Appendix H
Monitoring and Adaptive Management

TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 UMRR Authorization 1
1.2 Policy & Guidance 1
2 MONITORING & ADAPTIVE MANAGEMENT PLANNING 1
3 STUDY GOAL AND OBJECTIVES 2
4 SOURCES OF UNCERTAINTY 2
5 CONCEPTUAL MODEL 4
6 MONITORING OF OBJECTIVES TO DETERMINE PROJECT SUCCESS AND ADAPTIVE MANAGEMENT MEASURES 4
Hydrology Improvements 8
Emergent Wetland Enhancement 8
Reforestation 9
Timber Stand Improvement 9
7 DOCUMENTATION, IMPLEMENTATION COSTS, RESPONSIBILITIES, AND PROJECT CLOSE-OUT 10
8 REFERENCES 11

LIST OF TABLES

Table 1. Project Objectives, Indicators, and Time before the Effects of the Oakwood Bottoms HREP. 6
Table 2. Oakwood Bottoms HREP Conceptual Monitoring Schedule and Estimated Monitoring Costs. 7

1 INTRODUCTION

This appendix presents the feasibility level monitoring and adaptive management (MAM) plan for the Upper Mississippi River (UMRR) Oakwood Bottoms HREP feasibility study. This MAM plan identifies and describes the monitoring and adaptive management activities proposed for the considered action alternatives and estimates associated costs and duration. This appendix outlines how the results of the study-specific monitoring plan would be used to adaptively manage each of the action alternatives, including monitoring targets which demonstrate success in meeting study objectives. This MAM plan was developed by the project delivery team including agency partners and the project sponsor. This plan will be further developed in the pre-construction, engineering and design (PED) phase if changes to the project are made that warrant updating the plan in order to evaluate success.

The District's intent was to develop monitoring and adaptive management actions appropriate for the project's goal and objectives.

1.1 UMRR Authorization

The 1985 Supplemental Appropriations Act (Public Law 99-88) and Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) authorized implementation of ecosystem restoration projects to ensure the coordinated development and improvement of the Upper Mississippi River System.

At the UMRR programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within the UMRR Program. Using an adaptive management approach during project planning enabled better selection of appropriate design and operating scenarios to meet the Oakwood Bottoms HREP project objectives. Lessons learned in designing, constructing, and operating similar restoration projects within the UMRS have been incorporated into the planning and design of this HREP to ensure that the proposed plan represents the most effective design and operation to achieve project goals and objectives (McCain 2012).

1.2 Policy & Guidance

Section 1161 of WRDA 2016 requires that when conducting a feasibility study for ecosystem restoration, the proposed study includes a plan for monitoring the success of the ecosystem restoration. Additionally, paragraph (7)(d) of Section 1161 Implementation Guidance states that "an adaptive management plan will be developed for ecosystem restoration projects…appropriately scoped to the scale of the project." The implementation guidance for Section 1161, in the form of a CECW-P Memo dated 19 October 2017, also requires that an adaptive management plan be developed for all ecosystem restoration projects. Adaptive management "prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state" (Fischenich et al. 2012).

2 MONITORING & ADAPTIVE MANAGEMENT PLANNING

The resulting MAM plan for the UMRR Oakwood Bottoms HREP Feasibility Study

describes and discusses whether adaptive management is needed in relation to the considered action alternatives identified in the Feasibility Study. The MAM plan outlines how the results of study-specific monitoring would be used to adaptively manage the considered action alternatives, including specifications that will define success.

The MAM plan reflects a level of detail consistent with the feasibility study. The primary intent was to develop monitoring and adaptive management actions appropriate for the study's restoration goal and objectives. The specified management actions permit estimation of the adaptive management plan costs and duration. The MAM Plan:

- identifies the restoration goal and objectives;
- presents a conceptual model that relates management actions to desired study outcomes; and
- lists sources of uncertainty that would lend themselves to adaptive management.

Following the discussion of the above, the subsequent sections of this appendix describe monitoring, assessment and decision-making in support of adaptive management. The level of detail in this plan is based on currently available data and information developed during plan formulation as part of the Feasibility Study. Components of the monitoring and adaptive management plan, including costs, were similarly estimated using currently available information.

3 STUDY GOAL AND OBJECTIVES

The primary goal of the Oakwood Bottoms HREP is to improve hydrologic conditions for the regeneration of hard mast tree species. The following objectives and were considered in detail to achieve the Project goal:

1. Increase regeneration of bottomland hardwood forest within the study area during the period of analysis.
2. Restore natural hydrologic conditions and function to the floodplain by emulating natural flooding and drainage regimes.
3. Restore degraded wetland habitat within the study area for resident migratory wildlife during the period of analysis.

