WATERSHED BASED PLAN

FOR THE

LAKE EUCHA / LAKE SPAVINAW

WATERSHED

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PREFACE

Lake Eucha and Lake Spavinaw, in northeastern Oklahoma, are water supply reservoirs for a combined population of nearly 1 million people. The Eucha / Spavinaw watershed, covering 229,807 acres, spans the Oklahoma-Arkansas border, with approximately 60% located in Oklahoma (in Delaware and Mayes Counties) and the remainder in Arkansas (in Benton County). The major tributaries to Lake Eucha include Spavinaw Creek, Beaty Creek, Brush Creek, Rattlesnake Creek, and Dry Creek. Spavinaw Creek is impounded upstream of the Lake Spavinaw dam in order to form Lake Eucha approximately four miles away.

According to the Oklahoma Department of Environmental Quality (ODEQ) 2002 Integrated Report, both Eucha Lake and Spavinaw Lake are not supporting their Fish and Wildlife Propagation (Cool Water Aquatic Community) and Aesthetics designated uses. Causes of nonsupport include phosphorus and low dissolved oxygen for both lakes. In addition, Beaty Creek is listed on the 2002 Integrated Report as being impaired by pathogens, specifically *Enterococcus*. The excessive nutrient loading in the watershed and the resulting eutrophication of Lake Eucha is impacting the cities of Tulsa, Spavinaw, and Jay in Oklahoma, which depend on the lake to supply their populations with drinking water and recreation. Additionally, the City of Tulsa supplies drinking water to 7 other municipalities and 11 Rural Water Districts. Significant taste and odor problems have been linked to eutrophication in the lake, and complaints from water users have led to increased treatment costs and increased water quality monitoring.

Based on SWAT model results by Oklahoma State University (Storm et al. 2002), it is estimated that Beaty Creek and Spavinaw Creek supply approximately 85% of the phosphorus entering Lake Eucha and, subsequently, Lake Spavinaw. The phosphorus and bacteria in Beaty Creek likely originate from nonpoint source (NPS) pollution resulting from agricultural practices associated primarily with the poultry industry. In Spavinaw Creek, a combination of both point source pollution and NPS pollution results in high phosphorus levels.

Other than the problems discussed above, a 1997 Clean Lakes Study revealed that Lake Eucha and its tributaries are generally healthy. In fact, Lake Eucha ranks as one of the finest largemouth bass fisheries in the state and offers good channel catfish and crappie fishing. Fish flesh analysis revealed that the fish are free of notable levels of toxicants. The levels of pH, total dissolved solids (TDS), alkalinity, total hardness, total suspended solids (TSS), turbidity, conductance, sulfate (SO_4) and chloride (Cl) in both the lake and streams were comparable to the levels found in the area. Lake water samples were also generally free of excessive levels of health-threatening bacteria, although excessive levels of bacteria were found in one of the tributaries (Beaty Creek). The algal assemblage in Lake Eucha was typical of eutrophic lakes, and, overall, the benthic macroinvertebrate community was in fair condition.

In a draft TMDL by the ODEQ in 2003, modeling of the Eucha / Spavinaw watershed resulted in recommendations of a 95 percent reduction of total phosphorus to Lake Eucha and a 90 percent reduction of phosphorus discharge from the city of Decatur, AR, in order to produce acceptable chlorophyll-a water quality conditions (TSI=62 or less). Reducing the application of poultry litter to pastures, improving pastures, and reducing the discharge of the major point source in the watershed could dramatically improve the soluble phosphorus loading in the watershed, as well as the bacteria level in Beaty Creek, in a relatively short time frame.

The potential of BMPs to improve water quality in this watershed has been demonstrated in the Beaty Creek watershed. A paired watershed study was conducted comparing water quality in Beaty Creek before and after implementation of BMPs with Little Saline, where no BMPs were implemented. After implementation of BMPs, which included animal waste management, riparian management and improvement, pasture planting and nutrient management, offsite watering, and construction of heavy use areas for animal feeding and waste storage, phosphorus loading was 13% less than would have been expected without any BMP implementation. In addition, Beaty Creek showed significantly decreased levels of both *E. coli* and *Enterococcus*, which resulted in nomination for removal from the 2006 303(d) list for *E. coli* impairment (i.e., will be removed upon approval of the 2006 Integrated Report).

This plan refers to the expansion of actions similar to those in the Beaty Creek project, which are necessary to restore beneficial use support to both Lake Eucha and Lake Spavinaw, as well as Beaty Creek. Since most of the Spavinaw Lake watershed is composed of the Lake Eucha Watershed (Figure 1), and because 87% of the phosphorus load in Spavinaw Lake comes from Lake Eucha (OWRB 2001), most of the implementation to improve water quality in the watershed will be focused in the Lake Eucha watershed. Load reductions to Lake Eucha should significantly reduce loading to Spavinaw Lake as well, and BMPs implemented to address phosphorus should concomitantly improve the bacteria problem in the watershed.

INTRODUCTION

In 1997, a nationwide strategy to protect water quality was initiated which resulted in the development of the *Clean Water Action Plan* (CWAP). The CWAP established goals and implementation schedules for numerous strategies dealing with point and nonpoint sources. Oklahoma's Office of Secretary of Environment (OSE) was designated as the state lead agency to implement the provisions of the CWAP in Oklahoma. Under OSE's leadership, Oklahoma has successfully met the CWAP requirement to establish a *Unified Watershed Assessment* (UWA) strategy. Oklahoma's UWA is a written document whose development and implementation relied upon input from the state's UWA Work Group. Through the UWA process, the Work Group identified150 "Category I" watersheds in Oklahoma that were recognized as significantly impaired and in need of immediate federal and state funding to target restoration activities. Then, ten of these watersheds were targeted for immediate action to address NPS pollution. Lake Eucha was one of these high priority watersheds.

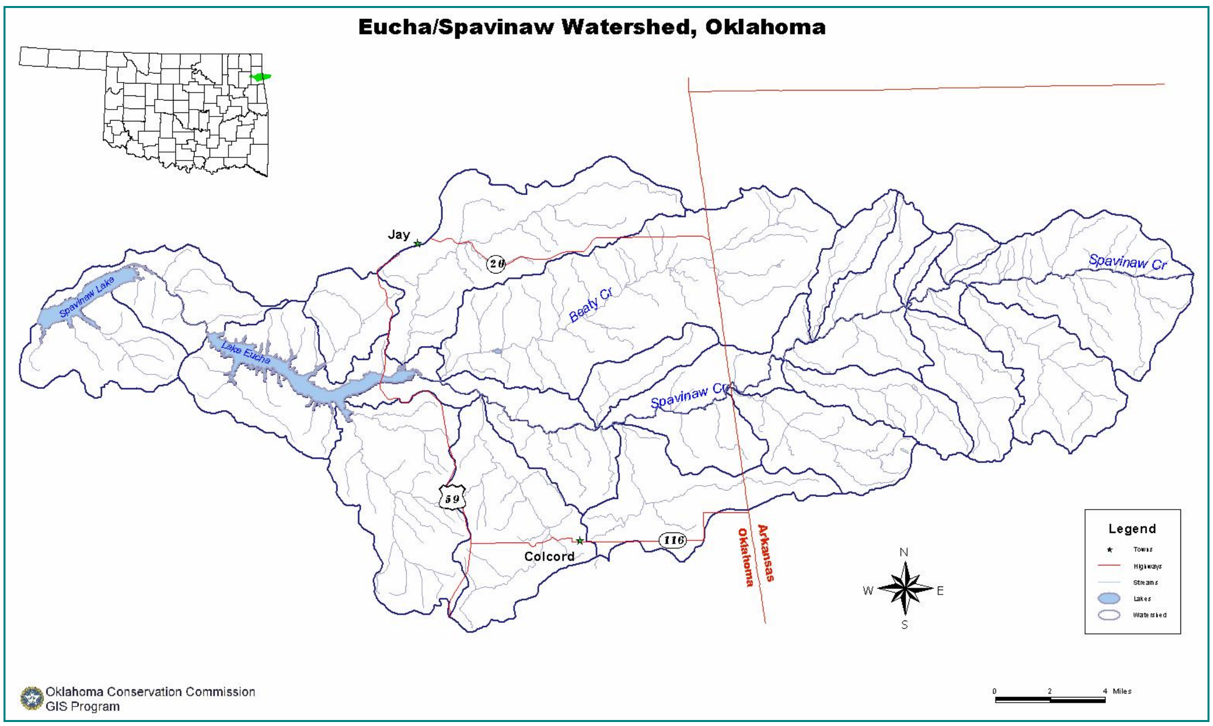


Figure 1. Location of Eucha/Spavinaw Watershed.

The Nonpoint Source Program and Grants Guidelines for States and Territories for FY 2004 and Beyond requires a *Watershed Based Plan* (WBP) to be completed prior to implementation using incremental funds. The guidance defines the 9 key components to be addressed in a watershed-based plan, much of which builds from the strategies outlined in the *Watershed Restoration Action Strategy* (WRAS). These components include: 1) identification of causes and sources that will need to be controlled to achieve load reductions, 2) estimate of load reductions expected from the management measures described, 3) a description of the management measures that will need to be implemented to achieve load reductions, 4) an estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources or authorities who will bear responsibility, 5) an information/education component that will be used to enhance public understanding of the project and encourage early participation in the overall program, 6) a schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious, 7) a description of interim, measurable milestones for determining whether control actions are being implemented, 8) a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made or whether the Watershed Plan or Total Maximum Daily Load (TMDL) needs to be revised, and 9) a monitoring component to evaluate the effectiveness of the implementation efforts over time.

In order for the WBP to become an integral part of the entire watershed restoration program, it must be amenable to revision and update. The Lake Eucha / Spavinaw WBP has been developed as a dynamic document that will be revised to incorporate the latest information, address new strategies, and define new partnerships between watershed shareholders. It is anticipated that at least biannual revisions may be necessary and that the responsibility for such revisions will rest primarily with the Oklahoma Conservation Commission (OCC), with support from the Office of the Secretary of the Environment (OSE) and the NPS Working Group. It is understood that the water quality goals set forth in this WBP, as well as the technical approach to address the goals, may not be comprehensive, so they may be expanded in the future. Federal and state funding allocations for future water quality projects designed to address the Eucha / Spavinaw Watershed problems should not be based solely upon their inclusion in this WBP; rather, the WBP should be considered a focal point for initial planning and strategy development.

CAUSES AND SOURCES

Watershed Characterization

The Lake Eucha / Lake Spavinaw watershed is located in Mayes and Delaware Counties in northeastern Oklahoma and in Benton County in northwestern Arkansas (Figure 1). The watershed includes Hydrologic Unit Codes 11070209050, 11070209040, and 11070209060. The principal stream in the Lake Eucha Watershed is Spavinaw Creek, which drains approximately 230,000 acres in Arkansas and Oklahoma (60% in Oklahoma). Spavinaw Creek is a tributary to the Neosho River, which is a tributary to the Arkansas River. Spavinaw Creek drains Lake Eucha and is impounded downstream to form Lake Spavinaw located approximately four stream miles downstream of the Eucha dam. Other major tributaries to Lake Eucha include Beaty Creek, Brush Creek, and Dry Creek (Figure 2).

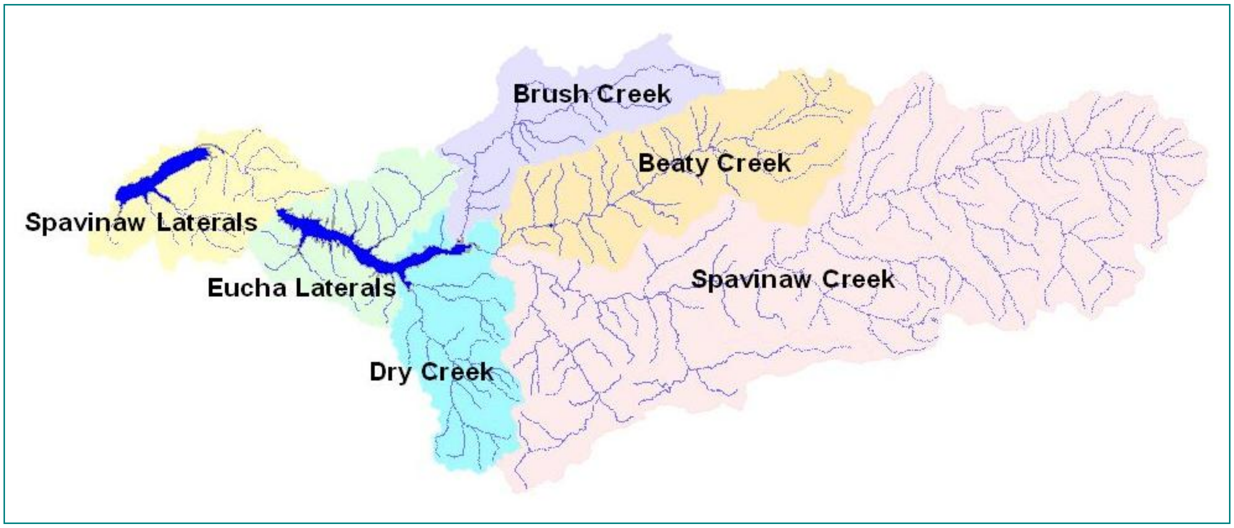


Figure 2. Major tributaries in the Eucha / Spavinaw watershed.

Physical / Natural Features: In Oklahoma, the Eucha / Spavinaw watershed lies in the Ozark Highlands and Central Irregular Plains level III ecoregions (Woods et al. 2005). The Ozark Highlands ecoregion is a highly dissected, partially forested ecoregion with many Karst features. The majority of this limestone plateau is predominantly an oak-hickory forest, but stands of oak and pine are also common. The maximum elevation of the Ozark Highlands in Oklahoma is about 1,500 feet and the maximum relief between hill crests and valley bottoms is about 400 feet. Soils are often cherty and have developed from carbonate rocks or interbedded chert, sandstone, and shale. Soil thickness can range from less than a meter to several meters, but generally soils are thin. Caves, sinkholes, and underground drainage occur, heavily influencing surface water availability, water temperature, and the potential for surface and groundwater pollution. Clear, cold, perennial spring-fed streams with gravel or bedrock bottoms are common. In addition, many small dry valleys occur where overland flow is entirely runoff-driven. Soil permeability can be as much as 15.0 cm/hr, resulting in a high potential for the leaching of dissolved constituents from the surface to ground water (Adamski and Pugh 1996). In general, ionic adsorption capacity of the ultisols of the Ozark Highlands is minimal. Thus, ionic constituents in infiltrating water are not readily absorbed by most soils and are easily flushed into nearby streams and shallow ground water (Adamski et al. 1995).

The Central Irregular Plains Ecoregion is a band of tallgrass prairie separating the forested Ozark Highlands from the Cross Timbers that is broken by limestone and sandstone cuestas, buttes, hills, and nearby level areas underlain by shale. Fire is required to maintain the grasslands. In its absence, woody plants such as sumac, blackberries, and persimmons will invade the grasslands. Geohydrology of the Central Irregular Plains portion of the watershed is characterized by soils derived from shale, sandstone, and limestone. In some nearly level areas, clay pan soils occur. On limestone slopes, exposed limestone slabs and gravels occur. Major streams have low gradients, meander considerably, and develop wide valleys except on areas of very hard rocks. Groundwater in the Central Irregular Plains tends to be saline and is more likely to be anoxic, as opposed to fresh, oxygenated groundwater generally found in the Ozark Highlands.

