Name of Project: Oak Grove - West Fork Red River 319

Lead Organization: The Cumberland River Compact

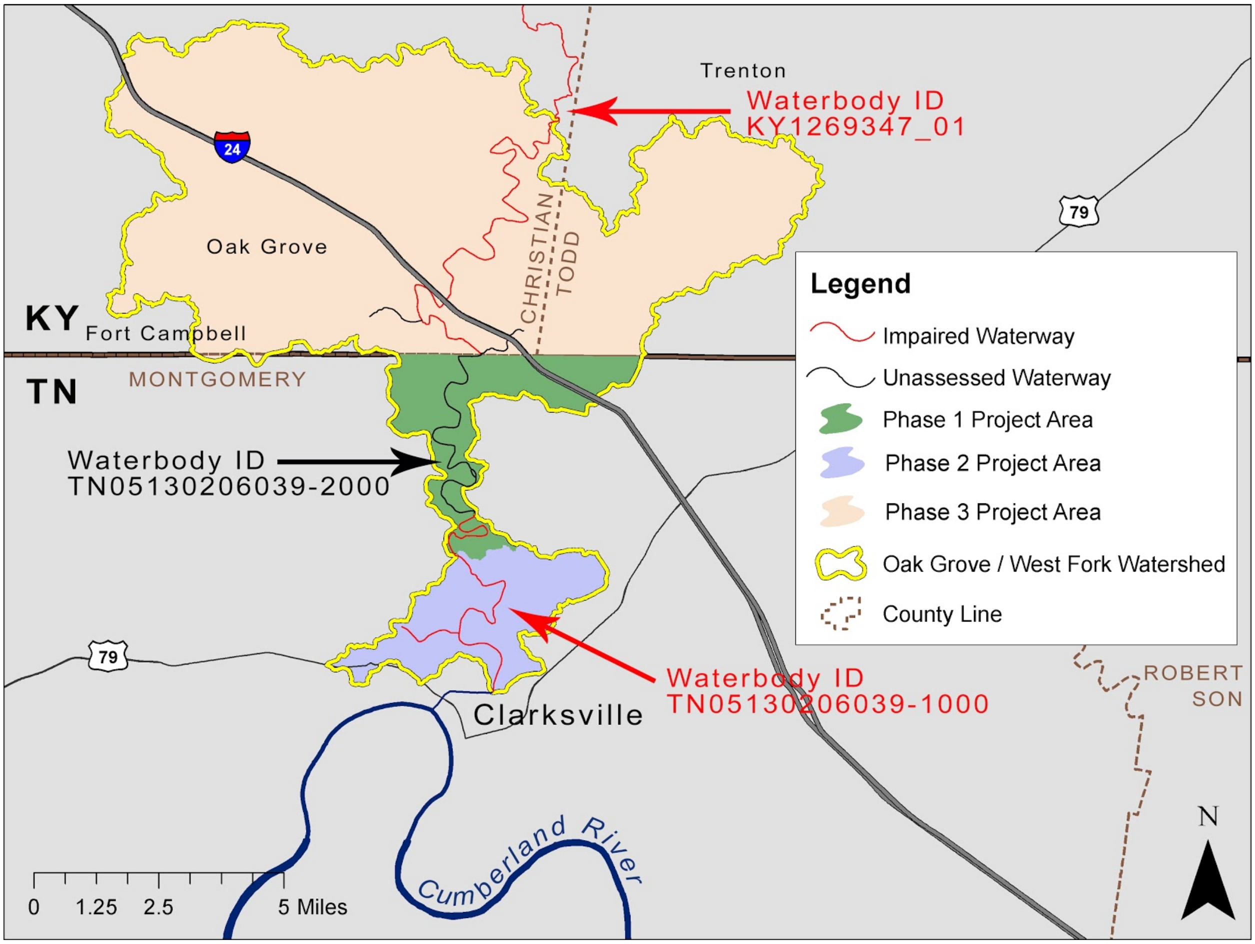
Watershed Identification (name, location, 12-digit HUC, etc.):

This watershed based plan is for the HUC12 051302060604, known as the Oak Grove - West Fork Red River watershed.

The Oak Grove - West Fork Red River Watershed (OGWF) drains the southern parts of Todd (KY) and Christian (KY) County, the north-central portion of Montgomery County (TN) and the City of Clarksville by way of the West Fork Red River, which flows south across the Tennessee/Kentucky state line to the confluence of the West Fork Red River and the Red River. En route to the Red River, the West Fork drains a mix of agricultural, densely developed suburban, and forested land uses. Though the TN portion of the watershed is undergoing heavy suburban development, the larger OGWF watershed is significantly more rural in nature, as a dramatic land use change occurs north of the state line in Kentucky. Across the entire watershed, over 60% of the HUC12 is agricultural, with a majority of the drainage (53%) being cultivated crop land. Only 20% is developed, and the majority of that developed land is classified as ‘Developed, Open Space’ in the 2016 National Land Cover Database (NLCD).

The West Fork Red River empties into the Red River north of Kraft Street, just over a mile upstream of the Red’s confluence with the Cumberland River near downtown Clarksville. The OGWF watershed is approximately 50,919 acres (~80 square miles) and contains 31.6 miles of streams. The population of the watershed, as estimated from 2010 census data, is approximately 40,730, with a population density of approximately 509 people per square mile.