4 SOURCES OF UNCERTAINTY

Adaptive management provides a coherent process for making decisions in the face of uncertainty. Scientific uncertainties and technological challenges are inherent with any ecosystem restoration study. Following is a list of uncertainties identified by the PDT associated with Oakwood Bottoms HREP considered action alternatives. The considered action alternatives all have some amount of the below proposed measures; therefore, the uncertainty is similar across all considered action alternatives. The alternatives differ in the amount of each type of restoration measure and the location within the study area. With the similarity across alternatives, the considered action alternatives will be discussed collectively unless otherwise noted.

Following is a list of uncertainties associated with Oakwood Bottoms HREP.

Reforestation.

The PDT evaluated the level of uncertainty and risk in the reforestation measure. The

primary uncertainty is the long-term survivability of the reforestation measures. An OMRR&R Manual will be provided to ensure proper maintenance for this measure to improve probability of success. Although the UMRR Program has evaluated adaptive management and monitoring designs for forestry and these lessons learned have been applied in the design of the reforestation measures in previous projects on the Mississippi River, there has not yet been a greentree reservoir UMRR project as complex as Oakwood Bottoms. Further, new species such as cherrybark oak (*Quercus pagoda*) will be utilized that have not been incorporated by a previosu UMRR project. Monitoring will be conducted to determine success, described below. Information gained from the UMRR Program will be used to guide the reforestation at Oakwood Bottoms.

Emergent Wetland Enhancement

Long-term success of emergent wetland to produce ideal moist soil plants depends on proper manipulation of water control structures for gradual drawdown as well as disturbance every 4-5 years to reset the vegetation community. The District evaluated this uncertainty and deemed the risk to be low since an OMRR&R Manual will be provided to ensure proper maintenance for this measure. Furthermore, other ecosystem restoration projects through the UMRR Program have extensively evaluated adaptive management and monitoring designs for emergent wetlands and these lessons learned have been applied in the design of emergent wetland enhancement meausure. Monitoring will be conducted to determine success, described below. Information gained from the UMRR Program will be used to guide emergent wetland enhancement at Oakwood Bottoms.

Timber Stand Improvement

Past timber stand improvement efforts have not greatly increased survival of oak seedlings. This uncertainty was considered during the feasibility study. The main source of uncertainty identified with past TSI efforts was due to hydrology. For the Oakwood Bottoms HREP the primary source of uncertainty involved with TSI remains hydrology.

Existing Infrastructure

Existing infrastructure currently at Oakwood Bottoms is a source of uncertainty. The main sources of uncertainty involved include electric service capacity required for the well pumps. However, this uncertainty and risk were deemed low as the pumps included in the alternatives would be of similar design to current pumps.

Hydraulic Modeling

The District evaluated the level of uncertainty and risk in using the existing 2D model for the study area and measure design. The 2D model is a model and cannot replicate nature precisely. Some of the sources of uncertainty with the 2D model are included below. See Appendix N – *Hydrology and Hydraulics* for more details:

- Berm Modification: the 2D model may overestimate or underestimate drain/fill times for the new management units, depending on the water levels within each unit.
- Water Control Structures: the 2D model assumed the existing structures

would be maintained and no blockages would occur.

- Pump Station: the 2D model does not model future climate change. The exact pumping capacity for future conditions may be underestimated or overestimated which could result in under- or over design of the proposed pump station measure.

5 CONCEPTUAL MODEL

A conceptual model (Figure 1) was developed to illustrate the interactions between drivers (i.e., climate, geology, ecological disturbance, and land use), essential ecosystem characteristics, and potential management measures. Essential ecosystem characteristics (EECs) are broadly defined categories of environmental features that are critical for sustaining ecological systems, and are valued by stakeholder interests (Nestler et al. 2010). Five EECs have been identified for the UMRS: Geomorphology, Hydrology and Hydraulics, Biogeochemistry, Habitat, and Biota (Lubinski and Barko 2003). The primary stressors for the study area are past and present land use, to include the Grand Tower and Degognia levee system. These stressors directly impact the Hydrology and Hydraulics EEC and the Habitat EEC. The potential measures were then identified to show how they interact with the various EECs.

