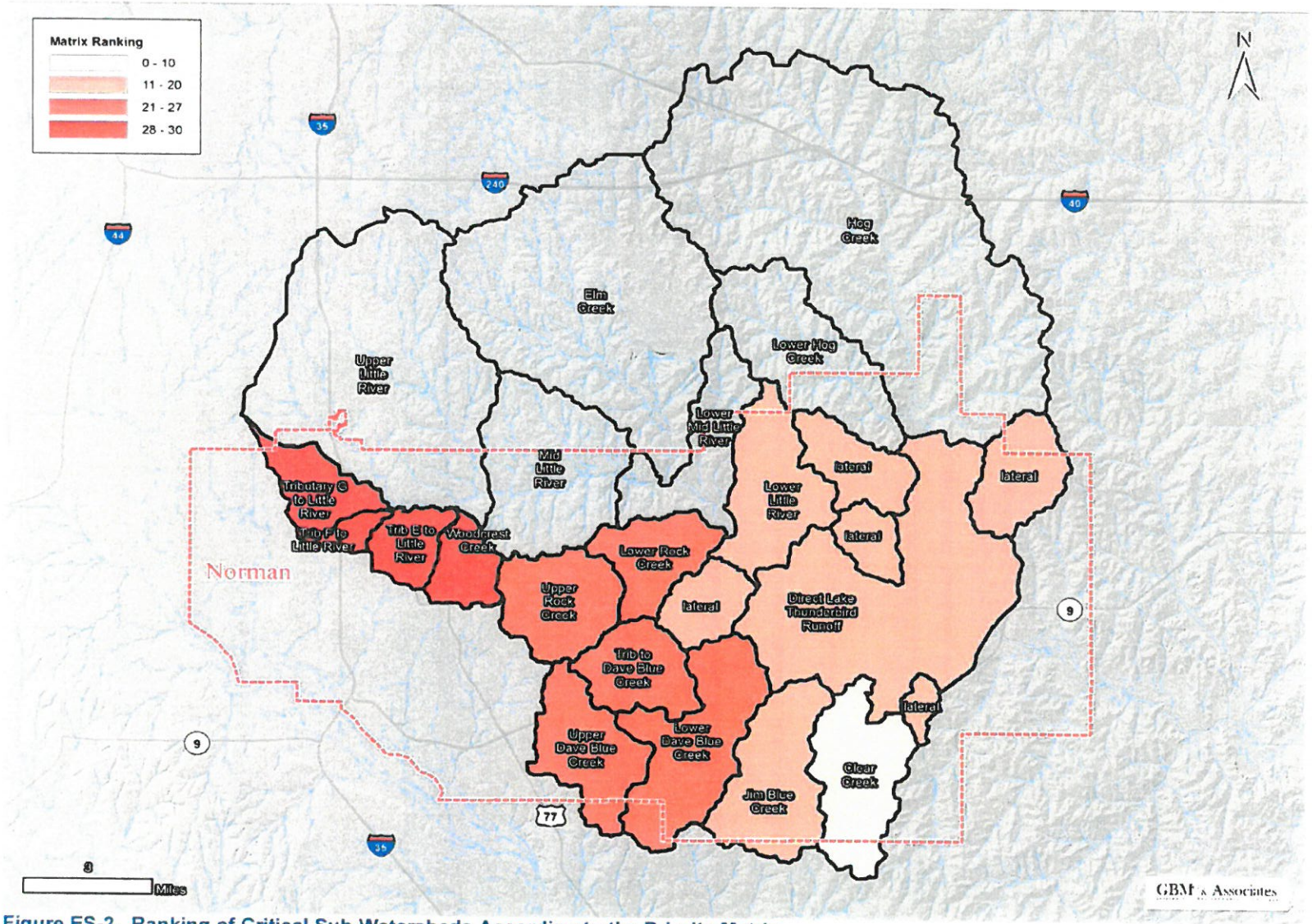

Figure ES-2. Ranking of Critical Sub-Watersheds According to the Priority Matrix.

Management Measures Already Implemented by Norman

The City of Norman has been implementing many good storm water management measures over the past few years. Several of these management measures have great potential to reduce pollutants in storm water. The City's Storm Water Master Plan (March, 2009) outlines many of their efforts including improving drainage and creation of several ordinances to protect streams and Lake Thunderbird. These ordinances have been written and approved by the City Council and are described briefly below.

