Maumelle River, Pulaski County, Arkansas
Section 206 Aquatic Ecosystem Restoration Feasibility Study

Appendix C-4 – Monitoring and Adaptive Management Plan

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1 Introduction

This Monitoring and Adaptive Management Plan (MAMP) outlines feasibility level monitoring and adaptive management strategy for Maumelle River Aquatic Ecosystem Restoration (ER) Feasibility Study. This plan identifies and describes monitoring and adaptive management activities proposed for the project and estimates costs and duration. As more design detail is provided during the Preconstruction, Engineering, and Design (PED) phase of the project, a more detailed MAMP will be developed. Any changes to the approved MAMP will be coordinated with U.S. Army Corps of Engineers Headquarters as required by policy guidance (Section 1161, Water Resources Development Act [WRDA] 2016).

The Maumelle River MAMP will describe and justify whether adaptive management is needed in relation to alternatives identified in the Feasibility Study. The plan will outline when the monitored environmental conditions (triggers) would require adaptive management measures to ensure the successful establishment of project restoration features.

The primary intent of the MAMP is to develop monitoring and adaptive management actions appropriate for the project's restoration goals and objectives. Management actions described in this document permit estimation of the adaptive management program costs and duration for the Maumelle River Aquatic Ecosystem Restoration Project. This plan is based on currently available data and information developed during plan formulation as part of the Feasibility Study.

1.1 Authority and Purpose

Ecosystem restoration feasibility studies are required to include a plan for monitoring the success of the restoration (Section 1161, WRDA 2016). "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits."

Section 1161 of WRDA 2016, as amended, directs the Secretary to ensure that, when conducting a feasibility study for a project (or component of a project for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration. The MAMP plan shall include a description of:

- Types and number of restoration activities to be implemented with the Recommended Plan.
- Physical actions to be undertaken to achieve project objectives.
- Desired outcome resulting from the Recommended Plan.
- Monitoring design and rationale.
- Decision criteria for ecosystem restoration success, including adaptive management triggers.
- Estimated cost and duration of the monitoring; and
- Adaptive management measures for taking corrective actions in cases in which the monitoring demonstrates that restoration measures are not achieving ecological success in accordance with criteria described in the monitoring plan.

In accordance with the Water Resources Development Act of 2016 Section 1161 (CECW-P Memorandum dated October 19, 2017), MAMP are required for both National Ecosystem Restoration (NER) project components and for any Mitigation Plan required for the National Economic Development (NED) component.

This MAMP includes all elements required by the WRDA 2016 implementation guidance for Section 1161.

1.2 Project Goals and Objectives

During the initial stages of project development, the Project Delivery Team (PDT) developed restoration goals and objectives to be achieved by the restoration measures. The goal of the Maumelle River project is to restore aquatic and riparian ecosystem function and structure in the Maumelle River study area similar to what historically existed there. The resulting objectives focus on restoring stream connectivity, restoring the structure and function of riparian wetlands, and restore floodplain connectivity in the study area to environmentally optimal conditions. . Additional information regarding the Tentatively Selected Plan (TSP) for the Maumelle River Aquatic Ecosystem Restoration Feasibility Study can be found in the Integrated Feasibility Report and Environmental Assessment (IFR/EA).

The PDT performed thorough plan formulation to identify potential management measures and restoration actions that address the project objective. The PDT subsequently identified a TSP. The TSP included the following nonstructural ecosystem restoration measures:

- Restoring a native floodplain bottomland hardwood forest that connects riparian forest communities to higher bottomlands and upland forested habitats, thereby reducing forest fragmentation and increasing habitat diversity, availability, and connectivity important for numerous native forest-dependent wildlife species.
- Restoring stream connectivity in the Maumelle River by removing two river crossings.
- Notching an earthen levee adjacent to RC1 to reconnect the Maumelle River to a historically meandering side channel, thus restoring floodplain connectivity and restoring important spawning and nursery habitat for many aquatic organisms.
- Restoring a natural tributary stream and riparian corridor to the Maumelle River that was channelized for agricultural purposes. This restoration will decrease excess sediment and nutrient into the Maumelle River and subsequently Lake Maumelle.

A list of potential native species for the restoration of forested wetland and riparian habitat is included in Attachment A to this plan.

1.3 Introduction to Monitoring and Adaptive Management

Monitoring and adaptive management provide directed iterative approaches to achieve restoration project goals and objectives by focusing on strategies promoting flexible decision making that can be adjusted in the face of uncertainties as outcomes from restoration management actions and other events become better understood. Initiating a formal MAMP early in the study process enables the study team to prepare for uncertainties and other potential issues that can positively or negatively influence project outcomes during every stage of the planning and project implementation process. Hence, early implementation of monitoring and adaptive management will result in a project that can better succeed under a wide range of uncertain conditions and can be adjusted as necessary. Furthermore, careful monitoring of project outcomes both advances scientific understanding and helps adjust policies and/or operations as part of an iterative learning process.