Three soil mapping units are identified in the Lake Eucha watershed: 1) Clarksville-Noark-Nixa--149,408 acres, or 66% of the watershed's area, 2) Clarksville-Nixa-Captina--70,060 acres, or 31% of the watershed's area, and 3) Craig-Dennis-Eldorado--6,892 acres, or 3% of the watershed's area (NRCS STATSGO). Erosion does not appear to be significant in the Lake Eucha watershed. The sediment load to the lake, which was calculated based on the TSS levels measured in the tributaries, indicate that the sediment load resulting from TSS was 7,058,581 kg during the study. This equates to only 68 pounds of soil eroded per acre in the watershed per year. Of course, this estimate does not take into account the bed load of eroded material carried by the stream. However, even if the sediment load indicated by the TSS levels equals only 10% of the total load, erosion would still be considered negligible. If the sediment load indicated by the TSS levels equals only 10% of the total load, then the total load would be 70,585,807 kg and equal 685 pounds of soil eroded per acre. It is generally accepted by the NRCS that from 1-5 tons may be eroded annually per acre of land to sustain crop production. The sediment load to Lake Eucha indicates that erosion in the watershed does not even approach levels considered significant according to NRCS standards (Wagner and Woodruff 1997).

The watershed area has a temperate climate (Adamski et al. 1995), with a mean annual temperature of 60^0Fand monthly mean temperatures ranging from 38^0F in January to 82^0F in July. Temperatures greater than 100^0F occur on average 15 days per year, temperatures above 90^0F occur on average 71 days per year, and temperatures below freezing occur on average 85 days per year. The prevailing wind is southerly. Spring is the wettest season, with an average of 38% of all rainfall occurs. Winter is the driest season with an average of 16% of the total rainfall. Total annual precipitation averages approximately 45 inches. The average annual snowfall ranges from 5-7 inches. Annual lake evaporation averages about 48 inches, with 72% of evaporation occurring during the months of May through October.

Land Use: According to Storm et al. (2002), landuse in the watershed can be described as:

- 2.6% row crop
- 51.3% forested
- 13.3% hayed pastures
- 23.1% well managed pastures
- 6.5% poorly managed pastures
- 0.1% brushy rangeland
- 1.3% urban
- 1.7% water

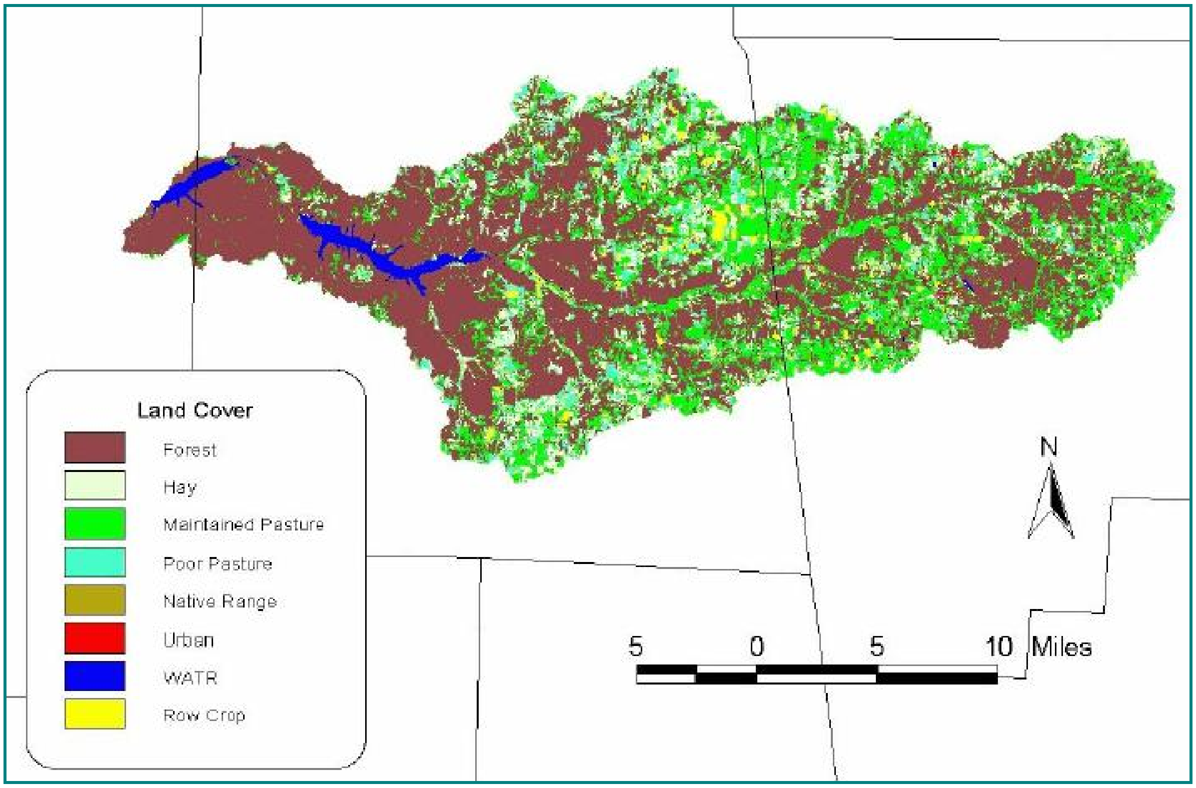


Figure 3. Landsat Thematic Mapper derived land cover for the Lake Eucha/Spavinaw basin. Source: Applied Analysis Inc. (Storm et al. 2002).

The major agricultural industry in the Oklahoma portion of the watershed includes cattle and poultry. The 1992 Census of Agriculture shows that poultry production in Benton County, Arkansas and Delaware County, Oklahoma increased drastically between 1982 and 1992 and continued to increase between 1992 and 2002 (Table 1). According to 2006 state permits from the Oklahoma Department of Agriculture, Food, and Forestry (ODAFF) and the Arkansas Soil and Water Conservation Commission (ASWCC), the Eucha / Spavinaw Watershed supports a poultry industry with the capacity to produce approximately 77 million birds annually. Along with these birds, more than 73,000 tons of litter are produced annually, containing over 1,300 tons of waste phosphorus (based on estimates by Everett, 2004).

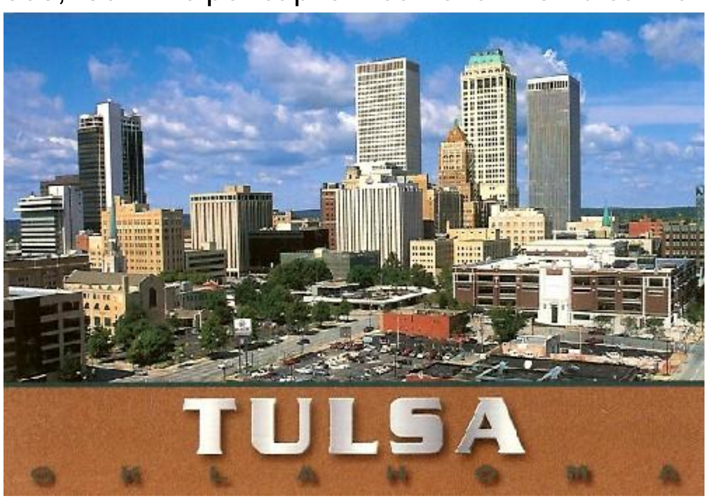
There are also a number of dairy and hog operations in the watershed. The 1992 Census indicates that hog and pig production increased significantly in Delaware County, Oklahoma, and the 2002 census figures show a three-fold increase from 1992. While the number of hogs sold in 2002 in Benton County is not available, statistics for 1997 indicate a 13% increase compared to 1992 data. Cattle production in both counties was fairly consistent between 1982 and 1992 and increased slightly in 2002 relative to 1992. The number of dairies has decreased in both counties.

Table 1. Numbers of livestock and poultry sold in Delaware County, OK and Benton County, AR in 1982, 1992, and 2002.

Ag Product Sold	County, State	1982	1992	2002
Cattle & calves	Delaware County, OK	28,236	30,830	40,251
Hogs & pigs	Delaware County, OK	39,936	85,007	285,661
Broilers & chickens	Delaware County, OK	10,798,137	26,359,308	37,154,935
Cattle & calves	Benton County, AR	48,032	50,465	54,172
Hogs & pigs	Benton County, AR	165,933	141,200	Cannot be disclosed
Broilers & chickens	Benton County, AR	53,914,589	93,596,018	128,066,609

Row crops comprise a relatively small percentage of landuse in this watershed (Figure 3). Row crop areas are typically managed as a winter wheat/green bean rotation, but corn for grain and silage, oats and rye for grazing, ryegrass, sorghum, soybeans, and sudangrass are also grown in the watershed.

Human Population: Lake Eucha is primarily used by the cities of Tulsa and Jay, Oklahoma for water supply and recreation. According to the Clean Lakes Study, an average of 16% of all recreational users came from Tulsa. According to the 2003 census, Tulsa has a population of approximately 387,807, although the metropolitan area has a population of 803,235. The per capita income for the Tulsa Metropolitan Area is $27,654 (USDC 2000).



An average of 25% of all recreational users came from Jay (Wagner and Woodruff 1997). Jay has a population of approximately 2,588 with a median family income of $21,875 (USDC 2000). An average of 33% of all recreational users came from other in-state communities (Wagner and Woodruff 1997). Total in-state recreational users made up an average of 74% of all lake utilization, while out-of-state users made up an average of 26% (Wagner and Woodruff 1997).

Additional statistics about the demographics around Lake Eucha are summarized below:

- County unemployment trends for Oklahoma show an overall decrease in unemployment rates between 1990 and 2000.
- Services and retail dominate private employment opportunities in Oklahoma Counties surrounding Eucha Lake.
- Delaware County is the sixth fastest growing county in Oklahoma, with a 4.4% growth rate between 2000 and 2003 (USDC 2000).

Waterbody Conditions: The physical attributes of Lake Eucha and Lake Spavinaw are given in Table 2.

Table 2. Summary of Lake Eucha and Spavinaw Lake morphometric features (OWRB 2002).

Parameter	Lake Eucha December 1999	Spavinaw Lake August 1999
Maximum Length	9.0 km	6.4 km
Maximum Width	2.04 km	1.67 km
Surface area	11.36 km^2	6.37 km^2
Capacity	93,602,155 m^3	32,562,903 m^3
Maximum Depth	25.6 m	14 m
Mean Depth	8.2 m	5.1 m
Median Depth	5.1 m	3.4 m
Relative Depth	0.67%	0.49%
Direction of Major Axis	NW-SE	SW-NE
Shoreline	77.8 km	43.7 km
Shoreline Development	6.50	4.86

According to a report evaluating the Eucha / Spavinaw Lake system (OWRB 2002), average outflow from Lake Eucha was 266,608 acre-feet per year. Inflow was estimated by adding outflow, water volume lost through evaporation, and water used for municipal drinking water, and then subtracting water volume gained from rainfall onto the lake surface. Using this method it was estimated that the annual inflow was 268,452 acre-feet per year. Rainfall onto the lake was estimated by multiplying the average precipitation of 45 inches per year by the lake surface area. Lake evaporation was estimated by multiplying the average annual lake evaporation for the area (48 inches per year) by the lake surface area. The mean water usage of Jay, RWD 1, the City of Tulsa offices, and the State Park for 1993-1994 was used to estimate the output for water supply. This figure does not include City of Tulsa water which is taken from Spavinaw Lake. Residence time, which was calculated by dividing storage capacity by outflow, was approximately 0.296 years or 3.6 months. Lake Eucha's hydrologic budget is:

	Volume (Ac-ft/yr)
Input	
Inflow	268,452
Rainfall	10,800
Output	
Lake Evaporation	11,520
Water Supply	1,124
Outflow	266,608

By taking this inflow volume and dividing it by the watershed acreage, the annual runoff for the area can be calculated. Estimates indicate that annual runoff from the Lake Eucha watershed is approximately 1.2 acre-feet per acre, which agrees well with USGS estimates of 1.0-1.25 acre-feet per acre for the area (OWRB 2002).

From USGS gauging data, it was determined that approximately 35% of total annual discharge results from base flow and 65% of total annual discharge was from storm flow. In addition, it was calculated from watershed size and annual runoff that Spavinaw Creek contributes 57% of total runoff, Beaty Creek contributes 17%, Brush Creek contributes 9%, Dry Creek contributes 6%, Rattlesnake Creek contributes 2%, and the remaining 9% is runoff from the unassessed area around the lake ("Eucha Laterals"). It is likely that springs discharge ground water directly into the lake, as they are common in the area. However, none are mapped and there is no data available to determine their hydrologic contribution to the lake. These springs are not considered to be major contributors to the total inflow to the lake.

Tables 3 and 4 compare certain hydrologic characteristics of both lakes.

Table 3. Inflow sources as percent of total for Lakes Eucha and Spavinaw (OWRB 2002).

	Precipitation	Eucha Dam	Surface Runoff	Groundwater
Lake Eucha	4.0	N/A	66.3	29.7
Spavinaw Lake	2.4	74.7	15.8	7.1

Table 4. Immediate groundwater and surface water drainage areas (acres) for Lakes Eucha and Spavinaw (OWRB 2002).

	Lake Eucha	Spavinaw Lake
Surface Water Drainage Area	203,902	47,206
Groundwater Drainage Area	215,670	49,930

Causes

The designated beneficial uses for Lake Eucha, Lake Spavinaw, and Beaty Creek include public and private water supply (PPW), fish and wildlife propagation--cool water aquatic community (CWAC), agriculture, primary body contact recreation (PBCR), and aesthetics. Both lakes have also been designated "sensitive public and private water supply" (SWS) and "nutrient limited watershed" (NLW). Sensitive public and private water supplies are prohibited from having new point source dischargers or increased loading from existing point sources without approval of the Oklahoma Water Resources Board. In addition, best management practices (BMPs) for control of NPS pollution should be implemented in watersheds of water bodies designated SWS (OWRB 2004a). Beaty Creek has a "high quality water" (HQW) designation, which indicates water quality that exceeds that necessary to support the propagation of fish and other aquatic life. This designation prohibits any new point source discharge or increased load or concentration from an existing point source which would lower water quality.

Both Eucha Lake and Spavinaw Lake are not supporting their Cool Water Aquatic Community (CWAC) and Aesthetics designated uses. Causes of nonsupport include phosphorus and low dissolved oxygen (less than 2.0 mg/L) for both lakes. Nutrients, especially phosphorus, in Eucha and Spavinaw Lake provide for excessive algae growth (TSI above 62) 32% of the time in Eucha Lake and 21% for Spavinaw Lake. In addition, Beaty Creek, a major tributary to Lake Eucha, is listed in the 2004 Integrated Report as being impaired by pathogens, specifically *Enterococcus*, and water quality monitoring indicates that Beaty contributes significantly to phosphorus loading in Lake Eucha (OCC 2006).

Sources

Modeling conducted by Dr. Dan Storm from Oklahoma State University (OSU) indicates that nonpoint sources (NPS) are the major contributors to the phosphorus exceedances in this watershed (Wagner and Woodruff 1997; Storm et al. 2001; Storm et al. 2002); however, one major point source is a significant contributor as well. Bacterial sources are likely to be NPS also, based on source-tracking research conducted in a similar watershed in the same county as Beaty Creek (USGS 2005).

The Soil and Water Assessment Tool (SWAT) subdivided the Eucha / Spavinaw basin into 68 subbasins (Figure 4) and considered the following factors: topography, soils, land cover, weather, slope, and ponds. Further explanation of the methodology for arriving at the load reduction goal can be found in the SWAT report (Storm et al. 2002).

