ATTACHMENT 11A

PERMITTEE RESPONSIBLE MITIGATION PLAN
for
CUB CREEK RESTORATION PROJECT
Hardeman County, TN
Lower Hatchie River Basin (HUC08010208)

PREPARED FOR:

BLUE OVAL CITY ARAP
HAYWOOD COUNTY, TENNESSEE

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EXECUTIVE SUMMARY

FORD (Permittee) proposes to construct the Cub Creek Stream Mitigation Project in Hardeman County, Tennessee ("Project") as compensatory Permittee Responsible Mitigation (PRM) for unavoidable impacts to aquatic resources in the Hatchie River watershed resulting from development of the West Tennessee Megasite. The Project is located on the University of Tennessee's 1,200-acre Lone Oaks Farm south of Bolivar, Tennessee. The permittee proposes to restore approximately 20,795 linear feet of stream channel along Cub Creek and several unnamed tributaries. The existing streams and wetlands are degraded from impoundment, channelization, ditching, unrestricted cattle access, and riparian buffers being managed for hay and pasture. Cub Creek is on the 2018 Tennessee Department of Environment and Conservation's Division of Water Pollution Control 303(d) list for low flow alterations, physical substrate habitat alterations, alteration in stream-side or littoral vegetative covers, and iron. Known pollutant sources include upstream impoundments, channelization, and grazing in riparian or shoreline zones.

Restoration of the identified reaches in Cub Creek in this mitigation plan has the potential to generate up to **10,491 functional feet** of lift upon demonstration of achieving performance standards by the end of the approved monitoring period.

There are currently no active banks or qualified In-Lieu Fee programs that can service the Blue Oval City project. The drainage networks in both project areas are similar in size and upland location for their respective watersheds.

1.0 OBJECTIVES

1) PROJECT GOALS

The overarching goal of the project is to restore functional stream and wetland habitat within the headwaters of the Cub Creek watershed. The existing streams and wetlands are degraded from impoundments, channelization, ditching, unrestricted cattle access, rock check dams, and mowing. These activities have contributed to the physical, chemical, and biological degradation of stream and wetland ecological functions within the project boundary. The project goals are to restore stream and wetland habitats, reduce sediment pollution, reconnect floodplain and near surface groundwater hydrology, and improve wildlife habitat.

2) OBJECTIVES:

- Restore approximately 20,795 LF of dynamically stable stream channels with improvements to bedform diversity, lateral stability, and floodplain connectivity;
- Plug floodplain drainage ditches and remove berms to improve floodplain connectivity and sediment transport continuity;
- Increase channel sinuosity to reduce flow velocities, promote the formation of natural riffles and pools, and improve lateral and vertical stability;
- Reduce excessive nutrient and pollutant inputs caused by unrestricted cattle access and agricultural activities within the riparian buffer by permanently removing livestock and agricultural activities from the project boundary;
- Re-establish riparian buffers by planting native hardwood forest tree and shrub species;
- Restore approximately 64.62 acres of riparian wetlands by plugging drainage ditches, reconnecting stream channels to wetland areas, changing land management practices, and planting native hydrophytic tree and shrub species; and
- Permanently protect restored streams, wetlands and riparian areas with land use restrictions.

These objectives will help address water quality impairments in Cub Creek and the Lower Hatchie River watershed (08010208). TDEC's Watershed Water Quality Management Plan for the Lower Hatchie River Watershed indicates impoundments, pasture grazing and channelization as the primary water quality stressors in the watershed. The following maps and figures for the Project are included in **Appendix A**.

- Locator Map of the Project within the 8-digit HUC
- Aerial Photo with Existing Aquatic Resources
- Historic Aerial Photo
- Land Use/Land Cover in the Surrounding Area
- Aerial Photo with NRCS Soil Mapping Units

- USGS Topographic Map
- Aerial Photo with Site Photo Locations
- NWI Data
- FIMA Firm
- Proposed Treatments with Hydrological Monitoring Locations
- Biological Sampling Locations

2.0 SITE SELECTION

A. Watershed Approach

The following characteristics were evaluated as part of a watershed approach to siting a project in the Hatchie River watershed:

- Resilient stream types that will respond well to restoration actions;
- Relatively long reaches and sufficient space to address pattern deficiencies;
- Rural landscape that is relatively free of site constraints;
- The site contains cohesive, fertile soils;
- The ability to implement an ecosystem restoration project by re-establishing stream and wetland connectivity and functions.
- Opportunities for ecological lift within the same landscape setting and aquatic resource type as impacts at Blue Oval City;
- Compatibility with surrounding land uses, including hydrologic and terrestrial connectivity;
- Potential of aquatic resources to achieve significant value and the ability to protect habitat connectivity;
- Accomplishment of aquatic resource goals outlined in the Lower Hatchie River Watershed Management Plan, and other planning documents;
- Effect the mitigation project will have on ecologically important habitats or rare species;
- The extent to which the site has potential to contribute to the protection or restoration of watershed processes or adjoining wetland habitats; and
- The potential of the site to accommodate timely implementation.

B. Site Location

The proposed site is situated in the Southeastern Plains Physiographic Province and Ecoregion (65) in Hardeman County. The site location is described more specifically in **Table 1**.

Table 1. Cub Creek Stream Mitigation Summary

Level III Ecoregion:	Southeastern Plains (65)
Watershed (8-digit HUC):	Lower Hatchie River (HUC 08010208)
Watershed (12-digit HUC):	Cub Creek (HUC 080102080204)
Location:	10,000 Lake Hardeman Road, Middleton, TN 38052
303(d) Status:	Cub Creek is listed (see Section 1.0)
Mitigation Area:	Approximately 65 acres
Coordinates (Centroid):	35.113; -88.971

C. <u>Site Modifications, Stressors and Ecological Services</u>

Throughout the project area site modifications have diminished the ecological services provided by streams, wetlands, riparian buffers and floodplains. Livestock productions activities over the past several decades have deforested riparian buffers and promoted direct livestock access to streams, leading to elevated temperatures, bacteria pollution and trampled banks. Project streams have also been impacted by channel straightening and the resulting incision, coupled with sparse to non-existent riparian buffers, has led to widespread bank erosion.

Table 2. Stressors and Impacted Ecological Services

Stressor	Impacted Ecological Services
Channel incision	Flood attenuation, fine sediment storage, maintenance of stable channel bed and banks
Bank erosion and mid-channel sediment deposition	Equilibrium sediment transport, maintenance of in-stream riffle and pool habitats
Buffer deforestation	Filtration of runoff, thermal regulation, input of organic matter
Direct livestock access	Protection of water quality from nutrient inputs.

D. <u>Evolutionary Trends</u>

Bank erosion, bank collapse and mid-channel sediment deposition are most evident in Cub Creek. Observations of the site over the past three years indicate that lateral bank migration and channel widening is continuing unabated. Trees continue to fall into the channel, creating debris jams and forcing flow into already exposed banks. Historic channelization of Cub Creek has led to active head cutting in the tributaries resulting in bank height ratios exceeding 2 to 1 in many areas.

The incision observed, especially in the headwaters region of Cub Creek and INT-17 in the mitigation area, causes confinement of flood flows, increased shear stresses on the banks and bed, and ultimately erosion of the beds and banks. Left unchecked, this evolutionary trend of incision, bank erosion, widening and mid-channel deposition will likely continue. Leaning trees fall and expose erodible soils, further exacerbating stability problems.

3.0 SITE PROTECTION INSTRUMENT

The University of Tennessee – Institute of Agriculture is a state organization and has agreed, as the property owner, to permanently protect the mitigation area using the current USACE Land Use Restrictions document. The land use restrictions will provide long-term protection of the mitigation area and prohibit incompatible uses that might otherwise jeopardize the objectives of the project. A draft copy of the land use restrictions document, signed property assessment and warranty, and survey plat and legal descriptions are located in **Appendix B**. No permit for the project will be authorized or issued for the project until an approved land use restrictions document is recorded by the state.

