Crooked Fork Watershed Restoration Plan

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Watershed Restoration Plan

This document was developed cooperatively by Tennessee Valley Authority, Natural Resources Conservation District, Morgan County Soil Conservation District and the Emory River Watershed Association to guide our efforts to restore Crooked Fork and its tributaries to fully support all of their designated uses, and protect public health and well being. This restoration plan follows Fiscal Year 2004 EPA Section 319 watershed plan guidelines and addresses each of the nine required components.

November, 2006

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Executive Summary

Crooked Fork, a tributary to the Emory River in upper east Tennessee, drains a 62 square mile area entirely contained within Morgan County. The entire 27.3 miles of the main stem of Crooked Fork are listed on the Proposed 2006 Final Version of the Tennessee 303(d) list. Causes of impairment include nitrates, physical substrate habitat alterations and loss of biological integrity due to siltation. Sources of these impairments include pasture grazing, municipal point source discharge, permitted small flows, abandoned mining and channelization (TDEC 2006). The upper reaches of Flat Fork, the primary tributary to Crooked Fork, are fully supporting. However, the lower 3.7 miles of Flat Fork, are included on the Tennessee 303(d) list due to nitrates, physical substrate habitat alterations and loss of biological integrity due to siltation. Sources of these impairments include pasture grazing and channelization (TDEC 2006).

This document was written to provide a plan to address the causes and sources of impairment in Crooked Fork with the initial focus on siltation and related habitat alteration. It was developed cooperatively by Tennessee Valley Authority, the Morgan County Soil Conservation District, Natural Resources Conservation Service and the Emory River Watershed Association to support our efforts to restore Crooked Fork Creek. This plan follows Fiscal Year 2004 EPA Section 319 watershed plan guidelines and addresses each of the nine required components (USEPA, 2003).

A Total Maximum Daily Load (TMDL) for Siltation and Habitat Alteration has been developed and approved for this watershed (TDEC, 2006). Target sediment loads expressed in lbs/acre/year of total suspended solids (TSS) were defined utilizing Level IV ecoregion reference sites. The TMDL identified the nonpoint sources of sediment loading in the larger Emory River watershed to be natural erosion processes, erosion from agricultural activities, urban erosion from bare soil areas, dust from impervious surfaces, erosion from unpaved roadways, runoff from abandoned mines and erosion from timber harvest and reforestation activities. The TMDL process sets load allocations for point and nonpoint sources of pollution and includes a margin of safety for each. It also sets reduction goals for nonpoint sources of pollution. Based on TMDL calculations, the Crooked Fork Watershed needs to reduce sediment load from nonpoint sources by 62%. (TDEC, 2006). The TMDL implementation plan includes the following steps: detailed survey of impaired subwatersheds, advocacy of local ordinances and zoning to minimize sediment load, educating the public regarding detrimental effects of sediment loading, and advocacy of agricultural best management practices (BMPs) to minimize erosion and sediment transport. This watershed restoration plan is built upon the TMDL target loads with an interim goal of 31% reduction.

Field investigations were conducted by Crooked Fork partners and local volunteers through a previously funded 319 program grant. This process identified priority areas, potential project sites and opportunities for improvement. In addition, a spreadsheet model based on the TVA Integrated Pollutant Source Identification (IPSI) platform was used to estimate the reductions in TSS loads anticipated from pasture, mine and barren

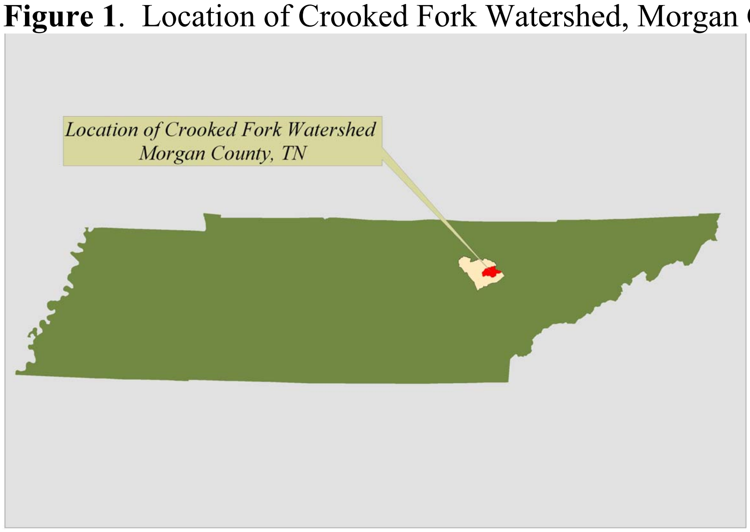
land improvements included in this plan. Total costs for this initiative, including pasture targeted BMPs, mine/barren land restoration/revegetation, monitoring, technical assistance, staff time and outreach are estimated to be $985,000 with 86% of the total budget for on the ground restoration work.

This plan proposes a two phased approach to restoring Crooked Fork. During Phase I, priority poor pasture, mine and barren lands will be restored with a package of best management practices including exclusion fencing, buffers, and revegetation. Phase I will require five years to complete and will include monitoring and additional watershed issue study. Phase II, will include data analysis and additional watershed planning for future phase implementation if needed based on resource condition. Watershed stakeholders will be kept informed about this initiative through a series of articles in the local newspaper, farm tours, outreach events, landowner newsletters, and a series of public meetings.

1.0 INTRODUCTION

Crooked Fork, a tributary to the Emory River (TN06010208) in upper east Tennessee (Figure 1), drains a 62 square mile area in Morgan County. The headwaters of Crooked Fork are located above the town of Petros, Tennessee in an area of past and active strip mining and logging operations. The stream then flows through the town of Petros, which is without a central sewage facility, and through an area of pasture and hay land. The historic Brushy Mountain State Prison, which does have a sewage facility, is also located in Petros. Flat Fork, the main tributary to Crooked Fork, has its headwaters in Frozen Head State Park, where it is a high quality reference stream while in the park. Its condition quickly degrades as it passes through an area of pastureland and the State of Tennessee operated Honor Farm and Morgan County Correctional Facility, which is currently under expansion. Downstream from the confluence of Crooked Fork and Flat Fork is the Plateau Utility District drinking water supply facility and the Wartburg Sewage Treatment Facility. Below these facilities are the popular swimming areas of Potters Falls and Laymance Falls. These sites are of considerable interest and concern to the citizens of Morgan County for their recreational and scenic significance.

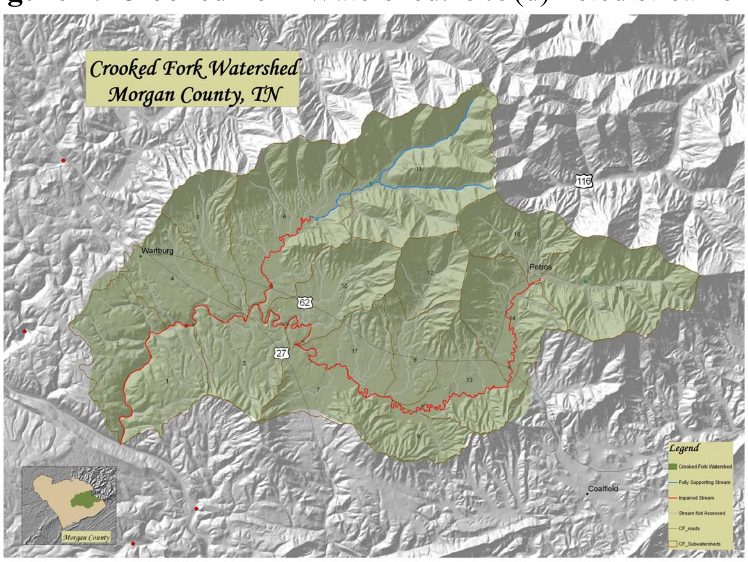
Figure 1. Location of Crooked Fork Watershed, Morgan County, Tennessee.