Oak Grove/West Fork Red River Watershed Location Map



Causes and Sources of Nonpoint Source Pollution in the Watershed

According to the current Draft 303(d) list for Tennessee (2018) and Kentucky (2016), 22.2 miles of the West Fork of the Red River are considered impaired, and another 9.4 miles within the watershed are unassessed. Total impaired waters make up 22.3 of 31.6 total stream miles in the watershed, or 71%.

The following stream segments within the watershed are listed on the Tennessee 303(d) list:

Waterbody ID	Impacted Waterbody	County	Miles Impaired
TN05130206039 - 1000	West Fork Red River	Montgomery (TN)	10.2
KY1269347_01	West Fork Red River	Christian (KY)	12.05

Segment TN05130206039 - 1000 of the West Fork of the Red River is impaired for ***Anthropogenic Substrate Alterations, Nitrate+Nitrite, Sedimentation/Siltation, and Total Phosphorus.***

Segment KY1269347_01 of the West Fork of the Red River is impaired for ***E. Coli.***

Though it has not been assessed for impairments, we infer that section TN05130206039 - 2000 has similar issues to the two aforementioned segments due to local land clearance/development and extensive upstream agricultural land use. We contacted the Tennessee Department of Environment and Conservation, and they expressed that the Tennessee Division of Water does not intend to conduct sampling on this segment during their next cycle due to other monitoring commitments. However, the upstream section of the West Fork (KY1269347_01) is impaired by pathogens, and the downstream section of the river (TN05130206039 - 1000) is impaired by sediment, nutrients, and anthropogenic substrate alterations. We hypothesize that there are similar impairments on this section due to similar land uses adjacent to all three sections.

The Kentucky Division of Water sampling location for pathogens on segment KY1269347_01 is located just 1.7 miles upstream from the TN/KY border; we suspect that the northern portion of segment TN05130206039 - 2000, downstream of the Kentucky segment, is also impaired for E. Coli, though it is not listed as so due to the change of state jurisdictions on this river segment.

Due to conversion of forest and grassland environments to suburban and agricultural land uses, high volumes of stormwater runoff are contributing to channel erosion along portions of the West Fork Red River. We have conducted stream walks in the area and observed high levels of channel erosion. This channel erosion in many areas of the watershed also has the potential to pose a physical hazard to humans and structures.

This watershed based plan addresses sediment, nutrient, pathogen, and habitat/substrate alteration issues within the OGWF watershed. With full implementation, the goal of the plan is to remove all impaired segments within the watershed from each State's 303(d) list by bringing the water quality into compliance.

For segment TN05130206039 - 1000, the most common source of nutrient and siltation loading, according to the Tennessee 303(d) list, is land clearance/site development and high levels of urbanization. Flashy conditions due to high urbanization carry nutrients into the storm sewers and streams, and the high flows contribute to bank erosion. Additionally, land clearance removed vegetation that would otherwise secure soil and protect it from the impact force of precipitation, which loosens soil and washes it into the storm sewers and streams.

For segment KY1269347_01, there is no known source of its pathogen impairment according to Kentucky's 303(d) list. Since this segment is primarily surrounded by agricultural land with a very low population density, we hypothesize that most of this pathogen impairment is due to agricultural runoff from applied manure as a fertilizer and livestock waste from pasturelands. This suggests that restoration work in the watershed should be centered around three primary activities – green infrastructure practices to reduce runoff pollutant loading; and bank repair/protection to reduce siltation; and public education about sediment, pathogen, and nutrient source load reduction practices.

To estimate pollutant loads within the entire watershed, we used the Environmental Protection Agency's Spreadsheet Tool for Estimating Pollutant Loads (STEPL). This tool allows us to estimate current loads within the watershed for Nitrogen, Potassium, and Sediment. Currently, STEPL does not provide estimates on pathogen loading or load reductions from best management practices.
Current bacterial loads were estimated using sampling data from the 2015 Kentucky Division of Water (KDOW).

Nutrients and Sediment

Total nitrogen, phosphorus, and sediment loading in the OGWF watershed was estimated from STEPL, using publicly available data from the NLCD 2016 dataset, the Natural Resources Conservation Service (NRCS), and the EPA. Unavailable data was estimated using a best educated guess. Using the STEPL model, we estimated total nitrogen loading at **611,125 lbs/yr**, total phosphorus loading at **158,080 lbs/yr**, and total sediment loading at **41,339.5 tons/yr**. A number of assumptions were used to arrive at these estimates. Erosion, along with land development, is noted to be a major contributor to sediment loading, with examples of collapsing, rapidly eroding stream banks observed throughout OGWF watershed.

Pathogens

The most recent available data for pathogen loading was provided by the Kentucky Division of Water, regarding sampling conducted in 2015 on segment KY1269347_01 of the West Fork Red River. In this sampling, MPN/100ml ranged from 117.0-411.0. The geometric mean for this segment is **220.5 MPN/100ml**. We will base our loading reduction goals on Kentucky's Total Maximum Daily Load (TMDL) for bacteria. Maximum concentrations (from KDOW criteria and the Kentucky TMDL) are 130 E. Coli colonies/100ml for a 30-day geometric mean, and a maximum of 240 E. Coli colonies/100ml to be met in at least 80% of all samples taken within a 30-day period during the Primary Contact Recreational season of May through October.