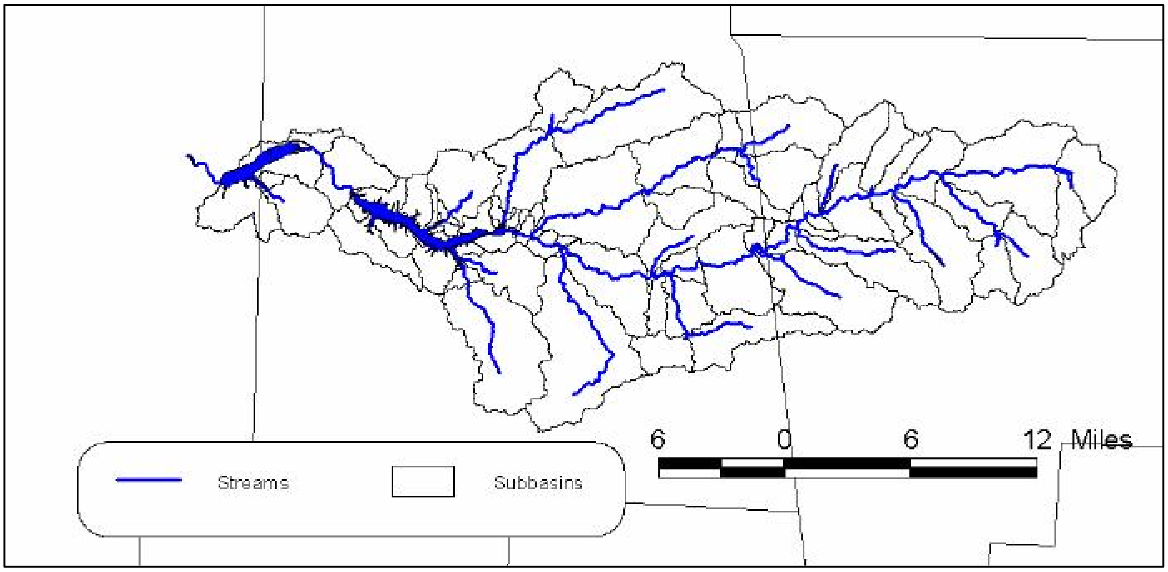


Figure 4. Subbasin layout used in SWAT model (Storm et al. 2002).

Point Sources

Point sources are defined as "discernable, confined, and discrete conveyances…from which pollutants are or may be discharged to surface waters" (EPA website). Point source discharges which are permitted through the national pollutant discharge elimination system (NPDES) can be grouped into three subcategories: municipal and industrial wastewater treatment dischargers (WWTPs), municipal and industrial stormwater dischargers, and confined/concentrated animal feeding operations (CAFOs).

One major municipal point source is located in the Lake Eucha / Spavinaw Basin: the City of Decatur, Arkansas waste water treatment plant, which receives waste from a poultry processing plant in addition to standard city wastes. Estimates of the Decatur NPDES discharge data from 2001 indicate that 11,600 kg of phosphorus were discharged a year to the Lake Eucha basin (OWRB 2001), and SWAT models estimate that 78% of this phosphorus reaches the lake (Storm et al. 2001). Since January 2006, however, the Decatur WWTP has reduced the amount of phosphorus in its discharge to a maximum of 1 mg/L. This should significantly reduce the point source loading to Lake Eucha. Gravette is the only other permitted point source municipal discharge in the watershed, but its nutrient contributions to Lake Eucha are considered inconsequential due to the quantity and intermittent nature of the discharge. Poultry operations of a certain large size are designated as CAFOs, whereas numerous smaller houses are not considered point sources but cumulatively have a large effect on phosphorus loading in the watershed. Poultry houses, regardless of size, are shown in Figure 6 (Storm et al. 2002).

Nonpoint Sources

Nonpoint sources are those which supply pollutants to surface water diffusely, rather than as a definite, measurable quantity at a single location. These sources typically involve land activities that contribute bacteria, sediment, and/or nutrients to surface water as a result of runoff during and following rainfall. SWAT modeling has indicated that nonpoint sources contribute significantly to the violations in the Eucha / Spavinaw watershed.

Rural Land Use

Poultry production and land application of poultry waste are significant sources of NPS pollution in this watershed; however, livestock in streams, riparian area destruction, and a small percentage of row crop agriculture also contribute to the NPS load in the watershed (Wagner and Woodruff 1997; Storm et. al. 2002). Land application of animal wastes is a common practice which can be misused. That is, waste may be applied at incorrect concentrations or at inopportune times, both of which may negatively impact water quality. Estimates of the current amount of litter being produced in this watershed range from 1,375 tons of waste phosphorus (based on 77 million birds and 73,000 tons of litter per year; ODAFF values and Everett 2004 estimates) to as high as 8,421 tons of phosphorus (based on 77 million birds and 481,000 tons litter annually; Joe Schneider and Eric Daniels, personal communication), depending on the frequency of poultry house cleanout. Regardless of the estimate used, poultry operations are significant sources of phosphorus in the watershed.

Pasture land is prevalent in the Eucha / Spavinaw watershed. Application of chicken litter to pastures allows increased forage production and, thereby, allows greater numbers of livestock to be produced per acre. Livestock grazing in pastures deposit manure containing fecal bacteria onto land surfaces, making it possible for both bacteria and nutrients to enter surface water with runoff. In addition, livestock often have direct access to waterbodies and may provide a concentrated source of fecal loading directly into streams and contribute to sediment loading as well. Livestock were found to be the primary sources of fecal bacteria in another study conducted in Delaware County (USGS 2005).

Figure 5 indicates the areas of highest phosphorus loading based on soil test phosphorus results incorporated into a SWAT model. Figure 6 shows the locations of poultry houses along with the litter application rate in the watershed. Although these predictions are subject to limitations, the estimates provide valuable information about areas contributing most significantly to watershed loading and suggest areas where incentives and other implementation programs should be targeted to have the greatest impact on water resources. Higher loading is evident from the eastern portion of the basin, which is expected due to higher soil test phosphorus (STP), litter application, and greater fraction of pasture and row crop than the rest of the basin.

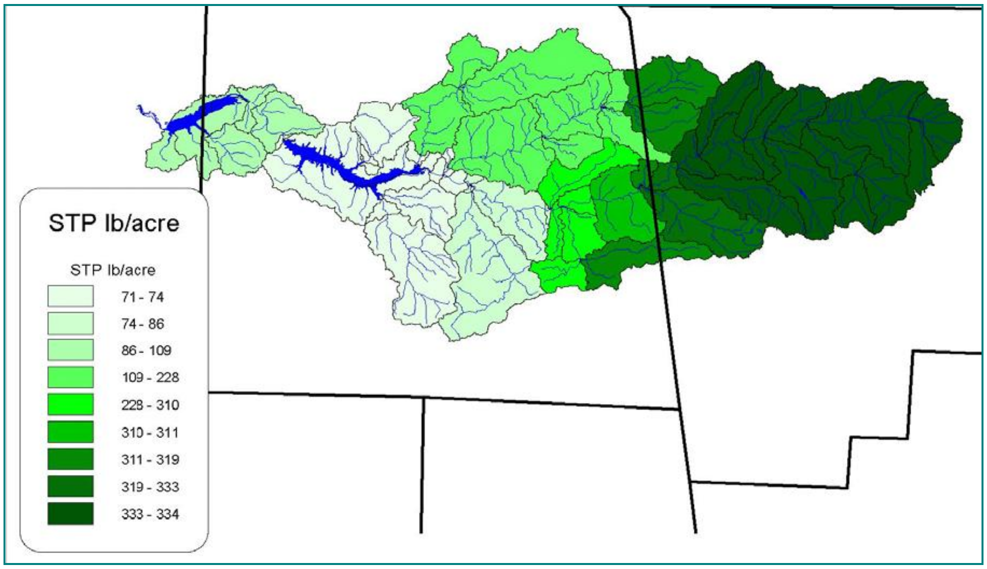


Figure 5. Average Lake Eucha and Lake Spavinaw Mehlich III soil test phosphorus (STP) for pastures by subbasin (Storm et al. 2002).

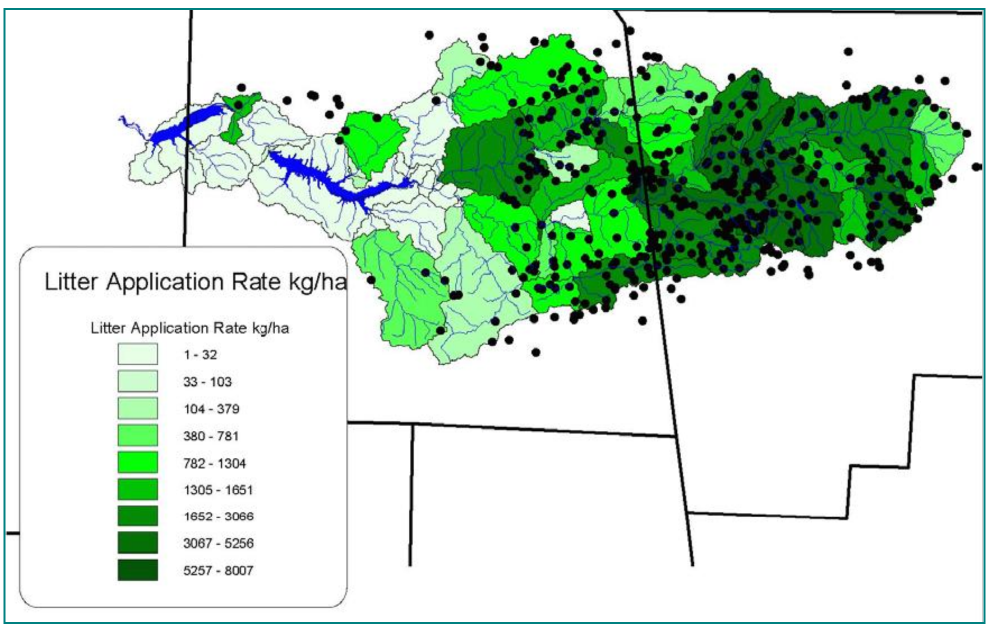


Figure 6. Litter application rates by subbasin, with poultry houses indicated by black dots (Storm et al. 2002).

Urban Land Use

Commercial fertilizer, pet waste, and soil erosion contribute the most significant portions of NPS loading from urban sources. Given the low population density (based on the US Census) in most of the Eucha / Spavinaw watershed, urban runoff is unlikely to be a major contributor to the bacteria and nutrient problem. However, since the population is increasing in Delaware County, urban runoff may need to be considered as a potential nonpoint source of pollution for the future.

Septic Systems

Failing septic systems can contribute to pathogen and nutrient problems in both groundwater and surface waters if leakage or illicit discharge occurs. Any loading of bacteria into the groundwater can enter surface water through seeps or springs. The SWAT model (Storm et al. 2002) found that poorly functioning private septic systems, although perhaps present in as many as 20% of watershed residences, contribute a relatively small portion of the load compared to the millions of livestock in the watershed.

Wildlife

Wild animals which produce fecal bacteria and have direct access to streams include deer, feral hogs, raccoons, other small mammals, and avian species. Based on a previous study in Delaware County which performed source tracking of fecal bacteria, livestock, rather than other animals, are likely to be the most significant source of bacteria in the watershed (USGS 2005).

Other

Unstable streambanks could contribute significantly to phosphorus loading in the watershed, especially since streambank soils are often high in phosphorus. Current monitoring suggests that as much as 48% (or 584 miles) of the streambanks in the watershed may be unstable. Background conditions in the soils of the watershed due to years of spreading litter onto fields are also a significant source of nutrients.

Relative contributions of sources

Storm and White (2003) determined the relative load allocations in the Eucha / Spavinaw watershed due to each landuse and by source of phosphorus occurring in the basin (Figure 7). Aside from the Decatur point source, row crops and pasture contribute the most phosphorus, so Figure 8 and Tables 7 and 8 break down the source, percentage, and estimated amount of phosphorus coming from row crops and pasture separately. It should be noted that the application of poultry litter over the past 40 years is ultimately responsible for the current soil test phosphorus (STP) levels. Tables 5, 6 and 7 indicate the percentages and estimated values of both total and soluble phosphorus loading to the watershed attributed to each source.

a) b)

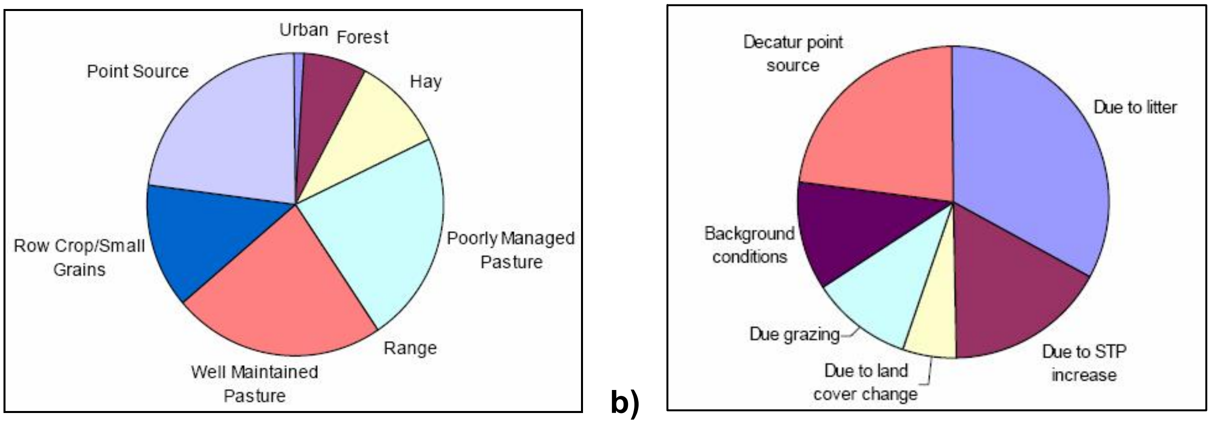


Figure 7. SWAT estimation of total phosphorus load allocation for the Lake Eucha/Spavinaw basin by a) land cover and b) source/activity (Storm and White 2003).

a) b)

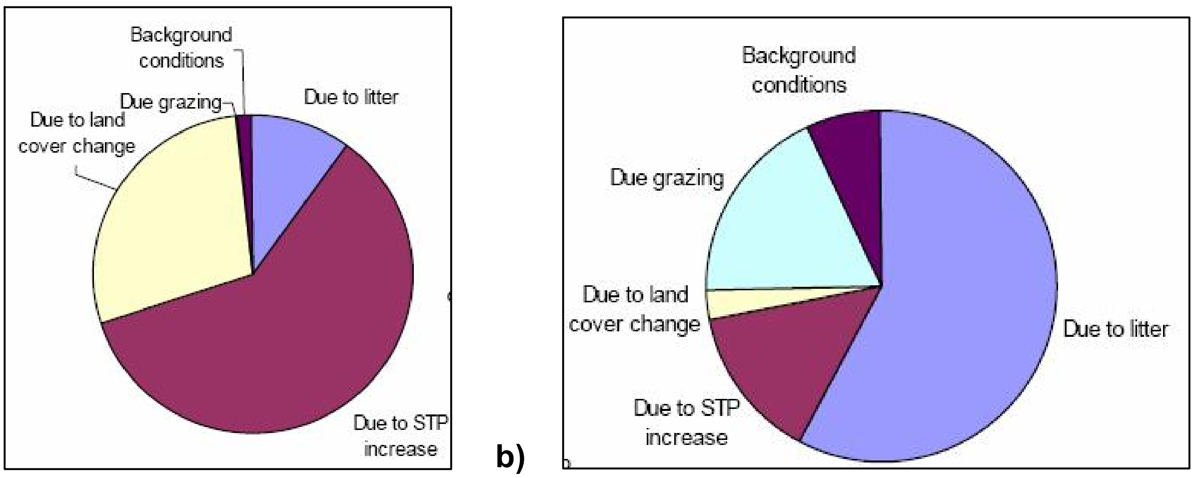


Figure 8. SWAT estimation of total phosphorus loading by source for a) row crop and b) pasture (Storm and White 2003).

Table 5. Phosphorus load allocation by land cover / source for the Eucha/Spavinaw basin as derived from SWAT model predictions for the period 1/1998 to 12/2001 (Storm and White 2003).