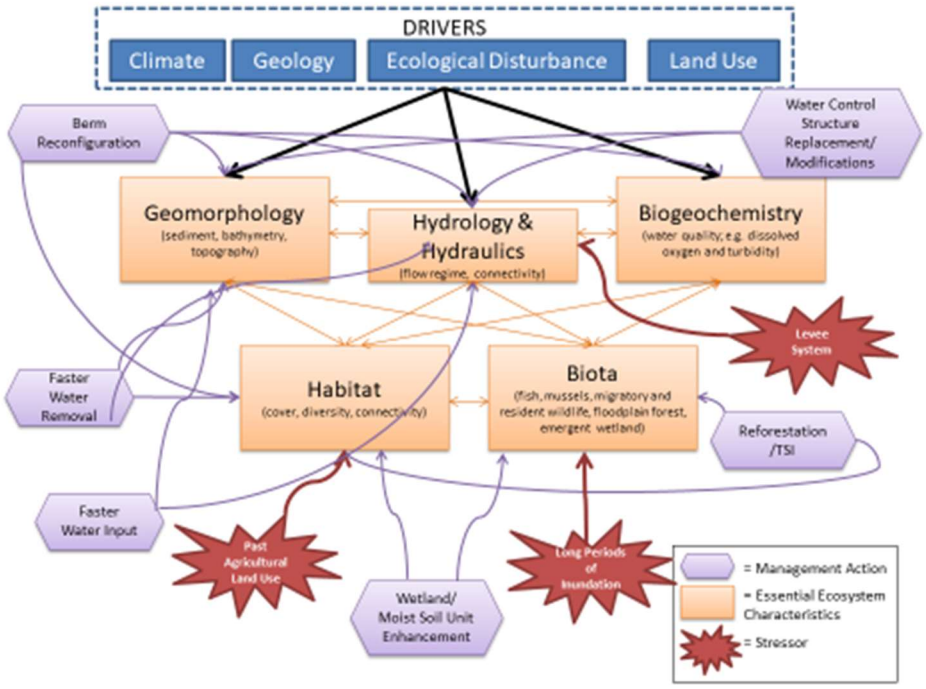

Figure 1. Conceptual model for Oakwood Bottoms HREP.

6 MONITORING OF OBJECTIVES TO DETERMINE PROJECT SUCCESS AND ADAPTIVE MANAGEMENT MEASURES

The power of a monitoring program developed to support determinations of project success and inform adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management. The

considered action alternatives all have some amount of the proposed measures; therefore, the monitoring plans are similar. The alternatives differ in the amount of each type of restoration measure; however, the monitoring plans would be similar with minor differences due to the amount within the study area. With the similarities across alternatives, considered action alternatives will be discussed collectively unless otherwise noted.

This monitoring and adaptive management plan was developed with input from state and federal resource agencies. Performance indicators to the above study objectives were developed with the best available knowledge. They were developed to be specific, measurable, attainable, realistic, and timely.

Each study objective was assessed by at least one performance indicator. For each performance indicator, the rationale behind the indicator and the methodology used are discussed. In addition, the monitoring targets (also referred to as desired outcomes) and action criteria (also referred to as adaptive management triggers) are listed. The action criteria are used to determine if and when adaptive management actions should be implemented.

Current performance indicators are summarized in Table 1. The conceptual monitoring schedule and estimated costs are provided in Table 2.

Table 1. Project Objectives, Indicators, and Time before the Effects of the Oakwood Bottoms HREP.

Objective	Performance Indicator	Monitoring Target (Desired Outcome)	Action Criteria (AM triggers)	Responsible Party	AM Measure
1. Increase regeneration of bottomland hardwood forest within the study area during the period of analysis.	Tree planting survival	Increase quantity and quality of floodplain forest on Oakwood Bottoms and survivability of planted trees	80% survivorship of planted trees	USFS	Supplemental planting
	Regeneration	Densiometer readings of less than 50% for mid-story	Less than 50% oak composition in understory/seedling layer by year 8	USFS	Additional TSI/ Planting
2. Restore natural hydrologic conditions and function to the floodplain by emulating natural flooding and drainage regimes.	Ideal surface water hydrology in 95% of the units as a whole by start/end of the growing season	Improvement of 14 days to drain/fill the GTR over exising conditions	Apply adaptive management actions if any of the monitoring targets fall outside the desired thresholds	USFS/USACE	Berm modifications, resize structures, additional well pumps
3. Restore degraded wetland habitat within the study area for resident migratory wildlife during the period of analysis.	Vegetation surveys	At least 80% species composition of annual moist-soil unit plants	Less than 80% species composition of desirable plants	USFS	Evaluate hydrology of site and management actions including disturbance and timing of water removal
	Capability to drain/fill at desired dates	Capability to remove water gradually and incrementally to promote moist soil unit plant species	Unable to perform gradual drawdown (not more than 2 inch increments)	USFS	Investigate sizing of structures relative to the MSUs. Re-evaluate management plan for water timing

Table 2. Oakwood Bottoms HREP Conceptual Monitoring Schedule and Estimated Monitoring Costs.