In the case of the Kentucky Division of Water sampling listed above, the West Fork Red River continues to exceed water quality criteria for 30-day geometric mean. Additionally, only 66.6% of samples taken during the Primary Contact Recreational season meet the 240 E. Coli colonies/100ml[1] maximum criteria, which does not meet the 80% sample pass requirement.

Substrate alterations

The 303(d) list is unclear as to what causes are responsible for the listed substrate alteration. The Compact reached out to the Tennessee Department of Environment and Conservation (TDEC) for more information regarding the cause of this impairment. The agency explained that streams are listed for physical substrate alterations if activities have altered stream substrate due to (but not limited to) gravel dredging, channelizing, or other non-regulated in stream activities. The agency informed us that this segment's assessment (TN05130206039_1000) was based on a 2001 biological and habitat survey, which scored poorly due to marginal bank stability and vegetative protection.

[1] In accordance with the EPA's *Protocol for Developing Pathogen TMDLs*, all fecal coliform units, expressed as CFU, counts, organisms, and most probable number (MPN), are considered equivalent measures of fecal coliform bacteria concentration.

Agency representatives further explained that today, they "would likely call this poor riparian/bank stability and maybe use Alteration in Stream-side or littoral vegetative covers or would refine the assessment further to just point to sediment from agriculture, development runoff, and/or stormwater." The Compact has found evidence supporting this assessment, as there are several bank locations of the West Fork Red River that are eroding, resulting in marginal substrate conditions due to sedimentation and poor riparian habitat due to lack or loss of bank vegetation. Substrate alterations will be further discussed later in this plan.

Estimate of Load Reductions

Nitrate + Nitrite

Total nitrate + nitrite was estimated using the STEPL model at 611,125 lbs/yr. The stream is considered nutrient impaired due to macroinvertebrate surveys, observations of algal blooms, and other factors, indicating that nitrate + nitrite (as well as phosphorus) must be reduced. In our stream walks within the watershed, we noticed some algae growth on surfaces but not an unusually large amount (streams were not "scummy" and covered in algae). Therefore we believe that a moderate nutrient reduction is likely needed. Tennessee lacks numerical total nitrate + nitrite criteria, so we set a percent reduction goal of 20% for nitrate + nitrite contamination, or ~**122,200 lbs/yr.**

Phosphorus

Total phosphorus was estimated using the STEPL model at 158,080 lbs/yr. Tennessee lacks numerical total phosphorus criteria, so we will set a percent reduction goal of 20% for phosphorus contamination, or **~31,600 lbs/yr.**

Sediment

Total sediment loading was estimated using the STEPL model at 41,339.5 tons/yr. Since Tennessee lacks numerical total sediment loading criteria, we will set a percent reduction goal of 20% for sediment contamination, or **~8,260 tons/yr.**

See BMP list in the following section for BMP sediment reduction estimates. Additional reduction as a result of behavioral changes driven by the educational outreach components of this plan is not included in this figure, but will supplement this total.

Pathogens

Total load reductions needed to reach pathogen standards were estimated by comparing 2015 sampling data from KDOW to their statewide TMDL criteria for pathogen loading. The West Fork Red River will need a 30 day geometric mean pathogen load reduction of **41**% to comply with the KDOW TMDL pathogen loading goals described above.

Modeling load reductions from installed BMPs within the HUC12 watershed is uncertain due to various potential point and non-point sources of pathogens, in-stream pathogen die-off, seasonal variability, etc. Additionally, the EPA's STEPL model, which we have used for our other pollutant load estimates, does not currently provide estimates for E. Coli, nor does it provide load reductions from installed best management practices.

Kentucky's 303(d) list states that the source of pathogens within segment KY1269347_01 is unknown, and it is difficult to ascertain the extent that this bacterial load is driven by non-point sources. Since a majority of this segment is surrounded by sparsely populated agricultural land,we hypothesize that a majority of E. Coli loading along this segment is due to non-point source stormwater runoff from poor agricultural practices.

Regardless of the values needed to reach the state water quality criteria, any activities that lower coliform will be useful in promoting healthier waters and communities. Therefore, we feel that pathogen loading reduction activities are worth funding. The primary focus of this watershed based plan with regards to pathogen mitigation will be agricultural best management practices, education, livestock exclusion, pet waste education, erosion control, and stormwater mitigation.

Anthropogenic Substrate Alterations

As substrate alterations are essentially unquantifiable, we cannot provide a load or load reduction goal. However, after discussion with TDEC regarding the causes of this impairment, we have identified several practices that can help mitigate this water quality issue. Specifically, riparian buffer plantings will help address some of the alterations in stream-side or littoral vegetative cover, and both major and minor bank stabilization projects will help stabilize eroding banks, addressing both poor bank habitat and sedimentation in the substrate.

BMP List, Educational Activities and Budget

Based on our above estimates for the non-numeric criteria load reductions and potential sources for pathogen loading, the following BMP activities should be sufficient to restore the OGWF watershed for most impairments. BMPs will be located in specific subwatersheds based on the impairments found in those subwatershed's stream segments. These BMPs focus on sediment, nitrogen, phosphorus, and pathogen reductions.

