Appendix E
Monitoring and Adaptive Management

TABLE OF CONTENTS

LIST OF TABLES

1 INTRODUCTION

This appendix presents the feasibility level monitoring and adaptive management (MAM) plan for the Upper Mississippi River Restoration (UMRR) Yorkinut Slough HREP Feasibility Study.

This MAM plan was developed by the U.S. Army Corps of Engineers St. Louis District, agency partners, and federal sponsor U.S. Fish and Wildlife Service (USFWS). The MAM will be implemented during 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 Yorkinut Slough HREP objectives. Lessons learned in designing, constructing, and operating similar restoration projects within the Upper Mississippi River System (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 (USACE, 2012).

1.2 Policy & Guidance

Section 1161 of WRDA 2016 requires ecosystem restoration feasibility studies includes a plan for monitoring Project success. Section 1161 paragraph (7)(d) of Implementation Guidance states that "*an adaptive management plan will be developed for ecosystem restoration projects…appropriately scoped to the scale of the project*." Section 1161 implementation guidance, dated 19 October 2017 (CECW-P Memo), requires 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).

MONITORING & ADAPTIVE MANAGEMENT PLANNING

The resulting MAM plan for the UMRR Yorkinut Slough HREP Feasibility Study describes and discusses whether adaptive management is needed in relation to the considered Project measures and alternatives identified in the Feasibility Study. The MAM plan outlines how the results of study-specific monitoring will be used to manage risk associated with Project alternatives, including monitoring targets that will define success.

The MAM plan reflects a level of detail consistent with feasibility level of design. 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 and describes uncertainties, monitoring and adaptive management activities proposed for the final array of alternatives,
- identifies cost and activity duration estimates,
- aligns Project goals and objectives with monitoring and adaptive management actions; and
- includes study-specific monitoring plan including monitoring targets which demonstrate success in meeting study objectives.
- components of the plan, including costs, are based on current historic program costs for similar activities

YORKINUT SLOUGH HREP STUDY GOALS AND OBJECTIVES

The primary goal of the Yorkinut Slough HREP is to restore and improve the quality and diversity of emergent wetland, woodland, and forest resources within the study area. The objectives identified to meet this goal are to:

1. Restore and increase early successional and emergent wetland within the study area over the 50-year period of analysis
2. Restore and increase floodplain forests within the study area over the 50-year period of analysis
3. Improve hydrologic conditions for wildlife including waterfowl, shorebirds, wading birds, Neotropical migrants, and others within the study area over the 50-year period of analysis

2 SOURCES OF UNCERTAINTY

Adaptive management provides a coherent process for making decisions in the face of uncertainty. Scientific uncertainties and technological challenges are inherent in any ecosystem restoration study. The District identified uncertainties associated with Yorkinut Slough HREP final array of alternatives. The identified uncertainties are similar for all alternatives included in the final array, except where noted. The alternatives differ in the amount of each type of restoration measure and the location within the study area. The final array of alternatives are described collectively unless otherwise noted.

The following uncertainties associated with Yorkinut Slough HREP were identified by the District.

Existing Infrastructure

Existing infrastructure currently at Yorkinut Slough is a source of uncertainty. Ducks Unlimited has proposed four electric well pumps and is scheduled to install two well pumps in the study area. The capacity and directional flow options (i.e. which units will have inputs from wells) at these measures as well as the need for additional well pumps are uncertain until installation is complete. Additionally, electric service to the well pumps is an uncertainty. Overall, the risk and uncertainty were deemed low as lessons learned from other recent HREPs will be used in the design of well pumps as well as power requirements.

Emergent Wetland Enhancement

Seepage of water from the Pump Station unit was identified as a source of uncertainty. If Pump Station unit continues to leak, this would result in a reduced ability to manage water levels. Actions to address uncertainty included collection of soil samples. Based on soil samples, the

District evaluated this uncertainty and considered multiple unit configurations during alternative formulation to isolate seepage concerns in the existing Pump Station unit (Figures 1-4). Additional unit configurations were developed and screened based on anticipated performance. If the source of leaking cannot be identified after further geotechnical surveys, only a minor reconfiguration to the Pump Station unit in the Tentatively Selected Plan (TSP), Intermediate B Alternative, may be needed to isolate impacts to water level management from other units. Both the intermediate A and Maximum alternatives would require more significant alterations to proposed unit configurations to reduce seepage issues within Pump Station unit. Further evaluation of this unit is underway to minimize risk in the Plans and Specs and Construction phases. Long-term success of emergent wetland to produce ideal moist soil plants depends on manipulation of water control structures during key plant lifecycle stages as well as mechanical soil disturbance every few years to reset the vegetation community. Other ecosystem restoration projects in 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 the emergent wetland enhancement measures. Monitoring will be conducted to determine success, as described in section 6.1 below utilizing USFWS Integrated Waterbird Monitoring and Management Protocol. Information gained from the UMRR Program will be used to guide emergent wetland enhancement at Yorkinut Slough. An OMRR&R Manual will be provided to ensure proper maintenance of structures for this measure to improve probability of success.