- Water Quality Protection Zone Ordinance
- Storm Water Management Ordinance(s)
  - Detention/Retention
  - Illicit Discharge Detection and Elimination
  - SSO/CSO Identification and Reduction
- Fertilizer Ordinance(s)

Modeling NPS Load Reduction Potential

Two water quality models were used to determine the potential of different management practices to reduce TSS and nutrients in the Norman portion of the Lake Thunderbird Watershed. The Center for Watershed Protections Watershed Treatment Model (WTM) was used to model non-structural BMPs. The EPA supported HSPF model (Bicknell, 2001), which contributed to the development of the TMDL, was used to model urban/suburban BMPs and rural BMPs.

Non-structural BMPs

The WTM is used in this plan exclusively as a tool to determine which non-structural (education based and City program based) BMPs most effectively reduce TSS and nutrients in each sub-watershed. BMPs evaluated with the WTM include:

- Residential Lawn Care Education
- Pet Waste Education Programs
- Street Sweeping
- Catch Basin Cleanouts
- Septic System Education Programs
- Sanitary Sewer Overflow Repair

Structural BMPs

The latest version of HSPF and the base model UCI file, which was used to develop the TMDL, were used to evaluate structural (requiring construction and/or installation on the ground) BMP removal rates from various land uses in the Norman portion of the Lake Thunderbird Watershed. HSPF addresses load reductions from BMPs on a land use by land use basis.

These land use applications are provided in Table ES-3. A goal to apply BMPs on approximately 25% of each respective land use was established. This goal is based on practicality and the reality that to achieve BMP implementation on more than 25% of an area is unreasonable and likely unattainable.

Table ES-3. Percent of each Land Use to which a Particular BMP was applied.

Land use[1]	BMP Group	% Land use Applied
Urban/Suburban (URLD, URML, URHD)	Detention	25
	Bioswale	25
Commercial (URCOM)	Detention	25
	Bioswale	25
	Rain garden/barrel	15
Rangeland (RNGE)	Cover Crops	25
Row Crops (AGRL)	Cover Crops	25
Pasture/Hay (PAST)	Grazing	25
Grass-open space (BERM)	Bioswale	25

[1]Each land use category includes the code used in HSPF for that land use.

Other BMPS

In addition to the traditional non-structural and structural BMPs discussed in the preceding sentences other key BMP recommendations are discussed below.

Construction Storm Water

Storm water runoff from construction activity can significantly impact water quality in receiving streams. ODEQ regulates discharges of storm water runoff from construction related activity through General Permit OKR10. Through City ordinances, the City of Norman imposes regulations to reduce the impacts of construction activity within areas of its jurisdiction.

Unpaved Roads Management

Potential reductions of pollutants through implementation of good unpaved road BMPs on 50% of the unpaved roads in the MS4 watershed can have a significant impact on load reductions.

Riparian Buffers Restoration

Riparian vegetated buffers are lacking or limited in several reaches of Lake Thunderbird Watershed. Riparian buffers are critical to the health of a stream system and serve to reduce pollutant loads transported to stream systems from adjacent land uses and they reduce or prevent stream bank erosion. Riparian areas throughout the Lake Thunderbird Watershed should be restored or enhanced

Stream Bank and Channel Stabilization

Several of the streams in the Lake Thunderbird Watershed are exhibiting significant stream bank erosion at several locations. It is recommended that efforts be implemented to reduce and prevent stream bank and bed erosion within City of Norman controlled areas of the Lake Thunderbird Watershed. These efforts include measures designed to reduce erosive peak storm flows as discussed in other sections of this report as well as stream bank stabilization and/or remediation efforts where practicable. Where stabilization and/or remediation efforts are implemented, prioritization of efforts should be based on a cost-benefit approach.

Load Reduction Summary

A summary of the load reductions that would be achieved through this Compliance Plan are provided in Tables ES-4-6. Load reductions for sediment are primarily gained from stream bank stabilization, urban area BMPs and construction storm water improvement (Figure ES-3). However, load reductions for nutrients (nitrogen and phosphorus) are primarily gained from urban BMPs and rural BMPs.

Table ES-4. Summary of Annual Sediment Reductions from Implementation of the TMDL Compliance Plan.