BMPs

Major Bank Stabilization Project: We have identified three major unstable streambank sections within the OGWF watershed, and anticipate the existence of at least one more needing a significant, intensively engineered project in order to correct. The highest priority locations are three locations in Billy Dunlop Park, a total of 540 feet in length (90 ft + 200 ft + 250 ft), each consisting of a high bank (10-15ft) that poses a public health hazard in addition to its environmental dangers. These banks have been prioritized for correction by the City of Clarksville for over five years.
We anticipate these major projects to account for much of the costs of implementing the watershed plan. Major streambank stabilization projects will primarily address sediment loading and will be conducted along the main stem of the West Fork Red River.

***Additional Streambank Stabilization*:** Streambank erosion contributes to sediment loading in many places in the OGWF watershed. Stormwater flow reduction will help reduce the erosive power of the watershed's waterways, but the existing eroded banks are vulnerable and will need repair in order to maximize load reductions. For this watershed plan, we envision a minimum of 2,000 feet of bank protection using natural methods (e.g. cedar revetments, coir logs, etc.). Streambank stabilization will be conducted primarily along tributaries to the West Fork Red River and along smaller intermittent drainages that are not represented on the national hydrographic database.

Riparian Buffers: While many of the waterways in the watershed do have riparian buffers, many are insufficiently narrow, and in some places nonexistent. If we assume an adequate riparian buffer is 50ft wide, the 30.2 miles of waterways (60.4 miles of buffer on both sides of all waterways) in the OGWF watershed should have about 365 acres of buffer within this 50 foot zone (<1% of the total watershed area). Based on a visual assessment of the condition of the riparian buffer zones of the watershed using Google Earth aerial imagery, we estimate that ~10% of waterway miles are either inadequately buffered or not buffered at all. There are also numerous smaller intermittent drainages that are not represented on the national hydrographic database that would benefit from buffering. These figures provide ample reason and opportunity for installation of riparian buffers, which can help minimize nutrient, sediment, and pathogen loading. Where needed, riparian buffers will be co-located with streambank stabilization measures in order to provide additional protection to vulnerable areas. All together, roughly 15 acres of riparian buffers will be planted, amounting to 13,000 linear feet, in order to create a 50 foot wide buffer.

Pet Waste Bag Dispensers: One of the main sources of pathogens in urban waterways is pet waste. Pet waste bag dispensers will be installed and stocked in highly visible public locations or high use private locations (such as large apartment complexes). This will help build awareness of the importance of pet waste control and provide residents with the easy means to do so.

Pet waste bags are currently being designed by the Cumberland River Compact and will be custom printed with tips about actions residents can take to improve water quality. We plan to install 20 dispensers in the watershed. Though *E. coli* is only listed as an impairment in the upper portion of the watershed, we anticipate *E. Coli* as a future impairment in the lower stretches of the watershed due to heavy urbanization and development. Currently, a TMDL exists for *E.Coli* for the entire Red River watershed, which includes the entire OGWF watershed, and proper pet waste management is one of the strategies suggested by the TMDL. Pet waste bag dispensers will be installed in the rapidly developing suburban areas of the lower portion of the HUC12.

Rain Gardens: Rain gardens assist with nutrient, pathogen, and sediment control, by infiltrating stormwater containing pathogens and nutrients, trapping sediment, and reducing high stormflow volumes that contribute to channel erosion downstream. Rain gardens can be placed adjacent to any impervious surface that would otherwise connect to a storm drain or wet weather conveyance, and can mitigate the effects of these surfaces. The Cumberland River Compact has had great success with our rain garden program and anticipates that finding collaborators for rain gardens will not be difficult. This plan will incorporate the installation of 10,000 square feet of rain gardens within the watershed. Rain gardens will be implemented in the Tennessee portion of the HUC12, as this section is undergoing heavy suburban development and will benefit the most from small bioretention projects.

Cattle Exclusion Fencing: Though to a lesser degree within the Tennessee portion of the watershed, the majority of the OGWF watershed is agricultural land, which includes a large number of livestock pastures. Though cattle are a smaller problem than in many other watersheds, they still contribute to sediment and pathogen loading if left unfenced from streams and small drainages. Horses may also be a problem and exclusion of these animals can also be addressed. We have identified at least two large cattle pastures with visible access to the river, and another three cattle pastures adjacent to the West Fork Red River that appear to need cattle exclusion fencing. We anticipate needing a minimum of 10,000 feet of cattle exclusion fencing to address the pastures with visible access to the river, and possibly more for the other adjacent pasture lands. Fencing is one of the cheapest BMPs, and additional fencing needs are unlikely to greatly affect the budget or feasibility of this project.

