US Army Corps of Engineers®
Memphis District

Appendix A: Environmental

Piney Creek Ecosystem Restoration
Bolivar, Hardeman County, Tennessee

Includes:

Species Lists
Habitat Modeling
CE/ICA Analysis
404(b)(1) Evaluation
Monitoring and Adaptive Management Plan

Piney Creek

Ecosystem Restoration

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Section 206

Species Lists

Memphis District

May 2021

Section I. Species

Table 1. State- listed rare aquatic species in Hardeman County

County			Scientific Name	Common Name	Global Rank	Federal Status		State Rank	Habitat	
Hardeman	Invertebrate Animal	Mollusc	Villosa vibex	Southern Rainbow	G5	S2	- -	Rare, Not State Listed	Mud or soft sand in small rivers & creeks in areas with moderate current; Conasauga, Hatchie, and Wolf (Miss. R.) river systems.	Aquatic
Hardeman	Vertebrate Animal	Fish	Noturus gladiator	Piebald Madtom	G3	S3	- -	D	Large creeks & rivers in moderate-swift currents with clean sand or gravel substrates; Mississippi River tributaries.	Aquatic
Hardeman	Vascular Plant	Flowering Plant	Ceratophyllum echinatum	Prickly Hornwort	G4	S1	- -	S	Slow Moving Streams	Aquatic
Hardeman	Vertebrate Animal	Fish	Cycleptus elongatus	Blue Sucker	G3G4	S2	- -	T	Swift waters over firm substrates in big rivers.	Aquatic
Hardeman	Vertebrate Animal	Amphibian	Acris gryllus	Southern Cricket Frog	G5	S2S3	- -	Rare, Not State Listed	Grassy margins of swamps, marshes, lakes, ponds, streams, ditches, and nearby temporary pools; far SW Tennessee.	Aquatic
Hardeman	Invertebrate Animal	Crustacean	Creaserinus hortoni	Hatchie Burrowing Crayfish	G1	S1	- -	E	Primary burrower; uses saturated or seasonally saturated soils associated with permanent bodies of water; Mississippi River tributaries, Coastal Plain.	Aquatic

Hardeman	Vertebrate Animal	Fish	Ammocrypta beani	Naked Sand Darter	G5	S2	--	D	Shifting sand bottoms & sandy runs; Hatchie & Wolf rivers & their larger tribs.	Aquatic
Hardeman	Vascular Plant	Flowering Plant	Magnolia virginiana	Sweetbay Magnolia	G5	S2	--	T	Forested Acidic Wetlands	Possible
Hardeman	Vascular Plant	Flowering Plant	Symplocos tinctoria	Horse-sugar	G5	S2	--	S	Floodplains And Moist Ravines	Possible
Hardeman	Invertebrate Animal	Insect	Ophiogomphus howei	Pygmy Snaketail	G3	S3?	--	Rare, Not State Listed	Clear rivers with strong current over coarse cobbles and with periodic rapids; possible in Southern Appalachians.	Aquatic
Hardeman	Vertebrate Animal	Amphibian	Hemidactylium scutatum	Four-toed Salamander	G5	S3	--	D	Woodland swamps, shallow depressions, & sphagnum mats on acidic soils; middle & east Tennessee.	Possible
Hardeman	Vertebrate Animal	Fish	Ammocrypta vivax	Scaly Sand Darter	G5	S2	--	D	Small to medium rivers with sandy substrate; Hatchie & Buffalo rivers.	Aquatic
Hardeman	Vertebrate Animal	Reptile	Sistrurus miliarius streckeri	Western Pygmy Rattlesnake	G5T5	S2S3	--	T	Usually near water in river floodplains, swamps, marshes, and wet prairies; occas drier wooded uplands; W half of Tenn., generally.	Possible
Hardeman	Vertebrate Animal	Mammal	Synaptomys cooperi	Southern Bog Lemming	G5	S4	--	D	Marshy meadows, wet balds, & rich upland forests.	Possible
Hardeman	Vertebrate Animal	Bird	Limnothlypis swainsonii	Swainson's Warbler	G4	S3		D	Mature, rich, damp, deciduous floodplain and swamp forests.	Possible

Table 2. Species Collected in Piney Creek in 2016 & 2017

Species Name	Piney Lower		Piney Middle		Piney Lower	
	7/25/16	6/28/17	7/25/16	6/21/17	7/25/16	6/28/17
Yellow Bullhead (Ameiurus natalis)	5	2	5	12		
Naked Sand Darter (Ammocrypta beanii)	1	1				
Scaly Sand Darter (Ammocrypta vivax)		1				
Pirate Perch (Aphredoderus sayanus)	2	3	1			
Central Stoneroller (Campostoma anomalum)						1
Bluntface Shiner (Cyprinella camura)		7	20	32		4
Creek Chubsucker (Erimyzon oblongus)					1	
Grass pickerel (Esox americanus)	2	3				
Harlequin Darter (Etheostoma histrio)	1					
Bright Darter (Etheostoma lynceum)			1			
Guardian Darter (Etheostoma oophylax)			1		3	
Goldstripe Darter (Etheostoma parvipine)			1	7		2
Speckled Darter (Etheostoma stigmaeum)	4					
Gulf Darter (Etheostoma swaini)	1	1	5	10		
Blackstripe Topminnow (Fundulus notatus)		2		10		2
Blackspotted Topminnow (Fundulus olivaceus)	5	3	9	38	1	3
Cypress Minnow (Hybognathus hayi)			7			
Mississippi Silvery minnow (Hybognathus nuchalis)	17				7	
Northern Hogsucker (Hypentelium nigricans)	3	5	5			
Least Brook Lamprey (Lampetra aepyptera)	1		16	20	4	1
Green Sunfish (Lepomis cyanellus)	2	3	4	20	4	1
Orange Spotted (Lepomis humilis)	3					
Bluegill (Lepomis macrochirus)	13	30	1	22	8	
Dollar Sunfish (Lepomis marginatus)		1				

Longear Sunfish (Lepomis megalotis)	10	22				1
Striped Shiner (Luxilis chrysocephalus)					1	
Ribbon Shiner (Lythrurus fumeus)	10			8		
Spotted Bass (Micropterus punctulatus)	2	5	1			
Largemouth Bass (Micropterus salmoides)	2	1	1			
Spotted Sucker (Minytrema melanops)	1					
Blacktail Redhorse (Moxostoma poecilurum)	1	7				
Orangefin Shiner (Notropis ammophilus)	5		6	54		6
Brindled Madtom (Noturus miurus)		2				
Brown Madtom (Noturus phaeus)	5	8	7	20	17	
Dusky Darter (Percina sciera)	3		8	18	3	
Creek Chub (Semotilus atromaculatus)	1	21	3	24	25	2
Total # Species	24	20	19	14	11	10
Total # Fish	101	127	102	279	74	23

Table 3. Species Found in recent and historic surveys (Keck & Etnier 2005)

Pteromyzontidae	2016-17	1975-2005	Pre-1975
Lamptera aepyptera Least Brook Lamprey	X	X	
Clupeidae			
Dorosoma cepedianum (Gizzard Shad)			X
Cyprinidae			
Campostoma anomalum (Central Stoneroller)	X		
Cyprinella camura (Bluntface Shiner)	X	X	X
Hybognathus hayi (Cypress Minnow)	X		
Hybognathus nuchalis (Mississippi Silvery Minnow)	X	X	X
Hybopsis amnis (Pallid Shiner)		X	X
Luxilus chrysocephalus (Striped Shiner)	X		
Lythrurus umbratilis (Redfin Shiner)		X	X
Lythrurus fumeus (Ribbon Shiner)	X		
Notemigonus crysoleucas (Golden Shiner)			X

Notropis ammophilus (Orangefin Shiner)	X	X	X
Notropis atherinoides (Emerald Shiner)		X	
Opsopoedus emiliae (Pug-nosed Minnow)			X
Pimephales notatus (Bluntnose Minnow)		X	X
Pimephales vigilax (Bullhead Minnow)		X	X
Semotilus atromaculatus (Creek Chub)	X		
Catostomidae			
Erimyzon oblongus/claviformis (Creek Chubsucker)	X		X
Hypentelium nigricans (Northern Hogsucker)	X		
Minytrema melanops (Spotted Sucker)	X		X
Minytrema poeciliurum (Blacktail Redhorse)	X	X	
Ictaluridae			
Ameiurus natalis (Yellow Bullhead)	X	X	X
Ictalurus punctatus (Channel Catfish)			X
Noturus gladiator (Piebald Madtom)		X	X
Noturus hildebrandi (Least Madtom)		X	X
Noturus miurus (Brindled Madtom)	X		X
Noturus nocturnus (Freckled Madtom)		X	X
Noturus phaeus (Brown Madtom)	X	X	X
Esocidae			
Esox americanus (Grass pickerel)	X	X	X
Aphredoderidae			
Apherdoderus sayanus (Pirate Perch)	X	X	X
Fundulidae			
Fundulus notatus (Blackstripe Topminnow)	X		
Fundulus olivaceus (Blackspotted Topminnow)	X	X	X
Poecilidae			
Gambusia affinis (Mosquitofish)			X
Atherinopsidae			
Labidesthes sicculus (Brook Silverside)		X	
Centrarchidae			
Centrachus macropterus (Flier)			X
Lepomis cyanellus (Green Sunfish)	X	X	X

Lepomis gulosus (Warmouth)		X	X
Lepomis humilis (Orange Spotted)	X		
Lepomis macrochirus (Bluegill)	X	X	X
Lepomis marginatus (Dollar Sunfish)	X	X	
Lepomis megalotis (Longear Sunfish)	X	X	X
Micropterus punctulatus (Spotted Bass)	X	X	
Micropterus salmoides (Largemouth Bass)	X	X	X
Pericidae			
Ammocrypta beanii (Naked Sand Darter)	X	X	
Ammocrypta vivax (Scaly Sand Darter)	X		
Etheostoma chlorosoma (Bluntnose Darter)			X
Etheostoma gracile (Slough Darter)			X
Etheostoma histrio (Harlequin Darter)	X	X	X
Etheostoma lynceum (Bright Darter)	X	X	X
Etheostoma oophylax (Guardian Darter)	X		
Etheostoma parvipinne (Goldstripe Darter)	X	X	
Etheostoma stigmaeum (Speckled Darter)	X		X
Etheostoma swaini (Gulf Darter)	X	X	X
Percina maculate (Blackside Darter)			X
Percina sciera (Dusky Darter)	X	X	X
Percina vigil (Saddleback Darter)		X	X
# of Species 56	36	33	38

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Habitat Modeling

Memphis District

May 2021

Habitat Suitability Index models were used to examine three species representing different guilds – mammals, amphibians, and fish and mussels. All show similar improvement ratios, i.e. approximately 3:1 over the future without project condition, but the absolute numbers of habitat units are ranges of magnitude different from each other. A habitat unit is calculated by multiplying acres of habitat by the suitability index. Species that use few acres, like fish which are confined to the water, will typically have low numbers of habitat units whereas a species that uses more acres, like mink, will have higher numbers. This does not mean the project has more value for mink than for fish.

Bullfrog

Graves, B.M., and S.H. Anderson. 1987. Habitat suitability index models: bullfrog. U.S. Fish Wildl. Servo Biol. Rep. 82(10.138). 22 pp.

The bullfrog (*Rana catesbeiana*) occurs in the project area. It is a large, aquatic frog that commonly inhabits permanent bodies of standing or slow-moving water. Conant (1975) states that the natural range of the bullfrog extends from Nova Scotia to central Florida, west to Wisconsin and across the Great Plains to the Rocky Mountains. Bullfrogs are usually found on or near shorelines, but move a number of meters into the water when water temperature is higher than air temperature in the fall (Willis et al. 1956). Males move away from the shore in spring and summer for mating choruses (Howard 1978). The bullfrog model was used to assess the edge and riparian habitat along Piney Creek and predict future conditions with and without project.

There is approximately 4,500 feet of habitat in the lower end of Piney Creek. The bullfrog habitat model analyzes habitat quality based on vegetative cover, water level, turbidity, temperature, substrate, and velocity. Piney Creek scores well for pH, temperature, and velocity but it lacks in channel cover and connectivity to shoreline cover. The existing habitat has an average Habitat Suitability Index (HSI) of 0.80 and 25.36 average annual habitat units (AAHU).

No Action: The habitat suitability for bullfrog is forecasted to decline from 0.80 to 0.75 as the channel entrenches further separating the vegetated shoreline from the water's edge. Habitat units would decline from 25.36 to 23.78.

Alternative 2. The increase in the length of the channel will increase edge habitats which are valuable for bullfrogs. Bullfrog habitat quality would increase to 0.87 and 94.5 acres for a gain of 58.44 AAHUs. The gain in habitat quality stems from increased canopy cover, distance to the shoreline, and shoreline cover. Most of the habitat benefits will be achieved when construction is complete. Over time the forest quality will improve as higher quality trees return and begin to mature. These changes will occur slowly over time and will not substantially change the results of the HSI model. The annual habitat units for bullfrog are estimated to remain static and therefore are assumed to be the average annual.

Alternative X is assumed to have the same habitat unit output as Alternative 2, although the amount of clearing necessary to allow excavation of the complete channel could actually reduce canopy cover for a few years post construction. A lower HSU calculation is shown, but not used in the subsequent CE/ICA.

Table 1. Bullfrog HSI

Variable	Existing (4500 feet)	FWOP (4500 feet)	Alternative 2 – pilot channel (13725)	Alternative X
S1V1 Mean distance from Shore to water >1.5 m	.5	.2	.75	.75
S1V2 % Canopy Cover	0.8	.6	1.0	(.8)-1.0
S1V3 % Shoreline Cover	.4	.4	.8	.6
S1V4 Mean water transparency	1.0	1.0	1.0	1.0
SIF (V1+V2+V3+V4)/4	**0.675**	**.55**	**.8875**	**.8875**
S1V5 Winter water depth > than maximum ice depth	1.0	1.0	1.0	1.0
S1V6 % silt in Substrate	.5	.5	.5	.5
S1WC (V5+V6)/2	**.75**	**.75**	**.75**	**.75**
S1V7 Mean Current Velocity	1.0	1.0	1.0	1.0
S1V8 pH	1.0	1.0	1.0	1.0
S1V9 Mean Water Temp	1.0	1.0	1.0	1.0
S1V10 Frequency of Water Level Fluctuation	1.0	1.0	1.0	1.0
SIR $(V7*V8*V9*V10)^{1/4}$	**1.0**	**1.0**	**1.0**	**1.0**
S1V11	1.0	1.0	1.0	1.0
HSI $(SIF*S1WC*SIR)^{1/3}$ * S1V11	**.80**	**.75**	**.87**	**.87**
Acres (length * 300 feet width)/43560	**31.7**	**31.7**	**94.5**	**94.5**
Habitat Units	**25.36**	**23.775**	**82.215**	**82.215**
HU Gain			**58.44**	**58.44**

Mink HSI

Devendorf. R and T. Yager. 2013. Modification of the Riverine Cover Type Component of the Habitat Suitability Index Model for Mink. St Paul District, U.S. Army Corps of Engineers.

Mink (*Mustela vison*) occurs in the project area. The mink is a predatory, semiaquatic mammal that is generally associated with stream and river banks, lake shores, fresh and saltwater marshes, and marine shore habitats (Gerell 1970). Mink are chiefly nocturnal and remain active throughout the year (Marshall 1936); Gerell 1969; Burgess 1978). Natural stream channels, when compared to ditched or channelized stream segments, typically are more diverse and provide higher quality and more habitat for aquatic invertebrate, fish and amphibian species. Natural channels generally support a wider variety and greater abundance of aquatic species which serve as prey/forage for mink. In addition to generally providing less prey/forage of mink, stream ditching or channelization reduces the amount of habitat available by reducing the length of the stream.

There is approximately 4,500 feet of habitat in the lower end of Piney Creek. The mink habitat model analyzes habitat quality based on vegetative cover, permanence of water and naturalness of the channel. Piney Creek scores poorly on most of these indices. The existing habitat has an average Habitat Suitability Index (HSI) of 0.36 and 37.188 average annual habitat units (AAHU).

No Action: No change from existing condition.

Alternative 2: Mink habitat will also increase in quantity and quality. The gain in habitat quality stems from increased canopy cover, stream condition, and shoreline cover. Most of the habitat benefits will be achieved when construction is complete. Over time the forest quality will improve as higher quality trees return and begin to mature. The shoreline cover will improve immediately because the new channel will not be incised; it will allow vegetation to grow right down to the water's edge. The habitat units are considered average annual.

It will increase from 103 to 315 acres and the HSI will improve to 0.85 for a gain of 230.56 AAHUs.

Alternative X: This alternative would have the same benefits as Alternative 2. The canopy cover within 100 meters of the stream would be on average the same although it would be thinner near the stream for a few years; the model is not sensitive enough to show a difference for mink.

Table 2. Mink HSI

Variable	**Existing (4500 ft)**	**FWOP**	**Alternative 2 (13725 feet)**	**Alternative X**
V1 % of Year with Surface Water present	1.0	1.0	1.0	1.0
V5 % Canopy Cover within 100 meters	.6	.6	.8	.8
V6 % cover within 1 meter of shoreline	.25	.25	.8	.8
Vstream Stream Condition	.3	.3	.8	.8
HSI (V5*V6*Vs)^1/3	**.36**	**.36**	**.85**	**.85**
Acres (length * 1000 feet width)/43560	**103.3**	**103.3**	**315.0**	**315.0**
Habitat Units	**37.188**	**37.188**	**267.75**	**267.75**
HU Gain			**230.56**	**230.56**

Slough Darter

Edwards, E.A., M. Bacteller, and O.E. Maughan. 1982. Habitat suitability index models: Slough Darter. U.S.D.I. Fish and Wildlife Service. FWS/OS-82/10.9. 13 pp.

There are 11 species of darter known to occur in the project area. Slough darters (*Etheostoma gracile*) were not found in the most recent surveys, but have been found previously. Slough darters range from Alabama to Texas, as far north as central Illinois and as far west as Kansas. They are typically found in pools and oxbows of lowland streams. They prefer warm, turbid waters with little or no flow and mud or silt substrates. The Slough Darter model was used to assess existing habitat conditions in the main channel of Piney Creek and predict future conditions both with and without a project. Similar models for freshwater mussels are not available, but mussels are dependent on fish for part of their history so this model also represents conditions for mussels.

There is approximately 4,500 feet of habitat in the lower end of Piney Creek. The slough darter habitat model analyzes habitat quality based on the water quality (dissolved oxygen, turbidity, pH and temperature), substrate, slope, pools, and velocity. Piney Creek scores well for pH, temperature, slope and velocity but it lacks pools and there are areas with poor dissolved oxygen in the summer. The existing habitat has an average Habitat Suitability Index (HSI) of 0.56 and 1.16 average annual habitat units (AAHU).

No Action: Habitat conditions for slough darters are not expected to change.

Alternative 2: The project would increase the length of Lower Piney Creek from approximately 4,500 feet to 13,725 feet. The slough darter HSI would improve to 0.78 for a total gain of average annual habitat units of 3.75. The habitat improvement would come from improved dissolved oxygen (less stagnant water) and more pools. Other elements of fish and mussel habitat would also improve like canopy cover, allochthonous inputs and more stable substrates.

Alternative X: This alternative would have the same habitat unit gain as alternative 2. Although it would excavate a wider channel initially, most of the extra width will only have water during higher flows. The pilot channel will be sufficient to carry the base flow that is critical for slough darters and for mussels.