4.0 **EXISTING CONDITION (BASELINE) INFORMATION**

A. Watershed Location

The location for the project is the Lower Hatchie River watershed (HUC 08010208). The primary threats to aquatic resources throughout this geographic area include incompatible agricultural practices in the floodplain of the area's major rivers, channelization of streams, and urbanization in close proximity to Memphis and Jackson.

B. Stream Geomorphic Assessment

The majority of the mitigation area is currently used as hayfield and wildlife food plots. Staff from Lone Oaks Farm regularly mow the mitigation area including the riparian areas. The upstream end of the site is bounded by the intersection of Lake Hardeman Road and Sain Road. The downstream end of the project is bounded by Lake Hardeman Road where Cub Creek flows underneath a bridge. The streams in the mitigation area have been straightened and channelized numerous times with the intent of draining the floodplain for more efficient use of agricultural fields and pastures.

Bank erosion and incision, and lack of riparian buffer are pervasive throughout the site. Previous channelization, dredging, realignment and straightening have left the streams unstable with vertical, eroding banks, poor bed form diversity, unstable patterns and incised conditions that have disconnected many of the stream reaches from their floodplains. Project streams are characterized as being in either Stage III (degradation) or Stage IV (degradation and widening) according to the Simon Channel Evolution Model.

The Cub Creek valley is classified as a Type VIII valley, as defined in the Rosgen Classification System. Type VIII valleys are indicative of wide, gently sloping floodplains adjacent to alluvial terraces. Alluvial floodplains are the major depositional features in the valley geomorphic setting, which produce high sediment supply to the Hatchie River system. Streams flowing through Type VIII valleys are usually associated with “E” or “C” type channel morphology, which is consistent with the stream classifications at the site.

C. Reach Descriptions

The mitigation area contains 14,721 linear feet of existing stream mostly located in a low slope, alluvial valley with a wide floodplain. Cub Creek at the lower limit of the project has a drainage area of approximately 6.56 square miles. Tributary drainage areas range from 0.04 to 0.29 square miles. The likely channel evolution sequence suggests that without restoration efforts, the streams will remain unstable and continue to contribute excessive sediment loads to the Hatchie River system for the foreseeable future. For detailed information on existing stream conditions, see the SQT workbooks located in **Appendix C**.

D. Wetlands

Seven jurisdictional wetlands are in the mitigation area and have a nexus with restored stream reaches (**Table 3**). A total of 2,478 feet of restored stream contain existing wetland habitat in the stream buffer. After floodplain reconnection there will be a total of 18,345 feet of restored stream with wetland habitat in the adjacent stream buffer. Wetland hydrology is currently provided by subsurface flow and surface runoff. Wetland habitats have been degraded by conversion of forested floodplain to pasture and hayfield, and lack of floodplain connectivity resulting from historic channelization and dredging activities. The palustrine emergent (PEM) wetland areas are dominated by soft rush (*Juncus effusus*). Palustrine, forested, seasonally flooded wetland areas (PFO1) are dominated by sweet gum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*). Wetland determination data forms for each wetland delineated in the mitigation area are located in **Appendix C**.

According to NRCS Web Soil Survey, soils in the mitigation area are predominantly mapped as the Enville silt loam and Chenneby silt loam. These soils are occasionally flooded and typically found along floodplains of secondary streams. Chenneby silt loam often contains hydric inclusions of Rosebloom silt loam and Enville silt loam often contain hydric inclusions of Bibb silt loam. A detailed NRCS soil report is located in **Appendix D**. Numerous soil samples were examined to determine the presence of hydric soil. The soils sampled in most wetland areas had low chroma colors within the upper 12 inches.

E. Vegetation

The riparian buffer habitat along streams in the lower reaches of the mitigation area are dominated by fescue and Bermuda grass. These open field areas were historically used for grazing cattle and are now maintained by regular mowing. The riparian areas in the upper reaches of the mitigation area typically contain one row of trees with red maple and sweet gum as the most dominant species. INT-20 and INT-25 contain some mature bottomland hardwoods in the buffer; however, the streams in this region of the project have recently down cut several feet and mature trees are falling into the channels. More detailed vegetation information is located in the wetland determination forms and SQT workbook located in **Appendix C**.

F. Biological Data and Threatened and Endangered Species

In coordination with TDEC, biological sampling locations were established and macroinvertebrate data were collected in May 2020 to develop a Tennessee Macroinvertebrate Index baseline scores. A map showing the sampling locations within the mitigation area is located in **Appendix A**. TMI scores are included in the SQT workbooks in **Appendix C**.

There are no critical habitats designated at the site. A USFWS IPaC report for the site is located in **Appendix D**. The following species are potentially affected by activities at the site:

- Indiana Bat (*Myotis sodalis)*
- Northern Long-eared Bat (*Myotis septentrionalis).*

G. Historic Properties

A Phase I Cultural Resource Assessment was performed at Lone Oaks Farm by the University of Tennessee's Archeological Research Laboratory in September 2016. The study area included portions of the mitigation area. No historic structures or features were identified during this survey. A copy of the report is included in **Appendix D**.

H. Surface Water Classification

Cub Creek at the lower limit of the project has a drainage area of approximately 6.56 square miles. UT16 is largest tributary with a watershed area of 1.59 square miles. Other tributary drainage areas range from 0.05 to 0.07 square miles. As mentioned previously, Cub Creek is on Tennessee's proposed 2018 303(d) list of impaired waters for low flow alterations, physical substrate habitat alterations, alteration in stream-side or littoral vegetative covers, and iron.

I. Historic and Existing Land Uses

Lone Oaks Farm has been used for livestock production and row cropping for decades (see historic aerial photo in **Appendix A**). Land uses in the floodplain and riparian zone in the mitigation area are highly degraded from historic channelization, impoundments, and active livestock production activities. The upstream end of the mitigation area flows into a lake built by NRCS in the 1960's. According to the previous landowner, streams below the impoundment have been repeatedly channelized and moved for livestock production. Land use in the immediate surrounding area is an equal mix of livestock production in the lower elevations and forested habitat in the uplands. Land use/land cover within the watershed is composed of pasture/agriculture, hardwood forest and some low-density rural residential development (see Land Use/Land Cover Map in **Appendix A**).

J. Property Ownership

The project is located withing the Lone Oaks Farm which is owned by the State of Tennessee and managed by the University of Tennessee's Institute of Agriculture.

K. Hydrologic Trespass and FEMA Floodplain

Most of the contributing drainage area for the project is located on Lone Oaks Farm, and there is no risk of hydrologic trespass. The site is not located in a FEMA flood hazard area (**Appendix A**). Base flood elevations have not been determined nor is there a defined floodway or non-encroachment area. Correspondence with the Hardeman County floodplain administrator indicated that a flood study would not be required for the proposed stream and wetland restoration activities.

5.0 DETERMINATION OF CREDITS

A. Stream Mitigation

Phase I of the project includes restoring approximately half of the Cub Creek watershed on Lone Oaks Farm. Functional uplift will be provided by improved stream and wetland hydrology, channel hydraulics and sediment transport, riparian buffers, and aquatic and terrestrial habitats. Construction will be completed through the University of Tennessee Foundation and a cooperative agreement with the West Tennessee River Basin Authority. Mitigation activities are summarized in Table 3 and described in more detail in the sections that follow.