Crooked Fork's designated uses include support of fish and aquatic life, recreation, livestock watering/wildlife and irrigation. In addition, some stream segments within the watershed are also designated for domestic water supply and as a trout fishery. Five miles of the main stem of Crooked Fork are listed on the Nationwide Rivers Inventory for exceptional scenic, recreational, geologic and fish/wildlife values associated with several beautiful waterfalls and the deep gorge area on the lower portion of the stream. The Nationwide Rivers Inventory, required under the Federal Wild and Scenic Rivers Act of 1968, is a listing of free-flowing rivers that are believed to possess one or more outstanding natural or cultural values (TDEC, 2002).

The entire 27.3 miles of the main stem of Crooked Fork are listed on the Proposed 2006 Final Version of the Tennessee 303(d) list. Causes of impairment include nitrates, physical substrate habitat alterations and loss of biological integrity due to siltation. Sources of these impairments include pasture grazing, municipal point source discharge, permitted small flows, abandoned mining and channelization (TDEC 2006). The upper reaches of Flat Fork, the primary tributary to Crooked Fork, are fully supporting. However, the lower 3.7 miles of Flat Fork, are included on the Tennessee 303(d) list due to nitrates, physical substrate habitat alterations and loss of biological integrity due to siltation. Sources of these impairments include pasture grazing and channelization (TDEC 2006). Figure 2 shows the location of 303(d) listed streams.

Figure 2. Crooked Fork Watershed. 303(d) listed streams indicated in red.



The Crooked Fork Restoration Partnership (CFRP) is a consortium of agencies and groups that are interested in restoring and delisting Crooked Fork and Flat Fork. Partners include Tennessee Department of Environment and Conservation (TDEC)/Division of Water Pollution Control (DWPC), Tennessee Valley Authority (TVA), Emory River Watershed Association (ERWA), Morgan County Soil Conservation District, Natural Resource Conservation Service (NRCS), the University of Tennessee Extension Service and the University of Tennessee Forest Resources Research and Education Center (UT-FRREC). CFRP seeks to implement a successful watershed restoration plan through partnerships and adaptive management that will allow de-listing of impaired stream segments in a reasonable time frame.

The CFRP will build on successful work already completed in the watershed including:

- Implemented 319 grant participatory process to train local volunteers to assess Crooked Fork Watershed to support development of this watershed restoration plan.
- Completed subwatershed visual assessment project.
- Developed updated land cover layer and pollutant load model to estimate loads and reductions.
- On-going education and outreach including brochures, Watershed tours, River Festivals, displays, Kids in the Creek events, and volunteer training classes.
- The Hornyhead Branch Restoration Project completed in 2006. This project was a
- 3100' streambank stabilization project that utilized multiple techniques. The project site, located on the UT FRREC property, has been the site for multiple tours and workshops. The project won the 2006 Governor's Environmental Stewardship Award in the Agriculture/Forestry category.
- Annual Riparian Buffer and Plant Distribution project: distributed over 10,000 native riparian seedings and information about stream buffers to over 200 Crooked Fork Watershed residents.
- Multiple presentations, meetings and newspaper articles about Crooked Fork Watershed, stream conditions and possible management options.

There is an approved Total Maximum Daily Load (TMDL) for siltation and habitat alteration in the Emory River Watershed (TDEC 2006). The TMDL was developed using target loads based on ecoregion reference streams in ecoregion 68a.

The TMDL includes an implementation plan to address nonpoint sources that recommends the following steps:

1. Conduct a detailed survey of impaired subwatersheds to identify additional sources of sediment loading.
2. Advocacy of local area ordinances and zoning that will minimize sediment loading to waterbodies, including establishment of buffer strips along

streambanks, reduction of activities in riparian areas and minimization of road and bridge construction impacts.

3. Educate the public as to the detrimental effects of sediment loading to waterbodies and measures to minimize this loading.
4. Advocacy of agricultural BMPs (e.g. riparian buffer, animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment protection, livestock exclusion, etc) and practices to minimize erosion and sediment transport to streams.

Partners and local volunteers have completed the first step of the TMDL implementation plan. The Emory River Watershed Association implemented a 319 funded volunteer training and assessment program which was combined with existing data sets and additional partner visual assessment to identify priority areas. A model has been developed to predict current estimated pollutant loadings and predict future post-restoration reductions based on iterative interactions with the model. In addition, significant progress has been made towards the third step of the implementation plan in terms of presentations, educational brochures, volunteer assessment training, student educational events and watershed tours. This plan will continue the TMDL implementation plan by addressing steps 2, 3 and 4, listed above.

This plan was written according to the fiscal year (FY) 2004 EPA Section 319 guidelines for watershed plan development. The initial focus tiers off the approved TMDL and addresses siltation/habitat alteration related impairment in the watershed. It addresses the most economically and physically feasible practices first to address an interim TSS reduction goal during phase I. A monitoring component to assess incremental improvements as well as further study of stream channelization, deep mines and suspect failing septic/straight pipes are included in phase I of this plan. Phase II will include adaptive management planning to address any additional or remaining impairment upon completion of phase I of this plan. Ultimately delisting of the stream will be based on biological assessments which show aquatic life that meets state standards for the ecoregion. Plans for future phases will be developed if necessary to reach the de-listing goals.

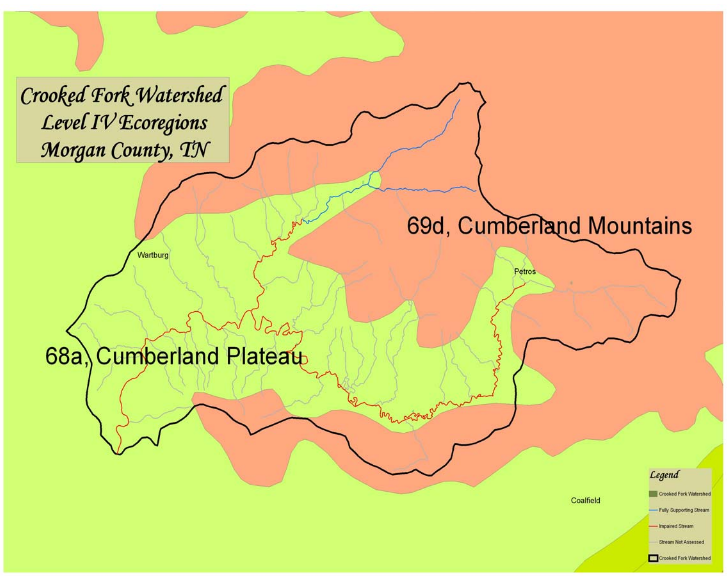
2.0 DESCRIPTION OF THE WATERSHED

2.1 Watershed Characteristics and Condition

The Crooked Fork Watershed is located entirely in Morgan County, Tennessee. It drains a 62 square mile area and is a tributary to the Emory River (TN-06010208).