Table 3. Slough Darter HSI

Variable	Existing (4500 feet)	FWOP	Alternative 2 (13725)	Alternative X
V1 Minimum DO	0.1	0.1	0.4	0.4
V2 % pools in summer	0.2	0.2	0.5	0.5
V3 average stream gradient	1.0	1.0	1.0	1.0
V4 substrate	0.6	0.6	0.6	0.6
V5 water temp	0.9	0.9	0.9	0.9
V6 turbidity	1.0	1.0	1.0	1.0
V7 velocity	1.0	1.0	1.0	1.0
V8 pH	1.0	1.0	1.0	1.0

Food-Cover (V2+V6)/2	0.6	0.6	0.75	0.75
Water Quality ($V1^2 x V5^2 x V6^2 x V8$)^1/7	0.25	0.25	0.747	0.747
Other ($V3 x V4^2 x V7^2$)^1/5	0.815	0.815	0.815	0.815
HSI=FoodxWQXOther^2)^1/4	0.56	0.56	0.78	0.78
Acres =(lengthx20feet)/43560	2.07	2.07	6.30	6.30
HUs	1.16	1.16	4.914	4.914
HU Gain			3.754	3.754

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CE/ICA Analysis

Memphis District

May 2021

Introduction

For environmental planning, where traditional benefit-cost analysis is not possible because costs and benefits are expressed in different units, two analytical methods are used to assist Corps planners in the decision process. First, cost effectiveness (CE) analysis is conducted to ensure that the least cost solution is identified for each possible level of environmental output. Subsequent incremental cost analysis (ICA) of the cost effective solutions is conducted to reveal changes in costs for increasing levels of environmental outputs. In the absence of a common measurement unit for comparing the non-monetary benefits with the monetary costs of environmental plans, cost effectiveness and incremental cost analysis are valuable tools to assist in decision making.

It is important to keep in mind that the most useful information developed by these two methods is what it tells decision makers about the relative relationships among solutions – that one will likely produce greater output than another, or one is likely to be more costly than another – rather than the specific numbers that are calculated. Furthermore, these analyses will usually not lead, and are not intended to lead, to a single best solution (as in economic cost-benefit analysis); however, they will improve the quality of decision making by ensuring that a rational, supportable approach is used in considering and selecting alternative methods to produce environmental outputs.

To perform the CE/ICA, use was made of the IWR Planning Suite Decision Support Software developed by the US Army Corps of Engineers Institute for Water Resources (IWR). IWR Planning Suite has been developed to assist with plan comparison by conducting cost effectiveness and incremental cost analyses, identifying the plans which are the best financial investments ("Best Buys"), and displaying the effects of each on a range of decision variables. The software is available via the IWR Planning Suite Internet. The latest version (2.0.9.1) has been certified for use by USACE Headquarters, meaning that it has been reviewed and certified by the appropriate Planning Center of Expertise (PCX) and represents a corporate approval that the model is sound and functional.

Cost Effective Solutions (CE)

In cost effectiveness analysis, it is necessary to filter out plans that produce the same output level as another plan, but cost more; or cost the same amount or more than another plan, but produce less output. This CE analysis was performed by the IWR planning model.

Table 1 displays the expected environmental outputs in terms of average annual habitat units along with the total cost and average annual cost for each of the restoration alternatives and no action plans. In this instance only Alt 2 is cost effective.

Cost Effective and Incrementally Justified (Best Buy Plans)

The final step in the analysis is to determine which subset of the cost effective solutions is also incrementally justified. These solutions, also known as Best Buy Plans or Best Buy Alternatives, are those plans that provide increases in benefits at the lowest average cost (per habitat unit). The IWR Planning model was run to make the necessary calculations producing the results shown in Table 2. In this case, Alt 2 is the Best Buy Plan.

Included in Table 2 are the incremental costs per habitat unit for the Best Buy Plan. Incremental cost is calculated by dividing the difference between the solution's costs by the difference between the solution's outputs. Reviewing this table with the incremental cost information now allows the decision maker to make the following comparisons of alternative restoration plans and to progressively ask "Is it worth it?"

As noted previously, neither cost effectiveness analysis nor incremental cost analysis will tell the decision maker what choice to make. However, the information developed by both analyses will help the decision maker make a more-informed decision and, once a decision is made, better understand its consequences in relation to other choices. Figure 1 shows the full range of solutions and highlights the non-cost effective solutions and the incrementally justified (Best Buy) solution.

Table 1
Summary of Outputs (AAHUs) and Costs

Name of Alternative	First Cost	Interest During Construction	Average Annual Cost	AAHUs	Cost Effective
No Action	$ -	$ -	$ -	-	-
Alt 2	$ 13,913,170	$ 423,778	$ 533,081	293	Yes
Alt X	$ 16,210,237	$ 493,743	$ 620,758	293	No

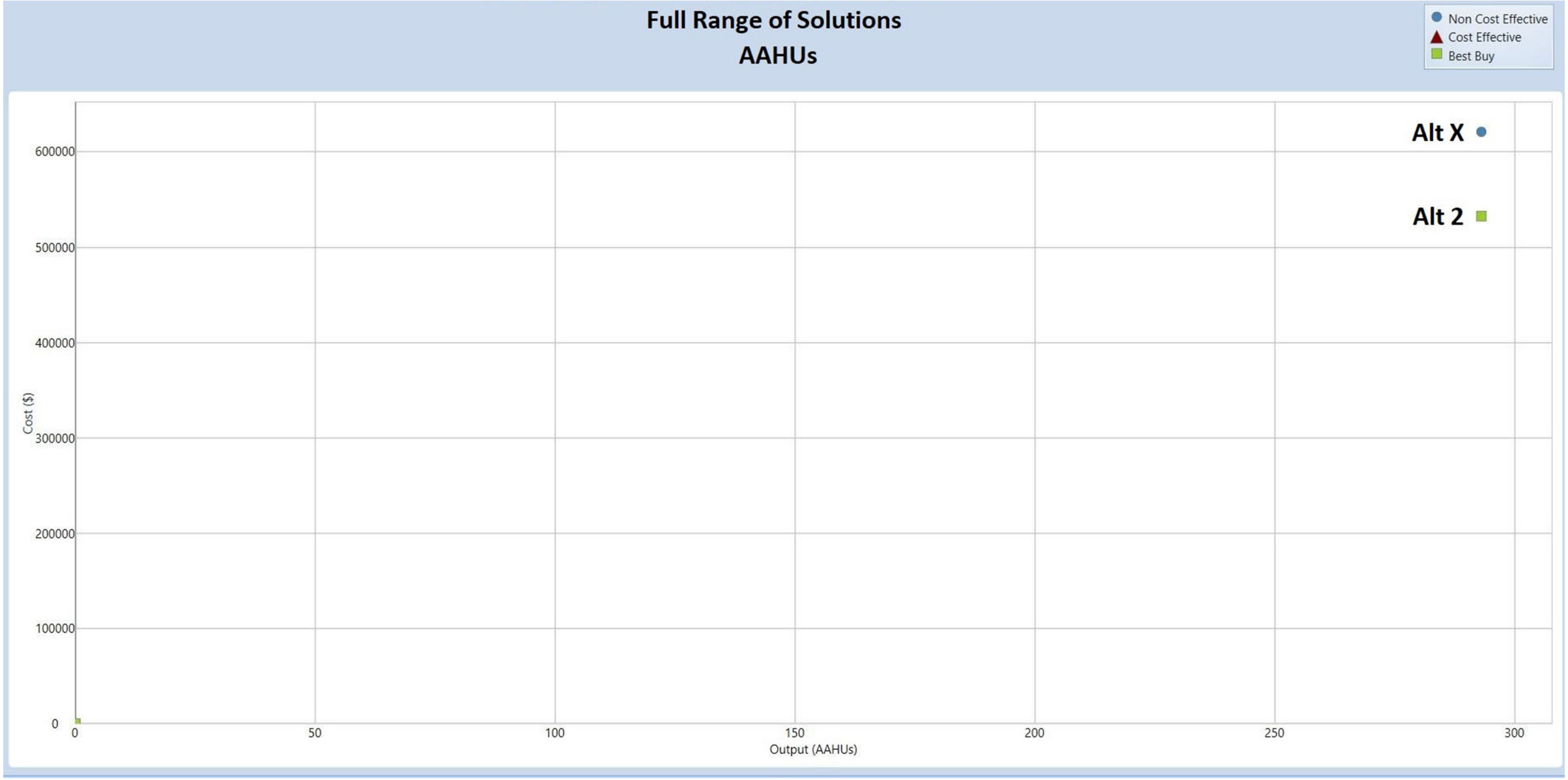
Note: Costs are shown at the 2020 price level and were annualized using the current FY20 Federal discount rate of 2.75 percent over a 50-year period of analysis.
Annual O&M costs are $2,000 for the 50-year period of analysis.

Table 2
Best Buy Plans and Incremental Costs (AAHUs)

Name of Alternative	First Cost	Interest During Construction	Average Annual Cost	AAHUs	Average Annual Cost per Habitat Unit	Additional Output (AAHUs)	Additional Average Annual Cost	Incremental Cost (per AAHU)
No Action	$ -	$ -	$ -	-	$ -	-	$ -	$ -
Alt 2	$ 13,913,170	$ 423,778	$ 533,081	293	$ 1,821	293	$ 533,081	$ 1,821

Note: Costs are shown at the 2020 price level and were annualized using the current FY20 Federal discount rate of 2.75 percent over a 50-year period of analysis.
Annual O&M costs are $2,000 for the 50-year period of analysis.

Figure 1


Full Range of Solutions
AAHUs
Non Cost Effective
Cost Effective
Best Buy
Alt X
Alt 2
Cost ($)
600000
500000
400000
300000
200000
100000
0
0
50
100
150
200
250
300
Output (AAHUs)

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404(b)(1) Evaluation

Memphis District

May 2021

404(b)(1) Evaluation
Piney Creek Ecosystem Restoration
Hardeman County, Tennessee

I. Project Description

a. Location: Piney Creek is a tributary of the Hatchie River located within the vicinity of Bolivar, Hardeman County, Tennessee (Figure 1). The project footprint would begin at the confluence of Piney Creek and the Hatchie and proceed approximately 13 miles upstream.

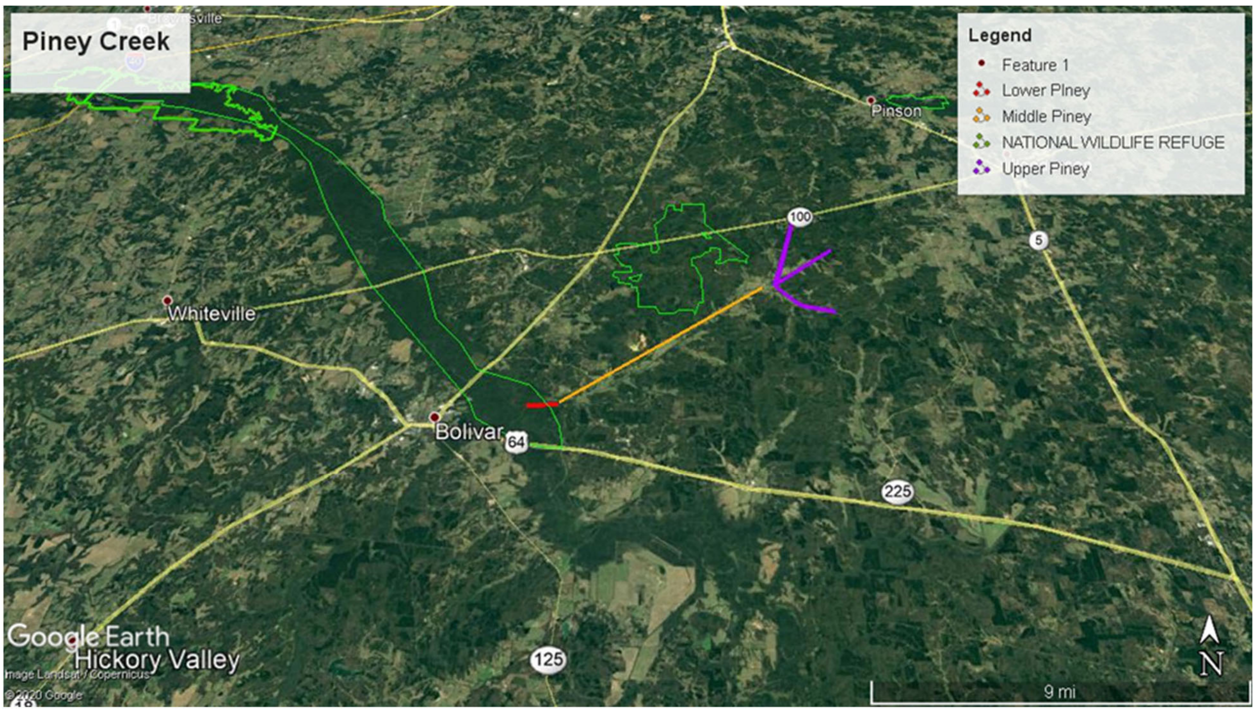

Figure 1Piney Creek Location Map

b. General Description: The goal of this ecosystem restoration project is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology. Indicators of success would include the presence of a large variety of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and the ability of the restored area to continue to function and produce the desired outputs with a minimum of continuing human intervention.

The direct changes to the channel for flood control changed the geomorphic and hydraulic character of the system. The Piney Creek floodplain no longer functions to direct water to the channel, to allow sediment to deposit, or to support healthy riparian and bottomland vegetation. Fish, mussel, amphibian and mammal habitat are all degraded.

Authority and Purpose: Section 206 of the Water Resources Development Act of 1996, as amended. The Secretary may carry out an aquatic ecosystem restoration and protection project if the Secretary determines that the project— (1) will improve the quality of the environment and is in the public interest; and (2) is cost-effective.

c. General Description of Dredged or Fill Material

1) General Characteristics of Excavated Material: Sandy soil will be excavated to recreate a meander streambed for Piney Creek. The material will be placed on the inside bends of the meanders to help form a new stable channel.

2) Quantity of Material: Quantity of excavated material is not expected to exceed 51,000 cubic yards of material for the pilot channel. For the weirs, excavation is estimated at 30,000 BCY expected quantity of R600 riprap is approximately 30,000 tons, R200 is approximately 13,000 tons, and quantity of bedding stone is approximately 4,500 BCY.

3) Source of Material: Excavated material would come from Piney Creek historic channel meanders. Riprap would be sourced from approved contractor.

4) General Characteristics of Fill Material: Riprap and bedding stone would meet appropriate BMPs. R600 riprap would have a thickness of approximately feet and R200 would be approximately 2 feet thick.

d. Description of the Proposed Discharge Site(s)

1) Locations: The Recommended Plan will remeander 2.6 miles of channel between the Hatchie River and Walnut Grove Road. No weirs will be placed in this stretch. Six low drop grade control structures would be placed in the 9 mile reach between Walnut Grove Road and Silerton. The small weirs would be on the tributary ditches upstream of Silerton. The exact locations of the sites have not been determined, but would be coordinated as plans become available.

2) Size: Approximately 13 miles of Piney Creek and tributaries would be treated. The final footprint of each weir would be less than 1 acre. The smallest weirs would be less than 1,000 square feet.
3) Type of Site: Perennial Stream
4) Type(s) of Habitat: Degraded stream channel and banks as well as some moderate quality riparian forested habitat on the stream banks.
5) Timing and Duration of Discharge: Construction would be conducted in compliance with water quality certification, once it is obtained.

e. Description of Disposal Method: An amphibious trackhoe will excavate the pilot channel and place the material on the inside bends. Some material will be placed at eh upstream end of the existing Piney Creek Ditch to block it when the pilot channel is complete. Low-drop weirs would be constructed using large equipment such as trackhoes. Best management practices would be followed per guidance from water quality certification.

II. Factual Determinations (Section 230.11)

a. Physical Substrate Determinations

1) Substrate Elevation and Slope: The intention of this action is to restore meanders and reduce sedimentation from unstable channels. The weirs will establish stable elevation and slope to the channel of Piney Creek and tributaries. Timber harvesting caused gullying and changes in the slope and elevation of the channel over time, and created steep banks which are subject to erosion and bank caving.

2) Sediment Type: The sediment in the Piney Creek is generally characteristic of other streams in West Tennessee, but is mostly sand with less silt than average.

3) Dredged/Fill Material Movement: Excavation materials and fill materials would be moved from the bank of the stream using land based equipment. Best management practices would be used to prevent or reduce the amount of sediment into the Piney Creek.

4) Physical Effects on Benthos: No permanent effects to benthos are expected. Over time, quality and quantity of benthic habitat are expected to improve.

5) Actions Taken to Minimize Impacts (Subpart H): All construction activities would be performed in accordance with the conditions stated in the water quality certification and follow best management practices.

b. Water Circulation, Fluctuation, and Salinity Determinations

1) Water. Effects on:

a) Salinity: N/A

b) Water Chemistry: No expected change

c) Clarity: Turbidity would increase during construction activities. Any increased sediment load would be local, temporary, and minor compared to the normal sediment load of the stream. No permanent change expected.

d) Color: No expected change

e) Odor: No expected change
f) Taste: No expected change
g) Dissolved Gas Levels: No expected change
h) Nutrients: No expected change
i) Eutrophication: No expected change
j) Others: No expected change

2) Current Patterns and Circulation

a) Current Patterns and Flow: Flow will be restored to a meandering channel that was bypassed with a ditch creating a more natural stream system.
b) Velocity: No expected change.
c) Stratification: No expected change.
d) Hydrologic Regime: No expected change.

3) Normal Water Level Fluctuations: No change.

4) Salinity Gradients: N/A

5) Actions That Would Be Taken to Minimize Impacts: All construction would be performed in accordance with best management practices and any conditions stated in the water quality certification. Areas cleared for construction would be reseeded or replanted post construction. Construction would occur, where practicable, in areas that would not require tree clearing, and wetlands would be avoided.

c. Suspended Particulate/Turbidity Determinations

1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site: Turbidity would increase during construction activities. Any increased sediment load would be local and temporary.

2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column

a) Light Penetration: The proposed action would temporarily cause only an increase in turbidity. Light penetration is not expected to be affected.

b) Dissolved Oxygen: No expected change.

c) Toxic Metals and Organics: No expected change

d) Pathogens: N/A

e) Aesthetics: No expected change.

f) Others: None

3) Effects on Biota

a) Primary Production, Photosynthesis: Some improvement in primary production can be expected due to a more stable environment. Adverse effects on photosynthesis, if any, would be minor, local, and temporary.

b) Suspension/Filter Feeders: Overall the project would be expected to improve conditions for these species due to the improved stability of the stream.

c) Sight Feeders: The project would be expected to improve conditions for these species due to the improved stability of the stream. Many of these species may temporarily move up or downstream during times of increased turbidity due to construction.

4) Actions taken to Minimize Impacts (Subpart H): All construction would be performed in accordance with best management practices and the conditions stated in the water quality certification. Areas cleared for construction would be reseeded or planted with appropriate tree species post construction.

d. Contaminant Determinations: No contaminants are expected to be released during the construction of the proposed action.

e. Aquatic Ecosystem and Organism Determinations

1) Effects on Plankton: Overall the project would be expected to improve conditions for these species due to the improved stability of the stream. Adverse impacts, if any, are expected to be minor and temporary.

2) Effects on Benthos: During construction, benthic macroinvertebrates in the immediate proposed construction areas are likely to move up or downstream temporarily. Overall the project would be expected to improve conditions for these species due to the improved stability of the stream.

3) Effects on Nekton: Effects, if any, are expected to be minor and temporary.

4) Effects on Aquatic Food Web: Overall the aquatic food web is expected to improve with the project. Adverse impacts, if any, are expected to be local to construction areas and temporary.

5) Effects on Special Aquatic Sites

a) Sanctuaries and Refuges: N/A

b) Wetlands: The proposed action will restore a natural stream and reconnect a functioning floodplain system. It will improve conditions for the forested wetlands.

c) Mud Flats: N/A

d) Vegetated Shallows: N/A

e) Coral Reefs: N/A

f) Riffle and Pool Complexes: Riffle and pool complexes are expected to increase with construction of the low-drop weirs creating habitat diversity and complexity.