Table 3. Stream Mitigation Credit Summary

Reach	Existing	Proposed	Change in Function	Credits
PER11R2	1,697.00	1,939.00	0.35	758.51
PER11R1	448.00	491.00	0.39	200.52
PER16R4	1,312.00	3,015.00	0.44	1,718.29
PER16R3	1,150.00	1,543.00	0.45	769.02
PER16R2	1,281.00	1,934.00	0.42	994.42
PER16R1	1,036.00	1,398.00	0.39	650.20
PER16R1b	285.00	285.00	0.37	105.45
INT20R4	1,398.00	2,028.00	0.45	1,051.20
INT20R3	1,056.00	1,422.00	0.41	678.18
INT20R2	598.00	709.00	0.36	288.54
INT20R1	593.00	581.00	0.43	247.31

INT25R2	988.00	611.00	0.39	128.96
INT1R3	864.00	660.00	0.25	101.76
INT3R1	538.00	962.00	0.33	410.74
PER6R1	989.00	1,511.00	0.39	698.91
INT13R2	80.00	332.00	0.27	177.84
INT10R2	90.00	341.00	0.36	162.92
INT8R1	74.00	646.00	0.34	311.16
INT17R1	61.00	179.00	0.44	105.29
INT19R1	183.00	208.00	0.40	90.24
TOTALS	**14,721.00**	**20,795**	**0.38**	**9,649.46**

B. Wetland Restoration

The Project will restore 11.734 acres of functional riverine-slope wetlands within the riparian areas of Cub Creek and several tributaries. The objective of wetland restoration efforts is to restore functions of the riverine-slope wetlands within the riparian areas of restored streams. No wetland mitigation credits are being proposed. Instead, the project will pursue an additional 10% functional lift to restored streams with restored wetland habitat in the stream riparian buffer. The reaches that will have restored wetlands within the stream buffer include all reaches, with the exception of INT20R4 and INT13R2, and total 8,420.42 functional feet in the wetland enhanced areas for an additional lift of 842.0 functional feet on the completed project. This brings the total potential generated credits to **10,491.46 functional feet** of stream.

6.0 MITIGATION WORK PLAN

Detailed design drawings for stream and wetland restoration activities and geographic boundaries of the project are included in **Appendix E**. The mitigation work plan includes the following:

- Re-constructing dynamically stable stream channels to improve bedform diversity, lateral stability and floodplain connectivity to streams that have been channelized;
- Removing hydrologic modifications (floodplain drainage ditches, berms, and other fill areas) in order to improve overland and subsurface water exchange and sediment transport continuity;
- Increase channel sinuosity and belt width in order to reduce flow velocities, promote the formation of natural riffles and pools, and improve lateral and vertical stability;
- Permanently remove livestock from the site in order to reduce excessive nutrients and pollutants caused by unrestricted cattle access and agricultural activities within the riparian buffers;
- Re-establish minimum 50-foot wide riparian buffers on both banks of all project streams, to be composed of planted native bottomland hardwood forest community;
- Cessation of mowing practices;

- Re-establish riparian wetlands by plugging drainage ditches, reconnecting stream channels to wetland areas, removing livestock, and planting native wetland plant species and remove non-native, invasive species;
- Permanently protect restored streams, wetlands and riparian areas through land use restrictions.

A. Stream Mitigation

The proposed mitigation approach for Cub Creek involves creating a new meandering stream system to reconnect aquatic habitats and restore interaction with the floodplain. Restoration and establishment practices will include construction of new, off-line channel, filling existing canals, installation of fish friendly grade control structures to reconnect the stream to its floodplain, debris and invasive species removal, riparian buffer establishment, and livestock exclusion.

Channel stability and habitat improvements will be accomplished using a natural channel design approach. The overriding goal of this approach is to restore channel dimension, pattern and profile to conditions that promote water and sediment transport equilibrium between a stream and its watershed. Achieving successful equilibrium establishes a connection between the streams, the watersheds and their floodplains, and it promotes healthy in-stream and riparian habitats.

On Cub Creek, proposed off-line restoration segments address historic channel dredging and channelization in the upstream and downstream reaches. As a result of these channel modifications, the stream is currently undergoing lateral migration as evidenced by massive bank erosion, fallen trees, the formation of mid-channel bars, and at the downstream end, destabilization of the Cub Creek. In these reaches, the project will include new off-line channel to improve channel hydraulics, sediment transport continuity, floodplain connectivity, bedform diversity and to provide for the recovery of natural stream functions.

Reaches PER11, INT16, INT20, INT1, and INT3 will all have reconstructed meanders that will be built off-line. Once the new reaches have been stabilized the existing stream will be plugged and diverted to the new locations. Restoration will include removal of spoil levees, excavation of floodplain benches to transition floodplain grades at the upstream ends, and installation of in-stream structures to promote bed form diversity and stability. Restoration over the downstream reaches will create new, dynamically stable stream channels that meander across their floodplains in sequences of suitably spaced riffles and pools, thereby improving bedform diversity, lateral and vertical stability, and floodplain connectivity. This approach will result in the re-establishment of several hundred feet of new channel. Restoration efforts will also involve re-establishment of riparian wetlands and backfilling the abandoned channel segments. Raised profiles in the downstream restoration reaches will restore the hydrology in adjacent wetlands by reducing entrenchment.

Reaches that flow into the reconstructed meanders (PER6, INT8, INT10, INT13, INT17, INT19) will be extended and the bed level raised as necessary to connect to the new meandering system. This will be accomplished in some areas by using part of the abandoned canal and modifying it to function as a smaller channel for tributary drainages.

Excavations from channel reconstruction will be used to fill the existing canals, create channel plugs, and reshape areas to serve as bottomland hardwood wetlands.

There are three locations where access roads cross the project and will require stream crossings. The existing crossing are all corrugated metal culverts. The proposed condition is a span bridge crossing with stone toe stabilization at the abutments to allow for lower velocities and aquatic organism passage at flood flows.

i. Design Methodology and Data Analyses

The design methodology incorporated both form-based and analytical approaches, using a combination of statistical relationships, local and regional references, and cross analyses to arrive at a set of design variables for each reach. Other primary design criteria, such as cross section dimensions, pattern and profile, are all linked to the design discharge and to each other. The following sections summarize each phase of the methodology; supporting calculations and data are included in Appendix E.

ii. Design Discharge

In order to estimate a range of design discharges for each reach, regional regression equations and estimated bankfull discharge in existing surveyed riffle cross sections were evaluated where reliable field bankfull indicators were evident. On reaches where reliable bankfull indicators were not evident, the design discharge value was based primarily on regional curve predictions. In addition to evaluating discharge at various surveyed riffle cross sections on the project reaches, we also evaluated the predicted discharge for the reference cross sections as a check of the analysis methodology.

Discharge estimates are sensitive to roughness estimates; channel and floodplain roughness values were assigned based on stream dimensions, bed materials and vegetation on the banks and floodplain. We are confident in the estimated discharges from surveyed riffles because they are based on site-specific measurements rather than predictions based on average regional conditions or empirical formulae. However, the selected design values are relatively close to the West Tennessee regional curve predictions. Design discharge values for each reach are summarized in **Table 4** below. The final column on the right was selected as the most appropriate design value for each reach.

Table 4. Design Discharges, cubic feet per second (cfs)

STREAM	Drainage Area (SqMi)	Site Gauge	WTRA Q1.01	USGS Q1.01	TDEC QbnkF	Design QbnkF
PER-11R2	6.56	300	250.1	261.4	215.2	185.6
PER-11R1	4.56		208.6	217.1	159.8	145.4
PER-16R4	2.08		141.1	145.4	84.1	85.9
PER-16R3	1.58		123.1	126.3	67.2	71.5
PER-16R2	1.47	103	118.7	121.8	63.3	68.1
PER-16R1	1.31		112.1	114.8	57.6	63.0
PER-16R1b	1.20		110.8	111.2	55.3	62.0
INT-20R4	0.294		53.3	53.5	17.0	23.1
INT-20R3	0.15		38.1	37.9	9.8	14.7
INT-20R2	0.11	12	32.6	32.4	7.6	12.0
INT-20R1	0.11		32.6	32.4	7.6	12.0
INT-25R2	0.044	6	20.7	20.3	3.6	6.5
INT-1R3	0.049		21.8	21.4	3.9	7.0
INT-3R1	0.076		27.2	26.8	5.6	9.3
PER-6R1	0.285		52.4	52.7	16.5	22.7
INT-13R2	0.032		17.7	17.2	2.8	5.2
INT-10R2	0.072		26.4	26.1	5.4	9.0
INT-8R1	0.0055		7.3	7.0	0.7	1.6
INT-17R1	0.0025		5.0	4.7	0.3	0.9
INT-19R1	0.0137		11.6	11.2	1.4	3.0

iii. Friction Slope

As a stream experiences a variety of flows, sediment loads, and vegetation patterns a bed slope will establish that is a reflection of the energy balance at the site, also known as the friction slope. The first step to establishing the friction slope is to assess the sediment slope along the stream bed and compare it to the slope of water levels and bankfull indicators.