Stream Crossing (Kayak/Canoe Access): In 2013, the City of Clarksville opened the first blueway for water recreationists along the West Fork of the Red River. Two kayak/canoe accesses were created, one within Robert Clark Park, and the other within Billy Dunlop Park, opening up approximately 2 miles of river for paddlers to utilize for recreation. In recent years, the Parks and Recreation Department has experienced extensive use of this blueway by local residents, resulting in loss of vegetation, bank erosion, and general overuse of the blueway. Additionally, since there are no take out points downstream, many recreationalists who miss the take out point have no way to exit the river without illegally accessing private property (and climbing up unprotected banks). The Parks Department has expressed interest in installing additional kayak/canoe access points to extend the blueway and relieve the current access location's overuse. Overuse has significantly degraded the current access points, their adjacent banks, and their parking areas. We will work with the City to create 3 kayak/canoe accesses in the Clarksville area to meet the demand for water recreation and to reduce erosion and sedimentation associated with overuse of the current access locations.

Winter Cover Crop, Filter Strips, and Nutrient Management: The OGWF watershed contains an estimated 28,000 acres of cropland, much of which is located within the Kentucky portion of the watershed. Though the Kentucky section of the West Fork Red River is not currently listed for nutrients and sediment issues, our STEPL model estimated that this cropland contributes a significant amount of nutrient and sediment loading in the watershed. Using satellite imagery, we discovered that many of the fields adjacent to the West Fork Red River contain rills and ephemeral gullies that continue to be tilled across. In addition, there are some classical gullies, which are too large to till or move equipment across. Depending on the types of cover crops utilized, cover cropping can reduce erosion by reducing the impact force of precipitation on soil, securing soil in place with root systems between crop growing seasons, and by reducing soil compaction (allowing potentially more runoff to percolate) due to deep root systems. By improving soil structure and reducing sheet and rill flow from rain events, cover crops can also reduce nutrient loading in local streams and rivers. This can be especially effective when coupled with proper nutrient management plans, which reduce nutrient loading by managing the amount, source, method of application, and timing of plant nutrients and soil amendments.

Due to the large acreage of agricultural land and evidence of erosion, we believe that if farmers begin implementing winter cover crops and development nutrient management plans, we can significantly decrease the amount of sediment and nutrients being washed into the river each year. We estimate that we will need to implement winter cover cropping and nutrient management planning on 7,700 acres of crop land, or roughly 28% of agricultural land within the watershed.

In addition to nutrient management and cover cropping, implementation of filter strips between cropland and drainage areas will reduce sediment, nutrient, and pathogen loads by slowing stormwater runoff and allowing it to percolate into the soil rather than wash contaminants into nearby streams. In addition to cropland, this practice can be utilized along other areas with high runoff and little to no established canopy vegetation, such as park land, sports complexes, large parking lots, etc.

The United States Department of Agriculture (USDA)and NRCS state that minimum flow lengths through filter strips should be “20 feet for suspended solids and associated contaminants in runoff and 30 feet for dissolved contaminants and pathogens in runoff.” For the purposes of this plan, we will estimate our load reductions using the 30 feet filter strip width criteria to address excess pathogen, sediment, and nutrient runoff. We estimate that implementation of 25 acres of filter strips, or ~6.8 miles, can greatly reduce nutrient loading into the West Fork of the Red River in addition to sediment and pathogen loading.

Forage and Biomass Planting: Proper forage planting in livestock pastures is crucial to enhance the quality of local waterways and to prevent pasture soils from degrading. By improving soil structure and health, perennial species reduce soil erosion, reduce runoff by improving water infiltration (which in turn reduces nutrient and topsoil runoff), and build soil organic matter. With approximately 4,700 acres of pastureland within the watershed, proper forage and biomass planting will reduce the impacts of intensive grazing on the West Fork of the Red River. We estimate that this practice will need to be implemented on 2,000 acres of pastureland to achieve the needed sediment and nutrient load reductions. To maximize the effect this practice will have on the West Fork of the Red River, pastures adjacent to the river will be prioritized over other pastures located throughout the watershed.

***Water and Sediment Control Basins and Retention Ponds*:** This class of BMPs is a catch all, potentially including detention ponds, bioretention ponds, and control basins providing water quality and quantity management for cropland, parking lots, sports fields, and large building developments . We estimate that there will be opportunities to do several medium sized projects to capture and infiltrate stormwater as an erosion and pathogen control measure. For this plan, we estimate that implementation of 10-20 such structures will be needed to address pathogen and sediment contaminants in the watershed. These will take place mostly in the lower portions of West Fork Red River, where urban development is greatest, but they can also be utilized in agricultural areas. These retrofits can remove nutrients, sediment, and pathogens from stormwater runoff.

Load Reductions

Without numeric criteria for many impairments, and without a clear differentiation between point and non-point sources of E.coli pollution, we will only provide reduction calculations for nitrogen, phosphorus, and sediment here. Load reductions for nitrogen, phosphorus, and sediment were calculated using the Tennessee NPS Program - Pollutant Load Reduction Estimation Tool.

The majority of *E. coli* reduction will be handled by structural stormwater practices (access control, rain gardens, water/sediment control basins, stormwater filtration, etc.), and educational outreach programming to address livestock exclusion from streams, better fertilizer/manure management practices, pet waste. Substrate alterations, which would likely be classified as streamside habitat alterations if classified today, will be addressed as described in the BMP description by riparian plantings, major and minor bank stabilizations, and other structural practices, but cannot be quantified with available data.