Ecoregion
Portions of the watershed fall in the Cumberland Plateau (68a) and the Cumberland Mountain (69d) Level IV subecoregions. Elevations in the Cumberland Plateau are generally 1200–2000 feet. Pennsylvania-age conglomerate, sandstone, siltstone and shale are covered by mostly well-drained, acid soils of low fertility. The Cumberland Mountains are more highly dissected with narrow crested steep slopes and younger Pennsylvaina-age shales, sandstones, siltstones and coal. Narrow winding valleys separate the mountain ridges (TDEC, 2006). Overall, the region is mostly forested with areas of agriculture, urban development and natural resource mining activities (USEPA, 1997).

Figure 3: Level IV Ecoregions, Crooked Fork Watershed.



Landcover

An updated version of the 2001 National Land Cover Dataset was used as the land cover input for the pollutant load model (PLM) developed for this plan. The original layer was updated with a digital problem mine areas from TDEC Abandoned Mine Land Problem Area quad sheets and a vegetative index value layer developed from 2006 multispectral satellite imagery through an interpretive process, see figure 4. The output of this process allowed the partnership to identify good, fair and poor vegetation cover on mine and agricultural lands. It also provided an estimate the acreages of each cover type. The general breakdown of landcover types for the entire watershed are shown in Figure 5. Overall, 72 % of the watershed is estimated to be in forest/scrub cover, 16.9% is agricultural cover and 11.1% is other, including 1.2% in mining.

Figure 4. NDVI derived from SPOT 10 meter multispectral satellite imagery. Brighter greens indicate healthy vegetation and browns indicate bare ground and man-made surfaces

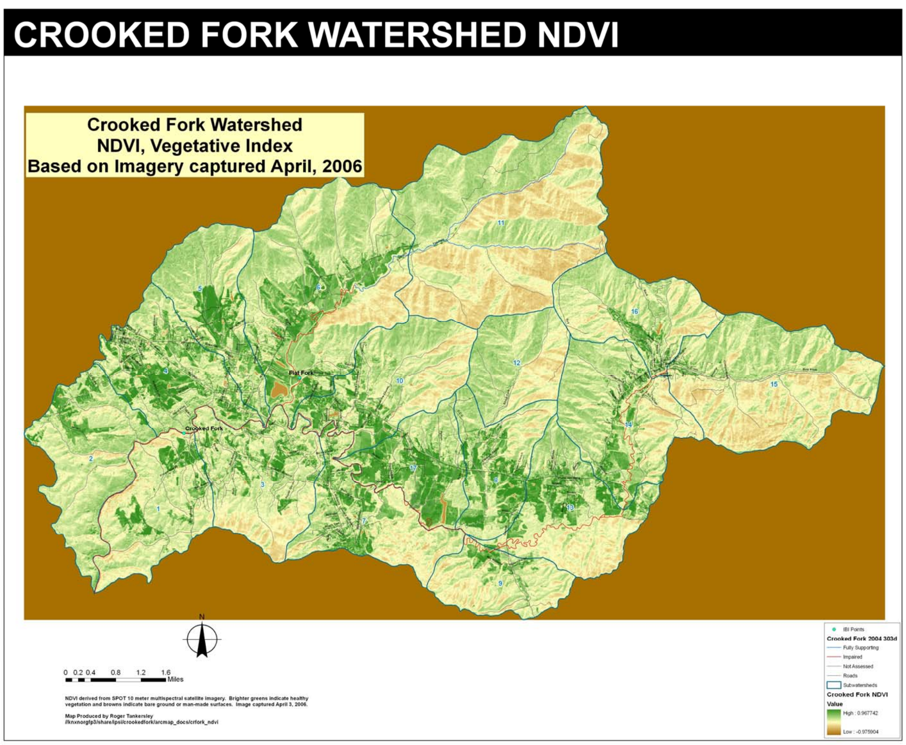
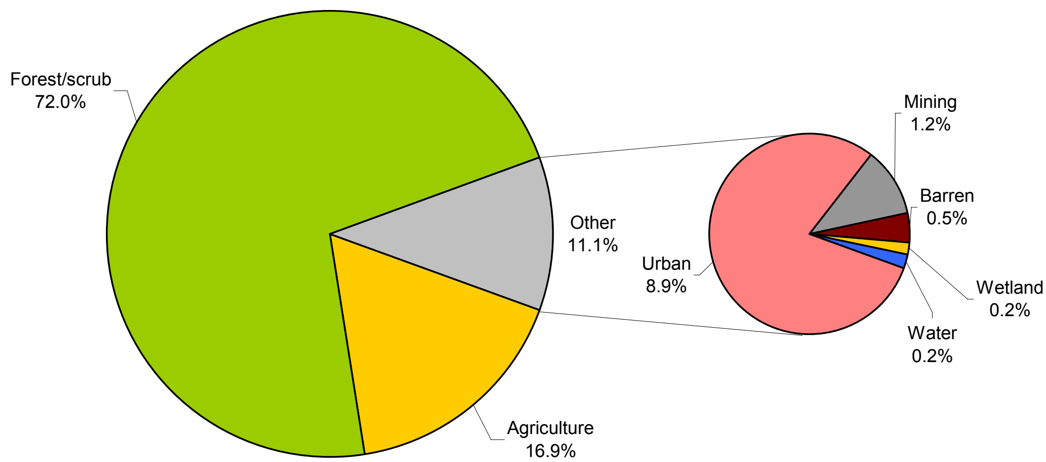


Figure 5: Estimated Existing Landcover for Crooked Fork Watershed



Population
Information derived from the US Department of Census Tiger Files indicates total population of the watershed to be approximately 6,000 people.

Water Resource Conditions
According to TDEC standards, the entire 27.3 miles of the main stem of Crooked Fork and 3.7 miles of tributaries are impaired (Proposed 2006 Final Version of the Tennessee 303(d)). The impaired sections are unable to support fish and aquatic life, domestic water supply, irrigation, livestock and wildlife watering and recreational uses at the same level of the ecoregion reference stream.

Stream Biotic Condition Data
The majority of fish (IBI) and benthic macroinvertebrate (EPT) scores range in the poor to poor/fair range since 1996. See table 1.

Table 1. Summary of Biologic Data for Crooked Fork Watershed

Site	Date	IBI Score	EPT Score	Habitat Score	Source
Crooked Fork mile 4.4	4/16/1996	--	8, fair	--	TVA
Crooked Fork, mile 4.4	7/17/1996	30, poor	--	33.5	TVA
Crooked Fork, mile 4.4	6/2/2001	--	28, fail	183/200	TDEC
Crooked Fork, mile 4.4	7/7/2003	38, poor/fair	5, poor/fair	32	TVA
Crooked Fork, mile 4.4	6/22/06	--	--	182/200	TDEC
Crooked Fork, u/s of STP	6/26/2001	--	36, pass	127/200	TDEC
Crooked Fork, mile 16.9	6/26/2002	--	26, partially supporting	99/200	TDEC
Crooked Fork, mile 16.9	6/22/2006	--	--	120/200	TDEC
Flat Fork, mile 0.5	4/16/1996	--	12, fair/good	--	TVA
Flat Fork, mile 0.5	4/29/1996	34, poor	--	23	TVA
Flat Fork, mile 0.5	8/2/2000	36, poor/fair	--	18	TVA
Flat Fork, mile 0.7	6/26/2001	--	28, fail	97/200	TDEC
Flat Fork, mile 0.7	6/6/2006	--	--	139/200	TDEC
Flat Fork, Frozen Head Reference Site	9/15/5006	--	--	171/200	TDEC

2.2 Pollution Causes and Sources

The entire 27.3 miles of the main stem of Crooked Fork are listed on the Proposed 2006 Final Version of the Tennessee 303(d) list. Causes of impairment include nitrates, physical substrate habitat alterations and loss of biological integrity due to siltation.. Sources of these impairments include pasture grazing, municipal point source discharge, permitted small flows, abandoned mining and channelization (TDEC 2006). The upper reaches of Flat Fork, the primary tributary to Crooked Fork, are fully supporting. However, the lower 3.7 miles of Flat Fork, are included on the Tennessee 303(d) list due to nitrates, physical substrate habitat alterations and loss of biological integrity due to siltation. Sources of these impairments include pasture grazing and channelization (TDEC 2006).