The sediment supply of this project site is out of balance and experiencing dysfunction from degradation. The bed slope of an alluvial unconfined channel is a product of the flows and sediment supply to a reach. Decreased sediment supply causes decrease in slope creating incision which moves upstream in a growing head-cut that generates large volumes of sediment through mass wasting of channel banks in the headwaters. The lower reaches of this project are incised and historically stabilized with many rip rap check dams along the length (~42 locations). This artificial gradient with a confined channel creates the hydraulic capacity to flush excess sediments downstream and eventually into the Hatchie River system. Excess capacity downstream leads to increased erosion in the headwaters.

Reconnection of the streams with a broad gently sloping floodplain will reduce the erosive stream power and distribute sediments evenly across the floodplain to begin to establish a dynamic equilibrium. The stream beds will be raised using meander reconstruction as the method to increase channel length and provide a consistent relationship between the slope of the valley and the friction slope of the channel. The outlet of the stream on the downstream end will transition to the existing streambed elevation under the Lake Hardeman Road bridge using an open grade control structure with specific geometry to allow passage of fish and other aquatic organisms. One additional grade control structure will be installed on the upstream end of the project on INT-20 in an area of steep valley transition that cannot be compensated through meander reconstruction.

Slopes for the reaches were determined through; a regional analysis by the WTRBA, cross section measurements by consulting engineers at CEC, and a more detailed analysis of local systems using high resolution LIDAR imagery from the USGS (**Table 5**). An equation was derived that relates stream friction slope as a function of the contributing drainage area.

Design Slope (Feet/Feet) is established in relation to contributing drainage area by:
$S = 0.0034 * (DA \wedge -0.407)$

Table 5. Stream Slope Table

STREAM	DRAINAGE AREA	DESIGN SLOPE
PER-11R2	6.56	0.0016
PER-11R1	4.56	0.0019
PER-16R1b	1.20	0.0031
PER-16R4	2.08	0.0027
PER-16R3	1.58	0.0030
PER-16R2	1.47	0.0031
PER-16R1	1.31	0.0032
INT-20R4	0.29	0.0077
INT-20R3	0.15	0.0107
INT-20R2	0.11	0.0088
INT-20R1	0.11	0.0088
INT-25R1	0.04	0.0127
INT-1R3	0.05	0.0069
INT-3R1	0.08	0.0031
PER-6R1	0.29	0.0057
INT-13R2	0.03	0.0138
INT-10R2	0.07	0.0105
INT-8R1	0.01	0.0045
INT-17R1	0.00	0.0100
INT-19R1	0.01	0.0239

i. Cross Section

Design discharge, regional channel references, and friction slope analyses inform the design of cross section dimensions and shapes; cross section dimensions and shapes along with slope govern hydraulic parameters that are relevant to design.

Past experience also informs the cross-section design. For example, projects designed for a forested floodplain and C or E channel geometries may not see ideal conditions for many years as trees, roots, and bed material sorting develop over a multi-year timescale. In the interim time period, the channel needs to survive the applied stresses of the first few seasons as the entire system adjusts to a more natural state. We evaluated reference cross sections as indications of bankfull area and general shape, but the design bank slopes are also governed by geotechnical stability needs during the monitoring period in areas where little or no deep-rooted vegetation will be present for the first few growing seasons.

As noted in the previous section, the design cross sections will accommodate sediment storage within the channel on point bars and/or in lateral bars upstream of vane structures. This stored sediment is available for transport during large flow events, which promotes long-term stability and sediment transport equilibrium. Mobilized sediment in the project reaches will be replaced by sediment from upstream.

Experience from past projects in the sand dominated systems of west Tennessee show that channels adjust dimensions very quickly along with developing vegetation. Slightly oversized channels will contract laterally and deepen vertically as side roughness develops and sediment becomes captured. This is the preferred method to promote successful establishment of bank and riparian vegetation.

ii. Plan and Profile

Plan geometry design is based on multiple factors, chiefly the selected design slope and lateral constraints such as topography. At a particular plan feature such as a meander bend, geometry is based on a range of dimensionless ratios that have proven to be effective in meeting design objectives while promoting stability. For plan geometry the radius of curvature ratio is important for plan dimensions; well-vegetated reference reaches suggest an outer radius of curvature that falls between 1.8 and 6 times the base channel width is common in the region. Less than about 1.8 places undue stresses on newly constructed banks that lack deep rooted vegetation. The valley slope and bed slope values were then used to establish a target for sinuosity to maintain a consistent channel depth in relation to the floodplain. Reference cross section/reach data are summarized in **Appendix E**.

References were reviewed in the Cub Creek system and in the area where Cub Creek adjoins the Hatchie River floodplain.

iii. In-Stream Structures

In-stream structure types and locations were selected based on design stability, habitat enhancement and sediment transport objectives within each reach. When appropriate, trees removed during grading activities will be re-used as log vanes, brush toes or other in-stream structures, or they will be placed in wetland areas to provide stream habitat and a source of organic carbon. **Table 6** below provides a summary of specific objectives for the proposed structures. Data and analyses supporting the sizing of stone for in-stream structures are provided in Appendix C.

Table 6. In-Stream Structure Summary

Structure	Objectives
Geolifts and Brush Mattresses	a. Bank stability at channel plugs and/or confined spaces b. Quickly establish deep rooted bank vegetation
Wood Toe and Rootwads	a. Bank Stability along tight curve radius. b. Creates aquatic habitat along scour pool in curves
Constructed Fish Passage Step Structure	a. Transition excess grade in profile b. Provide roughness in bed for a traversable flow for fish c. Initiate riffle habitat and sediment transport equilibrium
Stone Toe or Cross Vanes	a. Direct flows to center of channel b. Provide protection against bank erosion c. Establish near-bank cover and pool habitat

iv. General Design Equations

Some reaches have some variation from the equations shown below but the starting point for each reach is generally described by the relationships shown in **Table 7** below.

Table 7. General Design Equations

Equations		
QbnkF	=52.8*(DA^0.6745)	CFS
Q10	=735*(DA^0.554)	CFS
Slope	=0.0036*(DA^-0.407)	FT/FT
W BnkF	=16.1*(DA^0.342)	FT
D BnkF	=1.935*(DA^0.3268)	FT
W Bottom	=7.78*(DA^0.3828)	FT
XS Area	=21.523*(DA^0.6907)	SF
Valley	=343*(DA^0.4448)	FT
Floodplain	=VALLEY/2	FT
Buffer	=(FP/2)-(WbnkF/2)	FT
Pool Depth	=0.75 * D bnkF	FT
Sinuosity	=LENGTH/VALLEY	
Radius Min.	=W * 2.8	FT
Radius Max.	=W * 6.0	FT
Ent. Ratio	=FP/WbnkF	

B. Wetland Restoration

The goal of wetland restoration efforts is to restore functions of the degraded system and to return the site to a functional riverine-slope wetland complex. The selection of the wetland restoration areas is based on the location of hydric soils and hydrophytic vegetation in the floodplain. The objectives of wetland restoration efforts are to improve water quality and wildlife habitat and increase flood attenuation and sediment retention. Wetland restoration efforts consist of transitioning mowed hayfield and wildlife food plots to forested wetlands by plugging lateral ditches, removing berms, and planting hydrophytic vegetation. Additionally, the newly restored stream channels will reconnect stream and wetland hydrology that has been lost for decades following channelization and levee construction.