Feature	Performance Indicator	Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Sub-total
Berm	Days to drain/fill	Observation	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000		45,000
	Topographic Survey	LiDAR	50,000										50,000
	AM feature: Berm modification										**235,000**		235,000
Structures	95% of unit area has ideal surface water hydrology by spring/fall by drain/fill management	Monitor water input and drainage:	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500			20,000
	AM feature: Resize structures										**224,000**		224,000
Wells	Water supply not sufficient	Observation	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500			20,000
	AM feature: Additional well pumps										**145,000**		145,000
Emergent Wetland	Species diversity	Vegetation surveys	10,000								10,000		20,000
	Water management capability	Water drainage/filling	5,000				5,000				5,000		15,000
	AM feature :None identified												0
Reforestation	Forest Community Diversity	Forest monitoring			6,000				6,000				12,000
	AM feature: supplemental planting										49,000		49,000
Timber Stand Improvement	Regeneration occurring	Regeneration surveys								20,000			20,000
	AM feature: Additional TSI										**75,000**		75,000
	Performance Evaluation Report	Inspection and report writing						25,000				**25,000**	50,000
													$980,000

Hydrology Improvements

1) **Objective supported:** All
2) **Performance Indicators:** Number of days to drain and fill.
3) **Rationale:** Surface water is an indicator of physiologic stress to the forest. Water that is contained within the green tree reservoir during the growing season negatively impacts individual tree health, which negatively impacts overall forest health. This project feature is designed to reduce the time in which water travels throughout the study area, thereby reducing the number of days to drain and fill.
4) **Methodology:** The surface water hydrology will be assessed by determining whether or not 95% of the units as a whole are drained or filled by the start or end of the growing season, respectively.

   The water capacity will be assessed by determining whether or not 95% of the units as a whole are filled specific yearly guidelines by the start of waterfowl season. The specific yearly guidelines are set annually by the Forest Service to determine which units are flooded and which will remain dry in an attempt to reduce tree stress by rotating the units.

5) **Success Criteria (Desired Outcomes):**

   Criterion 1: Berm modification measures will be considered successful if the GTR is able to drain/fill 14 days faster than existing conditions.

   Criterion 2: Water Control structure modifications will be considered successful if the GTR is able to drain/fill 14 days faster than existing conditions.

   Criterion 3: Well pump will be considered successful if the GTR is filled by the start of waterfowl season

   Criterion 4: If greater than 2 inch increment drawdowns within the wetland unit, then USACE and/or sponsor would investigate sizing of structures relative to the wetland area and re-evaluate management plan for water timing

6) **Adaptive Management Trigger and Measure:** If monitoring results indicate an inability to reach success criteria by year three (3), then AM may be warranted. If the criteria are not met and any of the below begin to occur by year 5 post-construction, the AM would be implemented:
   - **a.** Regularly and reocurring inability to drain/fill the GTR in 30 days.
   - **b.** Desired wetland plant community not achieved. If less than 80% species composition of desirable moist soil unit plants, then the USACE and the sponsor would evaluate hydrology of site and management actions including disturbance and timing of water removal.

Emergent Wetland Enhancement

1) **Objective supported:** 3
2) **Performance Indicators:** At least 80% species composition of annual moist-soil unit plants.

3) **Rationale:** The wetland areas are to be managed for migratory waterfowl habitat. Moist soil plants provide foraging value with the seeds they produce. A diversity of moist soil species present in the wetland areas insures that adequate seed production for migratory waterfowl forage is present.
4) **Methodology:**
    a. Vegetation Survey: Transect surveys with percent species cover would be performed for each wetland unit following the Illinois Natural History Survey, Critical Trends Assessment Protocol for Wetland sites (INHS 2002).
    b. Capability to gradualy and incramentaly drain and fill for moist soil unit plant management.
5) **Success Criteria (Desired Outcomes):**

Criterion 1: Emergent wetland enhancement will be considered successful if 80% or more species diversity is composed of typical moist-soil plants including but not limited to: *Polygonum* spp., *Echinochloa* spp., *Carex* spp., *Cyperus* spp., etc.

Criterion 2: Emergent wetland enhancement will be considered successful if the gradual drawdown is able to be performed with 2 inch or less increments in moist soil management units.

6) **Adaptive Management Trigger and Measure:** None identified. Captured in hydrology improvements.