Land Cover	Area (%)	Background TP Load (Kg/yr)	Total P (Kg/yr)	Total P (%)	Soluble P (%)
Urban	1.3	106	521	1.00	1.10
Forest	51.3	3,553	3,553	7.10	3.70
Hay	13.3	571	4,894	9.80	13.40
Poorly Managed Pasture	6.5	292	11,280	22.60	11.50
Range	0.1	7	11	0.02	0.02
Well Maintained Pasture	23.1	1,094	11,575	23.20	32.70
Row Crop/small grains	2.6	91	6,598	13.20	1.60
Point Source	NA	NA	11,530	23.10	35.90
Total		5,714	49,962		

Table 6. SWAT predicted load by source for the Lake Eucha Basin by land cover (Storm and White 2003). Assumes point source is 90% soluble and is not modified by in-stream processes. STP indicates Soil Test Phosphorus.

Source	Total P			Soluble P		
	Total	Pastures	Rowcrop	Total	Pastures	Rowcrop
Due to litter	33.1%	57.0%	10.7%	40.7%	70.1%	16.3%
Due to STP increase	16.4%	14.0%	62.0%	8.2%	11.1%	81.3%
Due to STP/litter interaction	0.0%	0.7%	-3.0%	-1.4%	-2.4%	-3.6%
Due to land cover change	5.6%	2.6%	28.7%	4.9%	7.8%	-5.6%
Due grazing	10.3%	18.6%	0.2%	4.6%	8.0%	0.7%
Background conditions	11.4%	7.1%	1.4%	7.1%	5.4%	10.9%
Decatur point source	23.1%	N/A	N/A	35.9%	N/A	N/A

Table 7. Phosphorus load source by land cover for the Lake Eucha/Spavinaw basin . Derived from SWAT model predictions for the period 1/1998 to 12/2001. Assumes point source is 90 percent soluble and is not modified by in-stream processes (Storm and White 2003).

Source	Total P			Soluble P		
	Total	Pastures	Rowcrop	Total	Pastures	Rowcrop
Due to litter	16532	15827	705	11702	11628	74
Due to STP increase	8196	3888	4091	2352	1846	371
Due to STP/litter interaction	2	203	-200	-413	-397	-16
Due to land cover change	2818	720	1896	1418	1294	-26
Due grazing	5170	5155	15	1323	1319	3
Background conditions	5714	1957	91	2043	894	50
Decatur point source	11530	0	0	10337	0	0

Further detail about the estimation of causes and sources in the Eucha / Spavinaw watershed can be found in the SWAT model reports (Storm et al. 2002; Storm and White 2003).

LOAD REDUCTIONS

The ODEQ draft TMDL currently estimates that phosphorus reduction of up to 95% from nonpoint sources (NPS) and 90% from point sources may be necessary to restore beneficial use support to the watershed; however, the required load reduction may be less. As a first step toward improving the water quality in the Eucha / Spavinaw watershed, the ODEQ recommended the implementation of a phased TMDL with the initial reductions corresponding to those provided in the court settlement between the City of Tulsa and the poultry producers.

The City of Decatur, Arkansas, was required in the lawsuit settlement to reduce the output of phosphorus from its wastewater treatment plant to less than 1.0 mg/l, an 80% reduction.

Improvements are nearly complete to convert the plant from secondary to tertiary treatment, and the phosphorus output has been at or below the required limit since January 2006. Efforts to further reduce phosphorus loading from point sources are being researched. For example, a six-month trial of filters to remove phosphorus from sewage at the Siloam Springs, Arkansas wastewater treatment plant resulted in a phosphorus discharge of 0.025 mg/l. This indicates that improved technology may lead to significant reduction of nutrients from point sources, perhaps even surpassing the modeled reduction goal, assuming that cities are able and willing to fund such improvements.

Since the SWAT-estimated NPS reduction goal is so large, a goal of 50% reduction from NPS will be implemented initially. This corresponds to a reduction of 19,216 kg/yr. Once this target load reduction has been achieved, the waterbodies in the basin will be reassessed to determine the need for further load reduction. During this phased implementation period, the models can be further refined, and the water quality standards for anoxic volume and TSI should be reevaluated to determine if these criteria are appropriate. The SWAT estimated goals most likely strive to achieve water quality better than historical conditions; it is not apparent whether Lake Eucha ever consistently met the existing standards.

Nutrient budgeting showed 85% of Spavinaw Lake phosphorus to be from Lake Eucha, so improving the amount of phosphorus entering Lake Eucha should improve Lake Spavinaw. If phosphorus is reduced to meet water quality standards, the dissolved oxygen levels in the lakes should improve as well, so that the FWP--CWAC designated use should be attained. In addition, the BMPs recommended to reduce phosphorus loading should also work to reduce the pathogen level in Beaty Creek and elsewhere in the watershed.

Several studies have found correlations between sediment and bacteria (e.g., Whitman and Nevers, 2003). Significant correlations between bacteria and both turbidity and phosphorus were found for Beaty Creek, as indicated in Table 8, below. Similarly, for Little Saline Creek, significant correlations were found between bacteria and turbidity, as well as most nutrients (Table 8). These correlations indicate that, although the SWAT model data does not specifically address bacteria, it is expected that reducing the loading of nutrients and sediment should concomitantly reduce bacteria levels in the watershed.

Table 8. Significant correlations between bacteria and certain water quality parameters in Beaty and Little Saline Creek.

Site	Bacteria	WQ Parameter	p value (correlation significance)
Beaty Creek	*E. coli*	turbidity	0.000
Beaty Creek	*E. coli*	orthophosphorus	0.008
Beaty Creek	Enterococcus	turbidity	0.000
Beaty Creek	Enterococcus	orthophosphorus	0.007
Beaty Creek	Enterococcus	total phosphorus	0.000

Site	Bacteria	WQ Parameter	p value (correlation significance)
Beaty Creek	Fecal coliform	turbidity	0.000
Little Saline Creek	*E. coli*	turbidity	0.000
Little Saline Creek	*E. coli*	total phosphorus	0.025
Little Saline Creek	*E. coli*	TKN	0.019
Little Saline Creek	Enterococcus	turbidity	0.000
Little Saline Creek	Enterococcus	orthophosphorus	0.027
Little Saline Creek	Enterococcus	total phosphorus	0.042
Little Saline Creek	Enterococcus	ammonia	0.000
Little Saline Creek	Enterococcus	TKN	0.062
Little Saline Creek	Enterococcus	nitrate	0.010
Little Saline Creek	Fecal coliform	turbidity	0.000
Little Saline Creek	Fecal coliform	orthophosphorus	0.005
Little Saline Creek	Fecal coliform	total phosphorus	0.001
Little Saline Creek	Fecal coliform	TKN	0.004

BMPs which have been implemented as part of the Beaty Creek Project targeted at reducing nutrient loading have already been successful at reducing bacteria loads. Analysis of data before implementation compared to post-implementation shows significantly lower levels of both *E. coli* and *Enterococcus* (Figure 9). Continuation and expansion of these practices should result in further reduction in the larger watershed, with the ultimate goal of full attainment of the Primary Body Contact Recreation use for all waterbodies in the watershed.

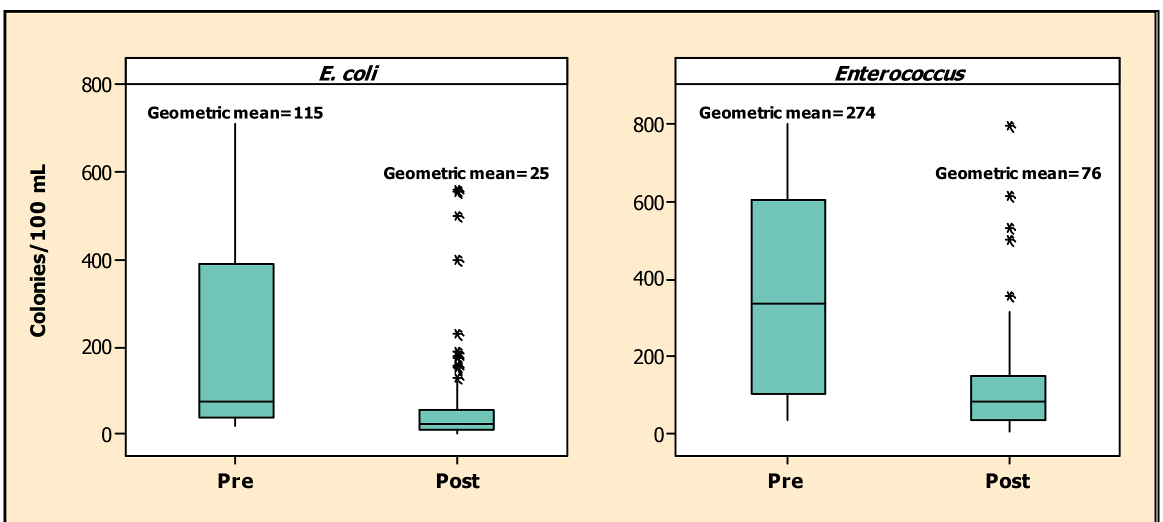


Figure 9. Boxplots indicate the interquartile range (25th-75th percentile) and median of Beaty Creek data in each of two periods: "Pre" contains data from August 1999-January 2001; "Post" includes data from July 2001-May 2005. Both *E. coli* and *Enterococcus* exhibited significant reductions in mean bacteria levels.

CRITERIA

Designated beneficial uses for Lake Eucha and Lake Spavinaw include public and private water supply (PPWS), cool water aquatic community (CWAC), agriculture, primary body contact recreation (PBCR), and aesthetics. Both lakes have “sensitive public and private water supply” (SWS) and “nutrient limited watershed” (NLW) designations as well. Both lakes exceed criteria for CWAC and Aesthetics due to phosphorus and low dissolved oxygen. In addition, Beaty Creek is not supporting the PBCR designation due to exceedingly high levels of *Enterococcus*. Only criteria relevant to waterbody impairment are presented below.

The initial goal of the WBP is to reduce the NPS loading to Lake Eucha of approximately 38,432 kg P/year to 19,216 kg P/year (50% reduction) and to decrease the point source loading from the Decatur WWTP to 1.0 mg/l phosphorus (80% reduction). Although this reduction is not predicted to result in complete designated use attainment, significant improvement should result once these goals are attained. Complete attainment, with a recommended 95% NPS and 90% point source load reduction, is based on the following criteria, according to Oklahoma’s Water Quality Standards (OWRB 2004b):

To attain **Aesthetics** use (for lakes of greater than 250 acres):

Nutrients (Phosphorus)

a) Must have a trophic state index (TSI) below 62, based on a minimum of 20 chlorophyll-a samples.

To attain **Fish and Wildlife Propagation--Cold Water Aquatic Community** use (for lakes of greater than 250 acres):

Dissolved oxygen (DO)

a) A minimum of 50% of the lake water column must have a DO concentration of at least 2.0 mg/L, based on a minimum of 20 samples **AND**
b) At least 90% of the surface samples, defined as the top 5 to 10 percent of the water column, must have a DO concentration of at least 5 mg/L (or 4.0 mg/L from June 16-October 15)

To attain **Primary Body Contact Recreation** use (for streams):

Samples must be collected during the recreation season, from May 1-September 30, and at least 10 samples are required to make an attainment assessment.

- Fecal coliform bacteria
  a) No more than 25% of total samples will exceed 400 colonies/100 ml
  b) Geometric mean of less than 400 colonies/100 ml
- *Enterococcus* bacteria
  a) No sample shall exceed 406 colonies/100 ml
  b) Monthly geometric mean of less than 33 colonies/100 ml

- *Escherichia coli* (*E. coli*)
    a) No sample shall exceed 406 colonies/100 ml
    b) Monthly geometric mean of less than 126 colonies/100 ml

These criteria stem from Oklahoma's Water Quality Standards (OWRB 2004a). The procedures by which the data must be collected and analyzed to verify whether or not these criteria have been met are identified in Oklahoma's Use Support Assessment Protocols (OWRB 2004b). Both of these documents fall under the jurisdiction of the Oklahoma Water Resources Board.

NPS MANAGEMENT MEASURES

SWAT models have allowed for estimation of load reductions expected from certain management measures. The strategies identified below should work together to achieve the initial NPS phosphorus load reduction goal of 50 percent, which should subsequently improve the dissolved oxygen in the lakes and help to reduce the bacteria loads in the streams. Although some strategies discussed below identify the load reduction expected with that particular strategy, it is recognized that not any one activity could realistically result in the required substantial phosphorus reduction; instead, numerous strategies will have to work together to achieve the desired result. It is anticipated that these programs and the goals themselves will change over time. Therefore, this document is not intended as the final, formalized plan, but rather one that should be updated, as needed, to reflect new information and new resources.

Since the time that the SWAT modeling was completed, most of the row crops in the watershed have been converted to pasture, some through the Beaty Creek implementation project with 319 funds, some through the EQIP program, and some simply due to market trends. From this practice alone, according to the SWAT model, phosphorus loads are expected to be reduced by nearly 50%; however, this value assumes the conversion of *all* row crops and the complete cessation of commercial fertilizer application on that land. In reality, fertilizer application is likely to continue on these converted pastures, and not all croplands have been converted, so loading reductions are expected to be less.

The most significant limiting factor to load reduction is current soil phosphorus concentrations in the watershed. Many soils in the watershed are supersaturated with phosphorus and will require many years (perhaps even decades) of depletion through leaching, crop harvest/export, and runoff to reach levels that do not contribute significantly to water quality problems. Of course, any reduction requires that additional phosphorus application to these soils be discontinued. However, over time, soil phosphorus levels should decline in the watershed. In addition to nutrient management plans that limit phosphorus application in the watershed, conservation planning must include practices that stabilize the soil and filter as much of the runoff as possible before it reaches the waterways. Therefore, a substantial amount of BMP implementation is recommended for the watershed.

All riparian and pasture areas in the watershed are critical areas, as these are where the bulk of the NPS loading is either derived from or delivered to the creek. The targeting exercises associated with the 2003 319 project have pinpointed the most critical of these areas, both through estimates based on GIS analysis and on-site verification. For example, Storm et al. (2005) modeled four different scenarios to target high phosphorus areas in the Spavinaw Creek watershed: 1) no litter applied—poor pasture condition; 2) no litter applied—good pasture condition; 3) commercial nitrogen fertilizer (no litter) applied—good pasture condition; 4) 3 tons/acre of litter applied—good pasture condition. The model showed that between 40% and 65% of the total phosphorus load from upland sources comes from just 10% of the basin, regardless of scenario. The average ranking across all scenarios was used to predict the 5%, 10%, and 20% of the basin with the highest phosphorus loss (Figure 10).