Adaptive management acknowledges the uncertainty about how ecological systems function and how they may respond to management actions. Nevertheless, adaptive management is not a random trial-and-error process; it is not ad-hoc or simply reactionary. An essential element of adaptive management is the development and execution of a monitoring and assessment program to analyze and understand responses of the system to implementation as restoration progresses. The MAMP was developed and will be used to:

- Allow scientists and managers to collaboratively design plans for managing complex, dynamic, and incompletely understood ecological systems.
- Reduce the ecological and financial impact of inevitable uncertainty over time.
- Implement systematic monitoring of outcomes and impacts.
- Incorporate an iterative approach to decision-making.
- Provide a basis for identifying options for improvements in the design, construction and operation of restoration through adaptive management.
- Ensure interagency collaboration and productive stakeholder participation as they are key elements to success.

1.3.1 Monitoring and Adaptive Management Process

The monitoring and adaptive management program and process is complimentary to the USACE Project Life Cycle (planning, design, construction, and operation and maintenance). The process is not elaborate or duplicative and enhances activities that already take place. The basic process was adapted from a technical note published by the Engineering Research and Development Center (ERDC 2019). Elements of the program include an iterative process involving: planning a program or project; designing the project; building the project; operating and maintaining the project; monitoring and assessing project performance; and continuing, adjusting, or terminating a project if the goals and objectives are not being achieved (Figure 1).

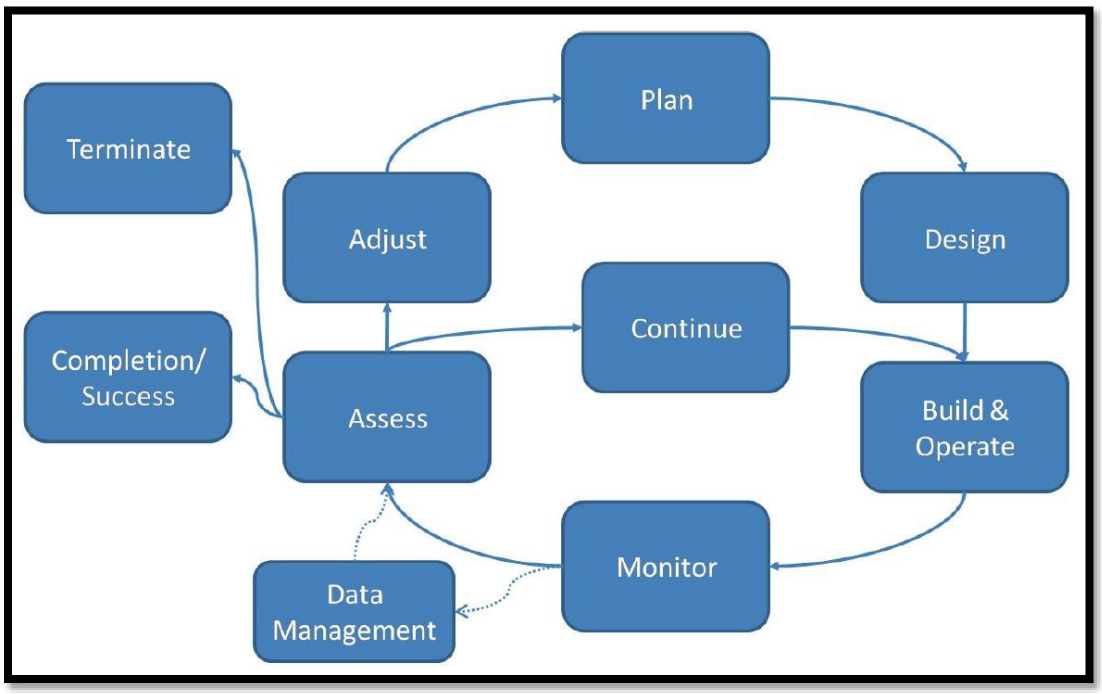

Figure 1. Monitoring and Adaptive Management Process for USACE Civil Works

1.3.2 Adaptive Management Team

As part of the MAMP, an interagency team is set up to implement the process. The MAMP provides the framework and guidance for the Monitoring and Adaptive Management Team (MAMT) to review and assess monitoring results and consider and recommend adaptive management actions when ecological success falls behind expectations and decision criteria are

triggered. The MAMT members shall work together to make recommendations relevant to implementing the MAMP. The MAMT is composed of USACE staff, the non-Federal sponsor (NFS), contracted personnel (if needed) and interested resource agencies and/or other stakeholders. Although the USACE has coordinated with the entities that will most likely comprise the MAMT in development of the IFR/EA, the MAMT will be officially established during Pre-Construction Engineering and Design.

The MAMT will focus on ecological function through related management actions to maintain and provide functional aquatic, wetland and riparian habitat within the project area. The MAMT shall review the monitoring results and advise on recommend actions that are consistent with the project goals and reflect the current and future needs of the habitat and the species they support within the project area. The USACE shall have final determination on all adaptive management actions recommended.

The USACE is responsible for ensuring that monitoring data and assessments are properly used in the adaptive management decision-making process. If the USACE determines that adaptive management actions are needed, it will coordinate with the MAMT on implementation of those actions. The USACE is also responsible for project documentation, reporting, and external communication.