Phosphorus

Using the Pollutant Load Reduction Estimation Tool referenced above, we estimate the following reductions from our BMPs:

Streambank/Shoreline Protection: *2,000 ft * 0.17 lbs P/foot/yr = 340 lbs/yr*
Riparian Forest Buffer: *15 acres * 22.6 lbs P/acre/yr = 339 lbs/yr*
Rain Garden: *10,000* ft^2 ** 0.06 lbs P/sq ft/yr = 600 lbs P/*ft^2 */yr*
Access Control: *10,000 ft * 0.01 lbs P/foot/yr = 100 lbs/yr*
Winter Cover Crop: *7,750 acres * 2.4 lbs P/acre/yr = 18480 lbs/yr*
Nutrient Management: *7,750 acres * 1.02 lbs P/acre/yr = 7,854 lbs/yr*
Filter Strip: *25 acres * 83 lbs P/acre/yr = 2,075 lbs/yr*
Water and Sediment Control Basin: *10 basins * 33.92 lbs P/basin/yr = 339 lbs/yr*
Forage and Biomass Planting: *2,000 acres * 0.66 lbs P/acre/yr = 1,320 lbs/yr*
Stream Crossing (Kayak/Canoe Access): *3 accesses * 7.5 lbs P/unit/yr = 22 lbs/yr*

Total phosphorus reduction from these measures: **31,470 lbs/yr**

We estimate that the remaining 140 lbs/yr reduction to reach our loading goals of 31,600 lbs/yr will be achieved through our outreach work that will promote best management farming practices, proper fertilizer use and reduction, and better residential lawn management practices. The above calculation does not address other structural practices that may also help with phosphorus reduction.

Nitrogen

Using the pollutant load reduction estimation tool provided in the watershed based plan guidelines, we estimate the following reductions from our BMPs:

Streambank/Shoreline Protection: *2,000 ft * 1.75 lbs N/foot/yr = 3,500 lbs/yr*
Riparian Forest Buffer: *15 acres * 308.4 lbs N/acre/yr = 4,626 lbs/yr*
Rain Gardens: *10,000* ft^2 ** 0.158 lbs N/*ft^2 */yr = 1,580 lbs/yr*
Access Control: *10,000 ft * 0.11 lbs N/foot/yr = 1,100 lbs/yr*
Winter Cover Crop: *7,700 acres * 11.4 lbs N/acre/yr = 87,780 lbs/yr*
Nutrient Management: *7,700 acres * 6.31 lbs N/acre/yr = 48,587 lbs/yr*
Filter Strip: *25 acres * 375.8 lbs N/acre/yr = 9,395 lbs/yr*
Water and Sediment Control Basin: *10 basins * 199.41 lbs N/basin/yr = 1,994 lbs/yr*
Forage and Biomass Planting: *2,000 acres * 6.78 lbs N/acre/yr = 13,560 lbs/yr*
Stream Crossing (Kayak/Canoe Access): *3 accesses * 50.3 lbs N/unit/yr = 151 lbs/yr*

Total nitrogen reduction from these measures: **172,273 lbs/yr**

This is well in excess of our load reduction goal of 122,225 lbs/yr, indicating that our goals for phosphorus should also achieve our nitrogen reductions. Further nitrogen reduction will be achieved through our outreach work that will promote best management farming practices, proper fertilizer use and reduction, and better residential lawn management practices. The above calculation does not include other structural practices that may also help with nitrogen reduction.

Sediment

Using the pollutant load reduction estimation tool provided in the watershed based plan guidelines, we estimate the following:

Streambank/Shoreline Protection: *2,000 ft * 0.047 tons/foot/yr= 94 tons/yr*
Riparian Forest Buffer: *15 acres * 3 tons/acre/yr = 45 tons/yr*
Rain Garden: *10,000* ft^2 ** 0.006 tons/* ft^2 */yr = 60 tons/yr*
Access Control: *10,000 ft * 0.001 tons/foot/yr = 10 tons/yr*
Winter Cover Crop: *7,700 acres * 0.84 tons/acre/yr = 6,468 tons/yr*
Nutrient Management: *7,700 acres * 0.282 tons/acre/yr = 2171.4 tons/yr*
Filter Strip: *25 acres * 32.9 tons/acre/yr = 822.5 tons/yr*
Water and Sediment Control Basin: *10 basins * 6.109 tons/basin/yr = 61.09 tons/yr*
Forage and Biomass Planting: *2,000 acres * 0.175 tons/acre/yr = 350 tons/yr*
Stream Crossing (Kayak/Canoe Access): *3 accesses * 2.8 tons/unit/year = 8.4 tons/yr*

Total sediment reduction from these measures: **10,306 tons/yr**

This brings our total estimated sediment reduction to well in excess of our 8,270 tons/yr goal, without even considering the impact of other incorporated measures, or behavioral changes driven by our educational outreach.

In addition, we estimate significant load reductions from three major bank stabilization projects that are planned for phase one of the watershed based plan. These three projects will be located in Billy Dunlop Park along the West Fork Red River. The City of Clarksville estimates that they are losing roughly 2.5 feet of bank per year along the waterway in the Park. Since this is based on a visual estimate, a more conservative two feet of bank per year can be used to estimate total annual soil loss from these areas. For the three proposed bank stabilization projects, which average 10 feet in height and are 540 feet in length, this amounts to 10,800 cubic feet of bank loss annually. Assuming a dry density of about 80lbs/ft3, we estimate annual sediment losses from the bank are approximately 430 tons. Assuming an equal division between total suspended sediment and bed load (which is quite conservative), we estimate a total suspended sediment reduction of 215 tons/yr for all three projects. The location of a fourth bank stabilization project is to be decided.