The increased frequency of inundation and saturation of the site is anticipated to restore the important hydrologic functions of a riverine-slope wetland complex. Ditch plugs will be used to slow the movement of surface water and increase water retention from precipitation events at WTL-16. The restoration requires ditch plugs at the bottom or lowest elevation of the ditch with additional plugs spaced every two to three feet of vertical slope of land surface. This stepped or segmented approach to performing ditch plugs helps to reduce excessive hydraulic “head” differences from one plug to the next and more evenly distributes restored hydrology throughout the wetland area. Detailed design plans for wetland restoration activities are located in **Appendix E**.

C. Erosion and Sediment Control Measures

Erosion and sediment controls will be implemented during and post construction in accordance with TDEC standards to ensure sediment resulting from project construction will remain onsite. A stormwater pollution prevention plan (SWPPP) that outlines construction measures used to ensure adequate control of sediment onsite will be submitted to TDEC. Disturbed areas will be stabilized in accordance with the SWPPP.

Off-line channel construction will be completed with flow maintained in existing channels, leaving plugs of bank material between the existing and new channel segments. Only after the new channel segments are stabilized with erosion control matting, in-stream structures and temporary seed will water be turned into the new channels. Work at the tie-ins will be scheduled to coincide with low flow conditions so as to minimize mobilization of fine sediments.

The contractor will be instructed to disturb only as much ground as necessary to complete the active phase of work. Silt fences will be placed on the stream sides of temporary stockpiles where such stockpiles could be a source of sediment to streams or wetlands. Erosion control matting composed of biodegradable coir fiber will be installed along the constructed channels or herbaceous cover will be established before water is turned into the new channel. The erosion control matting will extend to the top of bank and will be secured with wood stakes and live stakes. Immediately following any ground disturbing activities, both a temporary cover seed mix and a permanent native seed mix will be sown to provide rapid ground cover and stabilize exposed soil. The newly constructed channels will be further stabilized with live stakes and buffer trees and shrubs during the dormant season following construction.

D. <u>Project Phasing</u>

All project planning, design, construction, planting, as-built survey, and monitoring will be accomplished in a single phase. The timing of construction will be during warmer, dry months. Work on channel restoration will begin in the downstream segments and progress upstream to maximize the protection of the Priority 1 meander reconstruction and prevent downcutting or recapture during flood events.

E. <u>Re-vegetation</u>

Upon completion of wetland and stream grading activities, the mitigation area will be re-vegetated with species acquired from regional native plant nurseries (**Table 8**). All plants used for re-vegetation will be native to the region and from local genotypes when possible. The plants used will be woody species in bare root seedling form for the floodplain and live stakes in the newly constructed stream channels. Selected species will be adapted to bottomland floodplain settings and have desirable forage attributes for native southeastern wildlife species. Planting zone selection on the site will mimic natural stream bank and floodplain communities and will consider the frequency and magnitude of flows experienced by the project stream.

Planted trees and shrubs will provide a diversity of forest canopy structure, forage value, filtering capacity, soil stability, and riparian habitat.

Table 8: Proposed Tree and Shrub Species Plantings in the Wetlands and Riparian Buffers

Scientific Name	Common Name	Growth Type	Wetland Status	Note
Alnus serrulata	Hazel Alder	Shrub	FACW	1
Nyssa sylvatica	Black Gum	Tree	FAC	1
Itea virginica	Virginia Sweetspire	Shrub	FACW	1
Salix nigra	Black Willow	Shrub	OBL	1, 2
Taxodium distichum	Bald Cypress	Tree	OBL	1
Nyssa aquatica	Water Tupelo	Tree	OBL	1
Carpinus caroliniana	American Hornbeam	Tree	FAC	1
Betula nigra	River Birch	Tree	FACW	1
Platanus occidentalis	Sycamore	Tree	FACW	1,2
Quercus lyrata	Overcup Oak	Tree	OBL	1
Quercus pagoda	Cherrybark Oak	Tree	FACW	1
Diospyros virginiana	Persimmon	Tree	FAC	3
Prunus abgustifolia	Chickasaw Plum	Tree/Shrub	FAC	3
Quercus marilandica	Blackjack Oak	Tree/Shrub	FAC	3
Fagus grandifolia	American Beech	Tree	FACU	3
Carya laciniosa	Hickory	Tree	FACW	3
Quercus phellos L.	Willow Oak	Tree	FACW	3
Cephalanthus occidentalis	Buttonbush	Shrub	OBL	3,2
1 - Noted in reference survey				
2 - Likely volunteer species				
3 - Native species not in reference sample.				

Due to the recent and historic agricultural activity and existing soil fertility, no fertilizers are anticipated to be needed prior to vegetative plantings. Tree and shrub planting material will consist of bare root seedlings that are approximately 16 to 24 inches tall. Crooked, diseased, or injured trees will not be used. Trees and shrubs will be planted in the floodplain on 10 to 15-foot centers (~300 stems per acre). An alternate method, planting larger containerized trees at a 25-30 foot spacing may be used in areas where adaptive management may be needed to control establishment of invasive species. In these areas herbaceous seed mix will be used to establish a native cover and select maintenance will be performed in years 1 and 2. Live stakes will be planted in the newly constructed channels on 3-foot centers on the outer meander bends. The inner bends of meanders will be seeded and mulched to allow for a lower roughness during channel establishment and to reduce erosion pressure on the outer bends. The selected species are known to thrive in riparian areas and wetland habitats in the Hatchie River watershed.

Seedlings and shrubs will be transported at temperatures between 33° and 50° Fahrenheit and be protected from direct sunlight and air currents. If seedlings must be stored, they will be kept at 34° to 40° Fahrenheit. Seedlings and shrubs will not be stacked more than two bags deep during transport. All trees and shrubs will be planted during the dormant season (between November 15 and March 15). A shovel or dibble tool will be used to create planting holes deep enough to prevent roots from curling. The soil will be firmed around the seedlings, and seedlings shall not lean more than 30°.

Graded stream and wetland areas and other disturbed areas will also be seeded and mulched with temporary ground cover and native perennial herbaceous mixes. In areas where fescue and other non-native pasture grasses are not removed during grading activities, these grasses may be treated or disked in order to promote establishment of native grasses and sedges. Buffer widths will generally be well in excess of the minimum 50 feet from the newly restored banks.

F. <u>Invasive Species Management</u>

Bermuda grass and fescue are present in the lower reaches of the mitigation area and are maintained by regular mowing activities. A combination of grading operations and disking may be necessary to break up the non-native grasses and facilitate the successful establishment of native riparian and wetland forest habitats. Should non-native plant species get established in the mitigation areas during the monitoring period, they will be mechanically removed or treated with appropriate herbicides to provide for the recovery of native riparian and wetland vegetation.

G. <u>Soil Management</u>

Earthwork will include disking where soil compaction from stream restoration activities is evident. The proposed mitigation activities do not include soil amendments.

H. <u>Construction Timeline</u>

The proposed construction sequence and timing are outlined in **Table 9** below.

Table 9. Construction Sequence and Timing

TASK	TIMING
Construction and site preparation for planting	Spring 2022
Plant trees and shrubs	February 2023
Install monitoring equipment	Winter 2021-22
Conduct baseline monitoring	March 2022
Conduct annual monitoring	June – September annually
Submit annual monitoring reports	April annually

7.0 MAINTENANCE PLAN

Once initial project construction is completed staff will monitor the mitigation area quarterly. Assessments will record any issues such as erosion, presence of invasive plant species, hydrologic or vegetation alterations, damage to fencing or signage, and the general condition of the mitigation area. These observations will be in addition to all observations completed for performance standards monitoring requirements, and shall be recorded with appropriate photo-documentation. Maintenance issues will be rectified as they are discovered during routine site monitoring. Any maintenance activities undertaken during the monitoring period would be identified in annual reporting, and would not require immediate reporting to the Corps.