Threatened and Endangered Species: The U.S. Fish and Wildlife Service has stated the area lies within the potential range for Indiana and northern long-eared bats. Surveys may be required prior to construction. USACE will continue to coordinate with USFWS to ensure the project does not impact listed bats. Long-term, the project will restore and protect bottomland hardwood habitat and may benefit bats.

6) Other Wildlife: Effects, if any, are expected to be minor and temporary.

7) Actions Taken to Minimize Impacts (Subpart H): All construction would be performed in accordance with best management practices and conditions stated in the water quality certification. Areas cleared for construction would be reseeded or planted with appropriate tree species post construction.

f. Proposed Disposal Site Determinations

1) Mixing Zone Determinations

2) Determination of Compliance with Applicable Water Quality Standards: A General Aquatic Resource Alteration Permit for Minor Stream Grande Stabilization was received on 23 July 2015.

3) Potential Effects on Human Use Characteristic

a) Municipal and Private Water Supply: N/A

b) Recreational and Commercial Fisheries: N/A

c) Water Related Recreation: N/A

d) Aesthetics: N/A

e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves: N/A

g. Determination of Cumulative Effects on the Aquatic Ecosystem:
Piney Creek is the largest source of sediment to the Hatchie River. The project includes grade control to reduce sediment at tits source and replacing a 0.8 mile ditch with a 2.6 mile meandering channel. This channel will be connected to its floodplain and better able to manage its own bedload.

h. Determination of Secondary Effects on the Aquatic Ecosystem: N/A

III. Findings of Compliance or Non-Compliance With the Restriction on Discharge

a. Adaptation of the Section 404(b)(1) Guidelines to this Evaluation: No significant adaptation of the Section 404(b)(1) guidelines were made relative to this evaluation.

b. Evaluation of Availability of Practical Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem: The proposed discharge of riprap to construct low drop weirs would have a positive effect on the aquatic ecosystem.

c. Compliance with Applicable State Water Quality Standards: A General Aquatic Resource Alteration Permit for Minor Stream Grande Stabilization was approved on 23 July 2015. This permit may cover some of the project features.

d. Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 Of the Clean Air Act: No lasting impacts on air quality are expected. USACE would follow best management practices to minimize air pollution.

e. Compliance with Endangered Species Act of 1973: Consultation with USFWS is ongoing, but additional surveys are required prior to construction to determine the likelihood of impacting roost trees. Tree clearing will be done in the non-roosting season.

f. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972: N/A

g. Evaluation of Extent of Degradation of the Waters of the United States

1) Significant Adverse Effects on Human Health and Welfare

a) Municipal and Private Water Supplies: N/A

b) Recreation and Commercial Fisheries: N/A

c) Plankton: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

d) Fish: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

e) Shellfish: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

f) Wildlife: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

g) Special Aquatic Sites: N/A

2) Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems: None expected

3) Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity, and Stability: None expected

4) Significant Adverse Effects on Recreational, Aesthetic, and Economic Values: None expected

h. Appropriate and Practical Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem: All construction would be performed in accordance with best management practices and any conditions stated in the water quality certification. Areas cleared for construction would be reseeded or replanted post construction. Construction would occur, where practicable, in areas that would not require tree clearing, and wetlands would be avoided.

i. On the Basis of the Guidelines, the Proposed Disposal Site(s) for the Discharge of Dredged or Fill Material is:

1) _X_ Specified as complying with the requirements of these guidelines; or,

2) __ Specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem; or,

3) __ Specified as failing to comply with the requirements of these guidelines.

Date:

Prepared by:

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Memphis District (MVM)

Piney Creek

Ecosystem Restoration

Continuing Authorities Program

Section 206

Monitoring and Adaptive Management Plan

Memphis District

May 2021

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Introduction

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure, that when conducting a feasibility study for a project (or component of a project) under the Corps ecosystem restoration mission,that the recommended project includes a monitoring plan to measure the success of the ecosystem restoration and to dictate the direction adaptive management should proceed, if needed. This monitoring and adaptive management plan shall include a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring as well as specify that monitoring will continue until such time as the Secretary determines that the success criteria have been met.

Section 2039 of WRDA 2007 also directs the Corps to develop an adaptive management plan for all ecosystem restoration projects. The adaptive management plan must be appropriately scoped to the scaleof the project. The information generated by the monitoring plan will be used by the District in consultation with the Federal and State resource agencies and the MSC to guide decisions on operationalor structural changes that may be needed to ensure that the ecosystem restoration project meets the success criteria.

An effective monitoring program is necessary to assess the status and trends of ecological health and biotarichness and abundance on a per project basis, as well as to report on regional program success within the United States. Assessing status and trends includes both spatial and temporal variations. Gathered information under this monitoring plan will provide insights into the effectiveness of current restoration projects and adaptive management strategies, and indicate where goals have been met, if actions should continue, and/or whether more aggressive management is warranted.

Monitoring the changes at a project site is not always a simple task. Ecosystems, by their very nature, are dynamic systems where populations of macroinvertebrates, fish, birds, and other organisms fluctuate withnatural cycles. Water quality also varies, particularly as seasonal and annual weather patterns change. Thetask of tracking environmental changes can be difficult, and distinguishing the changes caused by human actions from natural variations can be even more difficult. This is why a focused monitoring protocol tieddirectly to the planning objectives needs to be followed.

This Monitoring and Adaptive Management Plan describes the existing habitats and monitoring methodsthat could be utilized to assess projects. By reporting on environmental changes, the results from this monitoring effort will be able to evaluate whether measurable results have been achieved.

Guidance

The following documents provide distinct Corps policy and guidance that are pertinent to developing thismonitoring and adaptive management plan:

a. Section 2039 of WRDA 2007 Monitoring Ecosystem Restoration

(a) In General - In conducting a feasibility study for a project (or a component of a project) for ecosystemrestoration, the Secretary shall ensure that the recommended project includes, as an integral part of the project, a plan for monitoring the success of the ecosystem restoration.
(b) Monitoring Plan - The monitoring plan shall--
(1) include a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, and the estimated cost and duration of the monitoring; and
(2) specify that the monitoring shall continue until such time as the Secretary determinesthat the criteria for ecosystem restoration success will be met.
(c) Cost Share - For a period of 10 years from completion of construction of a project (or a component of a project) for ecosystem restoration, the Secretary shall consider the cost of carrying out the monitoring asa project cost. If the monitoring plan under subsection (b) requires monitoring beyond the 10-year period,the cost of monitoring shall be a non-Federal responsibility.

b. USACE. 2009. Planning Memorandum. Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) - Monitoring Ecosystem Restoration

c. USACE. 2000. ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. Washington D.C.

d. USACE. 2003a. ER 1105-2-404. Planning Civil Work Projects under the Environmental Operating Principles. Washington, D.C.

e. USACE. 2019. EP 1105-2-58. Planning Continuing Authorities Program. Washington D.C.

General Monitoring Objectives

The following are general project monitoring objectives:

- To support adaptive management of implemented projects.
- To assess and justify adaptive management expenditures.
- To minimize costs and maximize benefits of future restoration projects.
- To determine “ecological success”, document, and communicate it.
- To advance the state of ecosystem restoration practice.

Project Area Description

The Piney Creek watershed lies in Hardeman County, TN. Piney Creek is a tributary of the Hatchie River. The West Tennessee River Basin Authority has requested that the Memphis District, United States Army Corps of Engineers (USACE) initiate a project under Section 206 WRDA 1996, as amended, Aquatic Ecosystem Restoration authority to address ecosystem restoration opportunities.

Problems and Opportunities

Problems:

1. Lack of aquatic habitat in the Lower Piney Creek ditch.

- Entrenchment eliminates shoreline vegetation.
- Sediment load is too high to provide stable substrate.
- Channel is 1/3 the length of the historic channel.
- No pool-riffle complexes.

2. Degraded bottomland forest around the historic Piney Creek meanders.

- Permanent standing water is killing trees.
- The historic meanders are not connected to the main channel so fish cannot access them.

3. Upper Piney Creek is a sediment source.

Opportunities

1. To restore aquatic habitat in Lower Piney Creek.
   - Reestablish pool-riffle complexes.
   - Recreate meanders.
   - Reduce entrenchment to allow rooted aquatic plants.
   - Regain channel length.

2. To restore natural channel functions to enhance floodplain habitat and bottomland hardwoods.
   - Restore a flowing channel and reduce standing water that kills trees.

3. To reduce sedimentation from headcutting in gullies.
   - To facilitate a natural, resilient, meandering system with gentler slope.
   - To reduce sand input to the Hatchie River to reduce shoaling.

Restoration Design Overview

The Tentatively Selected Plan would reestablish a 2.6-mile natural channel. The plan includes a mix of different types of grade control structures for a total of fourteen. The plan includes tree planting to fill in gaps in the existing canopy and replace any trees that have to be removed for construction. The estimated cost of construction is $14.5 million. The plan would improve the hydrologic function and geomorphic character of Piney Creek and would likely contribute to preservation and restoration of biodiversity in the watershed. The plan has a net gain of 293 average annual habitat units.

Monitoring Components

Monitoring Plan Goals & Objectives

Previous research on meandering channels, sediment control and grade control structures has indicated effectiveness in improving biodiversity and ecological conditions. Monitoring will be conducted to ensure stability, and to assess the ecological response to the project. This draft monitoring plan will be reviewed concurrent with plans and specifications and will be revised again upon completion of construction. Similar projects on Barnes Fork Creek and Stokes Creek are being monitored now and lessons learned from those monitoring plans will be taken into account. The Monitoring Plan will include the criteria and methods described here and specific criteria related to monitoring the condition of the meandering channel. The Hatchie River and Piney Creek have been the subject of university research projects for years and these projects are expected to continue and will provide information that is beyond the scope of typical USACE monitoring.

The monitoring objectives are specific to the proposed features and are different from the planning objectives.

Monitoring Objective 1: Channel

Reestablish a stable, meandering channel in Piney Creek that effectively manages its own bedload. This will improve conditions for fish and will also improve the surrounding bottomland hardwood forest. This supports all three planning objectives. The performance measures for Piney Creek were established based on monitoring of other projects in the area to determine meaningful and attainable levels of improvement.

Monitoring Task: Cross sections (approximately every ¼ mile)on the new channel will be established immediately upon construction completion. Because the meander section will be "new" habitat, there are no baseline conditions. The cross sections will be surveyed annually for 5 years to monitor the channel adjustment from pilot channel to full channel.

Performance Criteria: There are no specific performance criteria for this. Generally, the channel cross sections will be expected to increase and develop a typical profile, i.e. deeper on the outside of the bend with sediment deposition on the inside bends. If the surveys show the channel is not adjusting as expected, adaptive management may be necessary.

Adaptive Management: If localized issues are identified, they can be addressed with field crews and equipment such as chainsaws, four wheelers and winches. If the whole pilot channel failed to establish a stable channel it would be necessary to return to the site with an amphibious trackhoe and excavate a larger channel cross section. The report addressed this risk and found it to be very low, therefore no cost for this is included for adaptive management.

Monitoring Objective 2: Fish.

Monitoring Task: The new channel will be surveyed for fish species diversity and abundance upon construction completion. Reaches (100- 200 meters) will be established for quantitative fish sampling in Piney Creek, two in the new channel and two in Middle Piney Creek. The reaches will be sampled annually for 5 years.

Performance Criteria: At least 70% of the species that were previously found (see species list earlier in this appendix) in Piney Creek are expected to immediately inhabit the new channel. The Lower Piney section will be considered successful if the number of species reaches the number that have previously been found in Piney Creekand the number of fish (based on CPUE) holds steady after year 3 or increases.

Adaptive Management: If fish do not begin to reinhabit the new channel within two years, an interagency team will examine the channel from the mouth upstream to determine if there are obstacles to fish movement. The team will develop site specific monitoring to investigate the likely cause. This could include fish tagging or other measures. The probability of this is low since there are healthy fish populations both above and below the proposed new channel.

Monitoring Objective 3: Mussels.

Monitoring Task: The Middle Section will be surveyed (visual inspection for shells and light grubbing) for mussels prior to, or concurrent with, the construction of the meandering channel. The new channel will be surveyed (grubbing) for mussels in Year 3, 4 and 5 post construction in transects or quadrats within the same reaches established for fish.

Performance Criteria: Because no mussel data exists for Piney Creek, the criteria are estimated at this time. The results of surveys in Middle Piney Creek may provide more data to establish criteria. The presence of at least 5 species of mussels will be considered successful, however absence of mussels will not necessarily indicate failure. It will take some time for enough mussels to populate the new habitat to detect their presence.

Adaptive Management: There are no existing mussel surveys for Piney Creek so it is unknown if there is a mussel population upstream. As mentioned above, these criteria will be reassessed after baseline mussel data is available. Mussel distribution is linked to fish and if the host fish do not reinhabit the channel, mussels cannot. This will follow the adaptive management discussed for fish.

Monitoring Objective 4: Tree Survival

Monitoring Task: Survey at least 50% of planted trees at years 3 and 5 post planting.

Performance Criteria: Survival of planted trees must reach 80% or they will be replanted.

Adaptive Management: If tree survival is low, the trees will be inventoried by species to determine if some species are more successful than others. The area would be replanted with a mix of trees with a higher probability of survival. The risk of this is medium so $5,000 has been planned for species inventory and replanting.

Monitoring Objective 5: Riparian Conditions

Monitoring Task: The streambanks will be surveyed to determine percent shoreline cover and canopy closure. These surveys will cover the areas 100 meters upstream and downstream of the established cross sections.

Performance Criteria: Shoreline cover of 70% and canopy closure of 60% will be considered successful.

Adaptive Management: If canopy closure and shoreline cover do not meet the performance criteria at the monitored sites, a complete survey of the channel will be done to determine the extent of the failure. If the areas not meeting the criteria are limited, they may be given more time to revegetate. If the failure is more widespread, these areas may be planted with herbaceous plants, shrubs, or trees as appropriate. The plan allows $5,000 for additional plantings.

Monitoring Objective 6. Weirs

Monitoring Task: Each of the weirs will be examined annually to ensure it is in good condition and functioning as intended.

Performance Criteria: Weirs should maintain their design height and not show evidence of scouring along the banks or other issues.

Adaptive Management: If a weir is found to not function as intended, small adjustments such as notches or bank protection could be added. If a major problem with a weir were found, it would likely exceed the CAP limit to address and would be the responsibility of the non-federal sponsor. The report discusses the risk of this and found it to be low as weirs are a commonly used feature on streams throughout the area and significant problems with the standard designs are rare. The plan allots $5,000 for adaptive management to make minor adjustments.

If monitoring results are inconclusive or indicate corrective action is needed to achieve project success criteria, monitoring will continue for another four years or until the District Engineer determines the criteria for ecosystem restoration are met. If the criteria for success are not met within 10 years, monitoring will continue at 100% non-federal cost.

Monitoring Responsibilities

The West Tennessee River Basin Authority will be responsible for monitoring stream hydraulics, habitat, critical infrastructure, erosion points, and plants.

Monitoring Costs

Tasks	Pre Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Channel		2,000	2,000	2,000	2,000	2,000	10,000
Fish		2,000	2,000	2,000	2,000	2,000	10,000
Mussels	2,000			1,000	1,000	1,000	3,000
Trees				1,000		1,000	2,000
Riparian Conditions		500	500	500	500	500	2,500
Weirs		1,000	1,000	1,000	1,000	1,000	5,000
Total							32,500

Reporting Results

The West Tennessee River Basin Authority will prepare a yearly monitoring summary report that briefly summarizes the data collected and determines if adaptive management is needed. A final monitoring report would be completed to detail the outcomes of the restoration project.

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Appendix C: Hydrology and Hydraulics

Piney Creek Ecosystem Restoration
Bolivar, Hardeman County, Tennessee

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C.1. Introduction

The Corps and West Tennessee River Basin Authority are considering n ecosystem restoration within the Piney Creek watershed to reduce future bedloads (predominantly sand) and reinstate more natural conditions. The preliminary design includes the installation of six grade control structures, three rock weirs, five fish passages, and a channel realignment restoring meanders and historical thalweg slope. The U.S. Army Corps of Engineers Memphis District (MVM), along with the non-federal sponsor West Tennessee River Basin Authority (WTRBA), analyzed the hydrologic, hydraulic, and geomorphic components of the ecosystem restoration design according to the feasibility level SMART (Specific, Measurable, Attainable, Risk Informed, Timely) planning method. A more detailed hydraulics and hydrology study will be performed during the design phase of the project.

The Piney Creek confluence with the Loosahatchie River (latitude 35.2671° / longitude -88.9422° in the World Geodetic 1984 geographic coordinate system) is located approximately two miles northeast of Bolivar, Tennessee. The project spans approximately nine linear miles upstream from the confluence to a section of the stream just south of Sillerton, Tennessee. USGS StreamStats (2016) software indicates that the drainage area for Piney Creek watershed is approximately 49.6 square miles.

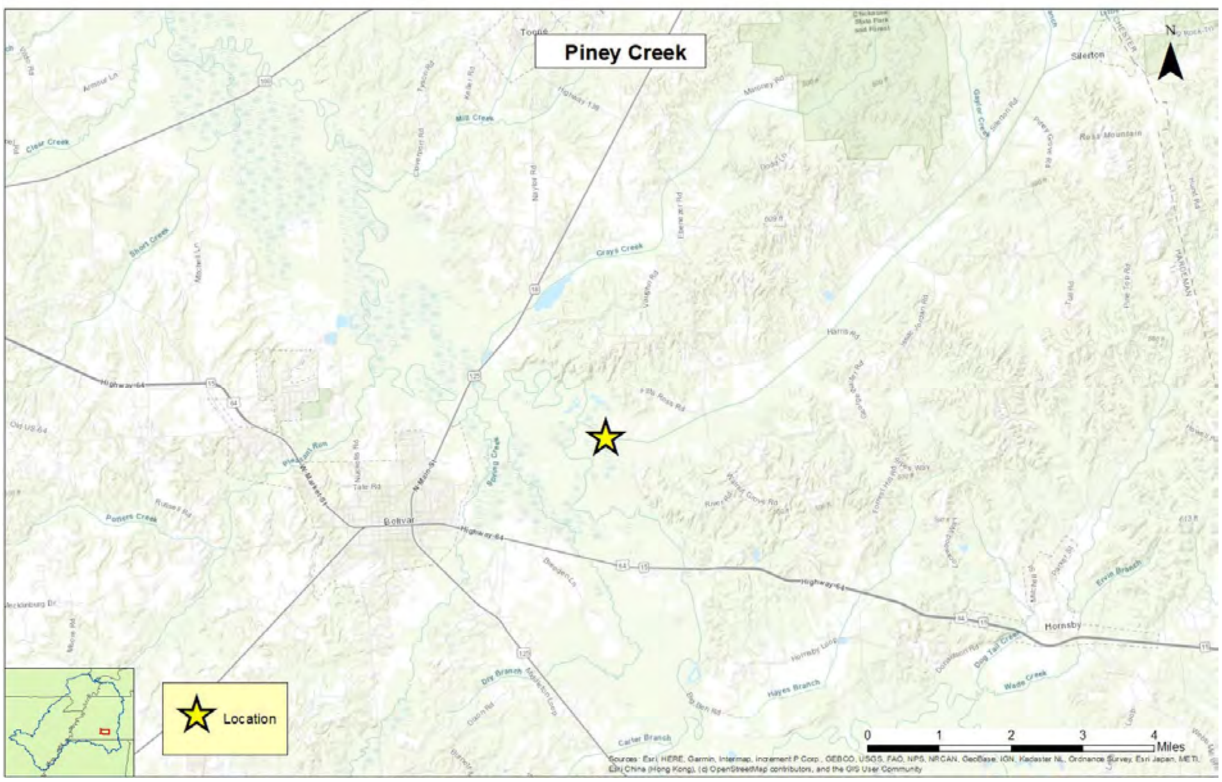

Figure 1 - Piney Creek Location

C.1.1 Background

Like most of the tributaries of the Hatchie River, the entire length of Piney Creek and its tributaries have been channelized. The channels are deeply incised, the banks are steep, and water cannot spread out on the floodplain. Channel instability causes shifting sediments, aggradation and degradation, and large bank failures. Pool-riffle complexes, riparian zones, and rooted aquatic vegetation have all been damaged or eliminated. Furthermore, the scoured banks are too steep for vegetation to reestablish. Erosion around culvert outlets and bridge protection have created barriers at many crossings. Sand deposits in some areas create stretches of stream with no surface flow. Bottomland hardwood and wetland habitats are greatly diminished. Many natural stream functions have been eliminated, and the channel will continue to degrade.