Educational Activities
As part of our watershed based plan, we recommend increasing awareness through educational outreach within the watershed. Outreach should be multifaceted, and, while some will be incorporated directly into BMPs, specific activities should be conducted with education and outreach in mind.

Foremost among the educational outreach needs for the watershed is a concerted effort to teach watershed residents about the need for and methods for reduction of nutrients and sediment through better agricultural land management, residential lawn management, rain gardens/native lawns/filterstrips, and riparian buffer protection. Though not a listed impairment within our project area, initiatives to reduce pathogens through in-stream cattle exclusion and proper pet waste disposal is an additional priority. Such outreach could involve mailers, scientific/educational presentations at local town hall meetings and other public events.

Another area in which we have had great success at the Cumberland River Compact is educational talks. We host weekly talks (known as River Talks) in the spring and fall at our event space in downtown Nashville, dedicated to a variety of topics relating to the science, history, and preservation of the Cumberland River. These seminars are well attended and benefit both the public and other non-profits. The talks have been so successful that we have expanded them to other cities within the Cumberland River Basin, including Clarksville. As part of this plan, we propose holding River Talks focused on the West Fork Red River, covering project work, water issues, and other environmental topics relevant to this Watershed Based Plan.

Additionally, youth education is of paramount importance to ensure the longevity of any work performed within the watershed. Future generations must grasp the importance of healthy habitat, biodiversity, and sustainable land management in order to protect best management practices implemented today and to support sustainable practices in the future. Without community support and interest on these issues, best management practices will be difficult to sustain into the future. Through K-12 educational programming, teacher trainings, and educational community events, we can engage youth in the importance of sustainable land management. In communities across the region, we have had success in youth engagement through our Creek Critters Program. Our Creek Critters Program teaches students about native aquatic biology, ecosystems, and the impact that various land uses have on the health of local streams. As part of this plan, we suggest implementing educational programming, such as our Creek Critters Program, teacher trainings, and educational community events to help current and future generations understand why implementation of these best management practices are important both now and in the future.

Budget for BMP's and Educational Activities

Based on estimates from our own previous work and estimates from collaborating organizations, we project the following budget breakdown for this watershed based plan (not including cost of volunteer time).

BMP Name	Quantity	Cost/Unit	Budget Estimate
Major Bank Stabilization	3 projects	$240,000 all projects	$240,000
Streambank/Shoreline Protection	2,000 ft	$75/ft	$150,000
Riparian Forest Buffer	15 acres	$2,500/acre	$37,500
Rain Garden	10000 ft^2	$5/ft^2	$50,000
Pet Waste Bag Dispensers	20 Dispensers	$750 each	$15,000
Access Control (Livestock Exclusion)	10000 ft	$5/ft	$50,000
Winter Cover Crop	7700 acres	$29/acre	$223,300
Nutrient Management	7700 acres	$39/acre	$300,300
Filter Strip	25 acres	$1,000/acre	$25,000
Water and Sediment Control Basin	10 projects	$24,000 each	$240,000
Forage and Biomass Planting	2000 acres	$245/acre	$490,000
Stream Crossing (or Kayak Access)	3 projects	$8,500 each	$25,500
Total			**$1,846,600**

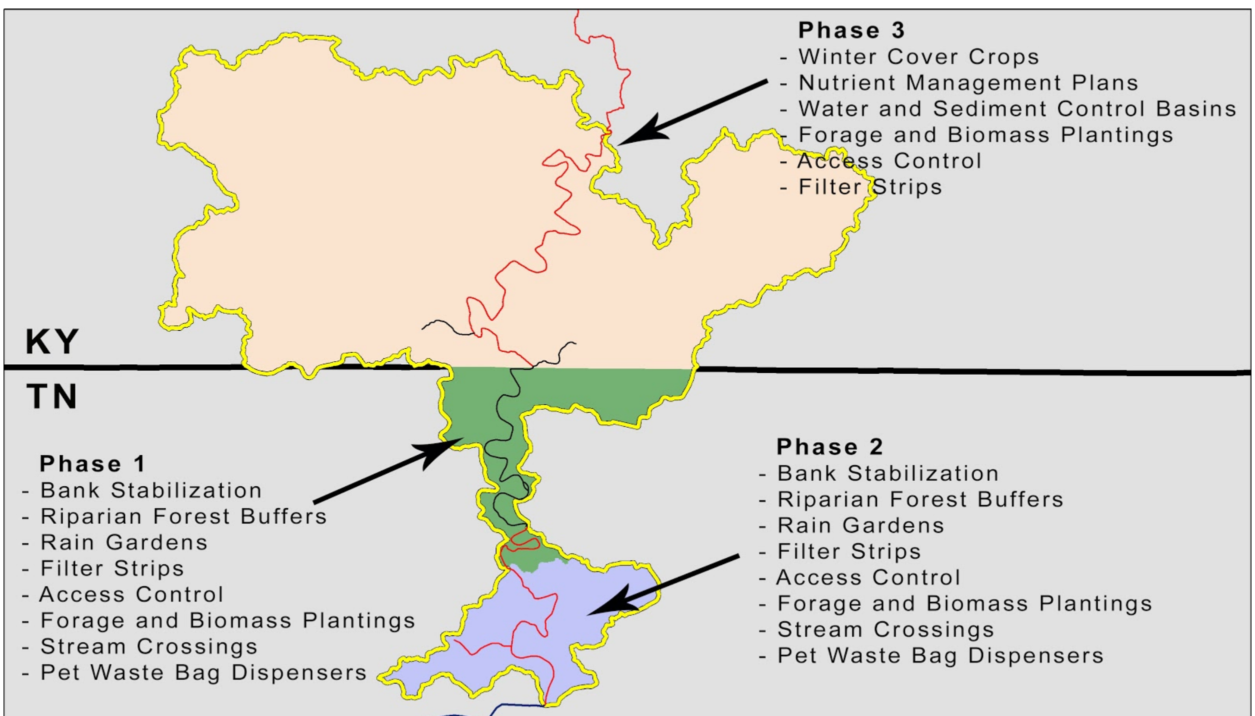
Educational Activity	Quantity	Cost/Unit	Budget Estimate
Annual Educational Festival (over 10 years)	10	$6,000 each	$60,000
Educational Classes, Talks, Seminars	30	$1,000 each	$30,000
Total			**$90,000**