The MAMT shall meet at a minimum of once per year, as scheduled by the USACE during the monitoring period, to review the results of monitoring and assess whether project objectives are being met. If objectives are not being met, the MAMT may recommend that adaptive management actions be taken in response to monitoring results as compared to decision-making triggers.

The MAMT may also consider other related projects in the hydrologic basin in determining appropriate adaptive management actions and may consult with other recognized experts or stakeholders as appropriate, to achieve project goals.

Recommendations for adaptive management should be based on:

- Monitoring data from previous years,
- Consideration of current habitat conditions,
- Consideration of current and potential threats to habitat establishment success,
- Past and predicted response by target species and habitats,
- Economic dynamics,
- Shifting municipal and government priorities,
- Human population behavior, and
- Unknown unknowns.

1.3.2.1 Team Structure

The MAMT shall include representatives from USACE and the NFS responsible for cost-sharing construction and future operations and maintenance.

The USACE may be represented by the Project Biologist(s), the Project Hydrology and Hydraulics (H&H) representative, and the Project Geotechnical representative, as needed. Other USACE attendees may include the Project Manager, Project Real Estate Specialists, and/or Operations and Maintenance designees, as needed.

For the feasibility study, the NFS is Central Arkansas Water (CAW). The NFS would ultimately be responsible for all Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) activities once USACE notifies the NFS of project completion. Prior to final project completion, USACE would transfer responsibility of functional elements of the project to the NFS as they are completed. The NFS may be represented by its designees which may include Project Managers, Planners, Design Engineers, Environmental Specialists, or other designees.

The MAMT should also include representatives from resource agencies who would serve in an advisory capacity, to assist in evaluation of monitoring data and assessment of adaptive management needs. The agencies may include, but are not limited to, and upon their acceptance:

- U.S. Fish and Wildlife Service (USFWS)
- The Arkansas Department of Environmental Quality (ADEQ)
- Arkansas Game and Fish Commission (AGFC)
- Arkansas Natural Resources Commission (ANRC)
- Arkansas Natural Heritage Commission (ANHC)
- Arkansas Highway Commission (AHC)

1.4 Sources of Uncertainty and Associated Risks

A fundamental tenet underlying the adaptive management process is achieving desired project outcomes in the face of uncertainties. Scientific uncertainties and technological challenges are inherent with any large-scale restoration project with the principal source of uncertainty typically including:

- Incomplete description and understanding of relevant ecosystem structure and function,
- Imprecise relationships between project management actions and corresponding outcomes,
- Engineering challenges in implementing project alternatives, and
- Ambiguous management and decision-making processes.

It is important to determine the type of risk each uncertainty comprises and to discern what constitutes sufficient knowledge to proceed considering those risks. There is significant institutional knowledge regarding the construction of the restoration measures; therefore, there is minimal uncertainty from a construction standpoint. Uncertainties relating to measure design and performance are mainly centered on site specific, design-level details (e.g. exact water quantities, invasive species removal needs, construction staging area locations, timing and duration of construction, engineering challenges, etc.), which would be addressed during PED. Identified uncertainties with the Maumelle River TSP are included below (note - in addition to “identified uncertainties” or rare events, true uncertainty cannot be identified, or it would not be uncertainty. The central idea is to plan and prepare for rare and unpredictable events as best as possible in order to minimize ecological and financial impacts during project delivery):

- Natural variability in ecological and physical processes,
- Soil dynamics,
- Riverine and riparian restoration requirements such as water and nutrient requirements including magnitude and duration of inundation, and type and quantity of nutrients to achieve desired productivity,
- Native seed and/or plant source (species selection),

- Invasive and nuisance species, and
- Project feature implementation timing, including schedule and timeline, and availability of construction funds.

2 Monitoring

An effective monitoring program will be required to determine if the project outcomes are consistent with original project goals and objectives. The power of a monitoring program developed to support adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management. A carefully designed monitoring program is the central component of the project adaptive management program as it supplies the information to assess whether the project is functioning as planned.

Monitoring must be closely integrated with the adaptive management components because it is the key to the evaluation of adaptive management needs. Objectives must be considered to determine appropriate indicators to monitor. In order to be effective, monitoring must be able to distinguish between ecosystem responses that result from project implementation (i.e. management actions) and natural ecosystem variability.

2.1 Monitoring Plan

According to the USACE implementation guidance memo for WRDA Section 1161, “Monitoring includes the systematic collection and analysis of data that provides information necessary to determine if the project is meeting its performance standards, and to determine when ecological success has been achieved or whether adaptive management measures are necessary to ensure that the project will attain project benefits. Development of a monitoring plan will be initiated during the plan formulation process for an ecosystem restoration project, or component of a project, and should focus on key indicators of project performance.”

The following discussion outlines a monitoring plan that will support the Maumelle River Aquatic Ecosystem Restoration Adaptive Management Program. The plan identifies performance measures along with desired outcomes and monitoring design in relation to specific objectives. A performance measure includes specific feature(s) to be monitored to determine project performance. Additional monitoring is identified as supporting information needs that will help further understand interrelationships of restoration features and external environmental variability and to corroborate project effects.