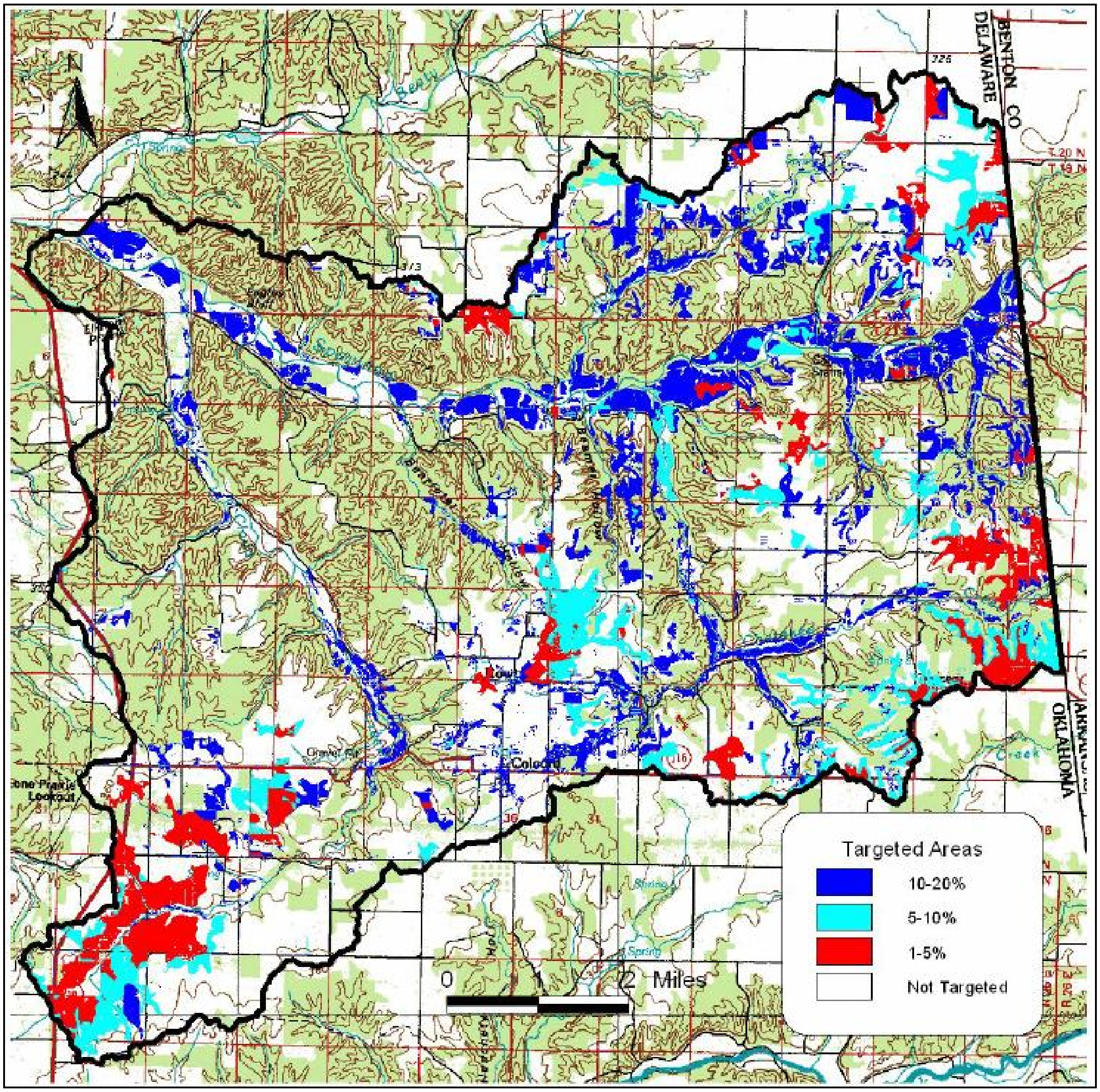


Figure 10. Targeted areas in the Spavinaw Creek Basin as predicted by SWAT (Storm et al. 2005).

For the purposes of designing an implementation effort to address identified sources, and given the phosphorus loading estimates from Storm and White 2003 and the ODEQ draft TMDL, the following assumptions have been made:

- Poultry litter, poultry production, production of other livestock, and some use of commercial fertilizers affect phosphorus loadings to hay, pasture, and rangeland.
- Background sources contribute close to fifteen percent of the total phosphorus load in the watershed.
- Streambank erosion was not modeled in the calculation of the TMDL and associated watershed modeling due to the lack of data on actual loading amounts from streambank erosion. Such data is currently being collected to allow for future adjustments to the models.

Possible management measures are listed in Table 9, along with the expected total NPS load reduction associated with that practice. Table 14 details both the short-term (interim) and long-term load reduction expectations.

Table 9. NPS Management Measures and expected load reductions.

Practice	Expected NPS Load Reduction (from SWAT)
Cease poultry litter application	20%
Row crop BMPs	6%
Convert row crops to pasture and cease fertilizer use	50%
Fencing of riparian areas	60-78%
Strip cropping / contour farming	up to 40%
Nutrient management plan / decreased litter application	10-15%
Pasture land BMPs (no litter, rotational grazing, pasture planting, terrace installation)	44%
Vegetated strips around urban streams	0.5%
Conservation easements around Lake Eucha (erosion control)	0.5-0.7%
Streambank stabilization	15%

Storm et al. (2001) modeled several different BMPs: litter application rate, soil test phosphorus, and grazing rate were varied and run through the SWAT model to assess the effectiveness of the practices. Litter application rate had a larger impact on nutrients than any other BMP simulated. Alterations to the current estimated grazing rate did not significantly reduce nutrient loadings, but doubling the grazing rate used in the calibration did have a significant effect on sediment-bound phosphorus. At the doubled rate, the amount of phosphorus loading increased dramatically, which indicates that over-grazed areas could be contributing far more than the same area would if the stocking rate were reduced.

Long term simulations were performed to estimate how average soil test phosphorus (STP) may change under different litter application rates (Storm et al. 2001). Plant growth depends on the litter as a source of nitrogen, so when litter application rates were reduced in the SWAT simulations, it was assumed that supplemental commercial nitrogen was used to maintain the current total nitrogen application rate. It is also likely that producers will use more commercial fertilizer if they reduce their litter application rates. The basin-wide STP for pastures was estimated at 250 lb/acre, based on actual soil test data. At the current litter application rate, the SWAT model predicted that the average pasture soil test phosphorus will increase by 50 lb/acre in 5 years and by 250 lb/acre in 24 years. A reduction of 18 lb/acre STP was predicted if no litter was applied for 30 years. The removal of phosphorus from the soil is dependent on management. For instance, exporting hay from the basin will remove more phosphorus than grazing, since the majority of the phosphorus consumed by cattle from grass is redeposited as manure. However, if the hay is fed inside the basin, the effect would be similar to grazing.

Two programs to accomplish BMP implementation in the watershed have been initiated. The first, the Beaty Creek Watershed project, was a 1998 319 large-scale demonstration project to reduce nutrients from NPSs. The project included monitoring, education, and demonstration components geared primarily towards reducing NPS derived nutrient input from poultry production and related activities. The project ultimately demonstrated $1,390,785 worth of best management practices (BMPs) throughout the watershed. Ninety-four producers cooperated in the program, 72 in Oklahoma and 22 from the Arkansas portion of the watershed. A variety of practices were implemented, including riparian areas, pasture management, nutrient management, septic systems, prescribed grazing, and heavy use areas. Preliminary analysis of water quality data indicated significant reduction in expected phosphorus loading. Implementation from this project is ultimately expected to reduce phosphorus loading to Beaty Creek by at least 30%, although these reductions may not be evident in water quality data immediately.

The second program, focused on the Spavinaw Creek Watershed, is part of an FY 2003 319 project in which specific areas in the Spavinaw Creek Watershed will be targeted for demonstration of Best Management Practices that can reduce NPS loads related to nutrients, siltation, suspended solids, and fecal bacteria. The practices that will be promoted in this area will focus on: 1) implementing the reduction goal for nutrient loading to the watershed in accord with the TMDL, and 2) implementing the objectives of this WBP. Best Management Practices will also be promoted that will reduce pollutants from the sources identified in the State's Integrated Report and pollutants identified in recent monitoring programs. The project in the Spavinaw Creek Watershed, like the project in the Beaty Creek Watershed, is not anticipated to meet all the needs for BMP implementation in the entire watershed, but rather is mainly demonstration purposes. Additional implementation, as detailed further in this document, will be necessary to meet the load reduction goals of the TMDL. Implementation from this project should reduce NPS phosphorus to Spavinaw Creek by at least 30%, although these reductions may not be evident in water quality data by the end of the project period.

An educational watershed advisory group (EdWAG) was established in 1998 as part of the Beaty Creek project in order to effect long term behavioral changes of watershed residents and users. The education program was designed so that it would assure protection of water quality in the entire Eucha watershed and continue past the life of the Beaty project. The EdWAG committee was comprised of local teachers, integrators/landowners, and conservation district staff from both Oklahoma and Arkansas. The public was educated through newsletters, brochures, school programs, meetings and demonstration tours, the Blue Thumb program, and seminars.

A wide range of audiences was reached, and behavioral changes are evident. In particular, more interest was shown in installing BMPs than there was funding for installation. Many cooperators were told about the project by their neighbors and wanted to participate. This local dissemination of information will continue, and programs such as the Blue Thumb volunteer monitoring program will help to formally inform and gauge the knowledge of the public in the Eucha/Spavinaw watershed.

In response to the lawsuit settlement, significantly less litter is being currently spread in the watershed, which should ultimately result in reduced loading to Lake Eucha. In addition, many producers have installed complementary best management practices through EQIP, 319, and other programs. However, it is not yet apparent how long the restrictions dictated under the settlement will be required. Should the settlement requirements lapse and not be replaced by other requirements, the amount of litter spread in the watershed will likely increase unless something else is done to address the problem. Public outreach will be crucial in producing lasting behavioral changes which will ensure successful, far-reaching nutrient load reductions.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

Funding needs are difficult to anticipate and will likely change over time. Currently identified funding needs focus on the following primary areas and are based on use of the PRedICT model (Evans 2003), with input from SWAT modeling of the watershed (Storm and White 2003). The estimated costs associated with the various implementation strategies are highly conservative and will likely change as targeting of the watershed is finalized and further information becomes available. In addition, funding for some of these efforts has already been identified and implementation is already underway; therefore these figures do not entirely represent additional funds needed. An initial estimate of the funds needed to address the primary load reduction strategies is seen below:

- The projects associated with installation of BMPs to reduce NPS loading are listed in Table 10. Overall implementation of BMPs to meet at least a 50% reduction in total load may require $20,000,000 -$120,000,000 (PreDICT model). The 95% NPS loading reduction suggested by the draft TMDL is probably not feasible. However, it is anticipated that, as soil phosphorus concentrations decrease over time, a 95% reduction will no longer be necessary to achieve attainment of all designated uses.

Table 10. Specific Projects/Efforts Identified for Implementation of Best Management Practices.

Task	Federal	State	Total	Agency	Status
Beaty Creek 319 Projects			$1,470,391	OCC and partners	Completed
Spavinaw Creek 319 Project	$522,260	$962,588	$1,484,848	OCC and partners	Ongoing
EQIP Program	$150,000 -$200,000 annually	$37,500 - $50,000 annually	$125,000 - $250,000 annually	NRCS	Ongoing
Stamper Project	$500,000	$358,684	$858,684	OCC and partners	Ongoing
Arkansas 319 Project	$31,309	$69,371	$100,680	ASWCC	Ongoing
Implementation of Soil Phosphorus Index for Litter application		$100,000 annually	$100,000 annually	ODAFF	Ongoing

Task	Federal	State	Total	Agency	Status
Lawsuit settlement CNMP development				Eucha Spavinaw Watershed Mgmt. Team and BMPs, Inc.	Ongoing
CREP Program	$9,775,085	$2,443,771	$12,218,856	USDA-FSA, OCC	Planned

- Upgrading the City of Decatur WWTP from secondary to tertiary treatment will likely require approximately $4,000,000. The improvements began in 2003 and are expected to be complete in the near future. The Decatur WWTP has been meeting the required 1.0 mg/L phosphorus output since January 2006.

- Maintenance of ongoing education and outreach efforts into the future will require $200,000 - $1,000,000 per year and is detailed in Table 11, below.

Table 11. Identified Education and Outreach Funding Efforts.

Task	Federal	State	Total	Agency	Status
Spavinaw Creek 319 Project			$119,000	OCC	Ongoing
Spavinaw Creek OWW Project			$25,624	OWRB	Ongoing
Nonpoint Source Education Program for Producers in Spavinaw Creek Watershed	$172,848	$116,120	$288,968	OSU Coop Extension	Ongoing
Soil Sampling Technique and Nutrient Variability Demonstration	$28,402	$18,935	$47,337	OSU	Ongoing
Poultry Growers and Litter Applicators Education Programs			???	ODAFF and OSU Extension	Ongoing

- Continuation of ongoing monitoring efforts in the watershed will require $200,000 - $1,000,000 per year, as specified in Table 12, below.

Table 12. Identification of Specific Monitoring Funding Needs.

Task	Federal	State	Total	Agency	Status
City of Tulsa Monitoring		$465,000	$465,000	COT	Ongoing
319 Beaty Creek Project			$82,230	OCC	Completed
319 Spavinaw Creek Project			$235,856	OCC	Ongoing
WQ Monitoring	$125,950 startup, $24,000 annually		$125,950 startup, $24,000 annually	USGS	Ongoing

- Computer modeling to assess the effect of implementation efforts is estimated to require $100,000 - $250,000 for the entire Eucha/Spavinaw watershed every five years. Table 13, below, indicates the amount that has been identified to date for the Spavinaw portion of the watershed.

Table 13. Specific Funding Identified for Computer Modeling.

Task	Federal	State	Total	Agency	Status
Spavinaw Creek 319 Project to Target NPS Pollution			$70,000	OSU and OCC	Ongoing

PUBLIC OUTREACH

Considerable resources have already been devoted to monitoring and preserving the water quality in the Lake Eucha watershed. Because Tulsa owns both source water lakes and is directly responsible for the quality of the treated drinking water, Tulsa will play a central role in developing, coordinating, and implementing watershed protection activities within the Eucha/Spavinaw Watershed, including public outreach programs. Tulsa will work closely with statewide programs and other focused education and public outreach programs initiated by other agencies.

The education component of the Spavinaw Creek Watershed Implementation Project will be guided and implemented by a full-time Project Education Coordinator employed by the OCC. The Education Plan developed by the Beaty Creek Educational Watershed Advisory Group in 1998 will be modified to develop an education plan for Spavinaw Creek Watershed. The Spavinaw Creek Plan will focus on specific educational goals which include:

(1) Work with Project Coordinator and Producer Education Specialist to allow producers in the targeted areas to tour the demonstration farm.
(2) Coordinate activities, when possible, with Producer Education Program (OSU Extension).
(3) Develop a series of demonstration farm tours for local citizens and youth.
(4) Develop a newsletter for the Spavinaw Creek Watershed landowners.
(5) Develop and present school educational component.
(6) Develop a display/exhibit for the project that can be used to educate the public on the 319 Program.
(7) Work with the Producer Education Specialist to plan and conduct educational meetings to include: tours, earth days, fairs, etc.
(8) Continue and expand the Blue Thumb program in the watershed conservation districts.
(9) Develop a recognition program for project cooperators.

(10) Work with OSU Cooperative Extension to employ a questionnaire to measure changes in behavior that might be a result of the project.
(11) Work with Benton and Washington County (Arkansas) Conservation Districts and Cooperative Extension Service to coordinate education activities.

The success of much of the water quality assessment and enhancement programs in the Eucha/Spavinaw watershed depends upon widespread public support and buy-in of stakeholders. A coalition of various local, state and federal agencies and organizations could provide the most efficient means to coordinate all activities in the Eucha Watershed. An organization called the Spavinaw Creek Working Group, coordinated by the Land Legacy, meets regularly to discuss issues in the watershed. This group includes representatives of State agencies, the City of Tulsa, U.S. Fish and Wildlife Service, Farm Services Agency, the Nature Conservancy, and the Special Master appointed by the lawsuit settlement. This group will serve a major role in coordinating the outreach program.

There are several statewide programs that are providing public involvement and education that will complement Tulsa's efforts. These include education programs offered through OSU Extension Service, Blue Thumb (through OCC), and Oklahoma Water Watch (through the Oklahoma Water Resources Board (OWRB)), as well as programs through ODEQ, Oklahoma Department of Agriculture, Food, and Forestry (ODAFF), and local programs through schools and local conservation districts. Tulsa also is an important participant in current public education programs within the Beaty Creek sub-watershed.

Through numerous meetings of the three work groups, as well as special meetings between industry and grower stakeholders and Tulsa staff, and perhaps reinforced by the lawsuit settlement, an unprecedented spirit of cooperation has been established between parties that have divergent interests in poultry production and animal waste disposal. These public outreach efforts have resulted in agreements from the principal integrators to supply technical data on animal production and generation and disposal of poultry waste. The integrators have actively pursued several alternative animal waste control measures such as detailed questionnaires to all growers about animal production and waste generation; use of alum in bedding to reduce phosphorus runoff; intensified research on phytase as a means to reduce phosphorus in feed; assisting growers with development of Animal Waste and Nutrient Management Plans; postponing spring clean-outs of poultry houses to reduce nutrient runoff; and direct funding of statewide education of growers and haulers as required by recent Oklahoma legislation. Integrators also contribute significantly towards varying efforts to reduce the impacts of the poultry industry including producer education, research into alternative uses and disposal methods for the litter, and toward the collection of environmental data necessary to monitor the impacts of pollution reduction strategies.