The point sources of impairments (municipal point source discharge and permitted small flows) are being addressed through the TDEC's National Pollutant Discharge Elimination System program.

This watershed restoration plan address the nonpoint sources of sediment related impairment. In order to further estimate the amounts and types of work needed to restore Crooked Fork, partners divided the watershed into 17 subwatersheds (Figure 6) that correspond to tributary streams and generally homogeneous land areas. These same delineations are used in this restoration plan. A summary of this information is presented in Table 2, below.

Figure 6. Crooked Fork Subwatershed Deliniations

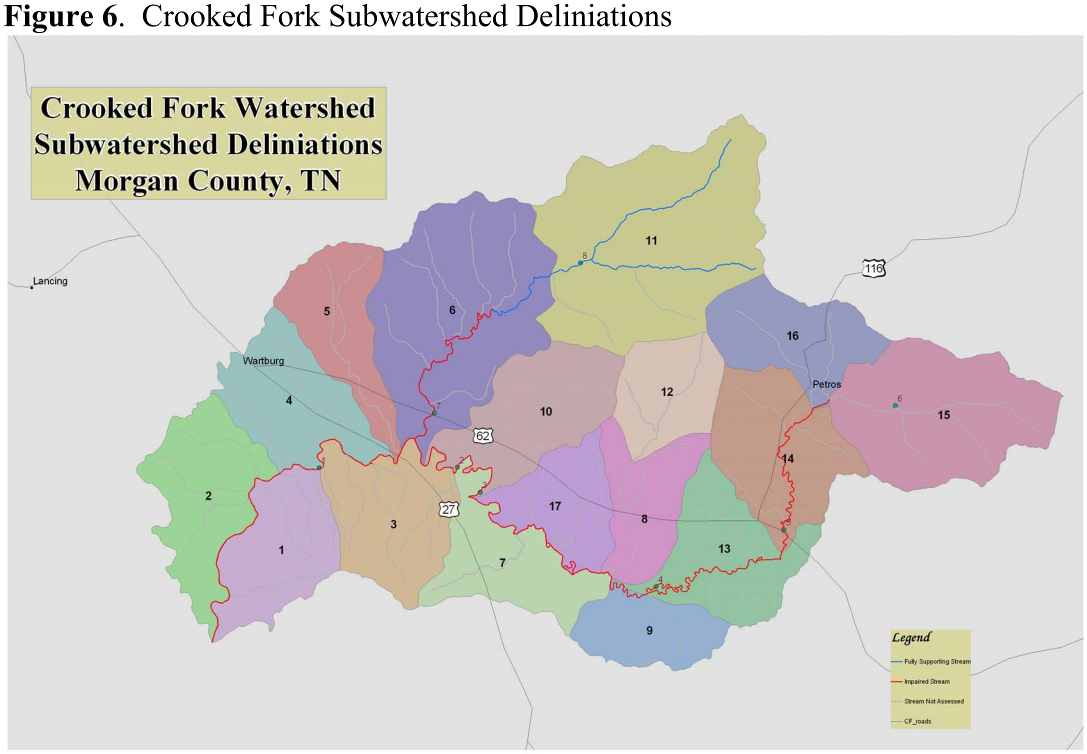


Table 2. Crooked Fork Subwatershed Summary.

Subwatershed Name	ID	Total Area, Acres	Miles Impaired	Segment ID	Cause	Source
Potters Falls	1	1934.6	4.2*	TN06010208 004-1000	Nitrates	Municipal Point Source Pasture Grazing
Vespie Branch	2	2204.4	3.5*	TN06010208 004-1000	Nitrates	Municipal Point Source Pasture Grazing
Knight Branch	3	2198.6	3.9*	TN06010208 004-1000	Nitrates	Municipal Point Source Pasture Grazing
Wartburg	4	2056.2	2.4	TN06010208 004-1000	Nitrates	Municipal Point Source Pasture Grazing
Mud Creek	5	1739.4	0.5	TN06010208 004-1000	Nitrates	Municipal Point Source Pasture Grazing
Lower Flat Fork	6	4556.8	3.1	TN06010208 004-0200	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Pasture Grazing, Channelization
Mossy Grove	7	1829.0	4.8*	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization
Beech Fork	8	1470.6	x	TN06010208 004-2999	n/a	n/a
Horneyhead Branch	9	1266.8	0.9	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization
Taylor Branch	10	2215.1	2.9	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization
Frozen Head	11	5354.5	0.0	TN06010208 004-0250	n/a	n/a
Little Fork	12	1431.3	x	TN06010208 004-2999	n/a	n/a
Jones Market	13	2134.2	2.8	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization
Lower Petros	14	2410.5	3.1	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization
Bletchers Creek	15	3404.1	x	TN06010208 004-0300	n/a	n/a
Stockstill Branch / Brushy Mtn	16	1833.4	0.3	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization
Petit Lane	17	1470.9	3.1	TN06010208 004-2000	Nitrates, Physical Substrate Habitat Alterations, Loss of biological integrity due to siltation	Permitted Small Flows, Abandoned Mining and Channelization

X = streams not assessed
* = impaired stream forms subwatershed border, stream segment shared with one or more additional subwatersheds.

As part of the process to define causes and sources of pollution, the CFRP conducted a citizen assessment/monitoring component, funded by a Section 319 Grant to Emory River Watershed Association, a visual assessment of each subwatershed, and generated an undated landcover layer using 2006 multispectral satellite imagery. These processes allowed us to identify pollutant source locations and priority areas to focus our work. Summaries of vegetative cover for priority landcovers and findings from the visual assessment/priority areas are shown in table 3 and Appendix A.

Table 3. Summary of Good/Fair/Poor cover on Pasture and Mine Sites

Subshed Name	ID	Total Area, acres	Acres Pasture, Good cover	Acres Pasture, fair cover	Acres Pasture, poor cover	Acres Mine, good cover	Acres Mine, fair cover	Acres Mine, poor cover	Acres Barren Areas
Potters Falls	1	1934.6	79.8	243.2	14.4	0.0	0.0	0.0	6.0
Vespie Branch	2	2204.4	45.1	258.3	66.7	0.0	0.0	0.0	0.0
Knight Branch	3	2198.6	74.7	309.6	11.8	0.0	0.0	0.0	3.1
Wartburg	4	2056.2	274.5	301.0	32.9	0.0	0.0	0.0	45.1
Mud Creek	5	1739.4	67.6	330.3	53.6	0.0	0.0	0.0	2.2
Lower Flat Fork	6	4556.8	22.5	503.3	664.0	0.0	0.0	21.1	83.4
Mossy Grove	7	1829.0	27.6	241.4	78.7	5.8	4.9	4.9	6.2
Beech Fork	8	1470.6	137.8	304.5	53.1	0.0	2.7	0.0	0.0
Horneyhead Branch	9	1266.8	6.0	180.5	0.7	0.0	0.0	0.0	5.6
Taylor Branch	10	2215.1	18.9	332.5	34.0	154.7	1.8	3.3	22.5
Frozen Head	11	5354.5	0.2	10.2	1.8	0.0	0.0	0.0	1.1
Little Fork	12	1431.3	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Jones Market	13	2134.2	72.9	468.1	22.9	0.0	2.4	0.0	6.2
Lower Petros	14	2410.5	20.5	259.0	128.7	0.0	28.7	42.7	7.8
Bletchers Creek	15	3404.1	0.2	86.5	0.4	0.0	101.8	14.0	0.0
Stockstill Branch / Brushy Mtn	16	1833.4	1.6	63.8	14.2	0.0	25.1	6.4	7.6
Petit Lane	17	1470.9	293.4	405.2	39.8	0.0	66.9	0.9	7.3
Total		**39510.4**	**1143.2**	**4299.2**	**1217.7**	**160.5**	**234.3**	**93.4**	**204.1**
Percent of total			**2.9%**	**10.9%**	**3.1%**	**0.4%**	**0.6%**	**0.2%**	**0.5%**

