Appendix G
Draft Operation and Maintenance Manual
Crabtree Swamp
Aquatic Ecosystem Restoration Project

September 2020

US Army Corps of Engineers ®

Berry County STORMWATER MANAGEMENT

1 Introduction

The purpose of this manual is ensure the quality and credibility of decisions, implementation, and operations and maintenance of this project. It will provides guidance for monitoring and maintenance of the Crabtree Swamp Aquatic Ecosystem Restoration Study.

1.1 Authorization

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure that when conducting a feasibility study for ecosystem restoration that the recommended project includes a plan for monitoring the success of the ecosystem restoration (USACE, 2009). Within a period of 10 years from completion of construction of the project, monitoring will be performed and reported. The first 5-years will be cost shared between USACE and Horry County. The remaining 5-years will be the sole responsibility of Horry County.

1.2 Location

Crabtree Swamp is a tributary of the Waccamaw River that flows through the City of Conway in Horry County. The project area is 7 miles long, 79.5 acres, and runs from Daniel Road downstream to Long Avenue.

1.3 Project Description

Crabtree Swamp has been grossly modified over time. Numerous culverts have been installed throughout the project area accelerating drainage of adjacent lands into the stream in support of agricultural operations. Woody debris has been removed and the stream has been deepened and widened in what was once accepted practices to reduce flooding for short flood frequency intervals (USACE, 1964). The scope of this project is to take a functional approach to naturalizing Crabtree Swamp from the bridge at Daniel Road downstream to the bridge at Long Avenue. Measures will be employed that are consistent with the standards of USACE using materials that are naturally found in the local environment as much as possible.

2 Construction Monitoring (ERDC TN-EMRRP-ER-19)

Construction monitoring will occur at each feature at least once during construction and once again upon completion of construction. Information gathered during construction monitoring will be used to assess whether project features were installed as planned. A brief year-end report will be prepared by Horry County and submitted to the USACE Project Manager by December 31st of the construction year(s). This construction monitoring report may be a one-time report but if construction occurs during 2-calendar years then a second report is required. Construction monitoring will be cost shared between USACE and Horry County. The report will be prepared by Horry County and will include a narrative of observations and photos taken at each installation site from each monitoring event.

3 Operation

This is an aquatic ecosystem restoration project meant to naturalize Crabtree Swamp. All measures implemented are non-mechanical and non-electrical. There are no operational needs.

4 Maintenance (ER 1110-2-401)

Maintenance of the following features should be minimal. Repairs are considered routine actions that maintain the project in a well-kept condition. Replacements are actions taken when a worn-out element is replaced. Rehabilitating a project are actions taken that bring a deteriorated project back to its original condition. Repairs, replacements, and rehabilitation must conform to project as-builts and specifications unless adaptations are deemed necessary. If repairs or

replacements are needed, determining the cause of failure should be investigated so mistakes if any are not repeated.

For the first 5 years after completion of construction of the project, USACE and Horry County agree to monitor and maintain the project cooperatively and adaptively. The two entities will monitor progress as laid out in the following section and alter the plan as needed to achieve and sustain success for the 50-year life of the project. After the first 5-year period of monitoring and maintenance, the sole responsibility of monitoring and maintaining the project for the 50-year life of the project has been accepted by Horry County.

5 Efficacy Monitoring (ERDC TN-EMRRP-ER-19)

Efficacy monitoring will be the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, and whether adaptive management may be needed to attain project benefits. The data will be used to determine efficacy of the project and to identify maintenance, repair needs, and to refine management techniques. The goals of monitoring is to determine:

- None of the features shall become an obstruction to aquatic life passage.
- Unobstructed connectivity between the main channel and associated floodplain at each berm breach. This should allow water from the main channel to enter the floodplain during 3-year or greater flood events. This enables the water velocity to diminish allowing sediment and pollutants to drop out of the water column prior to re-entering the main channel.
- Floodplain benching should be inundated during 3-year or greater flood events. This extra holding capacity for flood waters should help to slow water velocities and allow sediments and pollutants to settle from the water column before re-entering the main channel. Vegetation survival rate should remain high. No regular maintenance of the benching or adjacent easement should occur at any time except in the control of noxious weeds.
- Noxious weed infestations should be found early and treated aggressively using integrated vegetation management. Eradication of the noxious weed infestation(s) is the goal. Monitoring the noxious weed infestation site is required for 5 years after the last treatment.
- Holding and rearing habitat for aquatic organisms should improve around the log-drop features and root wads as morphological heterogeneity increases. An increase of abundance and diversity of species should be seen.