If it is determined that corrective action to a perceived problem area is not warranted at the time, the rationale for such a decision shall be stated. Continued monitoring of the condition or area, including the use of more detailed methodologies and at a more intensive rate, may be most appropriate. These actions shall also be documented. In instances where corrective action is deemed necessary, a plan shall be prepared which includes proposed actions and a schedule for completing the actions, if the mitigation is still within the monitoring phase.

Major deficiencies requiring corrective actions shall require coordination with the regulatory agencies. Major deficiencies affecting large spatial areas shall trigger the requirement of adaptive management (see Section 12 – Adaptive Management Plan). Major deficiencies may include, but are not limited to, replanting more than 20 percent of the site to improve species cover or diversity, adding supplemental soil amendments, hydrology modifications, or modifying management activities such as supplemental irrigation.

8.0 PERFORMANCE STANDARDS

Performance standards are established to meet several objectives, including measuring the success of a project's specific objectives, and comparing the ecological improvement or increase in function and value of pre- and post-restoration efforts. Should any portion or aspect of the mitigation project not meet the specified success criteria based on reporting and/or additional visual observations in a monitoring year, the nature and cause(s) of the resulting condition shall be thoroughly investigated and documented. If it is determined that corrective action to a perceived problem area is not warranted at the time, the rationale for such a decision shall be stated. Continued monitoring of the condition or area, including the use of more detailed methodologies and at a more intensive rate, may be most appropriate. These actions shall also be documented. In instances where corrective action is deemed necessary, a plan shall be prepared which includes proposed actions, a schedule for completing the actions and a revised monitoring plan, if the mitigation is still within the monitoring phase.

Table 10 summarizes performance standards for the riparian wetland buffers. Performance standards for each stream reach are provided in the TN SQT v1.0 workbooks for each reach of the project (**Appendix C**). An assessment to determine the TMI score following TDEC's 2017 Quality System Standard Operating Procedure (QSSOP) will be performed prior to making modifications to the streams or wetlands (i.e. baseline existing condition TMI score). TMI scores will be inserted into the TNSQT workbook for submittal with the final mitigation plan.

Table 10. Cub Creek Wetland Success Criteria

PERFORMANCE STANDARD	CRITERIA
Vegetation	A minimum of 135 stems/acre at Year 7 shall remain growing and be comprised of both planted and desirable native species at the end of the monitoring period. No more than 30% of any one species of the native wetland plant community shall contribute towards stems per acre. It is acknowledged that desirable, native volunteer species may comprise more than 30% of the actual stem count, but stems in excess of the 30% limit cannot be contributed towards the target values for applicable performance standards. Vegetation counted towards survival rates, including both planted and volunteer, should be desirable species typically found in the target wetland plant community and native to the ecoregion. This performance standard may be altered given consideration for reference conditions. The resultant mitigation plant communities shall contain less than 5% areal coverage of species identified on the Tennessee Invasive Plant Council list (www.tnipc.org) throughout the monitoring period. No contiguous areas greater than 200 square feet shall be vegetated with more than 50% relative aerial coverage of invasive species at the end of the monitoring period. Implementation of invasive species control measures should be conducted in accordance with the Adaptive Management Plan, and may be required on a case-by-case basis as determined by the regulatory agency.
Riparian Wetland Hydrology	During years with normal precipitation, inundation or saturation to within 12 inches of the soil surface must be observed during the growing season for 14 or more consecutive days. If normal precipitation occurred, as defined in ERDC TN-WRAP-05-2, it is required that this performance standard be met. In years where precipitation is determined to be below normal, the > 14 consecutive day performance standard does not have to be met. However, at least 50% of the monitoring years must meet the performance standard. If by the end of the monitoring period, more than 50% of the monitoring years are determined to be below normal condition, additional monitoring years may be added at the discretion of the USACE. The predominant hydrodynamics of slope wetlands are vertical fluctuations and slow lateral movement down gradient. Surface water may be present following heavy rainfall events, but long-term ponding does not occur.
Riparian Wetland Soil	Soil samples should be identified as "hydric" in accordance with the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region - Version 2.0 (2012). Positive indicators of hydric soil formation will be documented within 12 inches of the soil surface. IRIS tubes may be used to supplement hydric soil characteristics and conditions (ERDC TN-WRAP-09-1). Three out of five IRIS tubes in a given nest must display 30% or more removal of significant yellowing in a zone 6 inches long to meet the criteria for anaerobic conditions. During normal rainfall during the study period, the highest elevation within the delineated wetland where three of the five IRIS tubes displayed 30% removal is considered to be the upper limit of reducing conditions.

9.0 MONITORING REQUIREMENTS

The success of the mitigation efforts will be determined by following an established monitoring plan. The plan will document the success of the wetland restoration activities by monitoring and documenting vegetation establishment, hydric soils, and wetland hydrology. These performance standards will be monitored in Years 1, 2, 3, 5, and 7. An as-built report will be provided to the District Engineer within 60 days of construction completion. The as-built plan shall include photographs taken of each at sampling plot noting orientation, a plan-view topographic map of graded areas baseline in-situ soil profile descriptions at well locations, hydrographic data indicating changes in hydroperiod, and vegetation information (species and density of species planted). The as-built plan shall also provide location data including coordinates in decimal degrees, and shapefiles if available, of all monitoring activities (permanent and random vegetation plots), and monitoring wells.

A. Wetland Monitoring

Hydrophytic vegetation establishment, hydric soils, and wetland hydrology will be monitored at six locations (see Map in **Appendix A**). The six wetland monitoring locations will be re-established wetland habitat and not located in existing wetland habitat. These performance standards will be monitored in Years 1, 2, 3, 5, and 7. An as-built report will be provided to the District Engineer within 60 days of construction completion. The as-built survey shall include photographs taken from the four cardinal directions at sampling plots containing bearing and azimuth, a plan view survey, baseline in-situ soil profile descriptions at well locations, and vegetation information (species and density of species planted). The survey shall also provide location data including coordinates in decimal degrees, and shapefiles if available, of all monitoring activities (permanent and random vegetation plots), and monitoring wells.

Monitoring reports will include the following as per the schedule outlined in **Table 11**:

1. Narrative description
2. Photo documentation
3. Vegetation survey data
4. Visual assessments
5. Hydrologic monitoring data

Table 11. Wetland Monitoring Report Schedule

Activity	Submittal
Baseline Hydrology and Vegetation Report	Prior to restoration activities
As Built Report	Within 60 days of construction completion
1st Monitoring Report	At least 180 days after tree planting (Year 1)
2nd Monitoring Report	Before October 31st of Year 2
3rd Monitoring Report	Before October 31st of Year 3
4th Monitoring Report	Before October 31st of Year 5
5th Monitoring Report	Before October 31st of Year 7

B. Stream Monitoring

An as-built report will be provided to the District Engineer within 60 days of construction completion. The as-built survey shall include photographs taken from the four cardinal directions at sampling plots containing bearing and azimuth, a plan view survey, baseline in-situ soil profile descriptions at well locations, and vegetation information (species and density of species planted). The survey shall also provide location data including coordinates in decimal degrees, and shapefiles if available, of all monitoring activities (permanent and random vegetation plots), and monitoring wells. Stream geomorphic parameters and riparian buffer vegetation will be monitored according the guidelines established by the SQT as outlined in **Table 12**.

Table 12. Cub Creek Mitigation Stream Monitoring Schedule

Stream Parameter	Report	Submittal
Baseline Hydrology and Vegetation Report	PRM Mitigation Plan	Prior to restoration activities
Baseline Stream Morphology	PRM Mitigation Plan	Prior to restoration activities
Pattern	As Built Report	Within 60 days of construction completion
Vegetation	As Built Report; 1st monitoring report; 2nd monitoring report, 3rd monitoring report; 4th monitoring report; 5th monitoring Report.	At least 180 days after tree planting (Year 1); Before October 31st of Year 2; Before October 31st of Year 3; Before October 31st of Year 5; Before October 31st of Year 7.
Profile	As Built Report; 1st monitoring report; 2nd monitoring report, 3rd monitoring report; 4th monitoring report; 5th monitoring Report.	At least 180 days after tree planting (Year 1); Before October 31st of Year 2; Before October 31st of Year 3; Before October 31st of Year 5; Before October 31st of Year 7.
Stream Morphology	As Built Report;	At least 180 days after tree

	1st monitoring report; 2nd monitoring report, 3rd monitoring report; 4th monitoring report; 5th monitoring Report.	planting (Year 1); Before October 31st of Year 2; Before October 31st of Year 3; Before October 31st of Year 5; Before October 31st of Year 7.