Pollutant Load Model
The Pollutant Load Model (PLM) developed for this watershed is based on the platform of the TVA Integrated Pollutant Source Identification (IPSI) model, using a more simplified landcover layer developed for the project. The model contains Universal Soil Loss Equation parameters to calculate soil loss on appropriate landcovers and includes separate soil loss estimates for the good/fair/poor pasture and mine/barren lands identified during development of the updated landcover layer.

PLM calculations indicate that while agriculture is only 16.9% of the total area of the watershed, pasture contributes and estimated 65% of the TSS loads. Similarly, mine lands and barren lands constitute only 1.7% of the watershed but contribute an estimated 32% of the TSS load, see Figure 7. These lands considered to be the main nonpoint sources of TSS loading throughout the Crooked Fork watershed. Efforts to restore Crooked Fork will focus on pasture, mine and barren lands restoration and best management practices. The pasture related practices will include streambank stabilization and riparian zone establishment/protection. Priority areas include subsheds 4, 6, 7, 10, 14 which have the highest estimated total soil loss (see Figure 8) and subsheds 5, 8 and 17 which also have high estimated TSS loads in tons/acre/year (see Figure 9).

Figure 7. Estimated TSS Load by Land Cover Type.

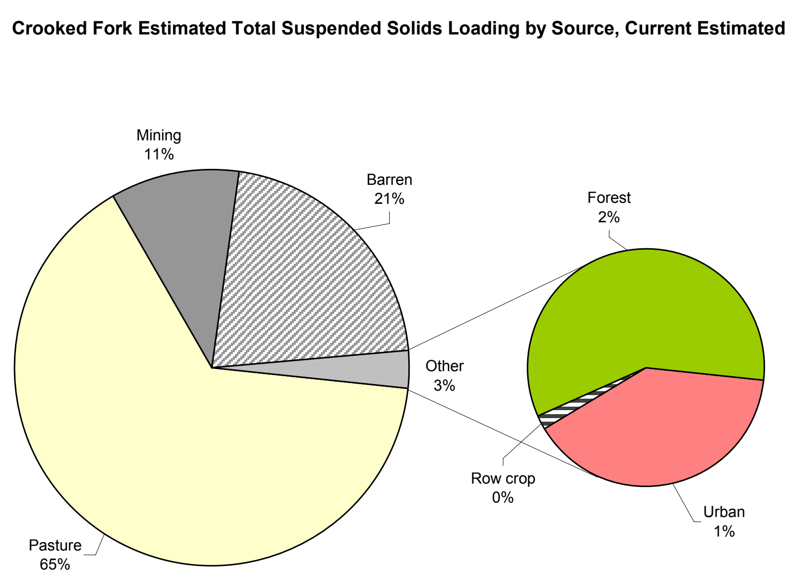


Figure 8. Estimated Current Soil Loss by Subwatershed. Current soil loss is estimated to be highest from subsheds 4, 6, 7, 10 and 14.

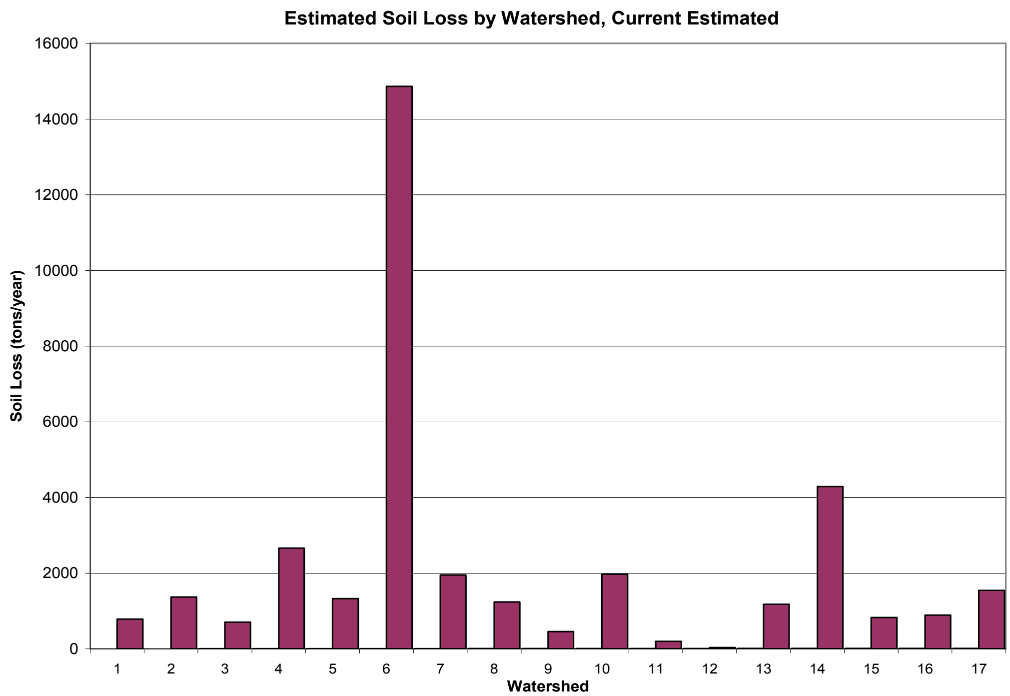
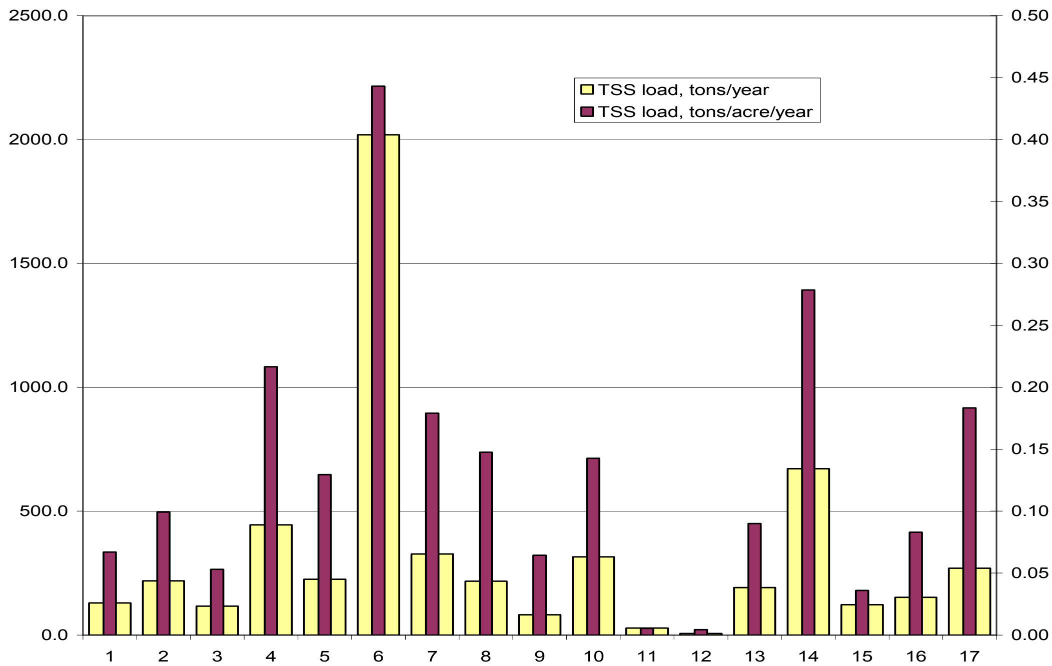


Figure 9. Estimated TSS Load by Subwatershed. Current TSS load/acre/year is estimated to be highest in subsheds 4, 5, 6, 7, 8, 10, 14 and 17.