Such criteria, or decision-making triggers, are related to each performance measure and desired outcome and identify the need to discuss potential implementation of adaptive management actions with the MAMT. These criteria/triggers are identified in Section 3.3.

The first stage in developing a monitoring plan is the site evaluation, which include data collection and evaluation of the site to better understand the existing conditions and develop a specific goal and objective for the site. Based on this information, a target forest type (TFT) is identified to help guide restoration efforts. The reforestation sites in the Maumelle River study area are currently in commercial sod production, thus no woody vegetation exists. To identify the TFT, we will select a reference site that closely resembles the desired future condition of the restoration site. This reference site establishes a target for determining the successful attainment of suitable soils, hydrology, and vegetative cover on the restoration site.

Overall, monitoring results will be used to evaluate the progress of habitat restoration toward meeting project objectives and to inform the need for adaptive management actions to ensure successful restoration is achieved.

2.2 Monitoring Period

Pre-construction/baseline data, during construction, and post-construction monitoring will be utilized to determine restoration success. Baseline monitoring will begin during PED, prior to project construction and continue during construction when possible. Monitoring will continue until the trajectory of ecological change and/or other measures of project success are determined as defined by project-specific objectives. Section 1161 of WRDA 2016 allows ecological success monitoring to be cost-shared for up to ten years post-construction. Once ecological success has been achieved, which may occur in less than ten years post-construction, no further monitoring would be performed. If ecological success cannot be determined within the ten-year post construction period of monitoring, any additional required monitoring would be the responsibility of the NFS.

2.3 Monitoring Elements

Defining and assessing progress towards project objectives are crucial components of the MAMP. The following section outlines the proposed performance measure metrics, desired outcomes and monitoring design needed to measure restoration progress, determine ecological success and support the adaptive management program should changes need to be made to improve project performance. The elements described in this section are based on the available project information and will be updated and refined during PED.

Performance Measure 1: *Restore side channel.*

> *Success Criteria* Success will be measured by side channel 1 remaining open for headwater flows as the Maumelle River rises during high water events, and erosion protection material placed at the levee breach location is performing as planned.
>
> *Monitoring Design and Rationale:* Monitor channel conditions in Side Channel 1 annually (3 years) for excessive erosion at culvert removal locations that could block headwater flows (or until native vegetation is established), thus recreating disconnected river reaches. Monitor erosion protection material/vegetation at levee opening to ensure it is functioning as planned (3 years).

Performance Measure 2: Remove river crossings.

> *Success Criteria* Success will be measured by minimal erosion at the locations of the former crossings.
>
> *Monitoring Design and Rationale:* Monitor river bank conditions where river crossings are removed for any excessive erosion caused by the removal. Monitor annually (3 years) or until stream banks become revegetated with native vegetation to reduce erosion potential.

Performance Measure 3: *Restore Tributary A.*

> *Success Criteria:* Success will be measured by minimal erosion along restored stream channel.

Monitoring Design and Rationale: Monitor restored streambank conditions to ensure erosion control measures are effective at preventing excessive erosion (erosion causing blockages in restored channel or diverting restored channel). Monitor annually for 3 years, or until native vegetation becomes established on stream banks.

Performance Measure 4: *Bottomland and riparian hardwood forest restoration.*

Success Criteria

- Post-Planting of hardwood seedlings – Year 1:
  - Visual evidence of planted species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat.
- Post-Planting of hardwood seedlings – Year 2:
  - Visual evidence of planted species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat.
- Post-Planting of hardwood seedlings – Year 3:
  - Visual evidence of planted species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat.
  - Seedlings show positive growth in trunk diameter and overall height.
  - Minimum of 150 trees/acre. Number can include volunteer species, but need to ensure diversity of species is still present.
- Post-Planting of hardwood trees – Year 5
  - Stocking rate of 150+ trees/acre. Number can include volunteer species, but need to ensure diversity of species is still present.
  - 50+ hard-mast producing trees/acre.
  - Less than 25% canopy cover of invasive species with no area >0.25 acres in size with >25% invasive species.
  - If above criteria are met, planting considered successful. Discontinue monitoring.
  - If above criteria are not met, consider supplemental planting to achieve stocking rates.
- Post-Planting of hardwood trees - Year 7
  - Stocking rate of 150+ trees/acre. Number can include volunteer species, but need to ensure diversity of species is still present.
  - 50+ hard-mast producing trees/acre.
  - Less than 25% canopy cover of invasive species with no area >0.25 acres in size with >25% invasive species.
  - If above criteria are met, planting considered successful. Discontinue monitoring.
  - If above criteria is not met, plant additional native bottomland hardwood species to achieve successful stocking rate of 150 trees/acre and 50+ hard-mast producing trees/acre.
- Post-Planting of hardwood trees – Year 10
  - Stocking rate of 150+ trees/acre.
  - 50+ hard-mast producing trees/acre.
  - Less than 25% canopy cover of invasive species with no area >0.25 acres in size with >25% invasive species.

Monitoring Design and Rationale: Current site condition is zoyzia sod production, thus pre-construction sampling isn't required. Initial control/removal of unwanted plants (zoyzia) will be evaluated, and determinations made during PED, however hardwood reforestation on similar sites in the study area have shown that the planting trees will out-compete existing grass and eventually shade it out.