Total Budget For Project	**$1,936,600**

Timeline, Tasks, and Assessment of Progress

This watershed based plan is envisioned as a comprehensive, 8-12 year long plan, to be completed by 2028. This plan will be divided into four 2-3 year long phases, with Phases 1-3 addressing three different sections of the watershed and Phase 4 serving as a wrap up phase to address trouble spots or neglected areas from Phases 1-3. Phase 1 will consist of the upper Tennessee section of the OGWF watershed (mostly rural and residential), Phase 2 will consist of the lower Tennessee half of the OGWF watershed, and Phase 3 will consist of the largely agricultural, Kentucky portion of the watershed. Funds will be sought from numerous sources, including the City of Clarksville, federal sources, private donors, and corporate sponsors.

The map below provides a visual of project phases and BMPs involved in each phase. Tasks are described in detail above in the BMP section. Project tasks will be distributed among individual phases and subwatersheds based on specific subwatershed impairments and needs. Further assessment coinciding with Phase 1 will identify specific locations and tasks for each subwatershed in the basin.



Map of Project Phases for OGWF Watershed Based Plan
The OGWF Watershed Plan envisions a 4-phase project over an 8-year period. In each 2-3 year phase, a different region of the watershed will be targeted. In the final phase, the whole watershed will be addressed, tackling previously unaddressed concerns identified during phases 1-3.The above map shows a potential geographical breakdown for phases 1-3. The map also includes potential BMP types to be implemented in each watershed.

Progress will be assessed based on percentage of progress tasks completed, remaining work to be done, and updated water quality monitoring data. Tasks associated with each phase will be described in proposals at the beginning of each phase, and each phase will conclude with a report detailing the proportion of project tasks completed, remaining needs, and expected efficacy and impact of completed tasks. This will inform future decision making and help shape the tasks for Phase 4, which will serve as a wrap up phase addressing any uncompleted tasks.

Criteria to Assess Achievement of Load Reduction Goals

If load reduction goals are met, affected streams will no longer exceed TDEC's and KDOW's state water quality criteria. Independent sampling coinciding with Phase 3 will allow identification of areas in need of additional work, allowing modification of the project during Phase 4 to address the most problematic locations.

Since riparian buffers and other natural methods take time to grow and reach full effectiveness, we anticipate that state water quality criteria may not be achieved immediately, but should be achieved for a given stream segment no later than five years after the end of the project phase addressing that segment's subwatershed. We anticipate project completion by 2028 and fully supporting conditions in all streams no later than 2032.

Monitoring and Documenting Success

The Cumberland River Compact and others involved in carrying out the watershed plan will keep the Tennessee Division of Water Resources and the Kentucky Division of Water aware of restoration activities to allow coordination of sampling. Restoration activities do not have immediate effects and positive results may take several years to appear. However, the duration of the plan means that the early phases of the plan can be assessed, allowing us to go back during Phase 4 and address problem areas or unresolved issues.

In addition to coordinating monitoring efforts with TDEC and KDOW, we hope to develop a partnership with Austin Peay State University, which is located close to our project area, to help with the development of supplemental monitoring and monitoring protocol, analysis, and other projects.

Observed water quality measurements should be on a positive trend by the end of the plan timeline, such that extrapolating results (i.e. assuming that continued riparian buffers will trap more contaminants as they grow, etc.) would demonstrate meeting state criteria by 2-3 years after the end of the plan's implementation. If observations indicate that meeting these criteria are unlikely, the program can be adjusted/extended in light of additional information. During Phases 1-3, we will be able to assess the effectiveness of the program prior to Phase 4 of the project, enabling us to revise the plan as needed. Successes and needed revisions would be documented at the end of each phase of plan implementation, allowing flexibility in implementing and improving the effectiveness of the plan.