C. Photographic Monitoring Stations

Permanent photographic stations will be established in each stream reach and wetland restoration area at the site. Four stations will be positioned to capture images along each of the cardinal directions and the fifth will be located in the center of each wetland to provide a visual approximation of vegetation density. Photographs from these same stations will be taken in subsequent years to document the evolution and development of the area. Stream photographic stations will be established at each permanent stream transect, at in-stream structures and at other locations determined to be relevant to channel morphology.

D. Vegetation Sampling

Vegetation monitoring shall be conducted for a period of seven years, and occur during the growing season within the same month of each monitoring year. Planted vegetation shall be in the ground for at least 180 days prior to the initiation of the first year of monitoring (Year 1). Monitoring events shall be used to evaluate the site for the presence of invasive species and associated aerial covers, which shall be noted in the monitoring report. Evaluation of invasive species cover on the mitigation site shall include, at a minimum, documenting the coverage within vegetative sampling plots.

Using the Carolina Vegetation Survey – North Carolina Ecosystem Enhancement Program Protocol for Recording Vegetation (2008) as a guide, permanent vegetation monitoring plots will be randomly established along transects within the stream and wetland mitigation area following project construction. A total of twenty-one $10m^2$ monitoring plots will be established for stream restoration monitoring efforts to determine species composition, growth (height), and survivorship (number of native woody stems per acre).

The locations of each plot will be marked with a T-post and shown on the as-built report. All native stems within the plot will be tallied in the appropriate height class. Dominant herbaceous species and any invasive exotic species will be noted as an important indication of wetland habitat health. Tables and graphs will illustrate change in species composition, survivorship, growth (height) and total number of stems from year to year. Permanent photography stations will be established in each vegetation sampling plot to document significant observations such as natural recruitment of species.

E. Visual Monitoring

Visual monitoring shall be conducted throughout the site during each monitoring event by traversing the entire mitigation site to identify and document areas of low stem density or poor plant vigor, exotic invasive species, encroachments, indicators of livestock or recreational vehicle access, or other items of concern. Visual monitoring of the wetlands is intended to identify potential problems early and allow them to be tracked and addressed, if necessary. Any items requiring corrective actions shall be performed in accordance with the Adaptive Management Plan in Section 12.

Permanent photography stations will be established at each site. Four stations will be positioned to capture images along each of the cardinal directions and the fifth will be located in the center of the wetland to provide a visual approximation of vegetation density. Photographs from these same stations will be taken in subsequent years to document the evolution and development of the area.

A brief narrative with photo points of the results of the visual assessments shall be included in the annual monitoring report. Any areas of concern shall be annotated on a plan view of the site with GPS coordinates provided in decimal degrees, with photographs, and with the written narrative describing the features and issues of concern. Once a feature of concern has been identified, that same feature shall be reassessed on all subsequent visual assessments. Depending on the nature of the concern, field measurements may be warranted to track conditions as they may worsen or improve with time. Photographs shall be taken from the same location year-to-year to document the current condition of the concern. The monitoring report shall identify all recommended courses of action, which may include continued monitoring, repair or other remedial action to alleviate the concerns.

F. <u>Soil Monitoring</u>

Soil samples will be collected in years 1, 3, 5, and 7 within each restoration and establishment plot and characterized according to soil color and texture. Groundwater monitoring will also be used as a positive indicator, in which case, monitoring wells must demonstrate free water or saturation within 12 inches of the surface for 14 consecutive days during the growing season. In year 5, nested IRIS tubes will be installed at each hydrologic monitoring well location in accordance with ERDC TN-WRAP-09-1.

G. <u>Hydrology</u>

The hydrology of the restored wetlands will be documented both by observable indicators, such as water lines or saturated soils, and water level data collected. Four water level recorders will be installed (see map in **Appendix A** for location of wetland hydrology monitoring). The recorders will be programmed to record the elevation of the groundwater every 12 hours so that subtle fluctuations can be documented, such as the response of the groundwater level to recent precipitation. The locations of each monitoring well will be marked with a t-post or PVC pipe, and shown on the as-built report.

The hydrology of restored streams will include three water level recorders will be installed as stream gauges to provide a partial duration record to inform floodplain access and monitor flood wave propagation through the site.

10.0 LONG-TERM MANAGEMENT PLAN

a. Long-Term Management Needs
   The long-term management needs for this project will include Conservation Easement boundary maintenance, signage, hardwood forest protections (beaver damage management), and control of non-native invasive species.
b. Responsible Party – The University of Tennessee Lone Oaks Farm facility will have long-term maintenance responsibilities. This area is also part of the West Tennessee River Basin Authority, a resource agency, that will provide maintenance assistance in streams.

11.0 ADAPTIVE MANAGEMENT PLAN

Potential problems that may trigger a need for adaptive management during the monitoring and adaptive management period include, but are not limited to: failure to attain performance standards, fire or other natural disasters, substantial infestation by invasive, non-native plants and animals, and unanticipated anthropogenic problems such as large scale trespassing and vandalism. Once a problem is identified, the Permittee is required to coordinate with USACE to identify potential courses of action and/or corrective measures. Based on coordination with USACE, the Program will recommend a course of action and develop a plan for implementing the measures. Minor problems such as trash, vandalism, isolated instances of plant mortality, or small-scale invasive species infestations should be rectified as they are discovered during routine site monitoring and maintenance and included in annual reporting. Minor problems do not require immediate reporting to USACE. Major deficiencies require coordination with the USACE. Corrective measures for major deficiencies may include, but are not limited to, replanting more than 20 percent of the site to improve species cover or diversity, adding supplemental soil amendments, hydrologic modifications, or modifying management activities to include additional practices such as supplemental irrigation. In some cases, performance standards may be modified in accordance with 33 CFR § 332.7(c)(4).

Within 60 calendar days of the date of written notice from the USACE of a deficiency in the project, Permittee shall develop an Adaptive Management Plan (AMP) and submit it for USACE's written approval. The AMP must identify and describe proposed actions to achieve the Performance Standards, or remedy injury or adverse impact to the project site and set forth a schedule within which TMF will implement those actions. Permittee shall, at Permittees's cost, implement the necessary and appropriate adaptive management measures in accordance with the AMP approved by the USACE. Appropriate measures outlined in the AMP should be immediately implemented after receiving the USACE's written approval. If appropriate measures are not captured in the AMP, then Permittee shall prepare an analysis of the cause(s) of failure(s) and, if determined necessary by USACE propose remedial actions for approval.

Modifications to the approved mitigation plan require approval by USACE. If (A) Permittee fails to develop and submit an AMP to USACE or to implement the AMP identified by the USACE, in accordance with this section, or (B) an AMP is agreed upon and implemented, but the conditions do not satisfy the plan's objective and measurable performance standards by the dates specified in the plan, then the USACE, in coordination with the regulatory agency, may find Permittee in non-compliance and take action accordingly.