2.3 Pollution Load Reduction Targets

Current and Target Loads

The current estimated TSS load is 0.14 tons/acre/year for the entire Crooked Fork Watershed, see Table 4. The approved TMDL developed by TDEC prescribes a 62% reduction in TSS from nonpoint sources to restore the stream to meet all designated uses. Since there is some level of uncertainty in landcover based PLM estimates, we are setting an interim goal that is half of the TMDL's prescribed reduction. We feel that this will allow us to put practices on the ground, monitor for changes and define future management options based on the results we obtain. It also will also provide for the most efficient use of agency, partner and landowner dollars in order to achieve the desired reductions.

Table 4. Current Estimated TSS Load in Tons per Year.

Watershed Name	Water shed ID	TSS load, tons/ acre/ year	Pasture, Good cover	Pasture, fair cover	Pasture, poor cover	Mining, good cover	Mining, fair cover	Mining, poor cover	Barren Areas
Potters Falls	1	0.07	2.995	45.639	36.155	0.000	0.000	0.000	37.546
Vespie Branch	2	0.10	1.648	47.166	162.363	0.000	0.000	0.000	0.000
Knight Branch	3	0.05	2.729	56.574	28.700	0.000	0.000	0.000	18.953
Wartburg	4	0.22	10.174	55.770	81.280	0.000	0.000	0.000	278.713
Mud Creek	5	0.13	2.593	63.378	137.048	0.000	0.000	0.000	14.217
Lower Flat Fork	6	0.44	0.700	78.504	1380.978	0.000	0.000	109.803	433.434
Mossy Grove	7	0.18	1.047	45.838	199.221	0.219	0.929	30.952	39.394
Beech Fork	8	0.15	5.474	60.484	140.688	0.000	0.530	0.000	0.000
Horneyhe ad Branch	9	0.06	0.246	36.954	1.820	0.000	0.000	0.000	37.925
Taylor Branch	10	0.14	0.689	60.662	82.721	5.644	0.324	20.275	136.517
Frozen Head	11	0.01	0.007	1.538	3.567	0.000	0.000	0.000	5.573
Little Fork	12	0.00	0.000	0.355	0.000	0.000	0.000	0.000	0.000
Jones Market	13	0.09	2.681	86.069	56.126	0.000	0.450	0.000	38.144
Lower Petros	14	0.28	0.733	46.403	307.496	0.000	5.138	254.919	46.470
Bletchers Creek	15	0.04	0.007	14.386	0.986	0.000	16.937	77.661	0.000
Stockstill Branch / Brushy Mtn	16	0.08	0.059	12.108	35.999	0.000	4.767	40.780	47.811
Petit Lane	17	0.18	11.655	80.481	105.365	0.000	13.288	5.886	48.562
		0.14	43.44	792.31	2760.51	5.86	42.36	540.28	1183.26

We have set an interim goal for TSS load of 0.0966 tons/acre/year, which represents a 31% reduction (reduce by 0.0434 tons/acre/year) from the current estimated load. This load is predicted to be achieved through the pasture, mine and barren land improvements defined in this plan, see Table 5. Upon completion of planned restoration practices, biologic and chemical monitoring will be completed to assess effectiveness and provide a basis for adaptive management if needed.

Table 5. Future estimated TSS Load in Tons / Year after Watershed Plan Implemented.

Watershed Name	Water shed ID	TSS load, tons/ acre/ year	Pasture, Good cover	Pasture, fair cover	Pasture, poor cover	Mining, good cover	Mining, fair cover	Mining, poor cover	Barren Areas
Potters Falls	1	0.07	2.995	45.639	36.155	0.000	0.000	0.000	37.546
Vespie Branch	2	0.04	3.477	47.166	40.660	0.000	0.000	0.000	0.000
Knight Branch	3	0.05	2.729	56.574	28.700	0.000	0.000	0.000	18.953
Wartburg	4	0.22	10.174	55.770	81.280	0.000	0.000	0.000	278.713
Mud Creek	5	0.09	3.744	63.378	60.301	0.000	0.000	0.000	14.217
Lower Flat Fork	6	0.23	13.194	78.582	507.997	0.625	0.000	109.913	327.908
Mossy Grove	7	0.11	2.943	45.838	72.661	0.219	0.929	30.953	39.394
Beech Fork	8	0.06	7.461	60.485	7.945	0.000	0.530	0.000	0.000
Horneyhead Branch	9	0.06	0.246	36.954	1.820	0.000	0.000	0.000	37.925
Taylor Branch	10	0.14	0.689	60.662	82.721	5.644	0.324	20.275	136.517
Frozen Head	11	0.01	0.007	1.538	3.567	0.000	0.000	0.000	5.573
Little Fork	12	0.00	0.000	0.355	0.000	0.000	0.000	0.000	0.000
Jones Market	13	0.09	2.681	86.069	56.126	0.000	0.450	0.000	38.144
Lower Petros	14	0.18	2.527	46.411	188.061	0.717	5.139	123.064	46.478
Bletchers Creek	15	0.04	0.007	14.377	0.986	0.333	16.793	77.593	0.000
Stockstill Branch / Brushy Mtn	16	0.08	0.059	12.108	35.999	0.000	4.767	40.780	47.811
Petit Lane	17	0.14	12.569	80.481	44.459	0.000	13.288	5.886	48.562
		0.096610	65.50	792.39	1249.44	7.54	42.22	408.46	1077.74

3.0 Management Strategies and Costs

Nonpoint source (NPS) pollution management measures to reduce sediment loadings will be targeted toward agricultural sources and abandoned mine and barren lands during the first phase.

Agricultural Management Measures
Main actions for improving water quality in pasture/hay land areas are grouped into a pasture packet, see Table 6. Practices included in the packet include exclusion of cattle from stream access, cross fencing for rotational grazing, alternative water sources, heavy use area protection, riparian buffers, stream bank stabilization and pasture renovation. These practices provide the greatest environmental impact with the least financial commitment. Conservation plans will be developed for each farm. Recommended systems of BMPs would vary for each farm and would include some or all of the following practices:

- **Pasture and Hayland Planting / Renovation -** Establishing native or introduced forage species.
- **Livestock Exclusion Fencing -** constructed barrier to animals
- **Alternative Water Source-** includes source development (spring or well), pipeline and tank.
- **Heavy Use Area Protection -** The stabilization of areas intensively used by animals, or vehicles by surfacing with a suitable material.
- **Streambank Stabilization -** Stabilizing the channel of a stream with suitable structures.
- **Riparian Buffer establishment** – a 3 zone buffer from the water's edge to the top of the bank (35 to 100 feet).
- **Critical Area Planting** - Establishing permanent vegetation on sites that have or are expected to have high erosion rates and that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal practices.
- **Stream Crossing** - A travelway constructed across a stream to allow livestock, people, and equipment to cross with minimal disturbance.
- **Soil Testing –** assessment of soil nutrient condition and prescription for fertilizer.