This project has the potential to restore connectivity between Piney Creek and its floodplain. In addition to restoring connectivity, it would provide numerous ecological benefits and interactions between the creek and its floodplain. This restored connection will provide valuable habitat for fish, amphibians, reptiles, mammals, and birds. Likewise, establishment of riparian vegetation will reconnect isolated patches of forested areas within the floodplain.

The section and bed slope of the Piney Creek channel favor the installation of a series of USDA - Agricultural Research Service (ARS) low drop structures to obtain the desired project benefits. The ARS low drop structure is a weir and stilling basin made of riprap designed with the weir at a height less than the critical depth of the design flow through the trapezoidal weir notch.

C.1.2 Basis of the Hydraulic and Hydrologic Study

The goal of the hydraulic and hydrologic feasibility is to use readily available data to perform a feasibility-level design and obtain a qualitative assessment of flowlines. In addition to USACE experience, design standards, and engineering literature, information used in the study consists of:

- USGS NRCS 2015 LiDAR Digital Elevation Models
- USGS regression equations for frequency flows
- USDA soil survey of Hardeman County
- FEMA flood profiles and tabulated results
- Google Earth aerial photography
- WTRBA analysis and recommendations
- USACE / WTRBA field inspections.

Methodology for the feasibility analysis includes:

- Utilize WTRBA expertise and experience to formulate initial feasibility-level design
- Delineate the basin and measure the associated drainage areas for different reaches
- Estimate storm frequency from USGS rural regression equations
- Review design and feasibility of headwater sediment control features utilized by WTRBA
- Use guidance prepared by Vicksburg District Corps of Engineers to locate and proportion ARS low drop structures along Piney Creek
- Use the empirical stable profile equation developed by the WTRBA to guide assessment of sediment transport and geomorphic response
- Determine likely effect of ARS low drop structures on flowlines.

The results of the hydraulic and hydrologic study are sufficient to estimate the approximate number and size of grade control structures, estimate the approximate magnitude of real estate requirements, and estimate approximate construction costs. The results of the hydraulic and hydrologic study are not sufficient to prepare final design drawings, specifications, and cost estimates. Ultimately, a HEC-HMS hydrologic model and HEC-RAS hydraulic model will be utilized to determine more accurate flows, velocities, and flowlines.

C.1.2 Previous Studies

The Natural Resource Conservation Service estimates that 640,000 tons of bedload accumulates in the Hatchie River every year. Furthermore, the majority of this bedload originates from the eastern two-thirds of the watershed. From this starting point, the United States Geological Survey and West Tennessee River Basin Authority performed a sediment accumulation study in 2000 on the Hatchie River and its tributaries. USGS findings showed that the channelized tributaries of the Hatchie are delivering this excess sand and sediment forming shoals at their confluences with the Hatchie. These shoals, or areas of shallower water, increase flooding and inhibit growth of hardwood trees in historically bottomland hardwood forest. According to the report, this excess bedload also forms valley plugs where channels with greater slopes (channelized ditches) flow into flatter areas of the Hatchie River floodplain (Diehl 2000). These valley plugs, or areas where channels become filled, temporarily redirect water as sheet flow before a new channel forms. This process also contributes to an increase in flooding and impacts on the bottomland hardwood ecosystem (Diehl 2000).

Piney Creek in particular is shown to be a large contributor of bedload that causes problematic issues within the Hatchie River watershed (Diehl 2000). Of all tributaries researched, Piney Creek has the largest shoal at the confluence with the Hatchie River measuring approximately 13 feet. At the mouth of Piney Creek, the bed of the Hatchie rises from about 21 feet below the bank to about 8 feet below the bank (Diehl 2000). The shoal at this location is even larger than shoals for tributaries with much larger drainage areas. As of February 2020, the shoal at his confluence is almost unpassable in a boat.

An additional USGS research project (Diehl 1994) focused on causes and effects of valley plugs in West Tennessee. The study focused on 12 tributaries across West Tennessee including Cub Creek, Porters Creek, and Piney Creek within the Hatchie River watershed. Nine of the 12 sites had their main channels blocked, while three had been reopened. Effects of valley plugs can be extensive, but complete removal of the plugs can induce degradation and widening downstream. When left in place, valley plugs increase the depth and area of seasonal flooding and inundation. This can impact bottomland hardwood forests and agricultural crops adjacent to or within the floodplain. Valley plug excavation can lead to upstream degradation and widening, and can increase sediment entering the excavated reach. An enlarged or straightened channel can also promote valley plug formations downstream. Several alternatives to valley plug excavation have been explored. Removal of driftwood that causes local aggradation and channel blockage is one option. It typically involves less disturbance to the environment than excavation and comes at a lower cost, but it also removes fish and invertebrate habitat. Minimizing upstream erosion is a good strategy in several ways. Nearly all downstream valley plug formations could be prevented if upstream erosion were sufficiently reduced. Another option is the creation or restoration of a smaller adjacent sinuous channel, as opposed to a straight channel of large capacity. One example of this was installed along the Middle Fork of the Forked Deer River at Law Road. A farmer inadvertently restored a river system when he excavated a small channel to relocate excess water from the blocked canal to a remnant meander of the historic channel. His goal was to simply drain his farm land better, but he effectively created a channel that when left to its own accord it self-enlarged and became the primary base-flow channel (Smith et al. 2009). This approach can restore flow and naturally-occurring volumes of sediment load transport, while avoiding the recurring problems that are caused from large straight channels. These smaller adjacent channels are also less likely to promote upstream erosion and downstream plug formation. Proper design of the restored channel requires a similar slope to up gradient section of channel. Otherwise, the new channel will be vulnerable to valley plugs just as the straightened channel was prior. Routine maintenance may also be required to prevent other blockages (Diehl 1994).

Passive restoration strategies have been researched in other channelized low-gradient areas of West Tennessee (Smith et al. 2009). Two self-restored river reaches are examples of how a valley plug can have beneficial effects on a river-floodplain system. In both systems, Cypress Creek in McNairy County and Jarrell Bottoms in South Fork Obion River, valley plugs effectively decommissioned the associated channel and trapped excess sediment. The sediment trapping had two effects, floodplain aggradation to the extent where hardwoods could survive and creation of a “sediment shadow” that reduces sand transport and deposition downstream from the plug. For these channels, passive self-restoration was a viable option due to the many possible evolutionary and successional pathways that occur after a valley plug is formed. However, the time required for passive self-restoration to occur can vary from nearly instantaneous to decades.

C.3 Existing Conditions

The Piney Creek watershed has a long history of anthropogenic alterations and impacts. The Chickasaw State Forest, located within the northern section of the watershed, was farmed and harvested for timber prior to the 1930s. These activities left the area deeply eroded and degraded - a status that has been hard to recover from. Large gullies have formed and are difficult to manage. They supply large amounts of sedimentation and sand to the adjacent creeks and streams. The channelization of Piney Creek exacerbated sediment control around the same time.

Land management practices changed in 1938 when the Resettlement Administration Program purchased the majority of land in the Forest. It was later deeded to the State of Tennessee in 1955. Since then the Forestry Division under the Tennessee Department of Agriculture has managed the property as a State Forest.

Currently, the watershed of Piney Creek upstream of the county line is a mixture of cropland, pasture, woods, residential, and commercial land uses, but the majority is undeveloped. Soil diversity is high in the upland sections of the watershed and consists of hydrologic groups B, C, and D within the USDA TR-55 classification system (USDA 1986). The most prevalent upland soils are Luverne and Smithdale sandy loams, while the dominant lowland soils are Rosebloom and Bibb soils, Chenneby silt loam, and Enville silt loam.

Piney Creek, along with many of the smaller headwater streams of the Hatchie River are straightened and channelized. Due to this activity, many of the typical geomorphological characteristics present in West Tennessee streams are not present such as sinuosity, natural grade controls, and riffle pool sequences.

C.3.1 Hydrology

Figure 2 below shows the demarcation of the Piney Creek watershed as analyzed by StreamStats (USGS 2016). The downstream confluence with the Hatchie River receives approximately 49.6 square miles of drainage.

C.3.2 Hydraulics

There are currently several bridges in the project area located along Piney Creek. Between the Hatchie River and the most upstream proposed structure, bridges are located at Walnut Grove Road, Harris Road, Pine Top Road, Piney Grove Road, and Highway 125.

C.4 Alternatives Analysis

Two alternatives were analyzed during the feasibility phase, the future without-project conditions and future with-project conditions. The future without-project conditions includes the existing conditions with a prediction for limited development in the future. The future with-project conditions includes the installation of six low drop grade control structures, five fish passages, three rock chutes, and a channel meander restoration.

C.4.1 Future Without-project Conditions

The future without-project conditions was investigated to determine future watershed status. Two potential future events were investigated, the exacerbation of environmental issues related to current geomorphological issues and the increased frequency flows and sediment loading due to potential land use changes.

As described above, valley plugs increase the depth and area of seasonal flooding and inundation. This can impact bottomland hardwood forests and agricultural crops adjacent to or within the floodplain. If left intact, long-term threats to the bottomland hardwood ecosystem will remain. The upstream sediment loads will remain steady if not increase. Flood concerns for the adjacent agricultural lands will not improve.

The potential for land development and land use changes was also investigated. A large section of the Piney Creek watershed lies within the Chickasaw State Forest. The likelihood of future impacts to this area is low. The demand for development to the rest of the watershed was in-part investigated by reviewing the Hardeman County Chamber of Commerce website. Two industrial sites are currently listed within the Bolivar, Tennessee area. These include the City of Bolivar Industrial Park located on Lucy Black Road and the Hardeman County Industrial Park located on Highway 18 South. Three other industrial sites are listed outside of the Bolivar area within Hardeman County.

The City of Bolivar Industrial Park is located northwest of downtown Bolivar, and Hardeman County Industrial Park is located south of downtown Bolivar. The purchase and development of either property is not expected to directly impact the Piney Creek watershed. Indirect impacts such as residential development is also unlikely as the Piney Creek watershed is located east of Bolivar on the opposite side of the Hatchie River from both properties. The likelihood for demand increase for other commercial or residential land is also not anticipated within the Piney Creek watershed.

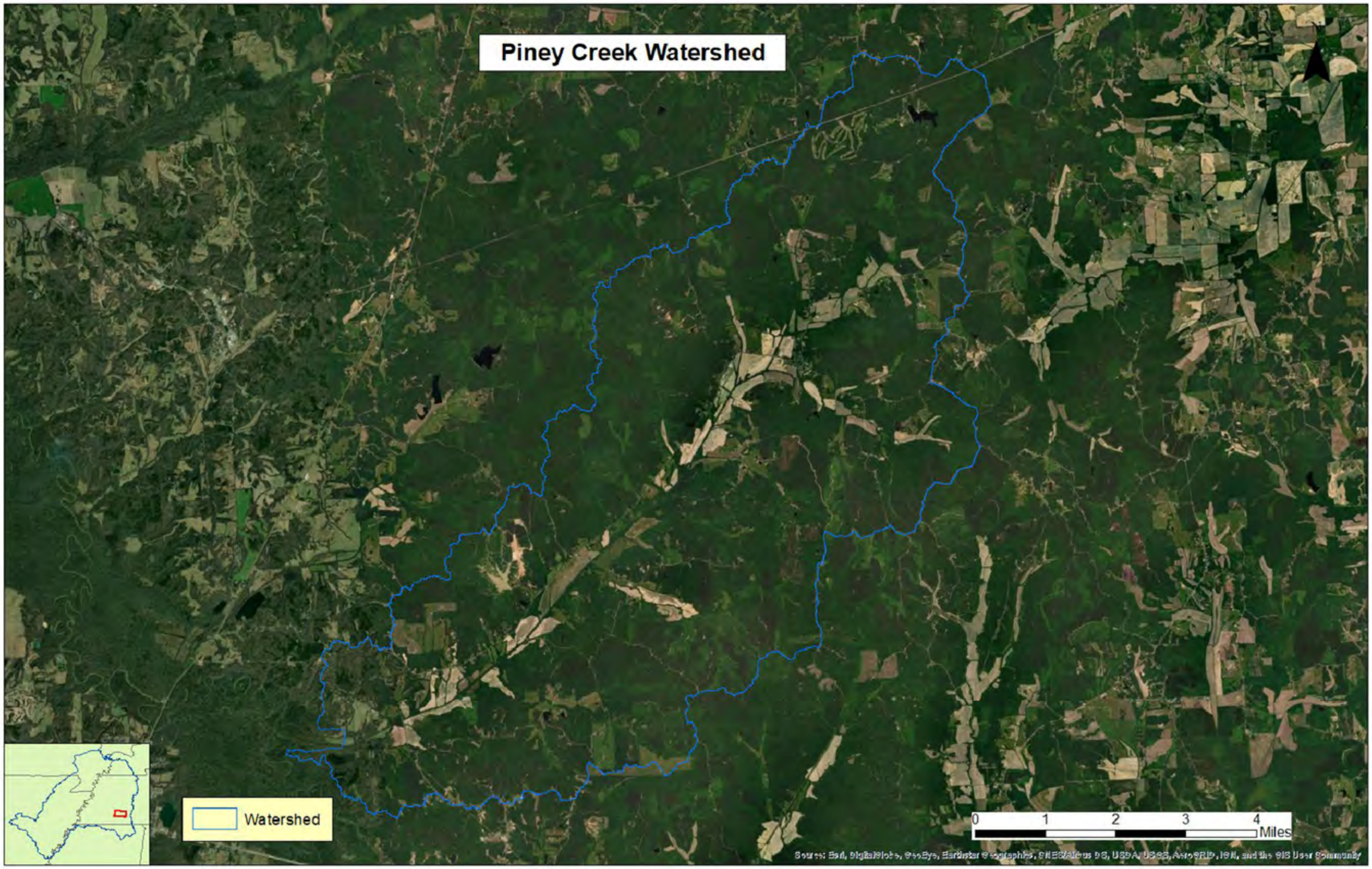

Figure 2 - Piney Creek Watershed

C.4.2 Future With-project Conditions (Alternative 2)

The future with-project conditions includes the installation of six low drop grade control structures, five fish passages, three rock chutes, and a channel meander restoration. Figure 3 shows the proposed location of each figure.

Various hydrology and hydraulic objectives will be fulfilled by each of the four project features. The low drop structure, rock chutes, and fish passages will decrease downstream sediment loading and stabilize channel dimensions from future incising. Additionally, the low drop structure and rock chutes will minimize potential head cuts moving upstream. The meander restoration will reduce erosion and turbidity by restoring stable bank dimensions and gradual channel slope, as well as establishing necessary riparian buffer and channel dimensions to reduce runoff impacts from adjacent land use. The new meander will also reopen the channel to water and sediment movement decreasing the likelihood for aggradation and flood impacts to the adjacent farm fields.

Ecological benefits from the proposed alternative include decreased sediment loads, cleaner water quality, and improved fish passage. The channel meander will restore natural inundation depths to return bottomland hardwood conditions to pre-anthropogenic conditions. Additionally, the low drop structures will fill with sediment and cause a series of riffle pool sequences creating habitat for fish and macroinvertebrates.

Ecological benefits from the proposed alternative include decreased sediment loads, cleaner water quality, and improved fish passage. The channel meander will restore natural inundation depths to return bottomland hardwood conditions to pre-anthropogenic conditions. Additionally, the low drop structures will fill with sediment and cause a series of riffle pool sequences creating habitat for fish and macroinvertebrates.

The channel meander will decrease future need for dredging and channelization in the downstream reach of Piney Creek. Historically, the reach was dredged to maintain water and sediment movement. Valley plugs returned after each dredging event. The installation of proper grade and channel dimensions will facilitate natural movement of water and sediment similar to an unimpeached feature. Additional economic benefits include the decrease in flood duration and depths in the upstream adjacent farm fields.

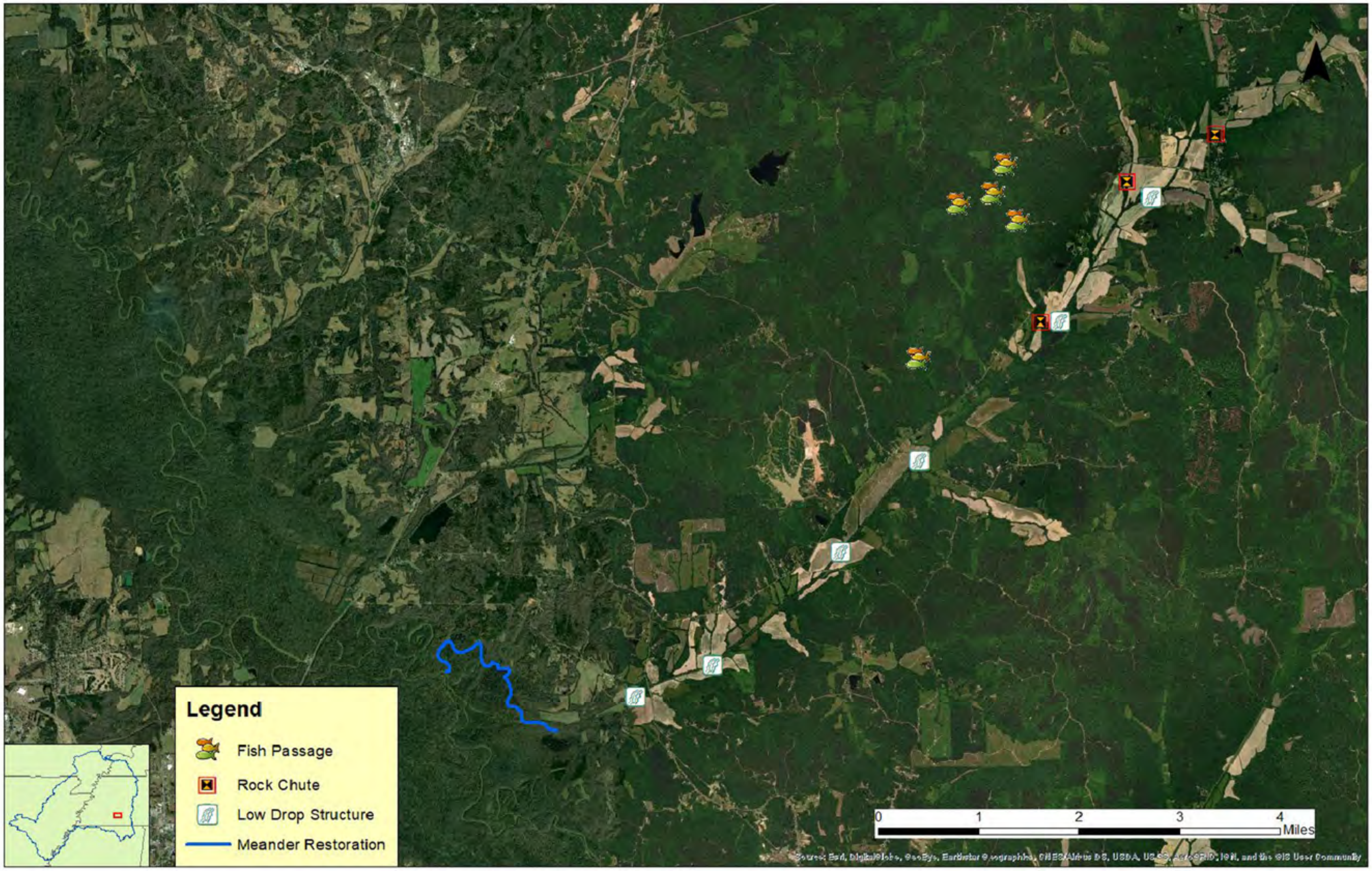

Figure 3- Proposed Restoration Efforts

C.5 Design and Analysis

The primary source of sediment for incised systems is in-channel generation and can be addressed through planned grade control structures on the main Piney Creek canal in conjunction with the fish passages and rock chutes on the unstable tributaries located north of Piney Creek within the Chickasaw State Forest.