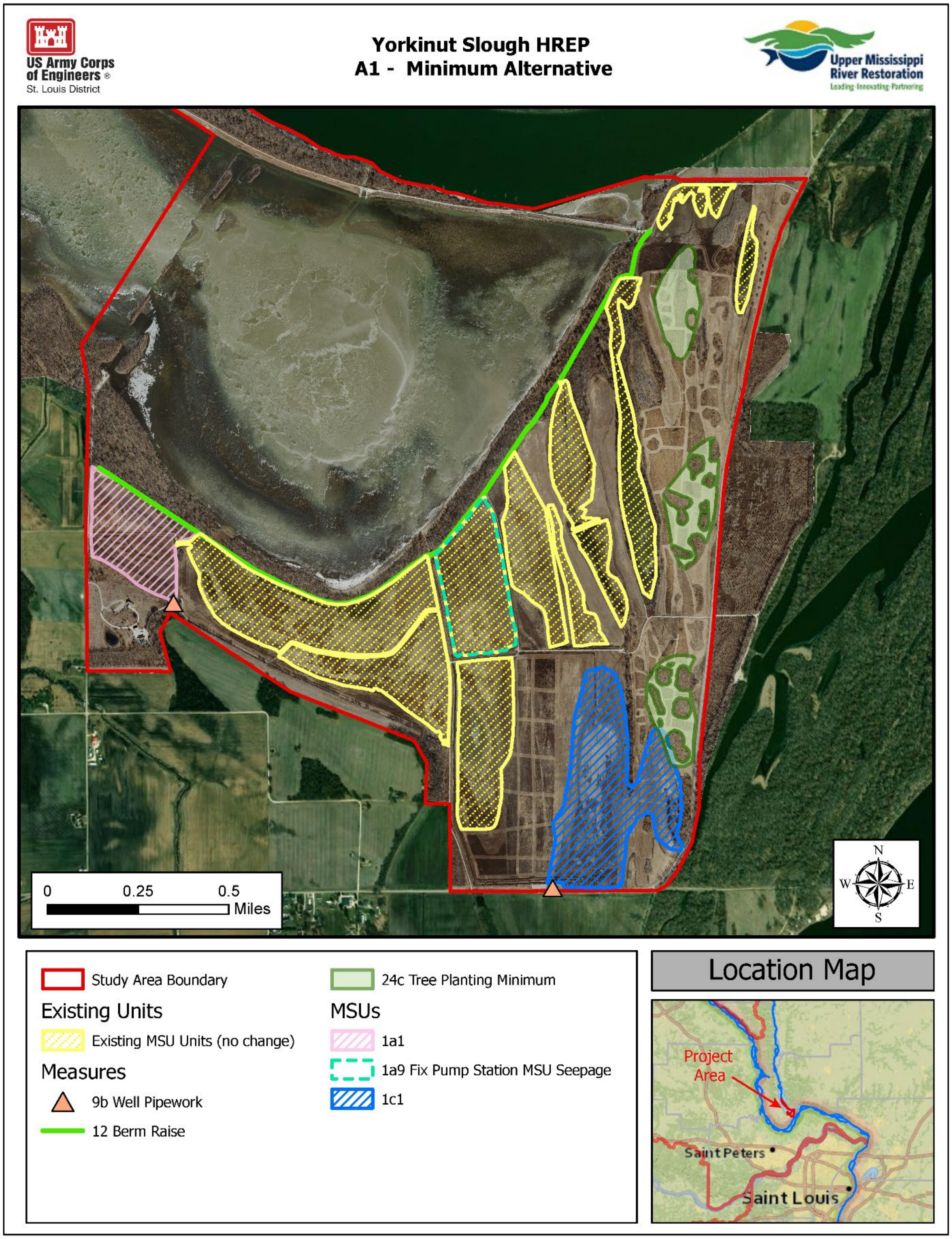

Figure 1: Unit configuration for Minimum Alternative

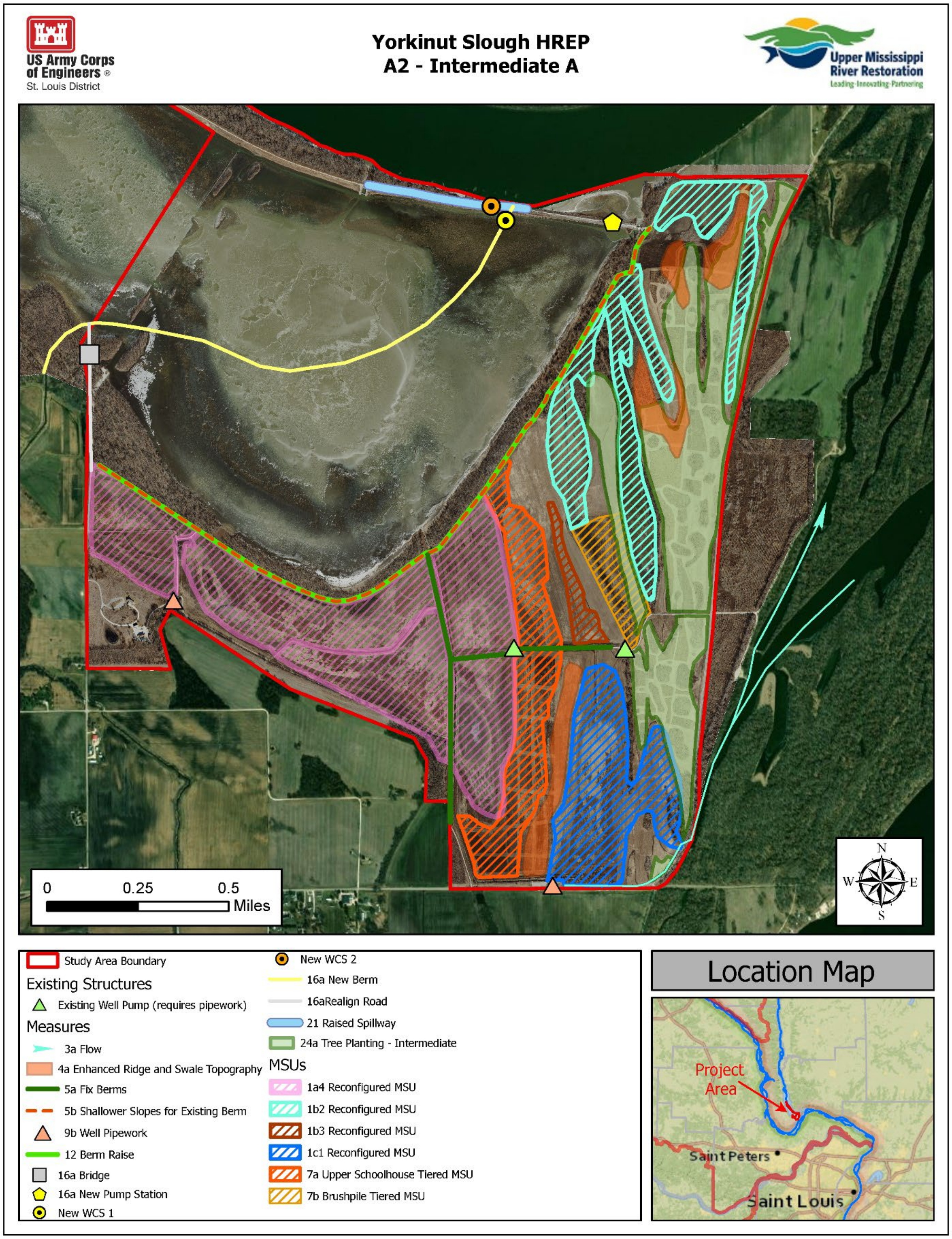

Figure 2: Unit configuration for Intermediate A Alternative

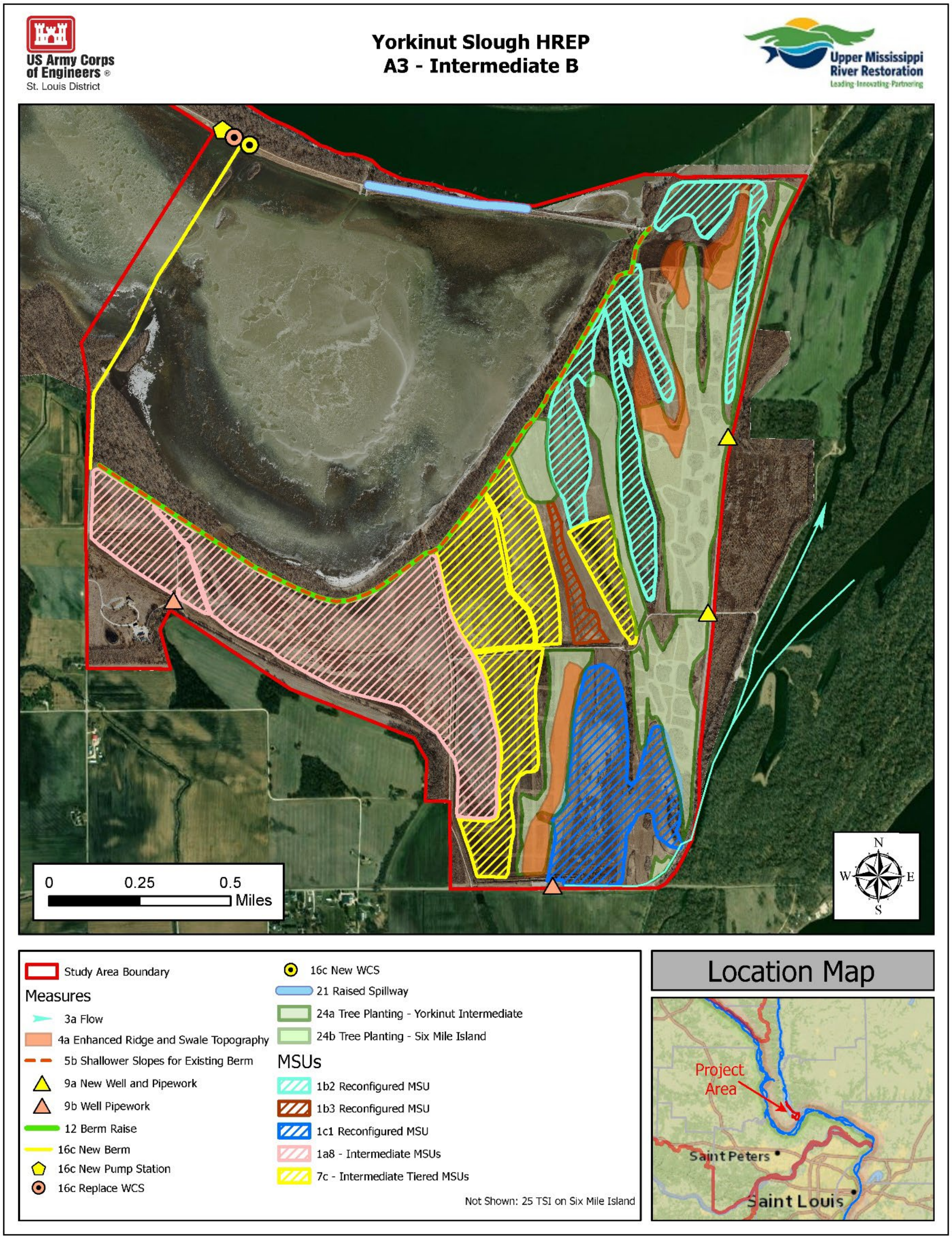

Figure 3: Unit configuration for Intermediate Alternative B

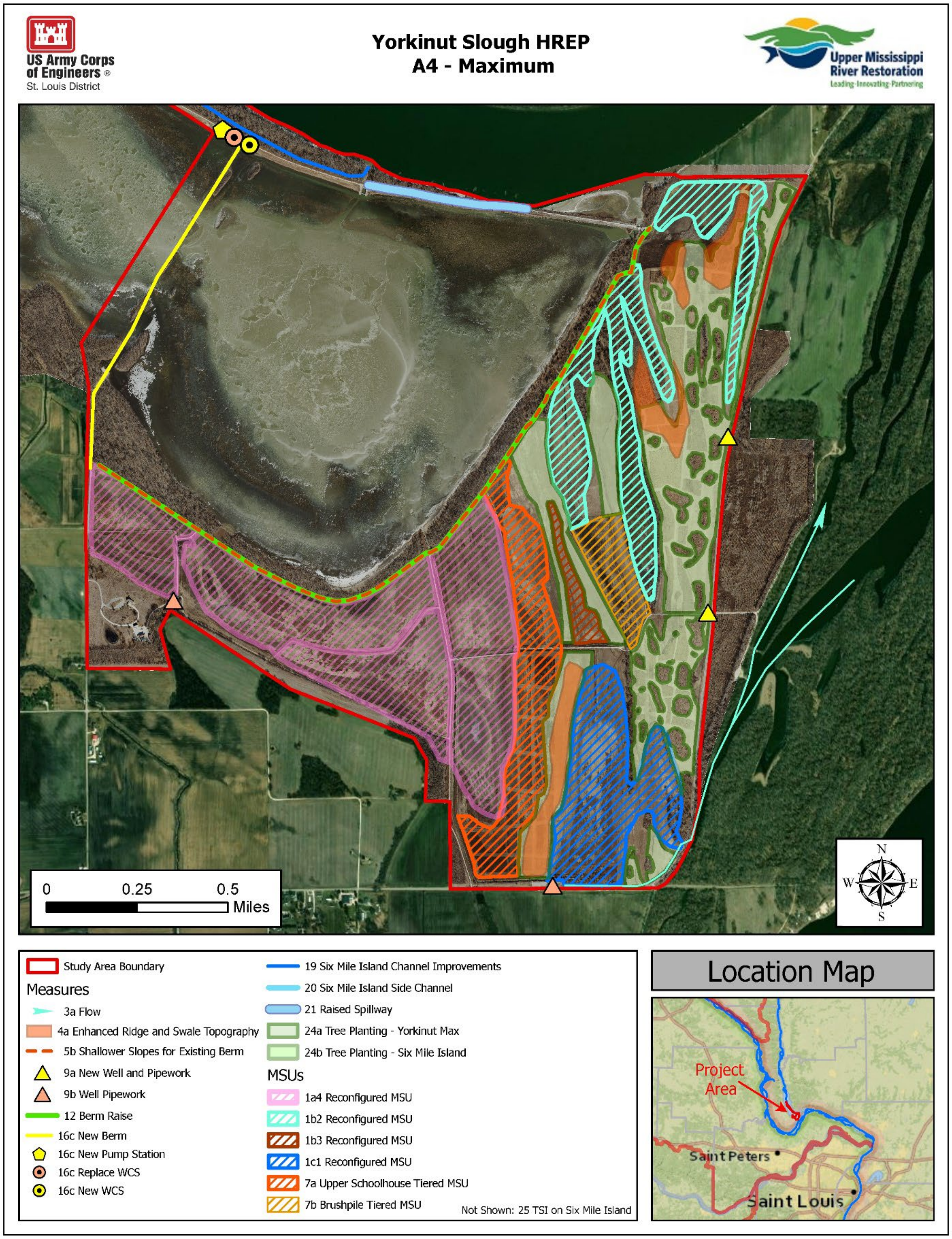

Figure 4: Unit configuration for Maximum Alternative

Tree Planting

The District evaluated the level of uncertainty and risk in the tree planting measure. The primary uncertainty is the long-term survivability of the tree planting measure due to natural factors that will continue to impact the site (e.g., flooding or severe drought after planting). Impacts from non-native invasive herbaceous species (e.g., Japanese hops) in the tree planting area present a secondary source of uncertainty during the establishment period of newly planted forest. An O&M Manual will be provided to ensure proper maintenance for this measure to improve the probability of success. Lessons learned from previous tree plantings at the Two Rivers National Wildlife Refuge and through UMRR Program tree planting efforts have been applied in the design of the tree planting measures. Lessons learned relate to likelihood of species to establish based on flood frequency, site preparation and protection of trees, maintenance schedule and duration to minimize competition from invasives and aggressive, native species, and spacing. This knowledge continues to evolve as more projects incorporate forestry measures. As a result, tree planting would incorporate the latest lessons learned early in the design phase. Overall, considered tree species will vary with elevation based on flood inundation tolerance. Monitoring will be conducted to determine success. Information gained from the UMRR Program will be used to guide the tree planting at Yorkinut Slough.

Timber Stand Improvement (TSI)

The main sources of uncertainty identified with TSI are invasive species, the regeneration rates of desirable trees in treated areas, and the exact hydrologic tolerances of considered species. Several aggressive, flood-dispersed native and non-native species are present in the region and could limit the regeneration rates of desirable trees. Some of the desirable species, such as cottonwood, disperse during narrow windows of time, have low seed viability rates, and are dependent on bare soil conditions with adequate light levels. A gradient of treatment may be required to reach desired results for other species. Previous UMRR projects have focused TSI toward hard-mast regeneration, so this may be one of the first to focus on improving structural and species diversity of “other” floodplain forest species. However, only well-founded forestry management methods have been proposed, and lessons learned from other sites will be applied to this study. Additionally, lessons learned from this study would be used to inform other project planning and implementation processes.