5.1 Required Monitoring

At a minimum, each of the features will be evaluated after significant rain or storm events or once, yearly, whichever is more frequent. Monitoring will occur and a year-end report will be compiled and submitted each year for 5 years after completion of construction. The first 5-years of monitoring and reporting whether it be in the implementation or efficacy phase will be cost shared between USACE and Horry County. The remaining 5-years of monitoring and reporting will be the sole responsibility of Horry County. The report will be prepared by Horry County and sent to the USACE Project Manager. It must be submitted by December 31st of each year. Each report must include monitoring dates, reasons dates were chosen, photos representing progress/challenges, and all empirical data collected. This must be accompanied by a narrative describing as quantitatively as possible whether ecological benefits are being met.

5.1.1 Berm Breaching

This part of the project is located between the US-701 bridge and the bridge at Long Avenue. The purpose of berm breaching is to reconnect the main channel with existing, high quality floodplain. In order to do so, where natural breaching was occurring, the berms were cut down to 3-year flood elevations and reinforced with articulated concrete block matting (ACBM). If installed properly and once plants establish through the matting, no regular maintenance should be required.

The areas of the berm that are breached should be inspected after every large rain/storm event or twice yearly whichever occurs more frequently. If obstructions do form at the breaches the obstructions should be removed. If additional breaching occurs they should be left to continue forming, naturally.

Loss of intimate contact of the ACBM from the subsurface is an indicator of compromise of the stability and continued performance of the system that may lead to failure. Loss of intimate contact is typically the result of the overturning of a block or group of blocks about the downstream contact point of the block. Indicators of the loss of intimated contact is the

- loss of soil beneath the system by gradual erosion beneath the system or washout through the system at joints and open cells
- deformation of the subgrade due to liquefaction and shallow slip failures caused by the ingress of water beneath the system (especially in silty soils on steep slopes)
- loss of block or a group of blocks (uncabled systems) which directly exposes the subgrade to the flow
- flow beneath the ACB causing uplift pressures and separation of the block from the subgrade

If loss of intimate contact occurs then the ACBM installation should be considered compromised or in failure and must be replaced.

5.1.2 Plantings at Floodplain Benches

Death of < 15% of plants is expected and accepted. Areas planted with vegetation will be monitored 2 times each year during the growing season from May until October. They will be evaluated by color and evidence of growth and percentages calculated. A plant is considered green if it is 100% green. A plant is considered brown if less than 20% of the plant is green. A plant is considered mixed if 50% of the plant is brown. If a plant is entirely brown it is considered dead. New growth should be noted with a "/" after determining its color (Thepaut, Libes, Young, Fuss, and Jayakaran, 2012). Percent canopy cover and shading of stream channel should be estimated. If survival drops below 60% within the first 2 years, the area should be evaluated to determine if soil enhancements or modification of plant species is warranted.

If trees are experiencing damage by wildlife that endanger their survivability then protective barriers must be employed. These barriers must be removed once the tree is established and before the trunk diameter nears the barrier.

No scheduled mowing or use of herbicide for routine vegetation control will occur in the floodplain bench areas to the edge of the easement. Early detection of noxious weed infestations should be addressed immediately and consistently to locally eradicate in order to reduce impacts on the project.