BMP Group	Rock Creek (lb/yr)	Norman tribs to Little River (lb/yr)	Dave Blue Creek (lb/yr)	Jim Blue (lb/yr)	Clear Creek (lb/yr)	Lake Direct and Laterals (lb/yr)	Total/ Practice (lb/yr)
Annual Average Reduction Required for Norman: 3,644,083[1]							
Non structural	31,548	53,731	31,832	2,874.0	2,721.0	16,562.0	139,268
Urban/Suburban	91,764.0	334,065.0	117,153.0	22,909.0	29,812.0	101,477.0	697,180
Rural	26,125.0	26,825.0	53,377.0	12,986.0	12,952.0	39,437.0	171,702
Unpaved Road Maintenance	17,447.0	755.0	11,654.0	5,906.0	8,901.0	31,496.0	76,159
Construction SW	88,573.5	400,221.0	97,321.5	40,459.5	22,963.5	28,431.0	677,970
Riparian Restoration	316.0	180.0	707.0	616.0	502.0	671.0	2,992
Stream Restoration	469,703	563,644	469,703	140,911	140,911	93,941	1,878,812
Totals	725,477	1,379,421	781,748	226,661	218,762	312,015	**3,644,083**

Table ES-5. Summary of Annual Nitrogen Reductions from Implementation of the TMDL Compliance Plan.

BMP Group	Rock Creek (lb/yr)	Norman tribs to Little River (lb/yr)	Dave Blue Creek (lb/yr)	Jim Blue (lb/yr)	Clear Creek (lb/yr)	Lake Direct and Laterals (lb/yr)	Total/Practice (lb/yr)
Annual Average Reduction Required for Norman: 35,881[1]							
Non structural	513.0	863.9	648.5	465.0	440.0	2,678.0	5,608.4
Urban/Suburban	2,216.0	7,918.0	1,901.0	178.0	232.0	797.0	13,242.0
Rural	1,791.0	1,577.0	3,381.0	835.0	911.0	2,717.0	11,212.0
Unpaved Road Maintenance	5.3	0.2	3.6	1.8	2.7	9.6	23.2
Construction SW	27.1	122.5	29.8	12.4	7.0	8.7	207.5
Riparian Restoration	0.1	0.1	0.2	0.2	0.2	0.2	0.9
Stream Restoration	1,396.8	1,676.1	1,396.8	419.0	419.0	279.4	5587.0
Totals	5,949	12,158	7,361	1,911	2,012	6,490	**35,881**

Table ES-6. Summary of Annual Phosphorus Reductions from Implementation of the TMDL Compliance Plan.

BMP Group	Rock Creek (lb/yr)	Norman tribs to Little River (lb/yr)	Dave Blue Creek (lb/yr)	Jim Blue (lb/yr)	Clear Creek (lb/yr)	Lake Direct and Laterals (lb/yr)	Total/Practice (lb/yr)
Annual Average Reduction Required for Norman: 6,765[1]							
Non structural	71.3	136.7	91.3	77.0	73.0	442.0	891.3
Urban/Suburban	2,542.0	9,356.0	2,008.0	150.0	196.0	673.0	14,925.0
Rural	1,099.0	978.0	2,076.0	507.0	562.0	1,678.0	6,900.0
Unpaved Road Maintenance	2.8	0.1	1.9	1.0	1.4	5.1	12.3
Construction SW	14.3	64.5	15.7	6.5	3.7	4.6	109.3
Riparian Restoration	0.1	0.0	0.1	0.1	0.1	0.1	0.5
Stream Restoration							
Totals	3,729	10,535	4,193	742	836	2,803	**22,838[2]**