Hydraulic Modeling

Both hydrologic and hydraulic modeling were developed for this study. Data calculated in the hydrologic modeling was used as input data for some, but not all, of the scenarios examined in the hydraulic modeling. There are uncertainties in developing both the hydrologic modeling and the hydraulic modeling. Some of the sources of uncertainty with the model are included below. See *Appendix G – Hydrology and Hydraulics* for more details:

Uncertainties in developing the hydrologic modeling include the following items:

1. The selection of hydrologic and soil parameters that the computer program HEC-HMS (Hydrologic Engineering Center- Hydrologic Modeling System) uses influences the results of the calculations. These parameters include infiltration, moisture deficit, determination of the length of the longest flow path in the watershed, and determination of land-surface elevations along the longest flow path. The best-available information is used to represent each watershed that is modeled, but there is some uncertainty in selecting the parameters and averaging of

parameters is used because of the size of the watersheds that are modeled.

2. Delineation of the watersheds that are modeled is based upon LiDAR data and other topographic information. These two types of information are sometimes dated and may not represent the conditions of the land surface in its present form, and therefore some uncertainty may exist in the delineation of the watersheds.

3. Design rainfall amounts are often distributed in time according to the results of research on historical storm events. Uncertainty exists in the design rainfall amounts, and in the way these amounts are distributed in time, because future rainfall events may not necessarily mimic historical events.

As a result, the pumping, draining, and filling capacities needed for water management infrastructure to perform as intended may be under- or overestimated.

Uncertainties in developing the hydraulic modeling include the following items:

1. There are many geometric parameters that are used in hydraulic modeling to describe and depict the modeled area. LiDAR data and other topographic information are used to produce a depiction of the surface upon which water flows. These two types of information are sometimes dated and may not represent the conditions of the land surface in its present form. For the surface upon which water flows in a hydraulic model, the land covering on that surface varies significantly. The land covering may include grass, weeds, brush, trees, pavement and water. The roughness, or the resistance to water flow, of the various land coverings is an important parameter and is mathematically represented by a roughness value. There is uncertainty in the roughness values as the result of temporal changes in land use, seasonal changes in the land covering, and variations in roughness for a given surface (e.g., concrete, farmland) as its condition varies with time. The model may overestimate or underestimate drain/fill times for new management units.

2. Depictions of natural and man-made features that convey water (rivers, creeks, channels, ditches) and that store water (lakes, reservoirs, detentions ponds, retention ponds) are used in hydraulic modeling. The functions and effects of these features are mathematically represented in the modeling with engineering methods, which in some cases are approximate or estimated representations of physical features. There is uncertainty in the modeling results because of the difficulty in modeling natural and man-made systems. The pumping capacity needed to manage water levels effectively in the Yorkinut Slough study area may be underestimated or overestimated. As a result, design of the proposed pump station measure may be under- or over designed.

3. Another geometric feature that is used in hydraulic modeling is hydraulic structures such as bridges, culverts, weirs and pump stations. These structures are often modeled by assuming that they are in their original condition and have their original engineering parameters (i.e., dimensions, invert elevations, roughness, shape of entrance and exit). There is uncertainty in mathematically modeling these structures because of degradation in their performance as they age, as they accumulate sediment and debris, and as they are deformed and damaged as the

result of everyday use. As a result, the model may overestimate or underestimate drain/fill times for new management units.

3 CONCEPTUAL MODEL

A conceptual model was constructed to facilitate identification of resource problems and stressors, and illustrates the interactions amongst drivers (i.e., altered hydrology, watershed land use, and inadequate infrastructure), primary stressors (excess flooding on site, sedimentation, loss of wetland habitat, and loss of ridge and swale topography) and primary resources of concern (migratory birds, emergent wetlands, and floodplain forests) (Figure 5). Past and present watershed land use change has directly altered hydrology by raising water elevations and sedimentation rates in the Illinois and Mississippi Rivers compared to historic levels and through the loss of wetland habitat and ridge and swale topography in the study area. The altered hydrology has resulted in inadequate water supplies during critical life history stages for vegetation, has led to altered plant mortality patterns due to prolonged flooding events, and has led to an overall reduction in habitat diversity (i.e. emergent wetlands and floodplain forests) and ability to support resources for migratory birds within the study area.

Past and present watershed land use change has directly altered hydrology by raising water elevations and sedimentation rates compared to historic levels, and through the loss of wetland habitat and ridge and swale topography in the study area. The altered hydrology has resulted in inadequate water supplies during critical life history stages for vegetation. Plant mortality patterns have been altered due to prolonged flooding events, leading to an overall reduction in habitat diversity (i.e. emergent wetlands and floodplain forests) and ability to support resources for migratory birds within the study area.