Table 6 Agricultural BMPs grouped in a pasture packet for TSS reductions with associated costs per acre of treatment

Units Per Acre	Unit	Cost Per Unit	Total Cost per acre for described treatment
1	Pasture Renovation	$150.00	$150.00
50	Exclusion Fence	$3.00	$150.00
0.04	Alternate Water Source and HUAP	$6,049.00	$241.96
0.017	Filter Strip // Buffer (based on 20 ft width and 2200 ft in length)	$6,000.00	$117.00
2.85	ft streambank stabilization	$50.00	$142.50
0.005	misc -- critical area, stream crossings		$60.00
0.1	soil test	$5.00	$5.00
Total Cost of Pasture Package per acre			**$866.46**

Mine and Barren Land Management Measures:

- **Regrading and Revegetation** – site re-grading, soil testing, soil amendment, mulching, fertilizer, permanent vegetation (seed or tree planting). Per TDEC Abandoned Lands Section, cost estimate ranges from $6,000 - $8,000/acre. Our budget is based on an average cost of $7,000/acre.

All agriculture related practices will include soil testing following University of Tennessee protocol and landowners will be required to follow soil testing requirements if applying fertilizer.

Table 7. Subwatershed Pollution Reduction Practices and Cost

Subwatershed	Number of Units	Restoration Practice	Cost	Life of Practice
SS 4	30 acres poor pasture to good pasture	Pasture Package 866.49/acre	$25,995	10 years
SS 5	50 acres poor pasture to good pasture	Pasture Package 866.49/acre	$43,325	10 years
SS 6	400 acres poor pasture to good pasture	Pasture Package 866.49/acre	$346,596	10 years
SS 6	20 acres barren to good mine	Barren land revegetation 7,000.00/acre	$140,000	25 years
SS 7	50 acres poor pasture to good pasture	Pasture Package 866.49/acre	$43,325	10 years
SS 8	50 acres poor pasture to good pasture	Pasture Package 866.49/acre	$43,325	10 years
SS 14	50 acres poor pasture to good pasture	Pasture Package 866.49/acre	$43,325	10 years
SS 14	20 acres poor to good mine	Mine revegetation Package 7,000.00/acre	$140,000	25 years
SS 17	23 acres poor pasture to good pasture	Pasture Package 866.49/acre	$19,929	10 years
Total	**693 acres treated**		**$845,819**	

Based on iterative interactions with the Pollutant Loading Model, addressing 653 acres of poor pasture and 40 acres pf poor mine/barren lands will reduce TSS loading by 0.0434 tons/acre/year which meets our target interim goal of a 31% reduction in TSS load.

Future Possible Management Measures
We anticipate some future conversion from hayland or other vacant lands to crop land due to an increase in demand for specific crop products for a new alternative fuel plant to be built in the watershed. For future crop land development, we propose to install the following types of management practices to reduce erosion and sedimentation:

- Filter Strip / Border – establishment of a vegetated border around crop fields to capture and filter run off.
- Streambank Stabilization - Stabilizing the channel of a stream with suitable structures
- No-Till (offset cost for drill rental) – alternative conservation planting method.
- Grade Stabilization Structure - A structure used to control the grade and head cutting in natural or artificial channels
- Grassed Waterway - A natural or constructed channel that is shaped to required dimensions and established with suitable vegetation.

In addition, further needs assessment is planned to study waste/nutrient issues for a portion of the watershed; a deep mine impact assessment and channel restoration needs assessment and planning.

4.0 EDUCATION CAMPAIGN

We plan to host 4 model farm tours to highlight the agricultural practices we are promoting, distribute 2 newletters annually to landowners in the watershed and host annual riparian buffer workshops to build interest in the program and provide education about NPS pollution issues. In addition, we plan to host workshops for elected officials related to the impacts of development on water quality and possible strategies they may use to address these issues; outreach to homeowners about sources of NPS pollution and actions they can take to reduce their impact; provide technical assistance and education on interpretation of soil tests.

5.0 MONITORING

A monitoring component will be used to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 6.0 below. The initial monitoring plan is outlined below. TDEC field staff will be consulted to refine this monitoring plan prior to its implementation. All monitoring will follow TDEC Standard Operating Procedures.

In-stream Water Quality Monitoring:

- TDEC Watershed Planning Cycle Monitoring is taking place for Crooked Fork and Flat Fork during 2007 Fiscal Year.
- Another course of TDEC Watershed Planning Cycle Monitoring is anticipated for the 2012 Fiscal Year and will include TSS monitoring.

Biologic Community Monitoring:

- Benthic macroinvertebrate sample collection at each TDEC monitoring site using SQKICK methodology during year 5 of Phase I.
- IBI assessment of fish community by TVA during the five year cycle at one sample location.

Long Term/Periodic Assessment:

- TVA IBI: TVA will continue to sample the fish community at one location on Crooked Fork at a five-year interval.

6.0 EVALUATION

Criteria that will be used to determine if loading reductions are being achieved and substantial progress is being made towards attaining water quality standards will be based on instream water quality analysis of TSS and biological health of the benthic community.

Once Phase I restoration projects have been installed, watershed-wide biological and physical/chemical monitoring will determine overall effectiveness of the restoration plan. The standard for TSS will be based on target loads from ecoregion reference streams in ecoregion 68a, 135.5 average annual sediment load (lbs/acre/year).

The ultimate measure of effectiveness will be based on biology with the goal that benthic macroinvertebrate samples at all impaired stream segments be within State standards for this ecoregion**. The benthic community assessment using SQKICK methodology should meet the target index score of 32 or higher**.

7.0 TECHNICAL AND FINANCIAL NEEDS

Phase	Practice	Units Needed	Cost per Unit	Total Estimated Cost	Source(s)
I	Pasture Package	652	$866.49	$564,951	319, TVA, Landowner, TSMP, TDA, MCSCD, NRCS
I	Mine and Barren Land Restoration	40	$7,000.00	$280,000	MCSCD, 319, TDEC, TVA
I	Monitoring / Assessment	1	$3,000	$3,000	TVA, TDEC, ERWA
I	NPS Education / Outreach	5 years	$3,000	$15,000	TVA, 319, TDA, NRCS, ERWA, UT
I	Staff / Implementation	5 years	$15,000	$75,000	MC, MCSCD, 319, TVA, NRCS, ERWA
I	Technical Assistance	5 years	$5,000	$25,000	TDEC, TVA, NRCS, TDA
I	Straight Pipe / Septic System // Alternative Waste Feasibility	1	$7,500	$7,500	TVA
I	Deep Mine Assessment	1	$5,000	$5,000	TDEC, TVA, ERWA
I	Channel Restoration Needs Assessment and Planning	1	$5,000	$5,000	TSMP, TVA, NRCS, ERWA
II	Future planning – phase III planning if needed	1	$5,000	$5,000	TVA, NRCS, ERWA
TOTAL				**$985,451**	

8.0 IMPLEMENTATION SCHEDULE AND MILESTONES

The proposed implementation schedule for this project is summarized on Table 8. This schedule includes five years of on–the-ground restoration activities (phase I), completion of needs assessments for decentralized/onsite waste systems, deep mines and stream channelization. In addition, monitoring to evaluate effectiveness scheduled for year 5.