Early results from some of these efforts indicate promise for some and significant concerns for the use of other methods. At the same time, efforts to reduce the amount of litter spread in the watershed related to the lawsuit settlement have resulted in approximately 65% less litter being spread in the watershed in early 2004 than was previously spread in the watershed (John Everett, personal communication).

These early successes and lessons learned cannot be attributed to any one agency or work group; rather, they are the result of many months of careful planning and implementation of public outreach initiatives by Tulsa, its three work groups, and other entities. The focus to date has been on development of reliable data and reaching agreements on control of animal waste in the watershed. New public outreach initiatives are being developed to address stakeholder participation in implementation of BMPs for animal waste controls and other structural and non-structural practices to reduce nutrient loadings into the watershed. These include activities associated with the Spavinaw Watershed Implementation Project, similar efforts on the Arkansas side of the watershed, and numerous efforts to find alternative strategies for litter disposal.

The roles of the groups and programs which are collectively contributing to the public outreach efforts in the Eucha Watershed are summarized in no particular order below:

1. City of Tulsa (COT) and Tulsa Metropolitan Utilities Authority (TMUA)

   The City of Tulsa and TMUA continue to work to solve water quality problems in the Eucha Watershed. Whether it is through water quality monitoring to assess the problems, legal action against known sources, or land purchase for protective easements. At least bi-monthly meetings are held to discuss activities, review data, and plan strategies. The City and TMUA maintain an extensive water quality monitoring program in the Lake and Watershed. These groups are also actively pursuing efforts ranging from easement and land purchases to investment in watershed BMPs to address problems.

2. Spavinaw Creek Working Group

   The Spavinaw Creek Working Group includes representatives of the Land Legacy, the Nature Conservancy, the City of Tulsa/TMUA, US Fish and Wildlife Service, and the Oklahoma Conservation Commission. Additional groups that have been involved include NRCS and FSA, BMPs, Inc., and the Oklahoma Water Resources Board. The group currently meets at least quarterly to discuss ongoing activities in the watershed and develop strategies to address priority issues in the watershed. This group will expand as necessary, to include the necessary partners to insure that all watershed interests are heard, and that all watershed interests are kept informed. Although BMPs, Inc. represents the Special Master of the Court and the poultry integrators, these groups, in addition to cattlemen, dairymen, swine producers, poultry growers, certified litter cleanout experts and litter haulers, homeowners, and recreational users will be included in the group. In addition, the group will expand to include ODAFF, ODEQ, and OSU Cooperative Extension.

3. Eucha-Spavinaw Watershed Special Master and BMPs, Inc.

The settlement agreement between the City of Tulsa and the Poultry Integrators required that a Special Master be appointed to serve as a liaison between the court, the two parties, and, in effect, the poultry growers of the watershed. The Special Master was to establish a team of water quality specialists who would be responsible for ensuring that litter was being managed according to the letter of the settlement and the will of the court. These water quality specialists are responsible for collecting soil samples from throughout the watershed anywhere the landowner desires to spread litter. The Special Master and his team then develop a Nutrient Management Plan (NMP) that determines the rate at which litter can be spread and other management practices that must be employed.

In addition, the Special Master's team works closely with BMP's, Inc., a group responsible for ensuring that additional avenues of reducing the amount of litter spread in the watershed (including litter transport outside of the watershed, alternative uses and markets for the litter) are explored and implemented. Both the Special Master and BMP's, Inc. are funded by the Poultry Integrators, as established in the lawsuit settlement.

4. Oklahoma Department of Agriculture, Food, and Forestry (ODAFF) Website

The ODAFF established a toll-free poultry litter hotline in 1998 to match buyers and sellers of poultry litter. The hotline was established to develop mechanisms for marketing excess animal waste in the impaired watersheds (e.g. Eucha/Spavinaw) to areas that can benefit from land application of litter. Interest in the hotline waned substantially since its development and it is largely maintained at this point as a website.

The ODAFF hotline is also available on OSU's Cooperative Extension Service web site at www.dasnr.okstate.edu/poultry/haul.htm. Poultry growers in the Arkansas portion of the Eucha/Spavinaw Watershed are encouraged to contact the ODAFF hotline regarding export assistance. ODAFF maintains information concerning Arkansas sources of litter through the voluntary assistance of private individuals, since the ODAFF cannot directly target Arkansas growers who may have litter to sell. BMPs, Inc. will provide information to be listed on the website about certified haulers, and, as they are willing, producers seeking to sell their litter as well as landowners interested in purchasing litter.

The ODAFF Water Quality Forester for the region will also play a key role toward developing an education program that focuses on environmentally sound silvicultural practices for the watershed.

5. Beaty Creek Watershed Advisory Group (WAG)

The Beaty Creek Watershed Advisory Group (WAG) was an advisory group established by the OCC to meet one of the requirements of the OCC's 319 Water

Quality Program in Beaty Creek, an important NPS tributary in the Eucha/Spavinaw watershed. The purpose of the WAG was to give guidance on the 319 program that the OCC will be implementing in the Beaty Creek Watershed. The OCC Beaty Creek 319 program was a demonstration and implementation project which offered land owners the opportunity to implement BMPs that would enhance water quality in Lake Eucha. The WAG also put into place an educational program that took a "show and tell" approach to the public in the entire Lake Eucha Watershed. The WAG was made up of fourteen members from Oklahoma and Arkansas and included the Mayor of Tulsa and a Tulsa staff person.

The WAG recommended a series of practices and cost-share rates to be offered as part of the Beaty Creek BMP demonstration effort. Those recommendations, with slight alterations based on performance in the Beaty Creek project, will be utilized in the Spavinaw Creek 319 Watershed Implementation Project and will form the basis of the ultimate plan for necessary BMPs to meet TMDL load reduction goals. In addition, the interests represented by this WAG should be represented in the Spavinaw Creek Working Group.

6. Oklahoma State University (OSU) Cooperative Extension Service

OSU has a website on Animal Waste Nutrient Management which provides all the background information needed for developing Nutrient Management Plans and Animal Waste Management Plans. OSU organized the High Plains Animal Waste Management Conference in March 1999. As required by recent Oklahoma legislation on poultry production, approximately 1200 growers have received training from OSU. The training includes general background on water quality and NPS impacts as well as descriptions of BMP options and implementation resources. The OSU Cooperative Extension will also work with the Arkansas Cooperative Extension Service to develop an overall producer-education program for the watershed that will focus on poultry production, grazing management, riparian protection, silviculture, and overall nutrient management.

OSU Cooperative Extension Service will also develop, in cooperation with the OCC, a demonstration farm in the Spavinaw Creek Watershed. This farm will be open to landowners from throughout the Eucha Watershed and will demonstrate all the types of BMPs that will be offered through the Spavinaw Creek Project. These practices were originally recommended by the Beaty Creek WAG, although some changes in the WAG's original recommendations will be implemented based on performance during the Beaty Creek Project. The farm will also maintain records to document economic impacts of implementing these practices.

7. OSU Web Page for Litter Marketing

In 1998, OSU's Department of Agricultural Economics established the Oklahoma Poultry Litter Line web page ". . . to promote better understanding of the movement and application of poultry litter in Oklahoma." This market web site is designed for agricultural producers wanting bulk amounts of poultry litter as a soil fertilizer and/or soil amendment. The web address is www.dasnr.okstate.edu/poultry/haul.htm and includes a list of contract haulers.

8. OSU Publications and Fact Sheets

OSU has developed several fact sheets including: (1) "Using Poultry Litter as Fertilizer", (2) "Soil Quality and Animal Manure", and (3) "Manure and Raising Soil pH". Other publications include a water quality driven soil handbook, "Oklahoma Soil Fertility Handbook". OSU will also produce a promotional video on poultry litter management and utilization that will support the marketing and export of poultry litter. Specific instances of loading, trucking, and spreading of poultry litter will be covered.

9. NRCS Local Offices - Oklahoma and Arkansas

The United States Department of Agriculture Natural Resource Conservation Service (USDA/NRCS) in Arkansas and Oklahoma have been involved with the Eucha/Spavinaw Creek Priority Area for the Environmental Quality Incentives Program (EQIP). This is a joint venture for Oklahoma and Arkansas. The NRCS designated the Eucha watershed as an EQIP Priority Area for FY 1998. Funds are available through the NRCS to implement practices intended to reduce phosphorus loading to Lake Eucha. An Education Plan was developed under EQIP, and included: 1) development of Animal Waste Management Handbooks (2000); 2) purchase of a Table Top Display unit for use in educational workshops to highlight water quality and conservation practices; 3) organization of an annual tour for producers to visually see the results of BMPs and effects of proper waste application; and 4) development of a Grassland/Wildlife Handbook for use in watershed protection. NRCS is in the process of adding an incentive payment to the EQIP program to facilitate litter transport out of nutrient sensitive watersheds such as Eucha/Spavinaw.

10. Local Conservation District Offices - Oklahoma and Arkansas

The OCC has obtained additional 319 funds to develop a demonstration project in the Spavinaw Creek Watershed to build from the success of the Beaty Creek Watershed Implementation Project. This is a demonstration project in the Spavinaw Creek Sub-basin that will demonstrate the effectiveness of BMPs. The intent of this project is to demonstrate the benefits of proper animal waste application on the water resources of the Lake Eucha watershed. The public outreach objectives of the project are to: 1) promote consistency in animal waste plans written in Oklahoma and Arkansas; 2) promote protection and re-establishment of buffer zones and riparian areas; 3) provide technical assistance to producers in the development of total resource conservation plans; 4) provide educational assistance to producers through producer meetings, workshops, and individual contacts; and 5) demonstrate management practices in the Spavinaw Creek watershed to achieve the nutrient control needed to protect Lakes Eucha and

Spavinaw.

11. Arkansas Soil and Water Conservation Commission (ASWCC)

In 1998, the ASWCC obtained 319 funds for a cooperative effort with the OCC to implement animal waste and grassland management practices throughout the Lake Eucha watershed in Arkansas and Oklahoma. A portion of the funds were used to hire a grassland specialist. The duties of this specialist will include preparation of Animal Waste Management Plans in the Lake Eucha watershed in Arkansas and presentation of public awareness programs in Arkansas. Activity associated with this grant is largely complete; however, ASWCC continues to develop new projects to address water quality concerns in the watershed.

ASWCC also has ongoing 319 programs to transport poultry waste outside of the watershed and to develop a litter bank to facilitate transport of waste outside of the watershed. ASWCC is also cooperating with the OCC to demonstrate a method of deriving liquid fertilizer, and ultimately, electricity from poultry litter that will be situated include the Eucha watershed as one of its primary sources for poultry litter. Finally, the ASWCC is exploring additional programs to develop alternative uses for poultry waste including on-farm burning units to provide heat to the poultry houses.

12. Integrators

Presently, the poultry industry is actively represented by officials from Peterson Foods, Tyson Foods and Simmons Foods. These three integrators represent the vast majority of all poultry production in the Eucha/Spavinaw watershed. All three are actively pursuing public outreach and public education initiatives through their relationships with their contract growers. All three integrators have established dialogue with their contract growers concerning Oklahoma legislative and regulatory requirements on animal production and poultry waste issues. The integrators have agreed to fund education programs for growers as required by Oklahoma legislation. The integrators were active participants in the three work groups established by Tulsa, and they hosted meetings of the work groups and other organizations.

Integrators are also substantial contributors to efforts to address pollution problems related to the industry. In addition to the sizeable lawsuit settlement payments made by the integrators, they have contributed well over one million dollars to match federally funded programs in the watershed. They also contribute significantly towards data collection efforts geared towards meeting the new requirements of the settlement.

13. Poultry Federation

The Poultry Federation, representing Missouri, Oklahoma and Arkansas, is currently involved with education of integrators and growers about legislative and water quality issues dealing with poultry production. This organization has become an important voice for the poultry industry. The Poultry Federation relies upon an effective education program for its members, and it is an important partner in the Eucha/Spavinaw watershed program. The Poultry Federation will increase its involvement with the rural stakeholders in the watershed.

14. Quad-State Poultry Dialogue

This organization has representatives of poultry integrators and contract growers, as well as state and federal agencies that represent Oklahoma, Arkansas, Missouri and Kansas. Like the Poultry Federation, the primary focus of this group is education of the public, and in particular those in the poultry industry, about issues that may affect their operations and businesses. This organization conducts regional meetings and shares data with the three work groups.

15. Town Hall Meetings

Since the release of the OCC Clean Lakes Report, the City of Tulsa has held Town Hall meetings at the Community Center in Jay, Oklahoma, and purchased full-page local newspaper ads. The newspaper ads were prompted by questions raised at a Town Hall meeting attended by approximately 300 area residents. Tulsa provides drinking water treatment for local communities and provides many services to the area, including: a National Weather Service Station in Delaware County to collect and report local weather data to assist boaters and others during emergencies; making a contribution of $75,000 to launch a Green Box trash collection program in Delaware County; providing a free recreation area with shelters around the lakes; providing a weekly fishing report to local newspapers and radio stations; providing educational materials for local students; and donating a fire truck to the City of Spavinaw.

16. Volunteer Monitoring Programs

The OCC and the Delaware County Conservation District will work with OSU to develop and implement education programs and to expand the ongoing Blue Thumb volunteer monitoring education efforts in the watershed. The Blue Thumb program is in the process of developing a website to keep volunteers updated on Blue Thumb activities as well as informing the general public about the program. A portion of this webpage will focus on priority watershed projects, like the ones in Beaty and Spavinaw Creek. The OWRB's Oklahoma Water Watch Program will continue their activities in the watershed and will expand current monitoring to include chlorophyll-a and total phosphorus sample collections in Lake Eucha.

Public Outreach to assure support of this and future evolutions the Watershed Based Plan will come from:

- Public meetings and listening sessions held throughout the watershed.
- Regular media coverage of activities/issues (both at local and State levels).
- Education programs such as the ones planned in the 2003 319 project that involve segments of the community ranging from school children to agricultural producers to homeowners and lakeside residents.
- Programs that encourage local citizens to experience “ownership and understanding” of environmental issues such as volunteer monitoring, clean-up events, and other educational grassroots efforts to address the problem.

IMPLEMENTATION SCHEDULE / INTERIM MILESTONES

Education, cost share, and demonstration directed at the poultry and recreation industries have been successful only at slowing the degradation of water quality. Priority in the watershed must now be given to reducing the overall load of nutrients reaching Lake Eucha to address water quality problems in the watershed. Riparian reestablishment and stream bank protection to maintain the stream habitat quality are of equal importance. The draft TMDL will be resubmitted to EPA in Fall 2007, tentatively. Implementation of best management practices is ongoing, focused on demonstration of pollution reduction strategies in the Spavinaw Creek Watershed, and will continue as Nutrient Management Plans are developed by the Court-appointed Special Master’s Team. Implementation of the Spavinaw Creek 319 demonstration project will be funded for four years, but it is anticipated that BMP implementation will continue for at least ten years.

Effects of implementation programs in the watershed on phosphorus and sediment loading to Lake Eucha from the various sources (pasture, row crop, forest land, stream bank erosion, urban, point source, and any new sources) will be evaluated every five years to determine the future strategy to be followed. Following that evaluation, this Watershed Based Plan will be revised to reflect new information and address short-comings identified with earlier plans.

The initial goal is that at least a fifty percent load reduction will be measured during the first five years. If this load reduction cannot be demonstrated with water quality data, it will be demonstrated through documentation of reduction at the sources (for instance, upgrade of Decatur plant or 80,000 tons of litter moved out of the watershed). Table 14 details the schedule of the goals and actions of the WBP, as well as the interim milestones (within five years of implementation) and long-term load reductions.