The WTRBA has experience designing and installing stream restorations and aquatic environmental enhancements across West Tennessee. The initial design, recommended materials, and estimated costs for the fish passages, rock chutes, and channel meander were provided by the WTRBA. Beyond estimated locations, USACE determined low drop sizes and proportions.

USACE performed a site visit and thorough review to assess the design for USACE standards and overall feasibility. The proposed design includes the design and installation of five minor grade control structures or fish passages, three rock chutes, six mainline low drop structures, and a channel meander restoration.

C.5.1 Minor Grade Controls

Minor grade control structures are proposed for the Piney Creek headwaters to control gully erosion and sediment movement. The proposed design for the structures allow for several vertical feet of control while still allowing upstream and downstream fish movement.

Figure 4 is an existing structure installed in 2018 in the Piney Creek headwaters. The five proposed structures will be designed similarly. Prior to installation, the existing channel was several feet below the root line of bank trees. The gully was moving laterally undercutting drainages to the channel. Since installation, the channel upstream has regained several feet of sediment through a reach of several hundred feet. The restored slope mirrors that of the stable slope equations discussed more in Section 5.4.

The goal of the minor grade control structures is to minimize sediment movement downstream and stabilize the channel upstream. Five structures are proposed in location previously identified as current gully locations or high risk for gully development. Combined with the downstream structures, the minor grade control structures will contribute to a full watershed-scale restoration.

Figure 4 - Minor Grade Control / Fish Passage Example

C.5.2 Rock Chutes

The three proposed rock chutes will work in tandem with the minor grade controls and low drop structures to stabilize eroded banks, control sediment movement, and elevate the existing channel elevation to historical elevations. Figure 5 below shows an example of an installed chute. The design is based on the channel width and length of erosion at the proposed locations. Vertical control is based on the stable slope equation discussed more in Section 5.4.

All three proposed rock chutes are located on tributaries to Piney Creek where erosion and channel incising have been identified. The structures will positively impact the Piney Creek watershed in multiple ways including protection from head cutting up the tributaries, permanent sediment control of erosion and channel incising, and limited sediment management as the slope fills in upstream of the chute structure.

Figure 5 - Rock Chute Example

C.5.3 Meander Restoration

The existing condition of the lower reach of Piney Creek is a channelized canal. Figure 6 shows the slope transition from the upper reaches to the floodplain of the Hatchie. Historically, this channel would have meandered through the floodplain with a higher sinuosity than the upstream section so the upstream and downstream reach slopes were congruent. As Figure 6 shows, the last mile or so is now less steep than the upstream sections. The change in slope creates a valley plug when sediment can no longer move through the system due to the change in slope.

The proposed solution to the channelized canal and valley plug is an approximate 2.6-mile natural channel restoration to replace the 0.85-mile of canal. The canal replacement will provide approximately 18 inches of vertical control. The equilibrium slope discussed in Section 5.4 provides an estimated slope of 0.00068 feet/feet) at the beginning (upstream location) of the proposed meander. The LiDAR water surface elevations calculate the slope in the same approximate area closer to 0.0008 feet/feet. A proposed restoration to the equilibrium slope would theoretically require a reduced sediment load of 15% providing further proof for the proposed upstream fish passages, rock chutes, and low drop structures. Combined with the upstream structures, the channel meander will restore historical conditions, improve habitat, and reduce sediment loads to the Hatchie. Figure 7 shows the current channelized canal. The channel is about 60 feet wide at the location of the beginning (upstream location) of the proposed meander. Figure 8 shows the likely abandoned meander of the historical Piney Creek and the proposed location of the downstream location of the restored meander.

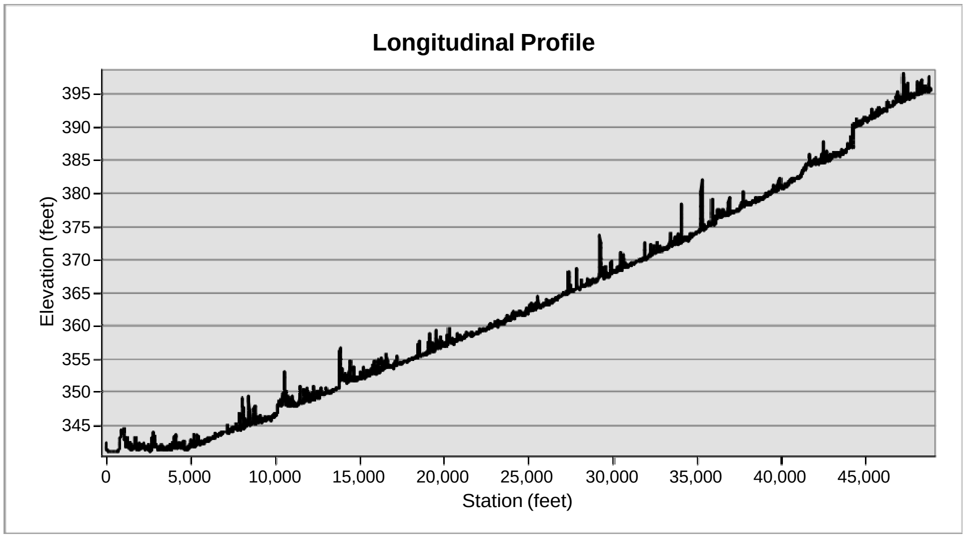

Figure 6 - Longitudinal Profile of Channel

Figure 7 - Photograph of Channelized Canal Proposed for Abandonment

Figure 8 - Photograph of the Proposed Restoration Site

Construction of this proposed channel will be completed using a pilot channel method that will provide an outlet for upgradient drainage. This channel will be slightly undersized and will self-restore during the first year's rain events to dimensions appropriate to the drainage area. The former canal will not be intentionally filled or blocked as the valley plug and slope will continue to block it and reinforce blockage in the future. As the channel is slightly undersized, there is not an associated vegetation restoration associated with the channel. As the channel grows and seasonal floodwater recedes, the existing seed bank will restore and stabilize the adjacent floodplain to Piney Creek. Long term erosion is not a concern.

C.5.4 Low Drop Structures

Six low drop grade control structures are proposed for the main stem of Piney Creek. The USACE Vicksburg District has researched, designed, and installed low drop grade control structures throughout their District boundaries. The benefits of low drop structures include sediment control, head cutting and channel incision protection, and fish/macroinvertebrates habitat development. Figure 9 and Figure 10 show a plan view and profile from a Vicksburg (2012) guidance document, respectively.

A key component of Vicksburg design methodology is the equilibrium slope. Calculated equilibrium slope equations are derived from intensive studies and observations of stable reaches and corresponding channel slopes and thalweg surveys. The Vicksburg District utilized the Yazoo basin data, but the WTRBA developed a Hatchie River basin equation utilized for this study. The equilibrium equation for the Hatchie River basin is:

$$S = 0.0034*DA^{-0.418}$$

Where S = slope (feet/feet) and DA =Drainage basin size (acres).

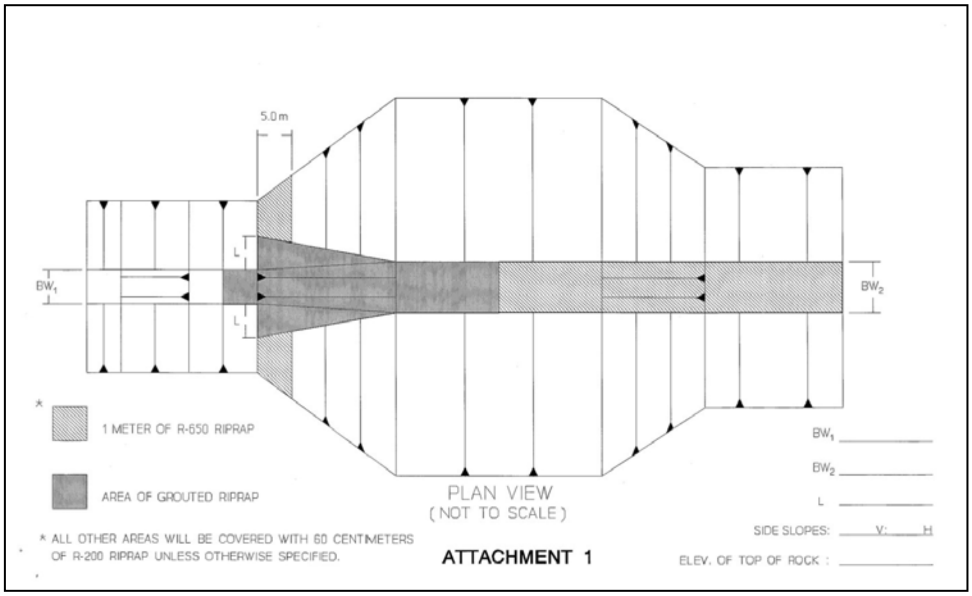

Figure 9 - Plan View of Example Low Drop Structure

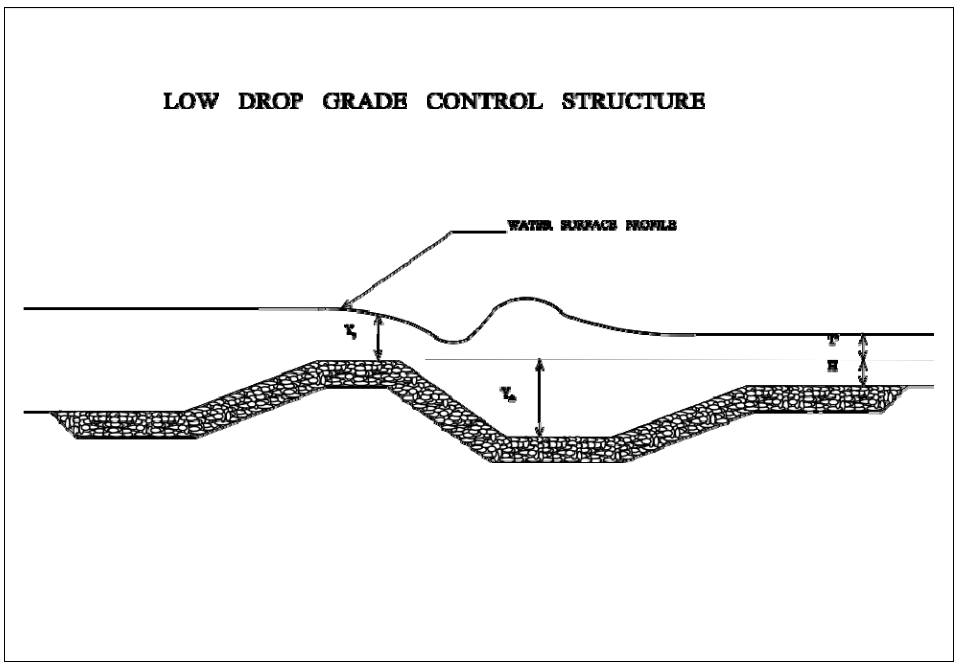

Figure 10 - Profile of Example Low Drop Structure

The feasibility-level design and analysis utilized LiDAR for approximate placement and elevation of each of the six structures. LiDAR can be misrepresentative in several ways. Elevation readings of the longitudinal profile shown in Figure 6 show numerous outlier readings that likely represent debris, overhanging canopy, or shallow water that doesn't reflect well.

In addition to obvious issues with LiDAR shown in Figure 6, the upstream sediment loads contribute to temporary sediment deposits behind obstructions. This temporary status of existing channel elevations and slope is misleading. For this reason, experience shows a more accurate slope can be determined by analyzing short (approximate half mile to one mile) sections of channel and then applying that slope upstream. The "unobstructed slope" will be referenced later in the analysis.

Future conditions of the channel were also considered when analyzing placement and elevation of each of the six structures. Following the upstream sediment control measures proposed with rock chutes and fish passages, obstructions and temporary exaggerated slope will downcut to establish a channel in equilibrium. To overcome these obstacles, the feasibility-level design and analysis includes consideration of downcutting and long-term equilibrium status of the channel.

Overall, the placement and elevation of each structure was an iterative method of placing the first structure and then moving upstream and placing each additional structure in a location and elevation were a low drop structure would be most beneficial. Existing grade controls, such as bridges, were considered during this placement. The Figure 6 LiDAR shows grade controls at the locations of three bridges Walnut Grove Road, Pine Top Road, and Piney Grove Road. Figure 11 shows effective grade control looking west at Piney Grove Road. The bridge over Harris Road does not appear to hold grade.

Figure 11 - Photograph at Piney Grove Road Looking Downstream

The first structure was chosen between the end of the pilot meander elevation/location and Piney Grove Road. Because the bridge grade control is already effective at elevation ~348, protection is placed far enough below/downstream to be useful. The LiDAR cross section of the channel at the approximate location of the proposed Low Drop - 1 is shown in Figure 12.

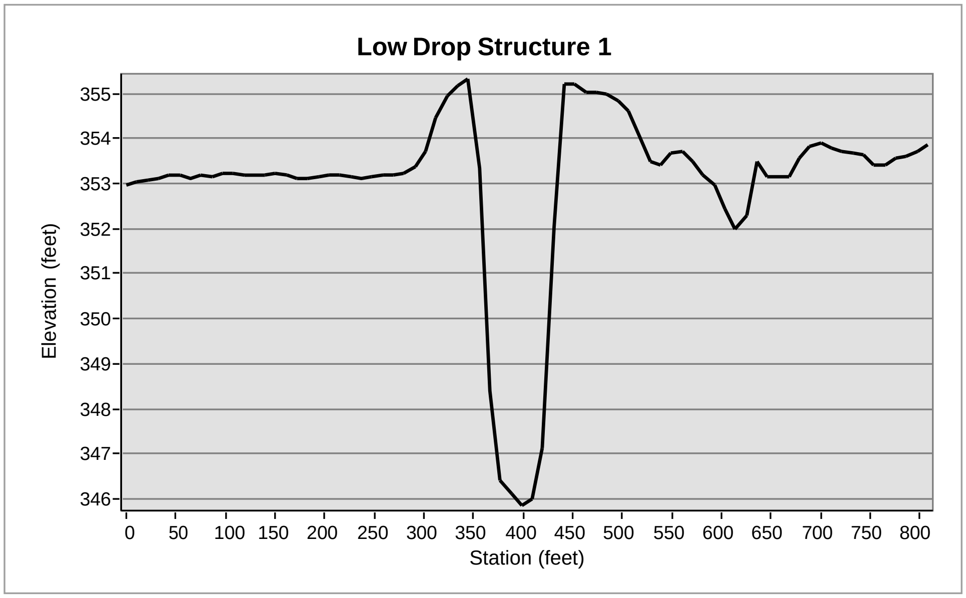

Figure 12 - Cross Section of Low Drop Structure 1

To determine locations of the second and remaining low drop structures, three different series of elevations were considered. The first series pulls the apparent, exaggerated elevations shown in Figure 6 from LiDAR. The cross sections of each proposed structure location for Low Drop Structure 2, Low Drop Structure 3, Low Drop Structure 4, Low Drop Structure 5, and Low Drop Structure 6 are shown in Figure 13, Figure 14, Figure 15, Figure 16, and Figure17 respectively. The additional two series of elevations are based on the starting elevation of the first structure with the equilibrium slope and unobstructed slope determining elevations upstream from there. Each of the slopes were used to determine elevations for each of the structures. Table 1 shows the elevations (feet) and slopes (feet/feet) at the proposed structure locations. Table 2 provides the two proposed alternatives for the top of structure elevations. Figure 18 shows a comparison of the longitudinal profiles listed in Table 1 and Table 2. For easy comparison, the colors in Table 1 and Table 2 correspond with the colors in Figure 18.