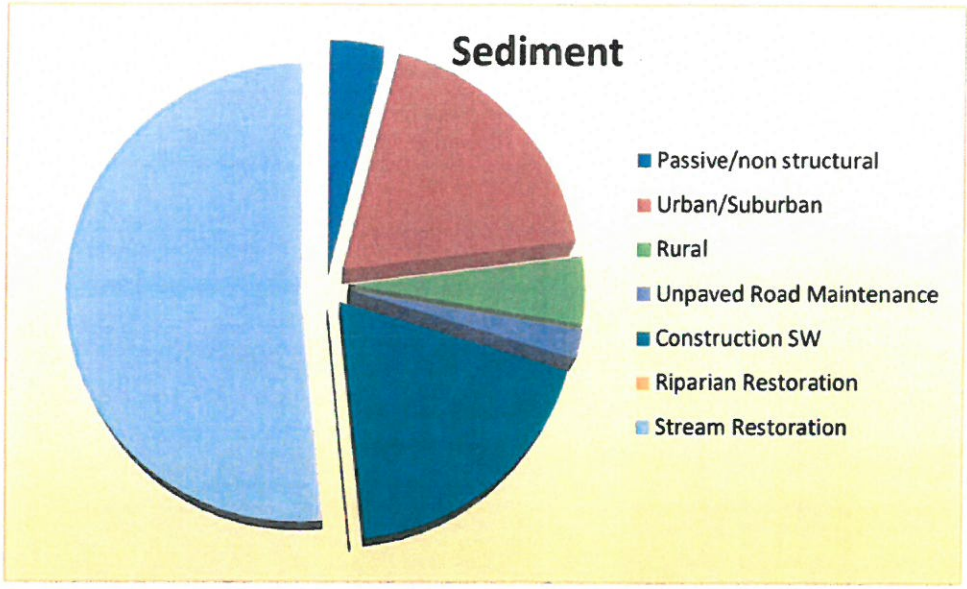

Figure ES-3. Sediment Reductions from Various Implementation Efforts.

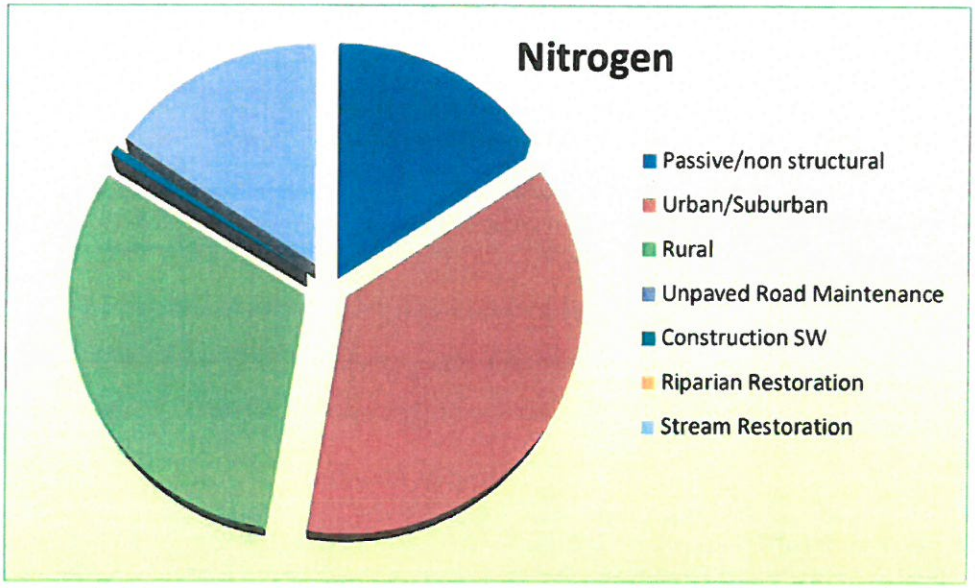

Figure ES-4. Nitrogen Reductions from Various Implementation Efforts.

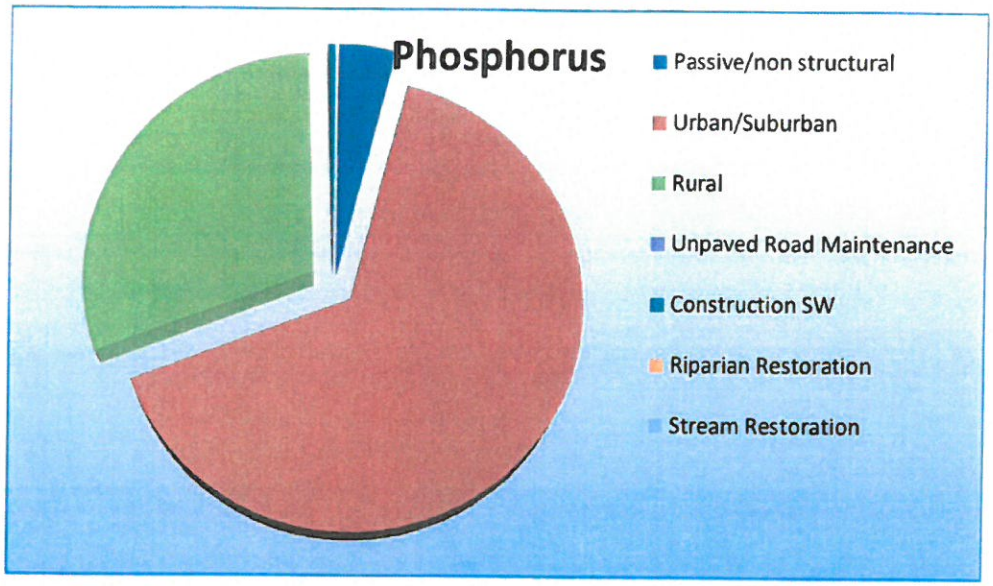

Figure ES-5. Phosphorus Reductions from Various Implementation Efforts.