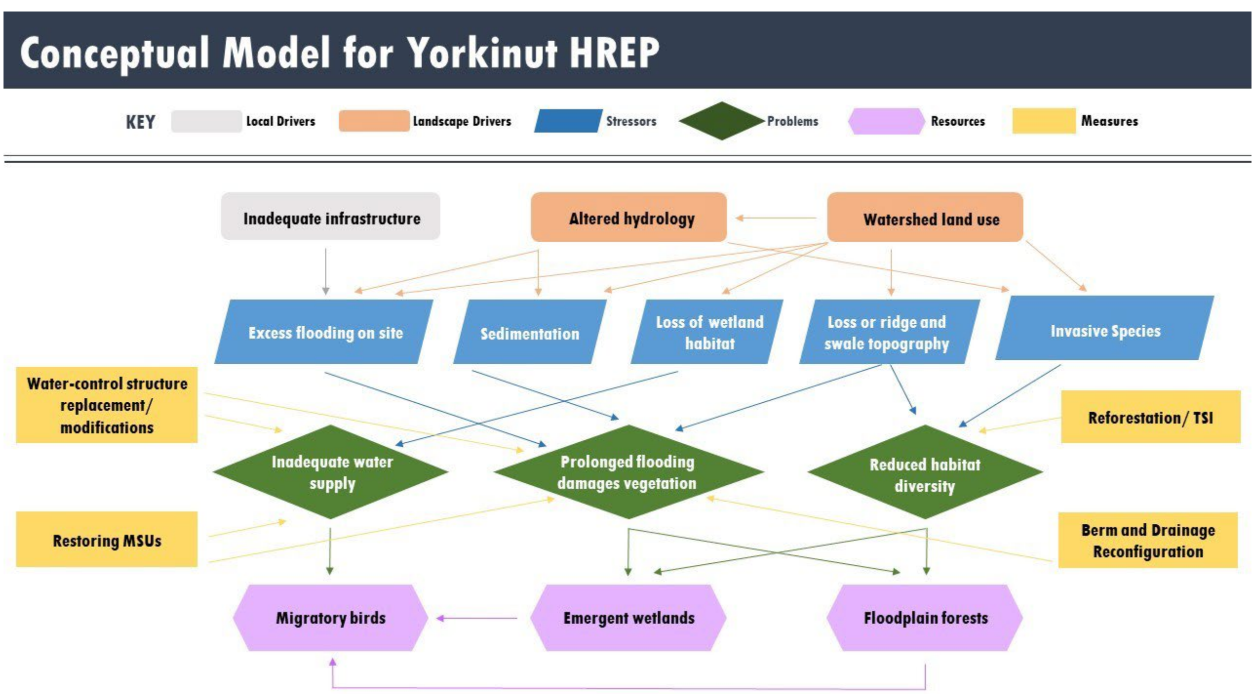

Figure 5. Conceptual Model for Yorkinut Slough HREP

4 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 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 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 related to the study objectives were developed with the best available knowledge 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 (Section 4.1-4.4). In addition, the monitoring targets and action criteria 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 Yorkinut Slough HREP.

Objective	**Performance Indicator**	**Monitoring Target (Desired Outcome)**	**Action Criteria (AM triggers)**	**Responsible Party**	**AM Measure**
1. Restore and increase early successional and emergent wetland	IWMM Vegetation surveys	At least 80% species composition in desirable moist-soil annual plants Species richness and diversity (Shannon's entropy)	Less than 60% species composition of desirable annual plants Species richness threshold ≥5 species	USFWS	Evaluate hydrology of site and management actions including disturbance and timing of water removal
1. Restore and increase early successional and emergent wetland	Ability to seasonally drain/fill and hold water at desired levels.	Ability to remove or fill water (in 5 inch increments) gradually to promote moist soil unit (MSU) plant species	Unable to perform gradual drawdown, fill, and maintain water levels (not more than 5 - inch increments)	USFWS	Investigate sizing of structures, drainage channels, delivery channels relative to the MSUs, and pumps.
2. Restore and increase floodplain forests	Tree planting survival in planted areas	Increase quantity and quality of floodplain forest in Yorkinut Slough and survivability of planted trees (80% survival)	<75% survivorship of planted trees and species.	USFWS	Evaluate planted area and survivability of species planted. Supplemental planting with suitable species.
2. Restore and increase floodplain forests	Regeneration In existing forest areas	Sapling cohort includes 150 trees per acres <4 inches in diameter by year 10.	Sapling cohort includes < 150 trees per acre.	USFWS	Additional TSI/ Planting
3. Improve hydrologic conditions	Meet flow and fill capacities of designed structures across study area.	Reach target water levels in <10 days After large overtopping flood event, drainage of study area < 10 days	Apply adaptive management actions if any of the monitoring targets fall outside the desired thresholds	USFWS/USACE	Berm modifications, delivery and drainage channels, resize water control structures, additional well pumps
3. Improve hydrologic conditions	Forest inundation duration	Hard-mast planting areas with less than 21 days of growing season inundation	Apply adaptive management actions if hard-mast areas fall outside the desired threshold during multiple years prior to year 10	USFWS/USACE	Additional planting with alternative species, modify, clear drainage channels or water control structures.