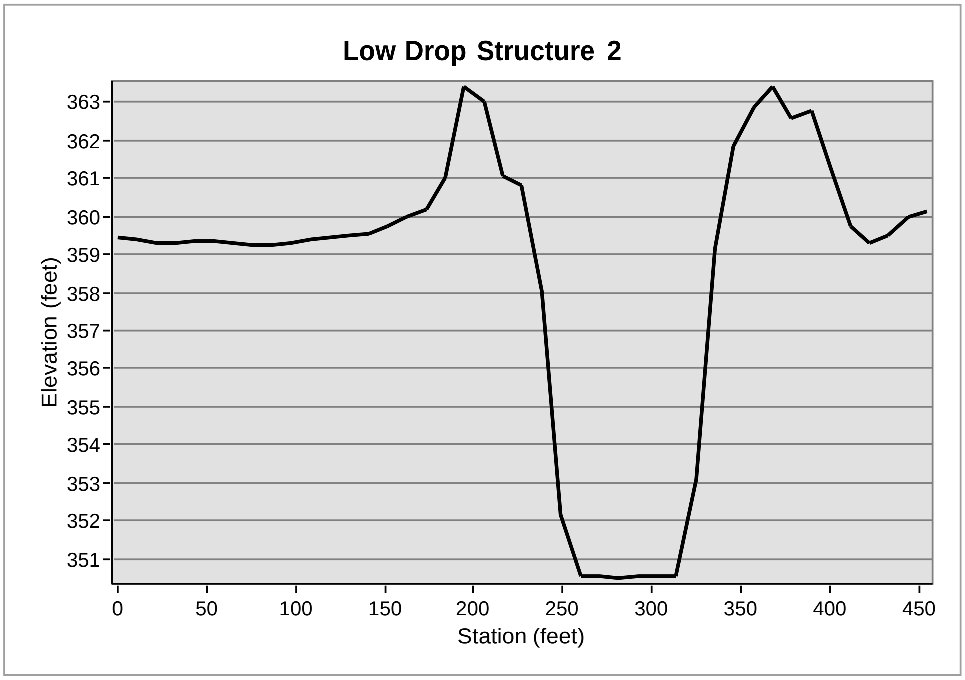

Figure 13 - Cross Section of Low Drop Structure 2

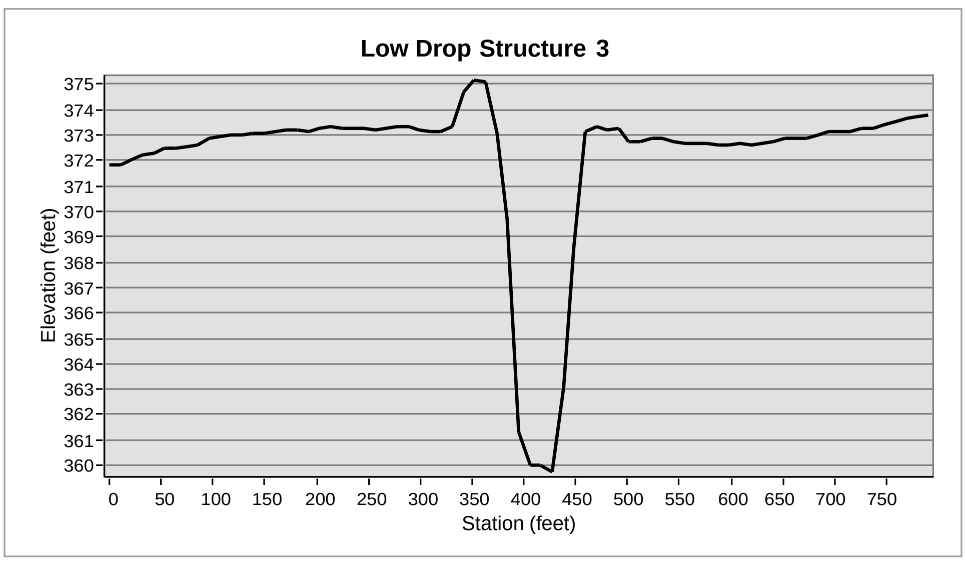

Figure 14- Channel Cross Section of Low Drop Structure 3

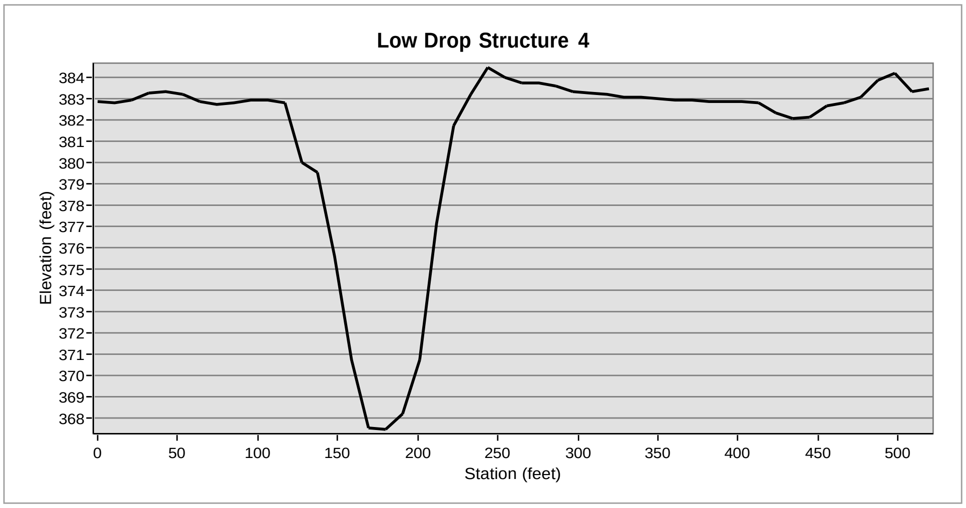

Figure 15 - Channel Cross Section of Low Drop Structure 4

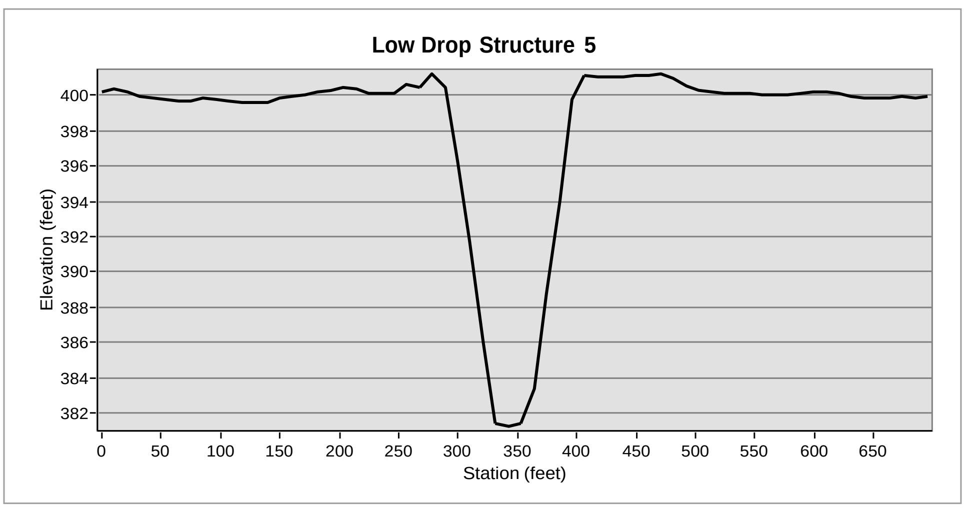

Figure 16 - Channel Cross Section of Low Drop Structure 5

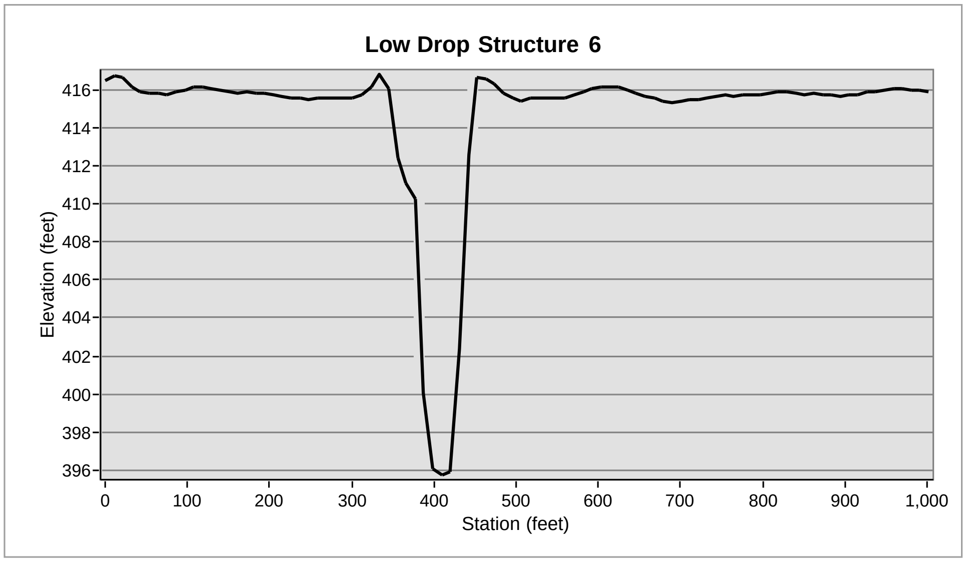

Figure 17 - Channel Cross Section of Low Drop Structure 6

Table 1 - Slope Analysis and Elevation Determinations for Structures

Name	River Mileage	DA (acres)	LiDAR WS Elevation	Unobstructed Slope	Unobstructed WS Elevation	Equilibrium Slope	Equilibrium Elevation
Hatchie River	0	49.6	339.75	0.0007	339.75	0.00066	339.75
Low Drop - 1	1.56	47.2	345.47	0.0007	345.52	0.00068	345.34
Low Drop - 2	2.38	44.44	350.39	0.0008	348.98	0.00070	348.36
Low Drop - 3	4.1	37.56	359.91	0.0011	358.61	0.00075	355.14
Low Drop - 4	5.31	29.37	367.13	0.0011	365.37	0.00083	360.43
Low Drop - 5	7.32	21.15	380.91	0.0013	378.64	0.00095	370.50
Low Drop - 6	8.9	16.58	395.67	0.0013	389.07	0.00105	379.27

Table 2 - Proposed Top of Structure Elevation Alternatives

Name	River Mileage	Proposed Low Elevation	Proposed High Elevation	Structure Height (feet)	Cumulative Grade Control (feet)
Hatchie River	0	339.75	339.75		
Low Drop - 1	1.56	345.35	347.35	2.00	2.00
Low Drop - 2	2.38	350.36	352.36	2.00	4.00
Low Drop - 3	4.1	359.15	361.65	2.50	6.50
Low Drop - 4	5.31	366.94	370.44	3.50	10.00
Low Drop - 5	7.32	380.51	384.01	3.50	13.50
Low Drop - 6	8.9	392.78	396.28	3.50	17.00

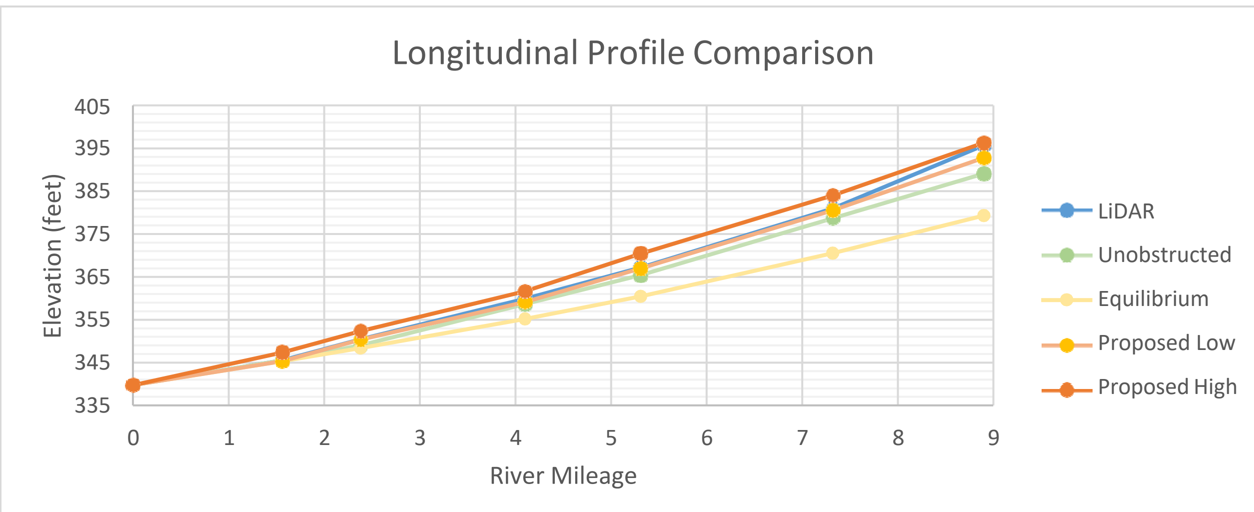

Figure 18 - Longitudinal Profile Comparisons

The two proposed alternatives in Table 2 are reasonable ranges for a feasibility-level design. The final design will be based on surveyed thalweg elevations rather than LiDAR water surface elevations. The ultimate goal of the design and proportioning of the structures is to protect against the equilibrium slope while meeting or slightly exceeding (rising above) existing grade. Structure dimensions and quantities are based on the proposed low elevations shown in Table 2 and Figure 18 for more conservative quantity estimates.

C.6 Structure Locations and Dimensions

Structures were positioned based on the slope analysis, erosional needs, and proximity to access roads. Approximate locations are provided in Table 3.

Table 3 - Approximate Structure Locations

Name	Approximate Latitude[1]	Approximate Longitude[1]	Location
Fish Passage - 1	35.341000°	-88.845569°	Tributary
Fish Passage - 2	35.339890°	-88.851728°	Tributary
Fish Passage - 3	35.345048°	-88.842888°	Tributary
Fish Passage - 4	35.336782°	-88.841571°	Tributary
Fish Passage - 5	35.318173°	-88.860963°	Tributary
Rock Chute - 1	35.346926°	-88.805009°	Tributary
Rock Chute - 2	35.321956°	-88.838556°	Tributary
Rock Chute - 3	35.341089°	-88.821300°	Tributary
Meander (Upstream)	35.269031°	-88.927984°	Piney
Meander (Downstream)	35.278213°	-88.949122°	Piney
Low Drop - 1	35.272713°	-88.915753°	Piney
Low Drop - 2	35.276179°	-88.901444°	Piney
Low Drop - 3	35.291165°	-88.877211°	Piney
Low Drop - 4	35.303437°	-88.862002°	Piney
Low Drop - 5	35.321893°	-88.835281°	Piney
Low Drop - 6	35.338698°	-88.817248°	Piney

[1] – World Geodetic System 1984

The fish passage structures will be constructed with aluminum sheet pile, rip rap, and concrete grout. Table 4 shows approximate quantities required to construct the structures. Note that this table does not include items such as Architectural and Engineering company fees, permitting costs, or installation. Estimated dimensions for each structure is an approximate 10-foot bottom width, 60-foot length, and riprap thickness of 24 inches.

Table 4 - Fish Passage Quantities

Item	Quantity per Structure	Total Quantity (x5)	Unit
Clearing and Grubbing	1	5	Acre
Excavation	150	750	Cubic Yard
Rip Rap	225	1125	Ton
Aluminum Structure	1	5	Each
Concrete Grout	15	75	Cubic Yard
Erosion Control	1	5	Acre

The rock chute structures will be constructed with rip rap and concrete grout. Table 5 shows approximate quantities required to construct the structures. Note that this table does not include items such as Architectural and Engineering company fees, permitting costs, or installation. Estimated dimensions for each structure is an approximate 20-foot bottom width, 100-foot length, and riprap thickness of 24 inches.

Table 5 - Rock Chute Quantities

Item	Quantity per Structure	Total Quantity (x3)	Unit
Clearing and Grubbing	1	3	Acre
Excavation	250	750	Cubic Yard
Rip Rap	1200	3600	Ton
Sheet Pile Cutoff	300	900	Square Foot
Concrete Grout	100	300	Cubic Yard
Erosion Control	1	3	Acre

The meander restoration will be constructed on the design grade with minimal impact. An estimated 10-foot buffer on both side is calculated for vegetation impact and replanting. Table 6 shows approximate quantities required to excavate the meander. Note that this table does not include items such as Architectural and Engineering company fees, permitting costs, or monitoring costs. The estimated dimension of the new channel is an approximately 13,750 feet long, 20 feet wide, and five feet deep.

Table 6 - Meander Restoration Quantities

Item	Quantity	Unit
Excavation	51,000	Cubic Yard
Vegetation/Plantings	31,000	Square Yard

The six low drop structures were located and sized in a joint USACE and WTRBA effort according to slope, flow, channel dimensions, and maximum depth. Locations of the six low drop structures were determined by WTRBA after performing a slope analysis as described above. USACE performed the sizing after assessing flow, channel dimensions, and depth. Flow was estimated with regression equations generated for unregulated streams of Tennessee (USGS 2000). The 100-year storm event was chosen for the West Tennessee equation with drainage basins that were calculated in StreamStats (USGS 2016). Critical depths were estimated based on structure location measurements in LiDAR and assumed trapezoidal channel dimensions. The calculated hydraulic parameters for the 100-year storm event are shown in Table 7. The vertical and horizontal dimensions of each structure was proportioned based on existing elevations and USACE Vicksburg District guidance (2012). Table 8 and Table 9 show the vertical and horizontal dimensions, respectively. Construction quantities were estimated based on these dimensions and are listed in Table 10.

Table 7 - Hydraulic Parameters for 100-year Storm Event

Name	Drainage (Square Miles)	Peak Flow (Cubic Feet per Second)	Critical Depth (feet)
Low Drop - 1	47.2	9,907	6.9
Low Drop - 2	44.44	9,570	7.0
Low Drop - 3	37.56	8,687	7.6
Low Drop - 4	29.37	7,542	8.3
Low Drop - 5	21.15	6,244	7.5
Low Drop - 6	16.58	5,429	6.9

Table 8 - Low Drop Vertical Dimensions

Name	River Mileage	Top of Bank Elevation (feet)	LiDAR WS Elevation	Crest Elevation (feet)	Structure Height (feet)	Outlet Apron Elevation (feet)
Low Drop - 1	1.56	355.6	345.47	345.35	2.00	343.3500
Low Drop - 2	2.38	364.8	350.39	350.36	2.00	348.3600
Low Drop - 3	4.1	375.0	359.91	359.15	2.50	356.6500
Low Drop - 4	5.31	384.5	367.13	366.94	3.50	363.4400
Low Drop - 5	7.32	401.0	380.91	380.51	3.50	377.0100
Low Drop - 6	8.9	417.3	395.67	392.78	3.50	389.2800

Table 9 - Low Drop Horizontal Dimensions

Name	River Mileage	Distance Apart (Feet)	Length (Feet)	Maximum Width (Feet)	Bottom Width (Feet)	Disturbed Area (Acre)
Low Drop - 1	1.56	-	160	180	65	8
Low Drop - 2	2.38	4330	160	220	80	10
Low Drop - 3	4.1	9082	160	200	60	8
Low Drop - 4	5.31	6389	170	210	40	7
Low Drop - 5	7.32	10613	160	210	40	7
Low Drop - 6	8.9	8342	120	220	40	7

Table 10 - Low Drop Rough Quantities

Name	River Mileage	Excavation (cubic yards)	Rip Rap R200 (ton)	Rip Rap R600 (ton)	Bedding Stone (ton)	Grout (cubic yards)
Low Drop - 1	1.56	4300	2300	3600	600	210
Low Drop - 2	2.38	5400	2600	4600	800	270
Low Drop - 3	4.1	4600	2600	4200	700	240
Low Drop - 4	5.31	4600	1800	4500	800	250
Low Drop - 5	7.32	4600	1700	4500	800	240
Low Drop - 6	8.9	3900	1700	3600	600	170

C.6 Project Considerations

Several potential implications and concerns exist when proposing to build structures within the regulated floodway. One of these concerns is a potential increase in the 100-year flowline along Piney Creek. The Federal Emergency Management Agency's Flood Insurance Study was reviewed for Hardeman County, Tennessee and shows Piney Creek floodplain listed as a Zone A. Zone A floodplains are estimated based on approximation without base flood elevations. Any potential flowline rise and/or increase in flooded area is difficult to estimate at the feasibility phase due to lack of survey and precise elevation data available. More detailed analysis will be performed during the design phase to minimize regulated activity within the floodway and floodplain, and compare the existing conditions with the proposed project conditions.

ER 1110-2-1150 *Engineering and Design for Civil Works*, Appendix C, Section 2, lists considerations for hydrologic and hydraulic studies nationwide. Considerations applicable to the Piney Creek project are addressed at the feasibility level in this section. Considerations are addressed in the feasibility-level design based on experience in West Tennessee and a conservative approach. Considerations and conclusions included:

1. Consequences of flows exceeding discharge capacity of the project:
    - mild damage to low drop structures
2. Project-induced changes obligating mitigation:
    - potential for clearing small areas of forest for low drop installation
3. Changes in discharge-frequency relationships:
    - negligible change
4. Consequences of 0.2% chance of exceedance flood:
    - mild damage to low drop structures
5. Change in stage-discharge relationships:
    - 1.0% chance exceedance flowline may rise upstream of each drop structure
    - if channel silts in upstream of the weirs on a slope equal to the calculated equilibrium slope, may rise more
6. Changes in flow duration:

- negligible change

7. Changes in flood inundation boundaries and flood stage hydrographs:
    - 1.0% chance exceedance flood boundaries may increase
    - if channel silts in upstream of the weirs on a slope equal to the calculated equilibrium slope may increase more
8. Water quality conditions:
    - water quality will not be harmed during construction
    - long-term water quality will not decrease
    - with respect to suspended sediment, long-term water quality should improve moderately
9. Preliminary Real Estate taking line elevations:
    - a detailed hydraulic model is required to address this issue
10. Criteria for facility/utility relocations:
    - the needs for utility relocations can be generally assessed at the feasibility level but cannot be completed until the design phase
11. Criteria for identification of flowage easements required for project function:
    - determination of the 100-year event flood outline in the floodplain
12. Criteria in support of project Operation and Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) requirements:
    - general needs for maintenance of low drops can be stated at the feasibility stage but specific instructions should be developed in the design phase, based on expectations of flow velocity and turbulence at low drop structures
13. Environmental engineering considerations incorporated into the design and regulation plan:
    - the project purpose is environmental restoration and that function has been incorporated into the proportioning of the low drops
14. The project will not create the types of flooding hazards that impoundments or flow-control projects can cause, therefore the project will cause:
    - no water impoundment above the level of floodplain flood levels
    - no increase in access and egress problems during a flood
    - no increased potential for loss of life
    - no increased loss of public services
    - no increased potential physical damages
15. Change in channel flow velocity:
    - at times flow will be faster and more turbulent in the stilling basin than in the existing channel
    - low-flow velocity upstream of the low drops will be slightly lower than under existing conditions due to reduced bed slope
    - high-flow velocity will not change greatly
16. Structural sizing needed to meet design capacities, including riprap or other slope protection:
    - the low drops have been proportioned to resist displacement of riprap
    - the low drops are inherently energy dissipating structures
    - the vicinity of the low drops will be graded and provided with stable drainage into the Piney Creek channel
17. Existing and post-project sedimentation:
    - any changes in upland and bottomland sheet, rill, and gully erosion have not been estimated, but any changes that occur will not be induced by the project

- the delivery of sediment via tributary channel to Piney Creek should decrease moderately as a result of installing the tributary grade control structures
- installation of the Piney Creek low drop structures will tend to reduce erosion of the bed and side slopes of Piney Creek and will tend to cause the deposition of any sediment being delivered to, or transported by, the channel

18. Order of work during construction:
    - ordinarily, the order of installation of grade control structures to be installed in a reach over a period of many years is from downstream to upstream
    - if the low drops for Piney Creek are installed in a period of, say, 2 years or less, then installing the structures from upstream to downstream will make construction easier for the contractor and should result in lower construction cost.