Vegetation sampling will occur at Post-Planting Years 1, 2, 3, 5, and years 7 and 10 (if necessary) within all restoration units the duration of the monitoring period. Sampling will occur during spring months, at the peak of the growing season. A minimum of 10 1/10th-acre monitoring plots will be located randomly during each monitoring period. Additional plots may be sampled, if necessary, to determine whether success criteria is met on all 140 acres. The distance between plots will be dependent on the project site area and variability. Monitoring will measure percent cover of native and non-native plant species and structural diversity. If all success criteria are met at Year 5 Post-Planting, the planting can be considered successful.

General observations, such as fitness and health of plantings, survival, growth, soil moisture, precipitation, phenology, native plant species recruitment, and signs of drought stress will be noted during the surveys. Additionally, potential soil erosion, flood damage, vandalism and intrusion, trampling, and pest problems would be qualitatively identified. A general inventory of all wildlife species observed using the project area will be documented. Nesting sites, roosting sites, animal burrows, and other signs of wildlife use of the newly created habitat and habitat structures will be recorded. These notes are important for early identification of species colonization patterns.

Permanent photograph stations will be established for documenting vegetation conditions during the monitoring period. Permanent photograph stations will be staked and documented via Global Positioning System (GPS) coordinates to reoccupy in each year of sampling. The number of permanent photo plots will be determined during PED.

2.4 Use of Monitoring Results and Analysis

Results of monitoring will be assessed in comparison to project objectives and decision-making triggers to evaluate whether the project is functioning as planned and whether adaptive management actions are needed to achieve project objectives. The results of the monitoring will be provided to the MAMT who will evaluate and compare data to project objectives and decision-making triggers. The MAMT will use the monitoring results to assess habitat responses to management, evaluate overall project performance, and make recommendations for adaptive management actions as appropriate. If monitoring results, as compared to desired outcomes and decision-making triggers show that project objectives are not being met, the MAMT will evaluate causes of failure and recommend adaptive management actions to remedy the underlying problems.

As data is gathered through monitoring, more information will also be available to address uncertainties and fill information gap. Effective operational regimes, restoration design needs, benefits generated by restored features, and accuracy of models can be evaluated to inform adaptive management actions and future restoration needs.

3 Adaptive Management

Scientific, technological, socio-economic, engineering, and institutional uncertainties are challenges inherent with any large-scale ecosystem restoration project. A structured monitoring plan will be implemented to provide the feedback necessary to inform decisions about future project adjustments.

Adaptive management is distinguished from more traditional monitoring in part through implementation of an organized, coherent, and documented decision process. For the Maumelle River ER adaptive management program, the decision process includes:

- Anticipation of the kinds of management decisions that are possible within the original project design,
- Specification of values of performance measures that will be used as decision-criteria,
- Establishment of a consensus approach to decision making, and
- A mechanism to document, report, and archive decisions made during the timeframe of the adaptive management program.

3.1 Rationale for Adaptive Management

The primary incentive for implementing an adaptive management program is to increase the likelihood of achieving desired project outcomes given project uncertainties. All ecosystem restoration projects face uncertainty due to the complexity of dynamic abiotic and biotic processes resulting in imprecise relationships between project actions and corresponding outcomes. Given these uncertainties, adaptive management provides an organized and coherent process that suggests management actions in relation to measured project performance compared to desired project outcomes. Adaptive management establishes the critical feedback among project monitoring, and informed project management, and learning through reduced uncertainty.

Many factors such as ecosystem dynamics, engineering applications, institutional requirements, and many other key uncertainties can change and/or evolve over a project's life. The MAMP will be regularly updated to reflect monitoring-acquired and other new information as well as resolution and progress on resolving existing key uncertainties or identification of any new uncertainties that may emerge. Specifically, the MAMP will be developed during the feasibility level of design phase and refined further in PED phase as more detailed project designs are developed. The MAMP would then be used during and after project construction to adjust the project, as necessary to better achieve goals, objectives, and restoration/management outputs/results.

3.2 Assessment

The assessment phase of the adaptive management framework describes the process by which the results of the monitoring efforts will be compared to the project performance measures, which reflect the objectives of the restoration actions.

The results of the monitoring program will be assessed annually by the MAMT. Monitoring results will be assessed to ensure the ecosystem response is on track to meet the restoration performance measures and goals. This assessment process will measure the progress of the project and determine if adaptive management actions are needed. Assessments will also inform the MAMT if other factors are influencing the response that may warrant further research.

USACE will document and report the monitoring results, assessments, and the results of the MAMT deliberations to the managers and decision-makers designated for the Maumelle River project. USACE, with assistance from the MAMT, will also produce annual reports that show progress towards meeting project objectives as characterized by the performance measures. Results of the assessments will be used to evaluate adaptive management needs and inform decision-making.

3.2.1 Database Management

Database management is an important component of the monitoring plan and the overall adaptive management program. Data collected as part of the monitoring and adaptive management plans will be archived as prescribed in the refined monitoring and adaptive management plan developed during PED. The database manager will be responsible for storing final monitoring reports and other study documentation (decisions, agendas, reports) and making them available when requested. Monitoring reports will be searchable by topic and principle author.