5.1.3 Log-drop Structures

Log-drop structures will be monitored for efficacy. Each structure should be monitored once every six months and after large storm events, to ensure the structure is stable and

functioning. The intent of these features is to provide habitat for aquatic organisms by providing habitat for prey, by providing calm waters for respite, by improving water quality, and by improving morphological heterogeneity within the channel. Vegetation will be planted along the banks where these features are installed so monitoring the vegetation at these sites will occur as well. These features are the most likely to fail or cause unintended consequences so until well established monitoring will occur there as often as practical. If negative consequences should occur as a result of these features then management measures will be adapted to eliminate the negative impacts. If structure failure is observed, structure should be repaired or replaced as necessary. If piping of structure or bank erosion is noted, structure should be evaluated to determine the cause (installation errors related to elevation or tie in, etc.). If necessary, structure should be re-installed and anchored properly. Any bed or bank erosion should be repaired and the area stabilized as soon as possible.

5.1.4 Entirety of Project Area

The whole of Crabtree Swamp will be monitored for unintended consequences of features constructed. If negative consequences should occur then alterations to the project must be made to counter the negative impacts.

If log-drop/step pool features form, naturally, they are not to be removed from within the channel. These features are only to be removed it they impede flow through bridge culverts.

No scheduled mowing or use of herbicide for routine vegetation control will occur along one bank of the main channel the width of the easement throughout the project area. Early detection of noxious weed infestations should be addressed immediately and aggressively to locally eradicate. Monitoring the site of the infestation will occur for 5 years after the last treatment.

Percent canopy cover and shading of stream channel should be estimated. Predominate vegetation type should be identified if possible and all noxious weeds must be controlled using integrated vegetation management methods.

After the initial 5-year monitoring period through the 50-year life of the project, if it is determined and agreed upon by USACE and Horry County that a structure in disrepair or failure has achieved it maximum benefit by evidence of planform and bedform channel development then replacement of in-channel structures will not be required. The reach of Crabtree Swamp used as the reference stream in this report will serve as an example of very early succession planform and bedroom channel development that is considered beneficial.

5.2 Recommended Monitoring

USACE encourages partnering with interested organizations in support of scientific data collection. This is an excellent opportunity to achieve the shared goal by Horry County and the Crabtree Swamp Watershed Restoration Initiative of outreach and education around issues with Crabtree Swamp. There is an opportunity to engage with environmental educators or citizen scientist groups to monitor water quality throughout the project area in support of *Toxolasma pullus*. If monitoring is performed consistently and seasonally then this baseline data can be used in environmental decisions moving forward (USFWS, 2008). South Carolina Department of Heath and Environmental Control have set acceptable levels for water quality criteria for the protection of fresh waters* (SCDEHC, 2014). Key parameters for monitoring should include but not limited to:

- Dissolved oxygen (*5 mg/L with a low of 4 mg/L)

- Water temperature
- Specific conductivity
- pH (*6.0-8.5)
- Ammonia
- Turbidity (*not to exceed 50 NTU)
- Salinity
- Surface velocity at thalweg
- Water depth at thalweg
- Substrate composition (% est.)
- Aquatic species density and diversity
- Public usage of trails and easements

An investigation by Burge and Libes sampled Crabtree Swamp for water quality parameter in reach 3, monthly, between June 2016 and November 2018 (unpublished data). They found that dissolved oxygen ranged between 0.1 mg/L and 5.4 mg/L. Specific conductivity ranged between 94.8 µS/cm and 623 µS/cm. Turbidity ranged between 7.5 NTU and 102 NTU.

5.3 Project Evaluation

Performance target is to visibly naturalize and improve aquatic life habitat in Crabtree Swamp. The year-end reports should include a brief narrative describing the state of Crabtree Swamp and include all data and photos from the site visits over the course of the year. The description should be as quantitative as possible in determining whether the project is successfully establishing and achieving the intended ecological outcomes. Responses may be "yes", "partially", "no", and "unable to determine" and are recognitions that achieving 100% restoration of the stream is unlikely but that some level of naturalization is achievable. "Yes" is the response if a structure or if the project as a whole is mostly or >80% successful. No is mostly or <20% successful. Partially is somewhere between yes and no.

6 Reference

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