C.7 References

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Appendix D: Cost Estimates

Piney Creek Ecosystem Restoration
Bolivar, Hardeman County, Tennessee

Corps of Engineers, Memphis District
Piney Creek, Bolivar, TN - Hardeman County, TN
Prices are based on Current Year Construction: Preparation Date (5/6/21)

Construction for Tributary Re-Channelization of Piney Creek along w/ Head Cutting Preventitive Measures on Piney Creek and it's Adjoining Tributaries

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
								47.17 Acres of Improvement Easement
01 Lands and Damages								12.86 Acres of Road Easment
Lands and Damages	1	JA	$ 207,800.00	$208,000	21%	$43,325.00	$251,325	Total Easement : 60.03 Acres
Mitigation Land	1	JA		$0		$0	$0	
Total 01				$208,000		$43,325	**$251,325**	
02 RELOCATIONS								
Roads and Bridges	1	JA		$0	25%	$0	$0	
Utilities	1	JA	$ 100,000.00	$100,000	25%	$25,000	$125,000	Possible Relocations will have to be made to allow equipment into sites.(Ex. Raising Powerlines)
Total 02				$100,000		$25,000	**$125,000**	
09 Channels and Canals								
Mob & Demob	1.0	JA	$ 130,527.00	$130,527	25%	$33,000	$163,527	Includes two mobs: one for clearing and one for excavation. This is to deal with Bat issue if warranted.
Environmental Protection	1.0	JA	$ 11,611.00	$11,611	25%	$3,000	$14,611	This is to allow for Fuel Containment
Storm Water Pollution Prevention	1.0	JA	$ 100,645.00	$100,645	25%	$25,000	$125,645	27500 lf of Silt Fence; 10 Rock Check Dams; SWPP
Clearing and Grubbing	18.9	ACR	$ 5,360.37	$101,311	25%	$25,000	$126,311	Includes burning
Excavation	51,000.0	BCY	$ 12.78	$651,780	25%	$163,000	$814,780	Quantity Provided by Sponsor, Excavation accomplished by (2) Long Reach Swamp Exc. 1/2 material will have to be double handled.
Access Roadway for Excavation of Piney Creek	1.0	JA	$ 235,051.15	$235,051	25%	$59,000	$294,051	Includes 10.6 acres of clearing as well as 2027 tons of gravel. Assummed left in place for land owner.
Seeding and Mulching	28.9	ACR	$ 2,130.80	$61,580	25%	$15,000	$76,580	Approx. 3.44 acres to be spread by hand. Remainder to be done by heavy Equipment.
Plant Trees	3,221.0	EA	$ 5.03	$16,202	25%	$4,000	$20,202	Trees to be planted by labor crew and boat.
Total 09				$1,308,707		$327,000	**$1,635,707**	
16 Bank Stabilization (Low Drop Weir Structures Main Channel+Minor Grade Control+Rock Chute)								
Mob & Demob	1.00	JA	$ 119,683.48	$120,000	25%	$30,000	$150,000	Includes two mobs: one for clearing and one for excavation. This is to deal with Bat issue if warranted.
Stormwater Pollution Prevention	1.00	JA	$ 208,740.00	$209,000	25%	$52,000	$261,000	Includes 4200 lf of sf, 42 check dams and SWPPP, Erosion Control

Corps of Engineers, Memphis District								
Piney Creek, Bolivar, TN - Hardeman County, TN								
Prices are based on Current Year Construction: Preparation Date (5/6/21)								
Construction for Tributary Re-Channelization of Piney Creek along w/ Head Cutting Preventitive Measures on Piney Creek and it's Adjoining Tributaries								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
Environmental Protection	1.00	JA	$ 29,466.00	$29,000	25%	$7,000	$36,000	
Excavation	28,900.00	BCY	$ 2.28	$66,000	25%	$17,000	$83,000	6 LD Weirs, 5 Grade Control Structures, 3 Rock Chutes
Clearing and Grubbing	14.00	ACR	$ 5,795.43	$81,000	25%	$20,000	$101,000	14 Acres or Approximately 1 acre per structure
Riprap R600	29,725.00	TON	$ 113.55	$3,375,000	25%	$844,000	$4,219,000	1125 Tons Minor Grade Control Structures, 25,000 Tons Low Drop Weir, 3600 Tons Rock Chute
Riprap R200	12,700.00	TON	$ 99.65	$1,266,000	25%	$317,000	$1,583,000	Used On Low Drop Weir
Bedding Stone	4,582.00	BCY	$ 99.94	$458,000	25%	$115,000	$573,000	282 Tons Minor Grade Control, 4300 Ton Low Drop Weir
Grout	1,755.00	CY	$ 271.62	$477,000	25%	$119,000	$596,000	75 cy Grade Control, 300 cy Rock Chute, 1380 Cy Low Drop Weir
Access Road	1.00	JA	$ 747,412.00	$747,000	25%	$187,000	$934,000	Improvements to 1200' of roadway: Clearing and Gravel
Turfing	25.00	ACR	$ 2,365.02	$59,000	25%	$15,000	$74,000	Includes 1 Acres per Structure + 10 acres for haul roads.
Trees	7,550.00	EA	$ 5.03	$38,000	25%	$10,000	$48,000	Includes refurbishing Clearing areas with trees and restoring to natural habitat.
Divert Flow	14.00	EA	$ 17,787.20	$249,000	25%	$62,000	$311,000	Divert Flow for 14 Structures
Sheet Pile	4,650.00	SF	$ 56.65	$263,000	25%	$66,000	$329,000	Minor Grade Control Structures 50' x 15' x 5EA.; Rock Chute 900 sf
Total 16				$7,437,000		$1,861,000	$9,298,000	
30 PLANNING, E&D								
E&D for Study Costs 2021	1	LS	$ 24,000.00	$25,000		$0	$25,000	Study Costs
E&D for Study Costs 2016-2020	1	LS	$ 170,000.00	$170,000		$0	$170,000	Study Costs
E&D for Relocations	1	LS	$ 15,000.00	$25,000	25%	$6,000	$31,000	15% of Construction Dollars
E&D for 09 Channels and Canals	1	LS	$ 196,306.04	$196,000	25%	$49,000	$245,000	15% of Construction Dollars
E&D for 16 Bank Stabilization	1	LS	$ 1,115,550.00	$1,116,000	25%	$279,000	$1,395,000	15% of Construction Dollars
Total 30				$1,532,000		$334,000	**$1,866,000**	17.32%
31 Supervision and Administration								
S&A for Relocations	1	LS	$ 15,000.00	$15,000	25%	$4,000	$19,000	15% of Construction Dollars
S&A for 09 Channels and Canals	1	LS	$ 196,306.04	$196,000	25%	$49,000	$245,000	15% of Construction Dollars

Corps of Engineers, Memphis District								
Piney Creek, Bolivar, TN - Hardeman County, TN								
Prices are based on Current Year Construction: Preparation Date (5/6/21)								
Construction for Tributary Re-Channelization of Piney Creek along w/ Head Cutting Preventitive Measures on Piney Creek and it's Adjoining Tributaries								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
S&A for 16 Bank Stabilization	1	LS	$ 1,115,550.00	$1,116,000	25%	$279,000	$1,395,000	15% of Construction Dollars
Total 31				$1,327,000		$279,000	**$1,395,000**	15.00%
TOTAL PROJECT COSTS (May 2021)	1	LS		$11,912,707		$2,869,325	**$14,571,032**	There is a 25% contingency allowance on all construction items.
TOTAL PROJECT COSTS (May 2021)	1	LS	$ 1.00			24.1%	**$14,571,032**	

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Appendix E: Real Estate Plan

Piney Creek Ecosystem Restoration
Bolivar, Hardeman County, Tennessee

Memphis District Real Estate
United States Army Corps of Engineers

Piney Creek Ecosystem Restoration

Appendix E: Real Estate Plan

Prepared April 2021

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Section 1

Purpose of Real Estate Plan

This Real Estate Plan (REP) sets forth the real estate requirements and costs for the implementation and construction of the Piney Creek Ecosystem Restoration Project. The lands, easements and rights-of-way required for the project are outlined in this REP are in accordance with the requirements of Engineering Regulation (ER) 405-1-12. The information provided within this REP is based on preliminary data suitable only for planning purposes and is subject to change after approval of this REP and feasibility study.

1.1 PROJECT PURPOSE

The goal of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology. Indicators of success would include the presence of a large variety of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and the ability of the restored area to continue to function and produce the desired outputs with a minimum of continuing human intervention.

Objective 1: Restore sustainable riverine habitat for the benefit of native fishes and mussels in Piney Creek. The Slough Darter Habitat Suitability Index will be used to calculate habitat units to measure this objective.

Objective 2: Enhance shoreline and transitional habitat for the benefit of native species. The Bullfrog Habitat Suitability Index will be used to calculate habitat units to measure this objective.

Objective 3: Restore sustainable habitat for species that use bottomland habitats in the Piney Creek watershed. The Mink Habitat Suitability Index will be used to calculate habitat units to measure this objective.

This study will examine Piney Creek, a tributary of the Hatchie River. The Piney Creek watershed lies entirely in Tennessee and covers more than 37,500 acres. Approximately 50 years ago, several miles of the downstream end of Piney Creek were bypassed and replaced with a ditch. Today, the historic meanders of Piney Creek remain cut off. Stagnant water around the old meanders is killing bottomland hardwoods and reducing the quality of the forested swamp habitat for a variety of native species.

For this assessment, Lower Piney Creek extends from its mouth at the Hatchie upstream to the edge of the contiguous bottomland forest; located approximately 0.8 mile downstream of Walnut Grove Road. Most of this reach lies within the bottomland hardwood floodplain of the Hatchie River. Going upstream, Middle Piney Creek extends from the edge of the bottomland hardwood forest upstream approximately 9 miles to the town of Silerton. Like Lower Piney Creek, the middle portion was also straightened and enlarged to alleviate agricultural flooding, but is stable now. The channel upstream of Silerton is designated Upper Piney Creek. Much of the Upper Piney Creek area was harvested for timber but the forest has regrown and part of it is now Chickasaw State Park. The small streams outside the Park are deep gullies that are headcutting and producing a considerable amount of sediment.

Piney Creek is the largest sediment source to the Hatchie River. Accordingly, the Hatchie downstream of the Piney Creek outlet is environmentally degraded and shows some signs of being unstable. (Diehl 2000). The Hatchie River is the only undammed and unchannelized tributary to the Lower Mississippi River. The Hatchie River contains the largest forested floodplain in Tennessee. There are two National Wildlife Refuges (Hatchie National Wildlife Refuge and Lower Hatchie National Wildlife Refuge) and two State Parks (Big Hill Pond and Chickasaw). The Hatchie, including the lower end of Piney Creek, is a Class 1 Scenic River under the Tennessee Wild and Scenic Rivers Act. Steamboats plied the Hatchie until the early 20th century and the historic head of navigation was at Bolivar, TN near the mouth of Piney Creek.

The Hatchie River and its tributaries are a high priority area for habitat restoration among state and federal agencies and non-governmental organizations. The ecosystem provides habitat for more than 100 species of fish including 11 species of catfish, which is possibly the most of any North American River; 50 species of mammals; 35 species of mussels; 250 species of birds including migrating birds; along with many reptiles, amphibians and invertebrates. Many of the Hatchie River's 36 tributaries have been channelized or altered. The habitat quality in these tributaries is poor and they deliver sediment to the Hatchie (Keck & Etnier 2005). The increased sediment from the tributaries creates valley plugs and shoals in the Hatchie. The habitat for freshwater mussels, crayfish, fish, amphibians, reptiles, mammals, and birds is degraded. Numerous scientific studies have documented population declines to all of these resources (Benz and Collins 1997).

Streams throughout the area were channelized starting in the 1920's Habitat degradation is extensive in the Hatchie tributaries like Piney Creek. The tributaries are unstable and unlikely to recover without intervention. Degradation of (bottomland hardwood) BLH systems is exacerbated in the loess belt region of the LMAV (Lower Mississippi Alluvial Valley), which includes portions of western Tennessee and northern Mississippi (Saucier 1994). The geology of the region and past land-use practices have resulted in extreme rates of gully erosion in the uplands areas of this region. Increased transport capacity of channelized streams has facilitated the transport of large quantities of eroded sediment into the lower reaches of these altered systems. Degradation, head-cutting, and bank failure of channelized reaches has also contributed to greater sediment loads. These processes have led to the formation of valley plugs and shoals throughout many of the altered systems in western Tennessee (Diehl 2000) and northern Mississippi (Happ et al. 1940). Valley plugs are within-channel geomorphic features that completely block the channel with accumulating sediment. Shoals are within-channel geomorphic features, at the confluence of two streams, that accumulate sediment causing a decrease in channel depth but not a complete blockage of the channel (Diehl 2000).

The Hatchie River is a tributary of the Mississippi River. Other studies have noted the importance of such tributaries on the health and function of the Mississippi. A majority of Lower Mississippi River tributaries have been altered to facilitate drainage (Benz & Collins 1997). Channelization has reduced or eliminated natural stream functions such as providing habitat for freshwater mussels, crayfish, fish, amphibians, reptiles, mammals, and birds. Habitat loss has caused population declines to all of these (Benz & Collins 1997). Geomorphic changes in tributary rivers have altered sediment dynamics in the Mississippi River. Large rainfall runoff volumes are quickly drained from the floodplain changing flood pulses (Baker et al. 2004) and reducing nutrient attenuation.

PROBLEMS AND OPPORTUNITIES [PURPOSE AND NEED]

Lower Piney Creek was channelized. Historically it was a meandering stream with a healthy bottomland hardwood forest that was connected to the Hatchie River Forest. The historic meanders are now cut off from Piney Creek and the forest is constantly inundated. The forest is stressed and many trees are dead or dying. The current Lower Piney Creek channel is only 4,500 feet long; historically it was 2-3 miles long. During high water, the water is trapped in the channel and cannot spread out over the floodplain. Lower Piney Creek contains poor aquatic habitat. The stream is entrenched so there is very little vegetation along the water's edge and no rooted aquatic vegetation. Fish and mussel habitat are poor.

Middle Piney Creek flows through an upland area. This reach was also straightened and some of the land was cleared for agriculture; most is now in pasture. There are a few homes along this reach and roads and bridges. The channel is slightly entrenched, but not as severely as the Lower Piney Creek channel. It does not have many pool riffle complexes, but is mostly stable with an intact riparian buffer. There are some minor scouring at bridges.

Upper Piney Creek overlies an area that was harvested for timber. The area is reforested, but the past activities caused gullying and headcutting which has not been arrested. This area generates much of the sediment that is seen farther downstream.

Sedimentation in the upper reaches produces excess sand in Piney Creek. The Middle and Lower portions of the channel are shortened and do not meander. The channel is entrenched so that the sand-laden water cannot spread across a floodplain and allow some of the sediment to deposit. These factors combine to make Piney Creek the largest sediment source to the Hatchie River. Conditions in the Hatchie downstream from the

Piney Creek outlet ditch are degraded (Diehl 2000). Shoals are associated with signs of channel instability. In the reach of the Hatchie River with depth measurements, only 10 meander cutoffs have formed since the first editions of topographic maps (generally based on 1947 photographs) were printed. Of these 10 cutoffs, 5 are clustered in the shoal reach below the mouth of Piney Creek (Diehl 2000).

Specific Problems

1. Lack of aquatic habitat in the Lower Piney Creek ditch.

- Entrenchment eliminates shoreline vegetation.
- Sediment load is too high to provide stable substrate.
- Channel is 1/3 the length of the historic channel.
- No pool-riffle complexes.

2. Degraded bottomland forest around the historic Piney Creek meanders.

- Permanent standing water is killing trees.
- The historic meanders are not connected to the main channel so fish cannot access them.

3. Upper Piney Creek is a sediment source.

Opportunities

There is an opportunity for Lower Piney Creek to have good habitat and a wider variety of aquatic species where it connects to the Hatchie River and to provide nursery habitat for larger species in the river. Today, it is an alluvial fan and discharges sand into the Hatchie River creating a shoal. In fact, this is one of the shallowest spots in the Hatchie and in summer is only passable in an airboat.

The forested area along Piney Creek is contiguous with the Hatchie Bottoms, which is the largest continuous forest in Western Tennessee. There is an opportunity to restore the forest that is stagnated in an early successional phase with box elder, and sycamore; some areas of cypress; and some areas of dead and dying timber.

There is an opportunity to restore aquatic habitat – pool-riffle complexes, meanders, and rooted aquatic plants in Lower Piney Creek, reduce sedimentation from head cutting in gullies, reduce sand input to the Hatchie River to reduce shoaling, and restore natural channel functions to enhance floodplain habitat and bottomland hardwood.

1.2 PROJECT LOCATION

Piney Creek is tributary of the Hatchie River. It falls within the Mississippi Valley Loess Plains ecoregion. The Hatchie River is a 238-mile long tributary of the Mississippi River and drains approximately 1 million acres in Mississippi and Tennessee. The watershed contains Chickasaw State Park and two National Wildlife Refuges - Hatchie National Wildlife Refuge and Lower Hatchie National Wildlife Refuge. The Hatchie River is the only undammed and unchannelized tributary to the Lower Mississippi River. The Hatchie River contains the largest forested floodplain in Tennessee.

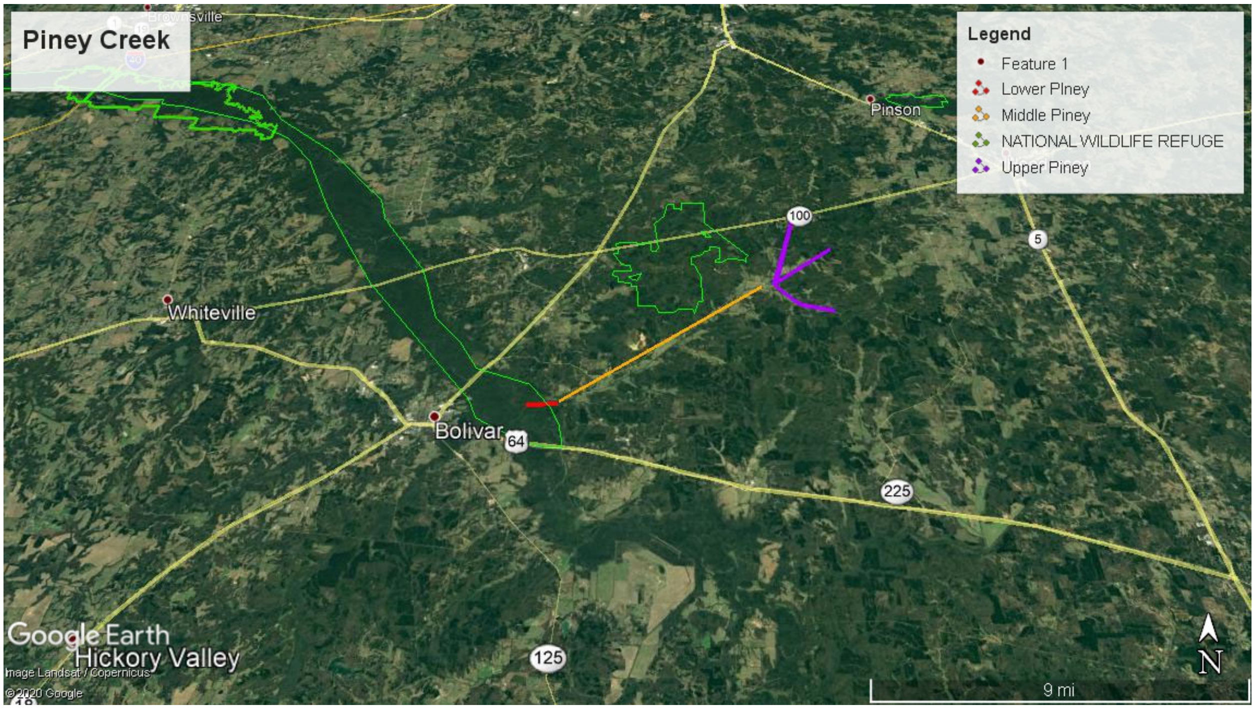


Figure D:1-1. Location of Hardeman County Study

1.3 PROJECT AUTHORITY

Section 206 of the Water Resources Development Act of 1996, as amended. The Secretary may carry out an aquatic ecosystem restoration and protection project if the Secretary determines that the project— (1) will improve the quality of the environment and is in the public interest; and (2) is cost-effective. Section 206 is part of the Continuing Authorities Program and is covered under USACE guidance in EP 1105-2-58. It has a federal limit of $10,000,000.