Data standards, quality assurance and quality control procedures and metadata standards will also be prescribed in the refined monitoring and adaptive management plan. The database will be designed to store and archive the monitoring and adaptive management data. The format of each data set will vary as appropriate to the type of monitoring. Therefore, data are expected to be archived separately, rather than collated in one master database. Each dataset will include data and metadata transfer and input policies and standards; data validation procedures; and mechanisms to ensure data security and integrity.

3.3 Decision-Making

Decisions on the implementation of adaptive management actions are informed by the assessment of monitoring results. The information generated by the monitoring plan will be used by USACE and the NFS in consultation with other MAMT members to guide decisions on adaptive management that may be needed to ensure that the ecosystem restoration project achieves success. Final decisions on implementation of adaptive management actions are made by USACE.

If monitoring determines that a management trigger has been “activated” the MAMT may determine that more data is required and continue or modify monitoring methods; or identify and implement a remedial action.

3.3.1 Decision Criteria

Decision criteria, also referred to as adaptive management triggers, are used to determine if and when adaptive management should be implemented. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. Desired outcomes can be based on reference sites, predicted values, or comparison to historic conditions. Several potential decision criteria are identified below, based on the project objectives and performance measures. More specific decision criteria, possibly based on other parameters such as hydrology, geomorphology, and vegetation dynamics, may be developed during PED.

If assessments show that any of these triggers are met, USACE would consult with the MAMT to discuss whether an adaptive management action is warranted, and if so, what that action will entail. Investigations may be required to determine the cause of need for action in order to inform

the type of adaptive management response that should be implemented, if needed. Additionally, prior to enacting any adaptive management measures, USACE would assess whether supplemental environmental analyses are required. Efforts will be made to make lessons learned available to the USACE community for incorporation into future projects.

Performance Measure 1: Restore side channel 1.

Success Criteria Success will be measured by minimal erosion at culvert removal locations and erosion protection material placed at the levee breach location is performing as planned.

Monitoring Design and Rationale: Monitor channel conditions in Side Channel 1 annually for excessive erosion at culvert removal locations that could block headwater flows, thus recreating disconnected river reaches. Monitor erosion protection material/vegetation at levee opening to ensure it is functioning as planned.

Trigger: Blockage exceeding 50% of channel width.

Possible Causes for Not Meeting Success Criteria: High volume water flow through Side Channel 1 in the first year could cause bank erosion at the sites where culverts are removed, or at the levee breach location.

Potential Adaptive Management Measures: Adaptive management measures would include evaluation of the site to determine the likelihood of continued blockage or stream attempting to reroute around blockage. Possible remediation would include 1) bank failure/erosion will be evaluated on a case-by-case basis by MAWT to determine whether intervention is needed. Bank failures causing <50% channel blockage will be monitored after subsequent high water to determine the need to clear the channel. Blockages >50% of channel width will be cleared with mechanical equipment (e.g. backhoe, track hoe, etc.).

Performance Measure 2: Removal of river crossings.

Success Criteria Success will be measured by minimal erosion at the locations of the former crossings.

Monitoring Design and Rationale: Monitor river bank conditions where river crossings are removed for any excessive erosion caused by the removal. Monitor annually for five years, or until stream banks become revegetated with native vegetation to reduce erosion potential.

Trigger: Excessive erosion causing sediment to enter the Maumelle River.

Possible Causes for Not Meeting Success Criteria: High volume water flow through the levee breach in the first year could cause bank erosion.

Potential Adaptive Management Measures: Adaptive management measures would include evaluation of the site to determine whether the erosion control material/vegetation is functioning as planned. Possible remediation would include 1) reduce the slope of the levee on each side of the breach to reduce erosion potential; 2) planting native grass and shrub species in areas of active erosion; 2) placement of erosion control material (e.g. mats, rock) in areas of active erosion.

Performance Measure 3: Restore Tributary A.

Success Criteria: Success will be measured by minimal erosion along restored stream channel.

Monitoring Design and Rationale: Monitor restored streambank conditions to ensure erosion control measures are effective at preventing excessive erosion (erosion causing blockages in restored channel or diverting restored channel). Monitor annually for five years, or until native vegetation becomes established on stream banks.

Trigger: Blockage exceeding 50% of channel width, or stream attempting to reroute around partial blockage.

Possible Causes for Not Meeting Success Criteria: High volume water flow through restored stream channel before native vegetation is established could cause bank erosion.

Potential Adaptive Management Measures: Adaptive management measures would include evaluation of the site to determine the likelihood of continued blockage or stream attempting to reroute around blockage. Possible remediation would include 1) bank failure/erosion will be evaluated on a case-by-case basis by MAWT to determine whether intervention is needed. Bank failures causing <50% channel blockage will be monitored after subsequent high water to determine the need to clear the channel. Blockages >50% of channel width will be cleared with mechanical equipment (e.g. backhoe, track hoe, etc.).