Implementation

The implementation portion of this TMDL Compliance Plan is designed to direct watershed management activities, including: BMP implementation to achieve load reductions, monitoring water quality to track goal attainment, continuing education efforts, etc. The Compliance Plan should be reviewed and updated at least every 5 years to ensure it is still relevant to the current conditions of the watershed and is in line with the data that has been collected over the past 5 years of monitoring. In order to help ensure success of the plan it is necessary to have a schedule prioritizing implementation and listing the tasks that need to be accomplished. The schedule provides 15 years for actions to be accomplished that will result in attainment of the pollutant load reductions assigned to the City of Norman MS4.

The basic strategy to attain these goals is to begin monitoring immediately, address education and other non-structural BMPs in the first five years. Years five through ten will be used to reassess the loading status and the Compliance Plan applicability, and to phase in implementation of rural and structural BMPs. Full attainment of the TMDL by the end of 2031 is anticipated.

Table ES-7. Implementation Schedule[1].

Action Item	Target Date for completion[1]
Begin Compliance Plan implementation	January 1, 2016[2]
Begin monitoring according to the Monitoring strategy	March 1, 2016[2]
Develop strategy to implement passive BMPs	June 30, 2016
Implement education based BMPs	December 31, 2016
Develop Strategy to Address Construction Storm Water	December 31, 2016
Implement Construction Storm Water Plan	June 30, 2017
Implement other non-structural BMPs	October 30, 2017
Review past three years of monitoring data, set baseline and adapt Compliance Plan as needed	June 30, 2019
Develop Strategy to implement rural BMPs	December 31, 2019
Develop Strategy to implement urban/suburban structural BMPs	June 30, 2020
Work with landowners and implement Riparian Buffer Restorations	December 31, 2020
Review past five years of monitoring data, assess compliance status and adapt Compliance Plan as needed.	June 30, 2021
Implement first phase of rural BMPs in priority sub-watersheds	December 31, 2022
Implement first phase of urban/suburban BMPs in priority sub-watersheds	December 31, 2023
Implement second phase of rural BMPs in priority sub-watersheds	December 31, 2024
Review past ten years of monitoring data, assess compliance status and adapt Compliance Plan as needed.	June 30, 2026
Implement second phase of urban/suburban BMPs in priority sub-watersheds	December 31, 2026
Restore/stabilize stream banks in priority sub-watersheds	December 31, 2028
Implement third phase of urban/suburban BMPs	December 31, 2029
Restore/stabilize remaining stream banks	December 31, 2030
Review past 15 years of monitoring data, assess compliance status and adapt Compliance Plan as needed.	June 30, 2031
Implementation complete and TMDL met	July 1, 2031[3]

[1] Participation by landowners and funding are an unknown and could have a significant effect on the schedule and implementation success.
[2] Following approval by ODEQ
[3] Success based on results of final review of data and measurable milestone achievement.

Monitoring

A synopsis of the plan is provided here. Norman will monitor water quality through sample collection, physio-chemical measurement and flow gauging at key sub-watershed locations representing upper watershed areas where urbanization is greatest and lower watershed areas that are more rural. Monitoring will occur at each key sub-watershed station on a monthly basis, with a minimum of four samples focused on high flow events. New stream gauges (water level loggers) will be installed in key sub-watersheds and rating curves developed to calculate loading in those sub-watersheds. The Norman MS4 will use loading data (TSS, TN (as NO3-NO2-N and TKN), TP) collected in the future to compare to the loading data collected historically in their program and data collected during TMDL development. Annual loading from the Norman MS4 will be calculated from monitoring data and compared to their WLA to determine compliance. Load reductions or increases will be determined using the loading data, control charts and trend analysis. Norman may use control charts and trend analysis to gauge if the watershed loading is responding positively or negatively to load reduction efforts.

BMP effectiveness will be monitored in at least two of three ways:

1. Implementation of BMPs on the ground, and
2. Modeling of reductions from BMPs implemented, or
3. Monitoring of sub-watershed loads.

In addition, a rotating storm water outfall sampling program will be implemented such that 40% of large outfalls (36 inch or greater) will be sampled at least once annually. Monitoring parameters will be the same for these outfalls as for the sub-watershed monitoring locations.