Section 2

Description of the Recommended Plan and Lands, Easements, Rights-of-Way, Relocations, and Disposal (LERRD) Sites

2.1 STRUCTURAL

The real estate costs presented herein for the REP are based on the estimated acreages and estates shown in the table below.

Table D:2-1 Piney Creek Ecosystem Restoration

		Unit
Structural Components		
Fee	35.70	AC
Perpetual Road Easement	55.76	AC
Temporary Road Easement (5Yr. Temporary)	TBD	AC
Temporary Work Area Easement (5Yr. Work/Disposal)	TBD	AC
Total	**91.46**	**AC**

2.2 ACCESS

Access to the project area would be via public roads and temporary and perpetual road easements.

2.3 BORROW

Borrow Material will not be needed for this project.

2.4 DISPOSAL

There will be no disposal. Excavated material will be used onsite to construct the project.

Section 3

Non-Federal Sponsor Owned LERRD

The Non-Federal sponsor for the Study is West Tennessee River Basin Authority. West Tennessee River Basin Authority signed a Federal Cost Share Agreement (FCSA) with the United States Army Corp of Engineers' Memphis District on March 2018. The NFS does not own any LERRD in the project footprint.

Section 4

Estates

1. ESTATES

The following standard estates will be required for the REP:

4.1 Road Easement (Perpetual and Temporary)

A (perpetual [exclusive] [non-exclusive] and assignable) (temporary) easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos.__________ ,and__________) for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.2 Temporary Work Area Easement

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos.__________ ,__________and__________), for a period not to exceed____________________, beginning with date possession of the land is granted to the (Grantee), for use by the (Grantee), its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.3 FEE

The fee simple title to (the land described in Schedule A) (Tracts Nos. ____, ____ and _____), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Section 5

Existing Federal Projects within LERRD Required for the Project

There are no existing Federal Projects within the Lands, Easements, Right of Way, Relocations and Disposals Sites (LERRD) required for the project.

Section 6

Federally-Owned Lands within LERRD Required for the Project

There are no federally owned lands within Lands, Easements, Right of Way, Relocations and Disposals Sites (LERRD) required for the project.

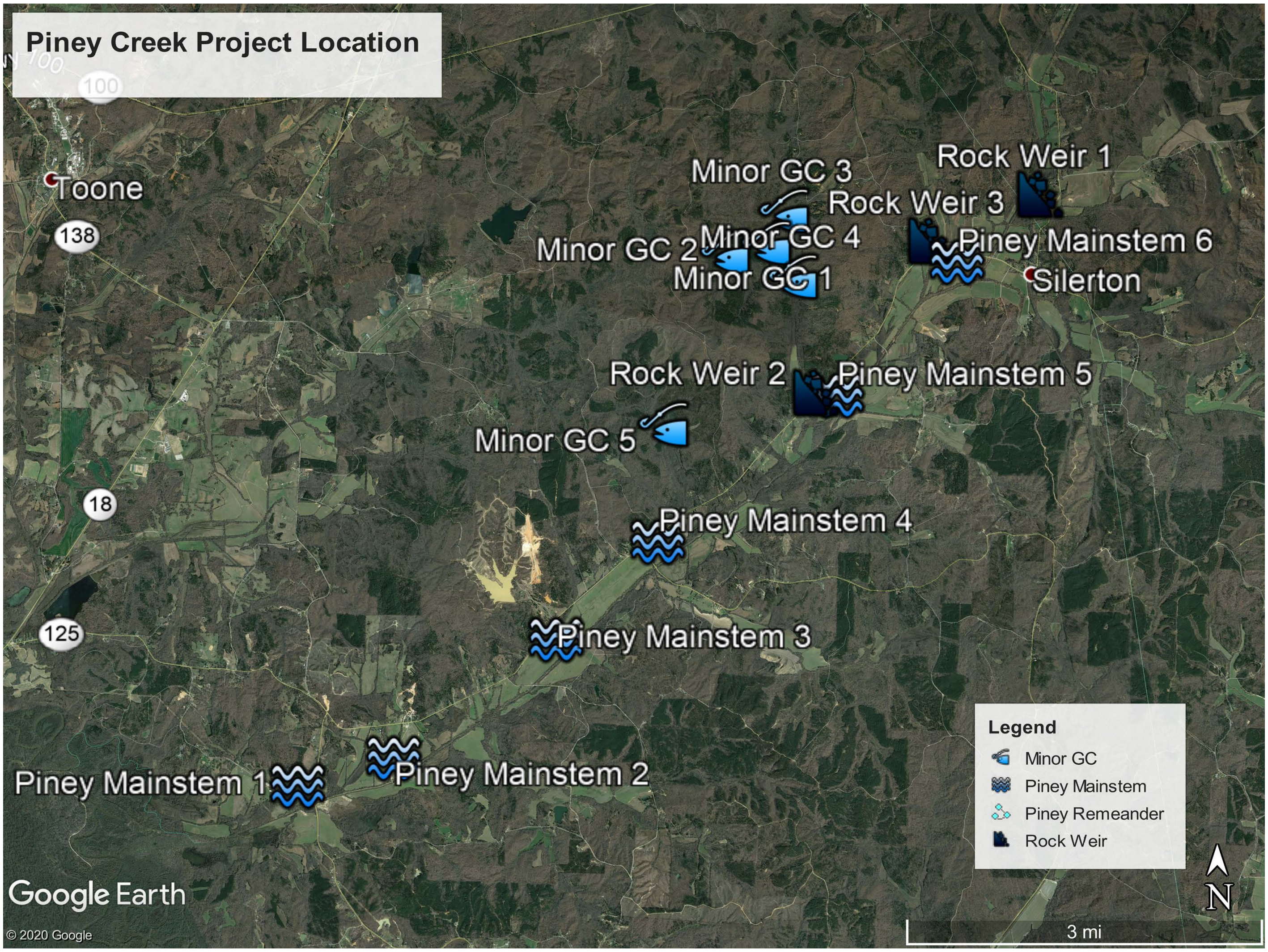
Section 7

Federal Navigation Servitude

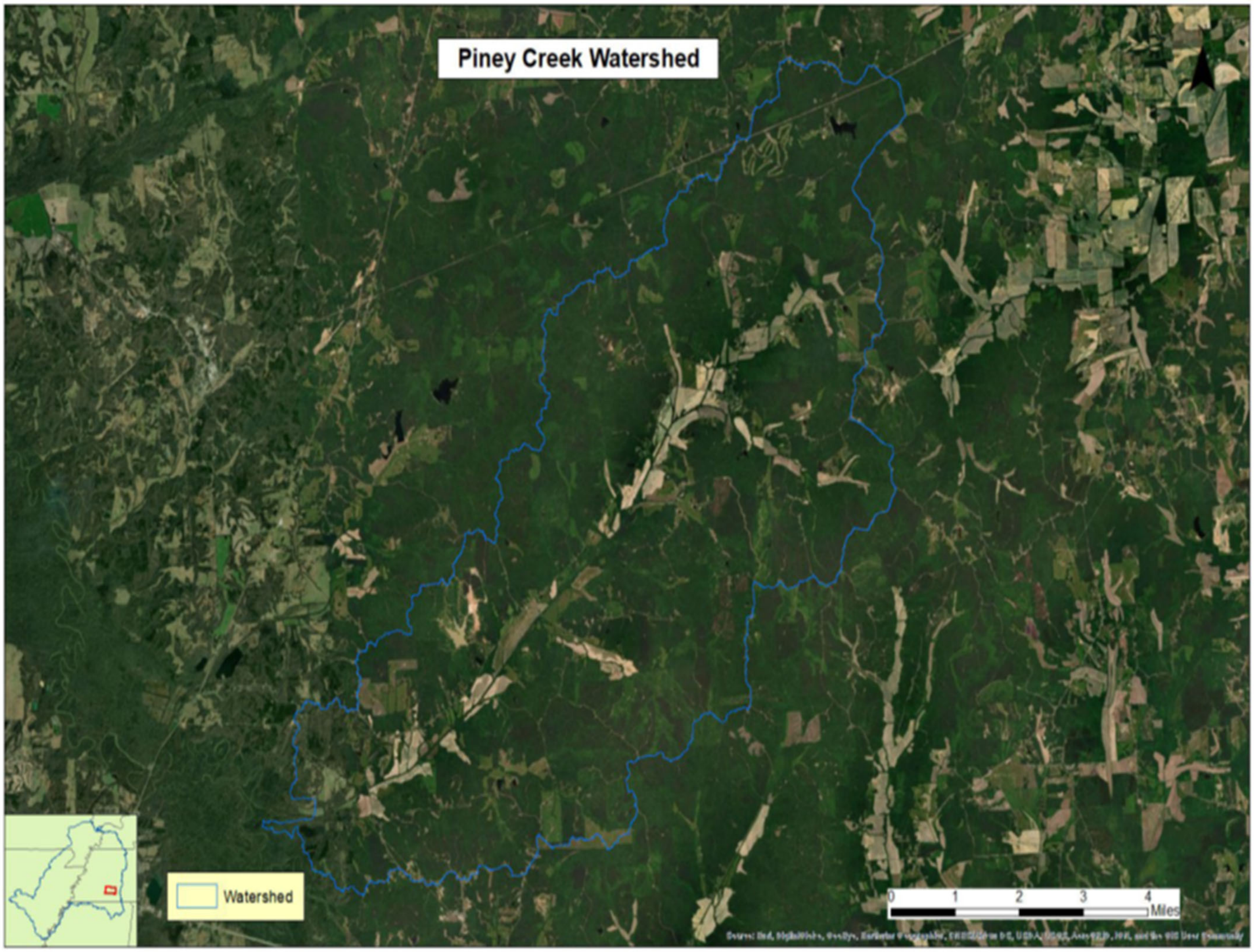
The navigation servitude is the dominant right of the Government, under the Commerce Clause of the U.S. Constitution, to use, control, and regulate the navigable waters of the United States and submerged lands thereunder. None of the features for the Piney Creek Ecosystem Restoration Project will be constructed within navigable waters of the United States, therefore, the navigation servitude will not apply.

Section 8

Project Maps



Project Maps Figure D: 8-1. Piney Creek Project Features



Project Maps Figure D: 8-2. Piney Creek Watershed

Section 9

Induced Flooding

There is no induced Flooding anticipated as result of the project.

Section 10

Baseline Cost Estimate

Total real estate costs, excluding mitigation, for the Piney Creek Ecosystem Restoration Project is $419,000.00. This includes the cost of acquiring fee estates, road easements, damages, and contingencies.

Section 11

P.L. 91-646 Relocation Assistance Benefits

There have not been any residential or nonresidential structures identified for this project that would require the application of relocation assistance benefits.

Section 12

Mineral Activity/Crops

There are no known mineral recovery activities currently ongoing or anticipated, or oil/gas wells present on the project LERRD and the immediate vicinity that will impact the construction, operation, or maintenance of the project. There will be no acquisition of mineral interest from the surface owner or outstanding in third parties over the easements. Subordination of any outstanding or third-party rights, easements, or leases will require evaluation on a case by case basis. If it is determined that any such outstanding right may negatively impact the intended use of the lands, subordination of that right by separate transaction is recommended.

Section 13

Non-Federal Sponsor Capability Assessment

The Capability Assessment has not been completed but will be included as an attachment to the Final REP.

Section 14

Zoning Ordinances

A. Zoning ordinances proposed in lieu of, or to facilitate, acquisition in connection with the project have not been determined.

Section 15

Acquisition Schedule

The following schedule shows the tasks and duration for acquisition of the LERRD required for the project. This schedule is subject to change based on project priorities and how the NFS will handle acquisitions. This schedule is for preliminary planning purposes for schedule estimating; it is based on a worst-case scenario that all tracts are acquired at the same time.

1. Mapping	2 months
2. Title	2 months
3. Appraisals (begin concurrent with title)	2 months
4. Negotiations	2 months
5. Closing	1 month
6. Condemnation *	2 months

*Overlaps with closing timeframe

Section 16

Facility/Utility Relocations

Utility and Facility Relocation surveys have not been completed. Any conclusion or categorization contained in this report that an item is a utility or facility relocation is preliminary only. The government will make a final determination of the relocations necessary for the construction, operation or maintenance of the project after further analysis and completion and approval of final attorney's opinions of compensability for each of the impacted utilities and facilities.

Section 17

HTRW and Other Environmental Considerations

The local sponsor shall be responsible for ensuring that the development and execution of Federal, state, and/or locally required HTRW response actions are accomplished at 100 percent non-project cost, and no cost sharing credit will be given for the cost of response actions. If an HTRW problem is discovered during the PED phase, all work on that portion of the project shall be delayed until the local sponsor, EPA, state and local authorities, as appropriate, are consulted and the extent of the problem is defined. Measures to avoid the HTRW site can then be considered, if necessary, or possible required design changes can be accomplished after the problem and response have been determined (ER 1165-2-132)

In the case of HTRW identification, changes to the project schedule, cost estimate and NEPA documentation must be considered. Should the discovered HTRW site result in significant impacts for the recommended project, preparation of a reformulation document and/or a post-authorization change report may be required. The local sponsor will be responsible for planning and accomplishing any HTRW response measures and will not receive credit for the costs incurred. This does not limit any rights the sponsor may have to recover such costs from PRP or responsible third parties or to work through state agencies to compel cleanup by PRP or responsible third parties prior to sponsor's acquisition of land.

A record search has been conducted of the EPA's EnviroMapper Web Page (https://www.epa.gov/enviro/myenviromapper). The EPA search engine was checked for any superfund sites, toxic releases, or hazardous waste sites within the vicinity of the proposed project. There have been multiple site visits to Piney Creek between 2017 and 2020. The records search and site surveys did not identify the presence of any hazardous or suspected hazardous wastes in the project area. As a result of these assessments, it was concluded that the probability of encountering HTRW is low. If HTRW is encountered during construction activities, the proper handling and disposal of these materials would be coordinated with the Tennessee Department of Environment and Conservation (TDEC) and USEPA.

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Section 18

Landowner Attitude

There have not yet been public meetings to address the study and any of the potential plans.

Section 19

Risk Notification

A risk notification letter has not been sent to the NFS. The NFS will be notified in writing about the risks associated with acquiring land before the execution of the Project Partnership Agreement and the Government's formal notice to proceed with acquisition. This will be sent prior to the final report.

Section 20

Other Real Estate Issues

It is not anticipated that there will be any other real estate issues for this project.

Prepared By:

FRISON.TORICK.U.1259465083 Digitally signed by FRISON.TORICK.U.1259465083 Date: 2020.09.21 10:53:44 -05'00'

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Zachery Derbes
Appraiser

Approved By:

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Chief of Real Estate, Memphis
Real Estate Contracting Officer

US Army Corps of Engineers®
Memphis District

Appendix G: Draft FONSI

Piney Creek Ecosystem Restoration
Bolivar, Hardeman County, Tennessee

FINDING OF NO SIGNIFICANT IMPACT

Piney Creek, TN Ecosystem Restoration
Continuing Authorities Program Section 206
Feasibility Report with Integrated Environmental Assessment
Hardeman County, TN

The U.S. Army Corps of Engineers, Memphis District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The final Integrated Feasibility Report and Environmental Assessment (IFR/EA) dated_______, for the Piney Creek, TN Ecosystem Restoration Continuing Authorities Program Section 206 Feasibility Report with Integrated Environmental Assessment addresses Ecosystem Restoration opportunities and feasibility in the Piney Creek Watershed in Hardeman County, TN. The final recommendation is contained in the report approved by the Mississippi Valley Division Commander, dated____.

The Final IFR/EA, incorporated herein by reference, evaluated various alternatives that would restore aquatic and riparian habitat in the study area. The tentatively selected plan is the National Ecosystem Restoration Plan and includes:

- an approximate 2.6-mile natural channel to replace the 0.85-mile of canal;
- 14 grade control structures;
- tree planting to fill in gaps in the existing canopy and replace any
- trees that have to be removed for construction;
- estimated cost of construction is $14.5 million.

The Piney Creek Monitoring and Adaptive Management Plan included in Appendix A. Monitoring is expected to last no more than 10 years.

In addition to a "no action" plan, five alternatives were initially evaluated. The alternatives were screened using the planning objectives and cost. The process identified one plan for restoration that met the objectives and was acceptable, complete, effective, and efficient.

For all alternatives, the potential effects were evaluated, as appropriate. A summary assessment of the potential effects of the recommended plan are listed in Table 1:

Table 1: Summary of Potential Effects of the Tentatively Selected Plan

	Insignificant effects	Insignificant effects as a result of mitigation	Resource unaffected by action
Aesthetics	☐	☐	X
Air quality	☐	☐	X
Aquatic resources/wetlands	☐	☐	☐
Invasive species	☐	☐	X
Fish and wildlife habitat	☐	☐	☐
Threatened/Endangered species/critical habitat	☐	☐	X
Historic properties	☐	☐	☐
Other cultural resources	☐	☐	☐
Floodplains	☐	☐	☐
Hazardous, toxic & radioactive waste	☐	☐	X
Hydrology	☐	☐	☐
Land use	☐	☐	X
Navigation	☐	☐	X
Noise levels	☐	☐	X
Public infrastructure	☐	☐	X
Socio-economics	☐	☐	X
Environmental justice	☐	☐	X
Soils	☐	☐	X
Tribal trust resources	☐	☐	X
Water quality	☐	☐	X
Climate change	☐	☐	X

All practicable and appropriate means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) will be implemented, if appropriate, to minimize impacts.

No compensatory mitigation is required as part of the recommended plan.

Public review of the draft IFR/EA and FONSI was completed on_________. All comments submitted during the public review period were responded to in the Final IFR/EA and FONSI.

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan will have no effect on federally listed species or their designated critical habitat.

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers determined that historic properties would not be adversely affected by the recommended plan. The Tennessee SHPO concurred with the determination on_________________.

Pursuant to the Clean Water Act of 1972, as amended, the discharge of dredged or fill material associated with the recommended plan has been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230). The Clean Water Act Section 404(b)(1) Guidelines evaluation is found in Appendix A of the IFR/EA.

A water quality certification pursuant to section 401 of the Clean Water Act will obtained from the Tennessee Department of Environment and Conservation prior to construction. In a letter dated _______, the STATE stated that the recommended plan appears to meet the requirements of the water quality certification, pending confirmation based on information to be developed during the pre-construction engineering and design phase. All conditions of the water quality certification will be implemented in order to minimize adverse impacts to water quality.

All applicable environmental laws have been considered and coordination with appropriate agencies and officials has been completed.

Technical and environmental criteria used in the formulation of alternative plans were those specified in the Water Resources Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in evaluation of alternatives. Based on this report, the reviews by other Federal, State and local agencies, Tribes, input of the public, and the review by my staff, it is my determination that the recommended plan would not cause significant adverse effects on the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

_____________________________	_____________________________
Date	Zachary L. Miller Colonel Corps of Engineers Memphis District Commander