In some cases, performance standards may be modified in accordance with 33 CFR 332.7(c)(4), including:

A) *Inadequate Hydrology*:

If monitoring indicates that the wetland mitigation site, or portions of the site is not meeting hydrologic performance standards, the Permittee must prepare a hydrologic remedial action plan to identify the impairments to hydrology and propose measures to bring the site into compliance. The remedial action plan should include a water budget and hydrologic monitoring data to consider all sources of hydrologic input to the site(s) (overbank flooding, groundwater table, precipitation runoff, etc.) and estimate hydrologic output leaving the mitigation area. The plan should use hydrologic monitoring data to identify the source of the impairments and propose solutions to restore proper hydrology to the site. Depending on the cause of hydrological impairment and potential adaptive management actions necessary for compliance, the Permittee or the regulatory agencies may choose to revise the credits generated by the mitigation site rather than endorsing or implementing technically complex activities (e.g. mass grading) or non-sustainable measures (e. g. pumps).

B) *Vegetation*:

If monitoring indicates portions of the site are not on track to meet required vegetation performance standards, replanting all or part of the site may be required. If supplemental plantings exceeding 10% of the total planted area of the site (measured cumulatively) are required, then additional monitoring shall be required within these areas to demonstrate success in accordance with the vegetation performance standards. Remedial action plans should take into account reasons for failure and provide for corrective measures if applicable. For instance, if inundation is determined to be a cause for poor vegetation performance, the replanted species may be adjusted to include species more tolerant to inundation. In the event a site is not meeting the vegetation vigor standards, the remedial action plan should seek to identify the cause of the problem and remediate if possible. This may include one or more of several options such as, deep ripping portions of the site and replanting, mowing or herbicide use to release the vegetation, fertilization, or replanting with species less subject to herbivory. In certain instances, it may be determined that performing remedial actions to address the factors limiting the vigor of planted vegetation is not practicable, and that no further work will improve the conditions. In this situation, the regulatory agency, will determine what level of remedial action may be required to satisfy impacts left unmitigated.

C) *Invasive Species*:

Should a plant community exhibit either a greater than 5% aerial coverage of species identified on the Tennessee Invasive Pest Plant Council (www.tnipc.org/invasive-plants), or a contiguous area greater than 200 square feet with more than 50% relative aerial coverage of invasive species during the monitoring period, a remedial action plan should be developed immediately to eradicate their recurrence. Treatment methods may include chemical or physical eradication methods. In either case, extreme care must be exercised such that the desirable species are not adversely impacted. Efforts taken to control invasive species shall always be noted in the monitoring reports.

Should any portion or aspect of the mitigation project not meet the specified success criteria based on reporting and/or additional visual observations in a monitoring year, the nature and cause(s) of the resulting condition shall be thoroughly investigated and documented by Permittee. If it is determined that corrective action to a perceived problem area is not warranted at the time, the rationale for such a decision shall be stated. Continued monitoring of the condition or area, including the use of more detailed methodologies and at a more intensive rate, may be most appropriate. These actions shall also be documented. In instances where corrective action is deemed necessary, a plan shall be prepared which includes proposed actions, a schedule, and a revised monitoring plan. Any corrective action shall be approved by the Corps, in consultation with the regulatory agency.

12.0 FINANCIAL ASSURANCES

The Permittee is responsible, for ensuring adequate Financial Assurances for the performance and completion of project construction, adaptive management, and monitoring in accordance with this Mitigation Plan, as set forth in this Section. The Permittee shall maintain the Project Financial Assurances in the full amount of $1,197,253 until the USACE has determined that the Project has met all Performance Standards and that the Project Financial Assurances are no longer required. A copy of the insurance policy provided by American Risk Management, which covers all Project Financial Assurances will be sent to the Army Corps prior to final approval of the mitigation plan. The estimates provided are based on West Tennessee River Basin Authority construction and maintenance costs for similar regional projects.

A. Construction Financial Assurance Contingency Plan:

Prior to Project construction, the Permittee shall furnish a Construction Financial Assurance in the amount of 100% of a reasonable third-party estimate or contract to establish, restore, or enhance Waters of the U.S. and/or Waters of the State in accordance with the Mitigation Plan in the amount specified in **Table 14**. The fully funded amount will be $1,087,003. The Construction Financial Assurance shall be in the form of insurance policy provided by American

Risk Management. The Permittee shall ensure the Construction Financial Assurance remains in effect in the full amount required by this Instrument Amendment throughout the performance of construction and vegetation establishment. Upon acceptance of the as-built survey and first year monitoring report the Financial Assurance may be reduced by 70% of construction costs ($760,902) with additional reductions of 10% ($108,700) each in monitoring years 3, 5, and 7 based on acceptance of progress by the USACE. Each release will depend on written approval by the USACE.

Table 14. Estimated Construction Costs for Cub Creek Stream Mitigation Project

CONSTRUCTION TASK	ESTIMATED COST
Excavation, Grading, Disking	$746,250
Construction Engineering/Oversight	$126,753
Erosion Control/Matting/Seed/Mulch	$106,500
Tree and Shrub Planting	$97,500
As-Built Survey	$10,000
TOTAL	$1,087,003

A claim on the Construction Financial Assurance may be warranted if:

1. Either (a) after the Project Establishment Date for impacts, but no later than the first full growing season after the first available construction season, USACE determines that the Permittee has not initiated construction and planting in accordance with the Mitigation Plan, or (b) two years has elapsed since the Permittee has initiated implementation of the Mitigation Plan, and construction and planting in accordance with the Mitigation Plan is not complete.

2. In the event of a claim, it would be the responsibility of the beneficiary receiving the funds to develop a proposal for accomplishing the mitigation project goals. USACE will have the ability to review and approve the plan prior to implementation.

B. Monitoring and Adaptive Management Financial Assurance:

The Permittee shall furnish to USACE the Monitoring and Adaptive Management Financial Assurance in the form of an insurance policy provided by American Risk Management. The Monitoring and Adaptive Management Financial Assurance shall remain available in the full amount required by this Instrument Amendment until the end of the Monitoring and Adaptive Management Phase.

Table 15. Estimated Monitoring and Adaptive Management Financial Assurance

ACTIVITY	ESTIMATED COST
Travel, staff time, reporting, and minor repairs	$19,000
Monitoring and Reporting	$30,000
Invasive Species Management	$3,750
Supplemental planting	$7,500
Contingency for hydrologic modifications	$50,000
TOTAL	**$110,250**

Monitoring and Adaptive Management Financial Assurance Contingency Plan:

Should USACE determine that a claim on the Monitoring and Adaptive Management Financial Assurance become necessary, American Risk Management shall allocate funds to a designated beneficiary, who shall be entitled to draw upon the Monitoring and Adaptive Management Financial Assurance if:

1. Either (a) the Permittee fails to develop and submit Adaptive Management measures to USACE or fails to implement the Adaptive Management measures USACE determines are appropriate, or (b) proposed Adaptive Management measures are approved and implemented, but the site conditions do not satisfy the approved plan's objective and measurable Performance Standards by the dates specified in the approved plan.

2. If any portion of the Monitoring and Adaptive Management Financial Assurance is drawn upon, then Permittee shall replenish the Monitoring and Adaptive Management Financial Assurance to the amount specified in Table 15 within 90 calendar days after written notice from USACE.

3. If significant adaptive management issues are discovered by the regulatory agencies that require remedial action resulting in additional monitoring, the Monitoring and Adaptive Management Financial Assurance shall remain funded at the same dollar amount set aside prior to discovery and implementation of the remedial action plan.

13.0 Other Information

Long-Term Maintenance: The Permittee shall ensure that the land use restrictions placed on the property must, to the extent appropriate and practicable, prohibit incompatible uses that might otherwise jeopardize the objectives of the compensatory mitigation project (332.7(a)(2)). Permittee shall ensure that the land use restrictions will specifically identify activities that will be prohibited to occur within the project boundaries. Additionally, Permittee shall ensure all long-term management activities required for the project are performed in accordance with the mitigation plan. Long term stewardship of the project and property will reside with the University of Tennessee as the landowner.

Access to Property: See attached permission for access to property and conservation easement area for purposes of monitoring, inspection, and general review of mitigation site.

Contact Information

Property Owner: University of Tennessee Institute of Agriculture

Primary Contact: Dr. Ben West; bwest10@utk.edu; (731) 487-9812