Performance Measure 4: *Bottomland and riparian hardwood forest restoration.*

Success Criteria Stocking rate of minimum 150 trees/acre (can include volunteer species, but species diversity similar to planting rate) and a minimum of 50 hard-mast producing trees per acre, 5 years post-planting.

Monitoring Design and Rationale: Current site condition is zoyzia sod production, thus pre-construction sampling isn't required. Initial control/removal of unwanted plants (zoyzia) will be evaluated, and determinations made during PED, however hardwood reforestation on similar sites in the study area have shown that the planting trees will out-compete existing grass and eventually shade it out. Additionally, the presence of zoyzia will aid in preventing the establishment of invasive species.

Vegetation sampling will occur at Post-Planting Years 1, 2, 3, 5, and years 7 and 10 (if necessary) within all restoration units the duration of the monitoring period. Sampling will occur during spring months, at the peak of the growing season. A minimum of 10 1/10th-acre monitoring plots will be located randomly during each monitoring period. Additional plots may be sampled, if necessary, to determine whether success criteria is met on all 140 acres. The distance between plots will be dependent on the project site area and variability. Monitoring will measure percent cover of native and non-native plant species and structural diversity. If all success criteria are met at Year 5 Post-Planting, the planting can be considered successful.

Trigger: By year 5, the stocking rate is <150 trees/acre (including volunteer plant species, but only if the species is consistent with the species diversity goals and is not a dominant component of the restoration target composition) and/or <50 mast-producing trees/acre.

Possible Causes for Not Meeting Success Criteria Potential failure mechanisms for the successful establishment of riparian habitats may include drought or extreme storm

events, predators (invertebrates and vertebrates), incompatible plant species selection, natural stream design errors/flaws resulting in excessive erosion or sedimentation, and/or infestation of non-native invasive and native noxious species.

Potential Adaptive Management Measures: Adaptive management measure would include irrigation during drought conditions (during construction period or afterwards during Adaptive Management period); predator control (i.e., exclosures) to ensure the vitality and survival of the plantings; supplemental planting to replace dead seedlings, changing the target plant species to those be more tolerant of site specific abiotic conditions; treating reforestation sites with herbicides to manage invasive and noxious plant species in the restoration areas.

This restoration plan involves active manipulation (as needed) to sustain project goals and objectives, primarily by applying an iterative process of assessing and learning from the results of management actions. The application of adaptive management principals in this project will therefore provide decision support tools to address site changes that may occur as the project progresses, as well as integrate additional project resources or technologies as needed. In some cases additional resources may be needed to address issues that occur (such as management of infestations of invasive species), but in most cases reallocation of resources (e.g., modifying planting lists/species selection based upon successes and failure of earlier plantings) can be used to meet or exceed project goals as defined by tree, shrub, vine, and herbaceous plant establishment combined with nuisance plant control.

3.4 Reporting

Evaluation of the success of the Maumelle River project will be assessed annually at a minimum until all performance standards are met. Site assessments will be conducted annually by the MAMT to determine success of performance standards and an annual report will be submitted to CAW and other interested parties by January 30th following each monitoring year.

Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The locations of photo points will be identified in the pre-construction monitoring report. Photographs taken at each photo point will be included in monitoring reports.

3.5 Adaptive Management Costs

The MAMP establishes a feedback mechanism whereby monitored conditions will be used to adjust or refine construction or maintenance actions to better achieve project goals and objectives. Monitoring and adaptive management are not to be used as a substitute for OMRR&R. Per WRDA 1986, as amended by Section 210 of WRDA 1996, the NFS would be responsible for all OMRR&R. This includes operations and maintenance (O&M) that provides day-to-day activities necessary to properly operate a component of a system and routine maintenance activities to keep the system operating as designed. This also includes non-routine or beyond the scope of typical O&M activities of repair or fixing damage caused by an event; rehabilitation or repair related to long-term wear and tear; and replacement of components when the useful life is exceeded.

In contrast, periodic monitoring of performance criteria which contain trigger values informs the iterative process of implementing specified adaptive management measures to help achieve

ecological success. However, the project area is susceptible to several uncertainties that could significantly impact the ecological success of constructed restoration features as described in Section 3.3.1.

Costs for the adaptive management program were based on estimated level of effort and potential frequency of need, and include participation in the MAMT and reporting. Only those actions which are most likely to be needed have associated costs. Measures included in the Proposed Action have been successfully implemented with very similar designs within the Maumelle River study area; therefore, the desired outcomes are expected and reasonable based on experience. The likelihood that extreme measures, such as complete replacement of all native vegetation, is very low. The current total estimate for implementing the adaptive management program is $222,000 (Table 1).