Tulsa has an ongoing long-term monitoring program to assess water quality in the lakes and streams in the watershed. They have partnered with the USGS, OWRB, OCC, and other agencies to collect water quality data and source information throughout the watershed. In addition, the State of Arkansas maintains long-term monitoring stations in the Arkansas portion of the watershed. These monitoring programs are in the process of coordinating to insure that they are adequate to determine whether watershed loading reduction goals are being met throughout the project period.

Trend analyses will be performed on these various data sets (lake chlorophyll-a concentrations, TSIs, and total phosphorus and stream total phosphorus concentrations and loading) and will be evaluated at five year intervals with the revisions of the WBP to determine whether measurable changes have occurred in water quality.

Table 14. Schedule and Load Reduction Goals Associated with Activities Planned. * **highest priority parameters are highlighted in blue; secondary priority parameters are highlighted in green**

Goal	Action	Parameter to address	Load Reduction of Primary Parameters to Attain within 5 Years of Implementation	Ultimate Total Load Reduction to Attain	Year to Begin	Year to Evaluate and Make Necessary Adjustments	Year to Complete
Characterize NPS contributions	targeting	Phosphorus, Sediment, Other Nutrients	NA	NA	2004	2008	Repeat at five year intervals
	TMDL development	Nutrients, Low DO, Pathogens	NA	NA	2000	2005	2007
Evaluate nutrient dynamics and impacts in watershed	OWRB/City of Tulsa Study	Phosphorus, Low DO	NA	NA	1999	2001	2001
	TMDL development	Nutrients, Low DO, Pathogens	NA	NA	2000	2005	2007
Evaluate point source discharger contributions and implement strategy to reduce	TMDL	Nutrients, Low DO, Pathogens	NA	NA	2000	2005	2007
	Upgrading WWTP		80% of point source phosphorus load	90% of point source phosphorus load	2003	2006	2007
Conduct comparative studies on soil sampling options to develop a soil P index	Lawsuit settlement monitoring	Phosphorus	NA	NA	2003	2005	2008 (at earliest)
	2003 319 Project (OSU/UA)				2005	2008	2008
Develop education and outreach programs	2003 319 Project- OSU Extension, OCC, OWW, and ODAFF	Nutrients, Sediment, Pathogens	50% NPS Phosphorus	95% NPS Phosphorus	2003	Semiannually throughout project period	2008

Goal	Action	Parameter to address	Load Reduction of Primary Parameters to Attain within 5 Years of Implementation	Ultimate Total Load Reduction to Attain	Year to Begin	Year to Evaluate and Make Necessary Adjustments	Year to Complete
Develop phosphorus target values for Lakes Eucha and Spavinaw	TMDL	Phosphorus, Low DO, Pathogens	NA	NA	2000	2005	2007
Develop and implement litter reduction and litter export strategies	AR/OK Demonstration of Process Technology	Phosphorus	3% reduction in NPS loading (Phase I)	20% NPS loading reduction[1]	2004 (Phase I); ??? (Phase II)	2006 (Phase I)	2007 (Phase I); ??? (Phase II)
	ASWCC 319 Project		5% reduction in NPS loading		2003	2004	2005
	OCC 2003 319 Project		5% reduction in NPS loading		2003	2005	2008
	Legislative Tax Cut		2% load reduction		2004	2009	2009
	Lawsuit Settlement		3% load reduction		2003	2005	2007
	EQIP		2% load reduction		2004	2005	???
Implement BMPs[2]	Beaty Creek 319 Project	Nutrients, Sediment, Pathogens, Low DO	10%	30% of P load to Beaty Creek or 14% of P load to Eucha	1998	Semi-annually	Completed
	2003 319 Spavinaw Creek Project		10%	30% of P load to Spavinaw Creek or 14% of P load to Eucha	2003	2006	2008
	Streambank Stabilization		10%	15%	???	???	???
	Row crop BMPs		3%	6 % NPS load	Ongoing	Ongoing	Ongoing
	Pasture Land BMPs		20%	43% NPS load	Ongoing	Ongoing	Ongoing
	Urban BMPs		0.1	0.5% NPS load	???	???	???
	CREP		10%	21% – 35% NPS P load	2007	Annually	2022
City of Tulsa Lake Management Plan	City of Tulsa Policy	Nutrients, Sediment, Pathogens	NA	NA	Ongoing	Ongoing	Ongoing

Goal	Action	Parameter to address	Load Reduction of Primary Parameters to Attain within 5 Years of Implementation	Ultimate Total Load Reduction to Attain	Year to Begin	Year to Evaluate and Make Necessary Adjustments	Year to Complete
Improve treatment of raw water	OWRB SRF grants	Taste and Odor			Ongoing	Generally, annually, but 2009, at a minimum	Ongoing
State, Local, and Federal Legislation to protect watershed	Oklahoma Poultry Regulations	Nutrients, Pathogens, Low DO		20% phosphorus	1998	Annually	Ongoing
	Tax Incentives for Litter Removal				2004		2009
Long term water quality monitoring programs	City of Tulsa	Nutrients, Sediment, Pathogens, Low DO, Taste and Odor	NA	NA	Ongoing	Ongoing	Ongoing
	OWRB Beneficial Use Monitoring Program, Oklahoma Water Watch Program				1998, 1992	Annually	Ongoing
	OCC Rotating Basin Monitoring Program, Data Gaps, and other monitoring programs				1993	At least every 4 years	Ongoing
	USGS				Ongoing	Ongoing	Ongoing
	ODEQ – toxics monitoring, NPDES permitting, TMDL monitoring				Ongoing	Ongoing	Ongoing

1 Storm et al. (2002) estimates that removal of all litter produced from the watershed would result in approximately a 20% decrease in phosphorus loading to the watershed.
2 Load reduction goals are to be met with a combined effort of the specified programs. These goals may be modified with the finalization of the TMDL.

As part of the interim assessments, reports will be performed by the City of Tulsa which include the following:

- Hydrologic budget
- Lake water quality and quantity trends
- Relationship between lake nutrient content and phytoplankton
- Nutrient load estimation from tributaries draining into Eucha Lake and Spavinaw Lake
- Phosphorus contribution from Lake Sediment in Eucha Lake and Spavinaw Lake

The USGS will present an assessment to TMUA in a report format. The assessment of data quality will be a continuous process while environmental sampling is ongoing.

MONITORING PLAN

Every Watershed Based Plan requires a monitoring plan to gage overall success of restoration and remediation efforts. The goal of the monitoring plan for this WBP will be to develop a long-range monitoring program with clearly defined milestones that will oversee the restoration of the beneficial use support in the watershed and preserve its natural resources for future generations.

The monitoring plan for this WBP provides for development of individual monitoring plans and associated quality assurance plans and Standard Operating Procedures for each underlying project or effort working toward the ultimate goal of restoration of beneficial use support. These monitoring efforts will need to be based on Oklahoma's Water Quality Standards and Use Support Assessment Protocols which define the process by which beneficial use support can be determined. Technical assistance in developing these plans can come from various sources including the Oklahoma State Agency peer review process and the Oklahoma Water Quality Monitoring Council. In addition, the City of Tulsa and Spavinaw Creek Working Group will be allowed to review these individual plans to insure both that the plans address monitoring needs identified by stakeholders and that stakeholders remain informed about watershed monitoring activities.

Methodologies developed for use in this WBP will be selected to provide: 1) a quantifiable measure of changes in parameters of concern, 2) success measures that can be easily understood by cooperators and stakeholders with a variety of technical backgrounds, and 3) consistent, compatible information throughout the watershed.

As the WBP evolves and expands to be more inclusive of the entire watershed and all the parameters of concern, it is anticipated that this list will expand and contract. At this time, the following parameters will continue to be monitored in the Lake Eucha watershed:

- Water quality: nutrients, sediments, suspended solids, fecal bacteria, dissolved oxygen, temperature, pH, conductivity, alkalinity, hardness, turbidity, chlorophyll-a, metals, pesticides, BOD

- Taste and odor problems in drinking water at the Mohawk treatment plant and for City users in the Cities of Tulsa, Spavinaw, and Jay, Oklahoma.
- Sediment quality: nutrients, metals, pesticides, and other organics of concern
- Hydraulic budget: in-stream flows, infiltration rates, aquifer recovery, groundwater levels
- Groundwater quality: nutrients, metals, pesticides, pH
- Landuse/Land cover: acreage in different landuses, quality and type of land cover, timing and other variables of associated management practices
- Riparian Condition: extent and quality of riparian zones in the watershed. To include quality and type of vegetation, degree of impact or stability, condition of streambanks, and primary source of threat or impact.
- Aquatic Biological Communities: assessment of the condition of fish and benthic macroinvertebrate communities related to reference streams and Biocriteria
- BMP and other implementation efforts: type, extent, and when possible, specific location of practices to include an estimate of the potential load reduction effected by implementation
- Behavioral Change: participation in Watershed Based Plan-related activities and behavioral changes of affected communities

With each WBP-related program, as well as for the WBP as a whole, baseline conditions will be established and monitored prior to implementation. A monitoring schedule and Quality Assurance Project Plan (QAPP) will be developed based on the type of project and timing of its implementation. Monitoring results will be reported to the appropriate entities as defined in the QAPPs.

Baseline Data

Water Quality

Considerable water quality monitoring has occurred in the watershed which is being updated on a regular basis throughout the watershed. The City of Tulsa, TMUA, OCC, ODEQ, and other appropriate entities will use portions of this data to establish baseline conditions. A draft TMDL has been developed, however it is not yet approved. Until then, water quality in this WBP will be guided by the following:

- ***Oklahoma Integrated Report***- CWA Section 303(d) List of Waters needing a TMDL, 2002. Lake Eucha and Spavinaw Lake (immediately downstream of Eucha) are of concern because both are listed on the 2002 Category 5 (303(d)) list for phosphorus and dissolved oxygen. In addition, Beaty Creek, a tributary to Lake Eucha is listed for pathogens (fecal bacteria).
- ***1997 Oklahoma Conservation Commission Clean Lakes Study*** - A 1997 Phase 1 Clean Lakes Study performed by the OCC on behalf of Tulsa confirmed that Lakes Eucha and Spavinaw are impacted by non-point sources of nutrients. The OCC report identified increased poultry production as the most likely source of excess nutrients. Eutrophication is due to elevated nutrient loading from Beaty Creek and Spavinaw Creek to Lake Eucha. It is estimated that Beaty Creek and Spavinaw Creek supply approximately 85% of the phosphorus entering the lake. The phosphorus in Beaty

Creek likely originates from nonpoint source (NPS) pollution resulting from agricultural practices associated with the poultry industry. The phosphorus in Spavinaw Creek likely originates from a combination of both point source pollution (Decatur WWTP) and NPS pollution (agricultural practices associated with the poultry industry). Another indication of possible NPS contamination and impacts from animal waste is suggested by the elevated levels of bacteria found in Beaty Creek.

- ***1998, 1999, and 2000 319 OCC Lake Eucha Watershed Implementation Project and 2003 Spavinaw Creek Priority Watershed Implementation Project*** monitoring. OCC monitored water quality in Beaty Creek and Little Saline Creek (a reference stream outside the watershed) as part of the first series of projects including parameters such as nutrients, fecal bacteria, biological communities, and physical habitat. This monitoring will be continued and expanded to include Spavinaw Creek, Cloud Creek, and Flint Creek (another reference stream outside the watershed) as part of the 2003 319 project through 2008.
- ***City of Tulsa/Tulsa Metropolitan Utilities Authority Studies***- continued and expanded water quality monitoring of the lake and its tributaries.
- ***The Oklahoma Water Resources Board's 2001 "Water Quality Evaluation of the Eucha/Spavinaw Lake System"***- provided an update of the clean lakes study and further evaluated the water quality of the Eucha/Spavinaw/Yahola system, along with recommending nutrient reductions to achieve desirable water quality in Lake Eucha and Spavinaw. The study found that both Lakes Eucha and Spavinaw were nutrient enriched and displayed high or excessive levels of algal production. Phosphorus was generally the limiting nutrient and the presence of specific diatoms and blue-green algal species known to produce undesirable taste and odors were detected associated with taste and odor complaints in the city water supply. The study recommended decreasing phosphorus loading to Lake Eucha by 70% in order to decrease phosphorus loading to Lake Spavinaw by 45% and reduce the Spavinaw Trophic State Index to 50.
- ***OSU Biosystems and Agricultural Engineering Department's "Stream Nutrient Retention in the Lake Eucha-Spavinaw Basin" (Haggard 2000)***- found that a stream such as Spavinaw Creek that was impacted by point sources passed a greater percentage of its nutrients to downstream sources (such as Lake Eucha) than a stream without point source impacts like Beaty Creek. In other words, Beaty Creek is able to retain and process a greater percentage of its nutrient load than Spavinaw Creek
- ***OSU Biosystems and Agricultural Engineering Department's "Determining Limiting Nutrients in Lake Eucha Tributaries" (Keyworth 2000)***- found that nutrient concentrations were high enough in almost all tributaries to the lake such that algal growth was limited by some factor other than nutrients such as light limitation. However, phosphorus was the nutrient factor that controlled algal growth most often in other tributaries, as opposed to nitrogen, or co-limitation of nitrogen and phosphorus.

Taste and Odor Problems

- ***City of Tulsa/Tulsa Metropolitan Utilities Authority Studies*** - continued and expanded water quality monitoring of the lake and its tributaries. This monitoring includes monitoring the algal communities as well as the presence of taste and odor causing compounds and potential toxins, when warranted.

Sediment Quality

- ***1997 Oklahoma Conservation Commission Clean Lakes Study*** - A 1997 Phase 1 Clean Lakes Study performed by the OCC analyzed sediments for nutrients and metals. None of the detected quantities of metals exceeded the EPA Sediment Screening Values (EPA 1995).
- ***The Oklahoma Water Resources Board's 2001 "Water Quality Evaluation of the Eucha/Spavinaw Lake System"***- found that lake sediments in Eucha contributed as much as 7% of the Lake's annual phosphorus load and that 80% of the phosphorus entering Lake Eucha is retained in the lake, as opposed to being passed downstream.
- ***OSU Biosystems and Agricultural Engineering Department "Sediment-Phosphorus Chemistry in Ozark Plateau Streams in Northeast Oklahoma" (Popova 2000)***- found that benthic sediments act as a sink for phosphorus in streams in the Eucha Watershed; however, sediments cannot as effectively capture phosphorus in point source impacted streams such as Spavinaw Creek compared to streams without point source discharges.

Hydraulic Budget

- ***USGS*** gauging system
- ***City of Tulsa*** - lake level and discharge monitoring
- ***OCC*** - Lake Eucha Watershed Implementation Project and Spavinaw Creek Priority Watershed Implementation Project

Groundwater Quality

- ***USGS*** - Reconnaissance of hydrology, water quality, and sources of bacterial and nutrient contamination in the Ozark Plateaus aquifer system and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999 – 2000 (2001).

Landuse/Land Cover

- ***NRCS and OCC*** - Color digital orthophotos (2003)
- ***OSU Biosystems and Agricultural Engineering*** -
  - Modeling Phosphorus Loading for the Lake Eucha Basin (2001)
  - Modeling the Lake Eucha Basin Using SWAT 2000 (2002)
  - Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma (2000)
- ***OCC*** - Lake Eucha Watershed Implementation Project and Spavinaw Creek Priority Watershed Implementation Project
- ***USGS*** - Reconnaissance of hydrology, water quality, and sources of bacterial and nutrient contamination in the Ozark Plateaus aquifer system and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999 – 2000 (2001)

Riparian Condition

- ***NRCS and OCC*** - Color digital orthophotos (2003)
- ***OSU Biosystems and Agricultural Engineering*** -
  - Modeling Phosphorus Loading for the Lake Eucha Basin (2001)
  - Modeling the Lake Eucha Basin Using SWAT 2000 (2002)
- ***OCC*** - Lake Eucha Watershed Implementation Project and Spavinaw Creek Priority Watershed Implementation Project

Aquatic Biological Communities

- ***OCC*** - Lake Eucha Watershed Implementation Project and Spavinaw Creek Priority Watershed Implementation Project

Best Management Practices and other Implementation Efforts (Coverages)

- ***NRCS/FSA*** - records of locations, specific practices installed and associated costs of programs such as EQIP, WRP, CRP, etc. – ongoing
- ***OCC*** -
  - records of locations, specific practices installed, and associated costs of locally-led State Cost-share Program (ongoing)
  - records of locations, specific practices installed, and associated costs of priority watershed cost-share program – Lake Eucha Watershed Implementation Project and Spavinaw Creek Priority Watershed Implementation Project
- ***OSU and OCC*** - Estimates of load reductions related to installation of specific practices through computer modeling (future)
- ***ODEQ*** - Permit upgrades for NPDES permitees in the watershed
- ***OWRB*** - Infrastructure upgrades supported through the State Revolving Fund Loan program.