Phase II of the plan includes additional work to develop/implement additional restoration plans, related funding proposal, education/assessment as needed for future phases based on water quality monitoring conducted at the conclusion of Phase I.

Table 8. Crooked Fork Creek Restoration Schedule and Milestones.

Phase I	Restoration Milestone	Education Milestone	Assessment Milestone
Year 1	100 acres of pasture improved.	1 article submitted to paper; host 1 riparian buffer workshop and plant distribution.	Track and report results. Conduct Straight Pipe / Septic System // Alternative Waste Feasibility
Year 2	125 acres of pasture improved. 10 acres mine or barren land improved	Host 1 Farm Tour / Award Ceremony and submit 1 article to paper; develop and mail 2 newsletters.	Track and report results.
Year 3	125 acres of pasture improved. 10 acres mine or barren land improved	Host 1 Farm Tour / Award Ceremony , 1 article submitted to paper; 1 public meeting/outreach event; develop and mail 2 newsletters.	Track and report results. Conduct Deep Mine Assessment.
Year 4	125 acres of pasture improved. 10 acres mine or barren land improved	Host 1 Farm Tour / Award Ceremony, 1 article submitted to paper; 1 public meeting/outreach event; develop and mail 2 newsletters.	Track and report results.
Year 5	177 acres of pasture improved 10 acres mine or barren land improved	Host 1 Farm Tour, complete 1 Project Report and related newspaper article.	Study Effectiveness; develop additional restoration plans as needed. Water quality monitoring: instream and biologic monitoring to

			determine if restoration effective to restore Crooked and Flat Fork. TSS loads must meet target loads based on ecoregion reference streams in ecoregion 68a and benthics must meet standards identified in Section 6.0 above. Conduct channel restoration needs assessment and planning
Phase II: Year 6 and 7			Develop additional phase III restoration plans and funding proposals based on water quality data collected and needs assessments completed.
Future Phase III	Implement additional restoration as needed.	Implement additional education as needed.	Implement additional assessment as needed.

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Appendix A. Visual Assessment Summary

Subshed	Name	Priority for Sediment NPS BMPs	Primary Concerns	Management Options
1	Potters Falls	**Low**	STP Outfall upstream - being upgraded; Location of only remaining dairy in watershed - candidate for BMPs; 1 rock quarry located by main stem.	Wartburg STP is upgrading. TDEC has jursidiction to regulate STP- point source outfall. Per TDEC, upgrade of STP will address impairment here. Dairy operation - waste and buffer BMPs; fencing, alt water.
2	Vespie Branch	**Low**	STP Outfall	See above SS 1
3	Knight Branch	**Low**	Ag land and lack of riparian zone	Ag BMP, buffer enhancement.
4	Wartburg	**Medium**	New construction and growth associated with road upgrades and comm growth. Large crop field under conversion to pasture, race track, bare spot behind HS, Soloman Park riparian zone.	Address sediment sources (HS, Construcition , Soloman Park). Offer growth readiness type training for decision makers to proactively address growth.
5	Mud Creek	**Medium**	Ag land BMPs needed and stream buffers needed. Sediment source – slope behind commercial business.	Ag land BMPs on Letory Loop Road and buffer enhancement. Stabilize slope behind commercial area sediment source or add structure to manage.
6	Lower Flat Fork	**High**	Mines: appr 75 acres may need additional revegetation. Prison area: Work with prison during and after construction. They will mitigation onsite which will help remeander a tributary stream and provide somewhat improved riparian habitat.; above prison, Ag BMPs needed to enhance riparian zone; repair one stream segment. Instream: stream channelized through the prison area: mitigation plan will allow some of channel to revert back to old. Additional log drop structures would be helpful.	Prison – explore potential project site for major restoration effort through TSMP. Prison currently under massive expansion project with large scale borrow and fill from onsite locations Work with farms above prison to install pasture BMPs.
7	Mossy Grove	**High**	Mines: abandoned from 40's / 50's - back of Little Brushy Mountain; and Edmonds Road / Black Water. Ponds off Williams and Heidel Rod //fish with sores Channelized Stream above levee: stream channel dredged and sediment deposited on banks/flooding issues. Several new houses, and more property for sale. Logging/UT Forest Land.	Reclaim additional mine land (off Heidel Mill and possibly UT Forest area). Restore 1,000 stream at church; stabilize area at Hwy 27 and Williams Road.

8	Beech Fork	**High**	Lack of Riparian buffer along main stem. Cattle related BMPs needed. Power line and ATV usage in upper section.	Establish buffer; exclude cattle – potential TSMP project site. ATV and forestry management BMPs to northern arms of subshed. (outreach to forest owners to help them protect their land during timber harvesting). Coordinate with Frozen Head to protect their boundary.
9	Horneyhead Branch	**Medium**	Farm above UT, Old mines on UT; Melhorn blown out stream / channelized.	Farm upstream of UT needs BMPs (buffer, cattle exclusion); mines are vegetated, but spoil never reclaimed; stream on Farm need restorations/repair and exclusion fence.
10	Taylor Branch	**High**	Very poor denuded old mine location on Russell Lamance Rd, with channelized and totally denuded stream. 3 current NPDES permitted mines. Ag issues: poor pasture.	Reclaim mine area (moonscape) on Russell Lamance Road (appr 10 acres) and restore stream channel thought site. Ag approach: exclusion fencing and rip buffer; rehab fair pasture to reduce sediment load
11	Frozen Head	**Low**	In good shape	n/a No additional management needed at this time.
12	Little Fork	**Low**	In good shape	No additional management needed at this time.
13	Jones Market	**Medium**	Ag Lands needing BMP - appr 470 acres fair pasture and 22 poor pasture; protect riparian buffer on main stem; add buffers and meaners to small channelized streams/ag drains.	Ag BMP - pasture related. Streambank restoration/meander and buffer restoration
14	Lower Petros	**High**	High priority due to sediment loading and possible waste issues/straight pipes. Large piece of poor pasture in lower section along Hwy 116, 128 acres coded as poor, and 259 acres coded as fair. Possible old strip / deep mine on eastern edge of subshed	Rehab poor pasture area near Hwy 62. Address 2 sediment source roads off Back Petros Road. Study waste issue and feasibility assessment for area. Streambank stabilization along main stem.
15	Bletchers Creek	**High**	Poor Mine area - 14 acres sediment source and possible ATV usage. Also significant fair cover mine along stream and north end of subshed. Also sedge/herbaceous along southern edge of subshed - NPDES permitted mine area.	Study waste issue and feasibility assessment for area. Address poor mine area at off upper Balk Knob Road. And fair mine area - large sediment source.
16	Stockstill Branch / Brushy Mtn	**High**	STP Outfall. Significant portion of stream with no riparian zone / intensively managed. Some sediment sources off hwy 116: road cuts and exposed soil areas.	Study waste issue and feasibility assessment for area. Restore stream segment through Petros Park. And up to prison if it closes -- may have opportunity. Also riparian zone work needed along stream below Petros Lake. Sediment sources: poor mine site and Hwy 116 road cuts.

17	**Petit Lane**	**High**	Ag Lands needing BMP (horse farm and cattle pasture). Old mine lands and mine pond / levee system. Utility Line in northern section off Patton Rd large bare area (possible development) and ATV usage. Channelized streams.	Ag Land BMP: cattle exclusion, buffer establishment, instream structure or restore channelized sections and mine reclamation at levee.