Table 1: Preliminary Cost Estimates for Implementation of the Monitoring and Adaptive Management Plan for the Maumelle River Ecosystem Restoration Project

Category	Activities	PED Set-up	Construction	3-year Post Construction (5-year for reforestation)	Total
Monitoring: Planning and Management	Monitoring workgroup, drafting detailed monitoring plan, working with PDT on performance measures.	$30,000			$30,000
Monitoring, Data Analysis, and Annual Reporting:	Monitoring erosion control measures at Trib. A, Side Channel A (culverts and levee), River Crossings.		$15,000	$45,000	$60,000
Adaptive Management Program	Detailed Adaptive Management Plan and Program Implementation and Management.		$67,500	$64,500	$132,000
TOTAL		$30,000	$82,500	$109,500	$222,000

4 Project Close-Out

Once ecological success has been documented by the District Engineer in consultation with the MAMT, and a determination has been made by the Division Commander that ecological success has been achieved, no further monitoring or adaptive management will be required, and the

project can be closed-out. Ecological success will be documented through an evaluation of the predicted outcomes as measured against the actual results. Success would be considered to have been achieved when all performance measures have been met or when it is clear they will be met based upon the trend of site conditions and processes.

The project could also be closed out when the maximum 10-year monitoring period has been reached. If the monitoring plan requires monitoring beyond the 10-year period, the cost of monitoring shall be a non-Federal responsibility.

Attachment A – Potential Tree Species for Reforestation

Potential Native Species List for the Maumelle River Project Area Soil pH Ranges* and Flooding Tolerances for Some Arkansas Tree Species **(**Adapted from Species Suitability and pH of Soils in Southern Forests, USDA Forest Service).

Common Name	Scientific Name	Range in	Flood Tolerance
Ash, Green	*Fraxinus pennsylvanica*	3.6-7.5	Moderately Tolerant
Baldcypress	*Taxodium distichum*	4.6-7.5	Tolerant
Beech, American	*Fagus grandifolia*	6.0-7.0	Weakly Tolerant
Birch, river	*Betula nigra*	4.5-6.0	Moderately Tolerant
Blackgum	*Nyssa sylvatica*	4.6-7.0	Weakly Tolerant
Buckeye	*Aesculus species*	6.0-8.0	Intolerant
Catalpa	*Catalpa species*	6.0-8.0	Intolerant
Cherry, black	*Prunus serotina*	4.6-6.2	Intolerant
Cottonwood	*Populus deltoides*	3.6-7.5	Weakly to Moderately
Dogwood, flowering	*Cornus florida*	6.0-8.0	Intolerant
Elm	*Ulmus species*	5.2-8.0	Intolerant - Moderately
Hickory, water	*Carya aquatica*	4.8-6.0	Moderately Tolerant
Holly, American	*Ilex opaca*	5.0-6.0	Intolerant
Honeylocust	*Gleditsia triacanthos*	6.0-8.0	Moderately Tolerant
Locust, black	*Robinia pseudoacacia*	4.5-7.5	Intolerant
Magnolia, southern	*Magnolia grandiflora*	5.0-6.0	Weakly Tolerant
Maple, red	*Acer rubrum*	4.4-7.5	Moderately Tolerant
Mulberry	*Morus species*	6.0-8.0	Weakly Tolerant
Oak, black	*Quercus velutina*	4.0-5.0	Intolerant
Oak, bur	*Quercus macrocarpa*	6.0-6.3	Weakly Tolerant
Oak, cherrybark	*Quercus pagoda*	4.5-6.2	Weakly Tolerant
Oak, northern red	*Quercus rubra*	4.5-6.0	Intolerant
Oak, Nuttall	*Quercus nuttallii*	3.6-6.8	Moderately Tolerant
Oak, overcup	*Quercus lyrata*	3.6-5.5	Moderate to Tolerant
Oak, pin	*Quercus palustris*	6.0-7.0	Moderately Tolerant
Oak, shumard	*Quercus shumardii*	4.4-7.5	Weakly Tolerant
Oak, swamp chestnut	*Quercus michauxii*	3.6-6.2	Weakly Tolerant
Oak, Southern red	*Quercus falcata*	5.0-6.0	Intolerant
Oak, water	*Quercus nigra*	3.6-6.3	Weakly Tolerant
Oak, white	*Quercus alba*	4.5-6.2	Intolerant
Oak, willow	*Quercus phellos*	3.6-6.3	Moderately Tolerant
Pecan	*Carya illinoensis*	4.8-7.5	Weakly Tolerant
Persimmon	*Diospyros virginiana*	4.4-7.0	Moderately Tolerant
Pine, loblolly	*Pinus taeda*	4.5-6.0	Weakly Tolerant
Pine, shortleaf	*Pinus echinata*	4.5-6.0	Intolerant
Plum	*Prunus species*	5.0-8.0	Weakly Tolerant
Red cedar, Eastern	*Juniperus virginiana*	6.0-7.5	Intolerant
Redbud, Eastern	*Cercis canadensis*	6.0-8.0	Intolerant
Sassafras	*Sassafras albidum*	4.7-7.0	Intolerant
Sugarberry	*Celtis laevigata*	5.0-7.0	Moderately Tolerant
Sumac, shining	*Rhus copalina*	4.2-7.0	Intolerant
Sweetgum	*Liquidambar styraciflua*	3.6-7.5	Moderately Tolerant
Tupelo, water	*Nyssa aquatica*	3.6-5.6	Tolerant
Walnut, black	*Juglans nigra*	5.0-7.5	Intolerant

Willow, black	*Salix nigra*	4.6-7.5	Tolerant
Yellow poplar	*Lirodendron tulipifera*	4.5-7.0	Intolerant