Data Collection Responsibilities

Responsibility for the collection of additional data of the types described above will reside with project managers of the individual projects as spelled out their individual work plans. These project managers will be responsible for ensuring that the data is submitted to the ODEQ for inclusion in the Oklahoma State Water Quality Database, which will ultimately be uploaded to the National STORET database. Data reporting under individual workplans will also be the responsibility of the project managers. Monitoring results for all projects will be available and accessible to the City of Tulsa and made public through the posting of final reports on agency websites.

In addition to those monitors to be identified in the workplans of the individual projects under this WBP, the following groups will be involved in monitoring activities:

- City of Tulsa (COT)/Tulsa Metropolitan Utilities Authority
- Oklahoma Water Resources Board (OWRB): Beneficial Use Monitoring Program and Oklahoma Water Watch Monitoring Program

- Oklahoma Conservation Commission (OCC): Rotating Basin Monitoring Program, Priority Watershed Project Monitoring, and Blue Thumb Project Monitoring
- U.S. Geological Survey (USGS): surface and groundwater quality and quantity monitoring and special studies
- Oklahoma Department of Agriculture, Food, and Forestry: soil sampling associated with CAFO regulations

Monitoring Details

Stream Monitoring

City of Tulsa (COT) / USGS:

The City of Tulsa, in collaboration with the United States Geological Survey (USGS), has an ongoing intensive stream monitoring program in the Eucha/Spavinaw Watershed, collecting monthly and storm-event water quality data and continuous hydrologic data. A system of sequential downstream monitoring sites (includes 5 USGS water quality stations) allows quantification of nutrient inputs from particular tributaries or subbasins such as the stream receiving the Decatur WWTP effluent. These sites, along with several non-gauged tributary sites, also provide general water quality information. Other USGS water quality stations provide information for determining outflow from lake, changes in storage, annual lake water budget, and surface-water discharge to another downstream lake. Table 16 indicates the scope of work by site and sampler for City of Tulsa and USGS monitoring. Figure 11 illustrates the sample site locations on Lake Eucha, Spavinaw Lake, and the surrounding creeks.

Instrumentation at gauge stations includes a continuous stage recorder and some rainfall data. Data for these parameters from gauge stations are logged at 15-minute intervals to one-hour frequency (depending upon hydraulic characteristics of site), uploaded via satellite to USGS's Water Control Data System, and then downloaded via satellite to become available to the public, real-time, via the USGS web site. USGS stream water-quality samples are collected utilizing the equal-width-increment methodology (EWI). Over the course of several years, a sufficient amount of sample points along the hydrograph will provide an adequate representation of the entire hydrograph. The samples are collected during six storm run-off events each year, once per storm, at each of the five sites.

The USGS sampling is performed in cooperation with the (12) monthly samples collected by the City of Tulsa. These (18) samples per year, over three consecutive years, will be used to compute annual nutrient loads using statistical regression methods at each site. These results can provide qualitative information concerning inflow loading (total, base flow, and surface runoff), Lake Eucha surface water discharge, and watershed yields.

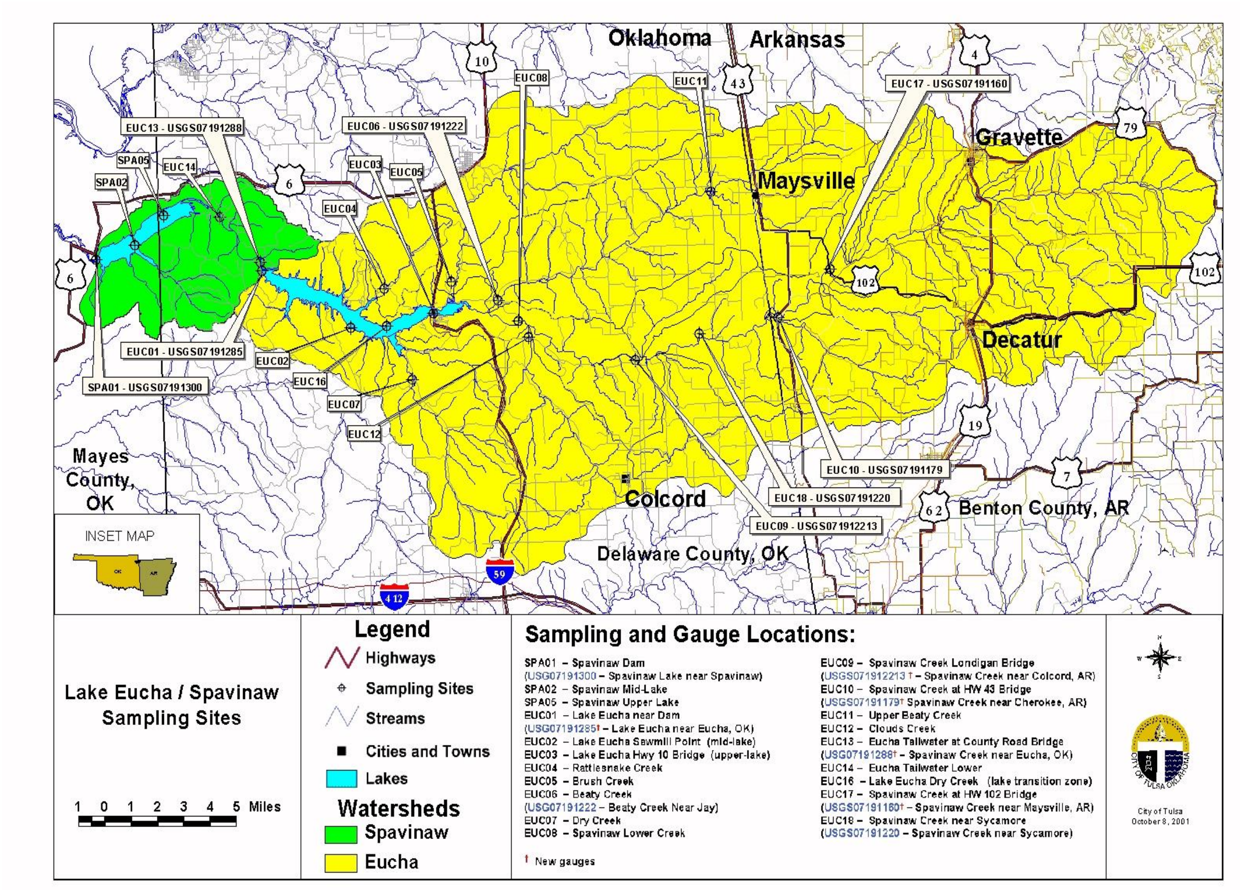


Figure 11. City of Tulsa and USGS monitoring sites.

These data will provide information about relative quantities of nutrients transported during both base flow and surface runoff conditions, as well as load contribution from each basin. As more data are collected, loading estimates will become more accurate. Loads will be estimated using a statistical multiple regression-loading model. Load estimates over time will be used to compute yields (area normalized loads) for the contributing drainage areas of each site. Hydrograph separation techniques will be used to distinguish base-flow nutrient discharge from total annual nutrient discharge. Base-flow loads and yields (attributed to ground-water discharges and point sources) will be compared against surface-runoff loads and yields (attributed to non-point sources).

Table 15. COT analytical parameters and sampling frequency for stream water.

Parameter	Sampling Frequency
Alkalinity, Ammonia-N, Dissolved Oxygen, Dissolved Oxygen (% Sat.), Hardness, Nitrite, Ortho-Phosphorus, Nitrite + Nitrate, pH, Redox Potential, Specific Conductance, Temperature, TKN, Total Phosphorus, Turbidity	Monthly + 6 high flow (20% increase) events per year
Total Dissolved Phosphorus (USGS only), TSS (USGS only)	6 high flow (20% increase) events per year

Table 16. Scope of work by site and sampling agency.

Site	Lat. Long.	Lake	Stream Monthly	Stream High Runoff	Daily Flow/Elev.
SPA01 – Spavinaw Dam (USGS07191300 – Spavinaw Lake near Spavinaw)	36.382752 -95.048126	COT	NA	NA	COT USGS
SPA02 – Spavinaw Mid-Lake	36.389548 -95.021713	COT	NA	NA	
SPA05 – Spavinaw Upper Lake	36.404220 -95.001304	COT	NA	NA	
EUC01 – (USGS07191285 – Lake Eucha near Eucha, OK)	36.374461 -94.935989	COT	NA	NA	USGS
EUC02 – Lake Eucha Sawmill Point (mid-lake)	36.344666 -94.876901	COT	NA	NA	
EUC03 – Lake Eucha Hwy 10 Bridge (upper-lake)	36.350365 -94.820057	COT	NA	NA	
EUC04 – Rattlesnake Creek	36.363711 -94.853087		COT		
EUC05 – Brush Creek	36.365778 -94.807471		COT		
EUC06 – (USGS07191222 – Beaty Creek Near Jay)	36.355420 -94.776225		COT	USGS	USGS
EUC07 – Dry Creek	36.317233 -94.835823		COT		
EUC08 – Spavinaw Lower Creek	36.345130 -94.762741		COT		
EUC09 – Spavinaw Creek Londigan Bridge (USGS071912213 – Spavinaw Creek near Colcord, OK)	36.323339 -94.685040		COT	USGS	USGS
EUC10 – Spavinaw Creek at HW 43 Bridge (USGS07191179 Spavinaw Creek near Cherokee, AR)	36.342039 -94.587071		COT	USGS	USGS
EUC11 – Upper Beaty Creek	36.406400 -94.629916		COT		
EUC12 – Clouds Creek	36.336600 -94.756059		COT		
EUC13 – Eucha Tailwater at County Road Bridge (USGS07191288 – Spavinaw Creek near Eucha, OK)	36.379085 -94.936981		COT		USGS
EUC14 – Eucha Tailwater Lower	36.402155 -94.963602		COT		
EUC16 – Lake Eucha Dry Creek (lake transition zone)	36.344564 -94.852336	COT	NA	NA	
EUC17 – Spavinaw Creek at HW 102 Bridge (USGS07191160 – Spavinaw Creek near Maysville, AR)			COT	USGS	USGS
EUC18 – Spavinaw Creek at CR bridge near Sycamore (USGS07191220 – Spavinaw Creek near Sycamore)	36.2005 -94.3829		COT	USGS	USGS

Oklahoma Conservation Commission (OCC):

The OCC has been monitoring the water quality of Beaty Creek since 1999 as part of the Beaty Creek Implementation Project. Monitoring on this waterbody is ongoing and occurs on Spavinaw, Little Saline, Flint, and Cloud Creeks as well (Table 17). The OCC sites are assessed as detailed in Table 18. For further details on OCC collection protocol, consult the Quality Assurance Project Plan for the Spavinaw Creek Watershed Implementation Project, OCC Task # 118, FY 2003 319(h) Project 4 (OCC 2006).

Table 17. OCC monitoring sites.

Site Name	Legal Location	Lat. Long.	County
Beaty Creek (middle)	SWNESW 23-22N 24E	N36°37’4” W094°71’91.0”	Delaware
Beaty Creek (lower)	SE30-T22N-R24E	N36°21’19.8” W094°46’33.0”	Delaware
Little Saline Creek	SW21-T21N-R21E	N36°16’45.0” W095°04’39.6”	Mayes
Spavinaw Creek	NWNWSW32- 22N-24E	N36°34’39” W094°77’20”	Delaware
Cloud Creek autosampler	SESE SE32-22N-24E	N36°33’65” W094°75’62”	Delaware
Cloud Creek grab site	SESE SE5-21N-24E	N36°32’15” W094°75’91”	Delaware
Flint Creek	NWNWSW24-20N-24E	N36°19’70” W094°70’80”	Delaware

Table 18. OCC analytical parameters and sampling frequency.

Parameter	Collection Frequency
Dissolved Oxygen, Conductivity, pH, Temperature, Alkalinity, Turbidity, Nitrite Nitrogen	Monthly + 6 high flow events per year
Total Phosphorus, Instantaneous Discharge, Nitrate Nitrogen, Ammonia-Nitrogen	Monthly grab samples + 6 high flow events per year; Weekly autosampler samples
Ortho-phosphorus, Total Kjeldahl Nitrogen	Weekly autosampler samples
Benthic Macroinvertebrates	Twice yearly (summer / winter)
Fish	Once a year (years 1, 3, & 5 only)
Habitat	Once (with fish) during years 1, 3, and 5
Total Coliform, *E. coli*, and *Enterococcus*	Weekly from May 1 – September 30

Point Source Monitoring

Information on discharges from Decatur, Arkansas Waste Water Treatment Plant (WWTP) is provided to the City of Tulsa from monthly NPDES Discharge Monitoring Reports (DMRs). This data provides information for evaluating changes in water quality entering the Columbia Hollow stream over time. Parameters reported in the DMRs include flow (as monthly average and daily maximum), pH, TSS, Total Ammonia-N, Total Phosphorus, Total Chlorine Residual, Total Nitrate-N, Fecal Coliform, and BOD.

Lake Monitoring

City of Tulsa

The collection of hydrologic data will provide an updated estimate for the hydraulic budget of the lake. The lake complex hydrologic budget will be the foundation for calibrating ODEQ's TMDL model. USGS gauging sites within the Eucha/Spavinaw Watershed will be used for the annual water budget and nutrient load estimation. Lake sites are listed in Table 16 and shown in Figure 11. Table 19 summarizes all the analytical parameters and methods for the lake samples.

Table 19. Analytical parameters sampling frequency for lake water (COT).

Parameter	Collection Frequency
Geosmin, Methylisoborneol (MIB), Phytoplankton, Chlorophyll-a, Secchi Depth, Total Phosphorus, Dissolved Oxygen , Dissolved Oxygen (% Sat.), pH, Redox Potential, Specific Conductance, Alkalinity, Temperature	Weekly at SPA01, EUC01, and EUC16 (surface only). Monthly at all sites/depths.
Turbidity, Alkalinity, Hardness, Dissolved Ortho-Phosphorus, Ammonia, Nitrite, Nitrite+Nitrate, TKN, Dissolved Silica, Dissolved metals (aluminum, arsenic, copper, manganese and zinc)	Monthly at all sites.

Benefits of the Monitoring Plan

Implementation of this monitoring plan will enable the City of Tulsa, TMUA, the Spavinaw Creek Working Group, and their partners to meet the goals of the WBP, which is ultimately to restore beneficial use support to waters of the Lake Eucha / Lake Spavinaw Watershed. Implementation of the plan will allow the ODEQ to finalize TMDLs for the Eucha / Spavinaw Watershed to help meet the goals of watershed restoration. Implementation of the monitoring plan will help define areas of the watershed where restoration activities should be focused to realize the optimum benefit for the investment as well as evaluating the impacts (realized and potential) of implementation efforts. Collection of the data described under this monitoring plan will help define the relative contributions from various sources in the watershed and the processes contributing to water quality degradation in the watershed. Collection of this data will help Oklahoma and Arkansas work together to arrive at a mutually agreed upon solution for the watershed. Finally, continued collection of this data and evolution of the monitoring plan for the watershed will allow the program to adapt to meet the changing needs of watershed protection in the Lake Eucha / Lake Spavinaw Watershed.

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