Reforestation

1) **Objective supported:** 1
2) **Performance Indicators:** Tree planting survival.
3) **Rationale:** Berm degrade locations would need to be reforested to ensure success of bottomland hardwood forest restoration, rather than allowing the reforest naturally.
4) **Methodology:** Forest monitoring would include success of planted trees at years 3 and 7 years post-planting to determine survivorship (tree count of dead versus alive).
5) **Monitoring Target (Desired Outcome):** The amount of floodplain forest due to reforestation would increase by a total of approximately 53 acres. Reforestation will be one of the last features completed. The monitoring target for initial and long-term monitoring is 80% survivorship of planted trees through year 10 post-planting.
6) **Adaptive Management Trigger and Measure:** If monitoring results indicate an inability to reach success criteria by year 3 and less than 80% of initial tree survivability then USACE would evaluate hydrologic conditions and adjust species mixture accordingly.

Timber Stand Improvement

1) **Objectives supported:** 1
2) **Performance Indicator:** Regeneration of oak species in the study area.
3) **Rationale:** Regeneration of oak species in the study area is critical for long-term success and sustainability of a bottomland hardwood forest. Bottomland hardwoods, have been reduced within the Project Area due to altered hydrology, limiting species

survivability to only more water-tolerant species. Project features of timber stand improvement are expected to increase quality of floodplain forest in Oakwood Bottoms.

4) **Methodology:** Regeneration monitoring will use densitometer readings for the seedling layer/mid-story. The methodology will follow common USFS data collection methods. Success of timber stand improvement will be monitored at year 8.
5) **Monitoring Target (Desired Outcome):** The monitoring target for regeneration is a densiometer reading of at least 50% in the mid-story and at least 50% oak composition in the seedling layer by year 8. This assumes that the non-desirable species have been removed through timber stand improvement actions and regeneration of oak species is occurring.
6) **Adaptive Management Trigger and Measure:** If monitoring results indicate an inability to reach 50% densiometer readings for mid-story and at least 50% oak species composition in the seedling layer by year 8 then the USACE and the sponsor would conduct additional timber stand improvement to encourage oak species regeneration.

7 DOCUMENTATION, IMPLEMENTATION COSTS, RESPONSIBILITIES, AND PROJECT CLOSE-OUT

Documentation, Reporting, and Coordination. The Project Delivery Team will document each of the performed assessments and communicate the results to the HREP program manager and partners designated for the Project. Performance Evaluation Reports (PERs) will be produced to measure progress towards the Project goals and objectives as characterized by the selected performance measures.

Cost. The costs associated with implementing monitoring an adaptive management measures were estimated based on currently available data and information developed during plan formulation as part of the feasibility study. Because uncertainties remain as to the exact Project measures, monitoring elements, and adaptive management opportunities, the estimated costs in Table 2 will need refinement in PED if changes to the project are made that warrant updating the plan in order to evaluate success.

Responsibilities. The USFS will be responsible for monitoring berm functionality, structure capacities, well water availability for study area, emergent wetland vegetation monitoring, reforestation monitoring, and timber stand improvement monitoring. The sponsor and the Corps will be responsible for site inspections and visual observations to assist in overall project success evaluation.

Project Close-Out. Close-out of the Project would occur when it is determined that the Project has successfully met the Project success criteria described above. Success would be considered to have been achieved when the Project objectives have been met, or when it is clear that they will be met based upon the trends for the site conditions and processes. Project success would be based on the following:

- Success criteria met;
- Continued site inspections to determine continued Project status; and
- Continued OMRR&R into the future

8 REFERENCES

Fischenich, C., & Vogt, C. (2012). *The Application of Adaptive Management to Ecosystem Restoration Projects. (ERDC TN-EMRRP-EBA-10 April 2012).* Vicksburg, MS: US Army Corps of Engineers, Ecological Management and Restoration Research Program.

Henderson, D., Botch, P., Cussimanio, J., Ryan, D., Kabrick, J., & Dey, D. (2009). *Growth and Mortality of Pin Oak and Pecan Reforestation in a Constructed Wetland: Analysis with Management Applications. Missouri Conservation Technical Report Series.* Jeffereson City, MO: Missouri Department of Conservation.

Illinois Natural History Survey (INHS). 2002. *Critical Trends Assessment Program Monitoring Protocols.* Illinois Natural History Survey, Office of the Chief Technical Report: 2002-2.

McCain, K. (2012). *Upper Mississippi River Restoration - Environmental Management Program Monitoring Design Handbook Section 1: Vegetation.* Rock Island, IL: US Army Corps of Engineers.