Table 2. Yorkinut Slough HREP Adaptive Management Schedule and Estimated Monitoring Costs for TSP

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	$300	$300	$300	$300	$300	$300	$300	$300	$300		$2,700
Berm	**AM feature: Berm modification**							**$187,220**					$187,220
Structures	Meet flow and fill capacities of designed structures across study area	Monitor water input and drainage	$300	$300	$300	$300	$300	$300	$300	$300	$300		$2,700
Structures	**AM feature: Resize structures**							**$90,750**					$90,750
Wells	Water supply not sufficient	Observation	$300	$300	$300	$300	$300	$300	$300	$300	$300		$2,700
Wells	**AM feature: Additional well pumps**							**477,400**					$477,400
Emergent Wetland	Species diversity	Vegetation surveys (IWMM surveys)	$0	$0	$0	$0	$0	$0	$0	$0	$0		$0
Emergent Wetland	Species composition	Vegetation surveys (IWMM surveys)	$0	$0	$0	$0	$0	$0	$0	$0	$0		$0
Emergent Wetland	Ability to seasonally drain/fill and hold water at desired levels.	Water drainage/filling	$300	$300	$300	$300	$300	$300	$300	$300	$300		$2,700
Tree Planting	Forest Community Diversity and Survivorship	Forest Monitoring*											
Tree Planting	**AM feature: supplemental planting**							**$12,100**					$12,100
Timber Stand Improvement	Regeneration occurring	Regeneration Surveys	$5000	$5000	$5000	$5000	$5000		$5000		$5000		$35,000
Timber Stand Improvement	**AM feature: additional TSI**							**$95,040**					$95,040
	Performance Evaluation Report	Inspection and report writing						$25,000				$25,000	$50,000
	Total												**$ 958,310.00**

+Timing of activities are approximate and may need to be delayed due to flooding.

*Captured through planned USACE Rivers Project Office forestry monitoring.

AM – Adaptive Management. TSI – Timber Stand Improvement.

4.1 Emergent Wetland Enhancement

1) **Objective supported:** 1
2) **Performance Indicators:** Species richness and at least 80% species composition of desirable 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 in the wetland areas ensures that adequate seed production for migratory waterfowl forage is present. Measure of the proportion of desirable vegetation present in units can be used to support management capabilities
4) **Methodology:**
    a. Vegetation Survey: IWMM vegetation surveys following the protocol (Loges et al., 2015)
    b. Ability to gradually drain, fill, and maintain water levels seasonally for moist-soil unit plant management.
5) **Success Criteria:**

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., *Cyperus* spp., *Leptochloa* spp. etc., species richness is equal to or greater than 5 species per unit.

Criterion 2: Emergent wetland enhancement will be considered successful if gradual water elevation changes are able to be performed in increments of 5 inches or less in moist-soil management units.

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

4.2 Tree Planting

1) **Objective supported:** 1
2) **Performance Indicators:** Tree planting survival.
3) **Rationale:** Areas greater than 427 feet elevation would need to be reforested to ensure the success of bottomland hardwood forest restoration. Sites identified for planting at lower elevations would include appropriate species that survive more frequent flooding and longer duration mean growing season floods.
4) **Methodology:** Woodland monitoring would include success of planted trees at years 3, 6, and 9 post-planting to determine survivorship (tree count of dead versus alive).
5) **Success Criteria:** The area of floodplain forest due to tree planting would increase by a total of approximately 215 acres. 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 75% of initial tree survivability then USACE would evaluate hydrologic conditions and adjust the species mixture accordingly.

4.3 Timber Stand Improvement (TSI)

1) **Objectives supported:** 1
2) **Performance Indicator:** Tree planting survival and regeneration of desired species per treated stand.
3) **Rationale:** Regeneration of hard mast and early successional species in the study area is critical for the long-term success and sustainability of floodplain forest. Floodplain forest

diversity and structure has been reduced within the region due to altered hydrology and historic disturbance frequency and intensity. This places the study area at risk of losing hard mast (i.e. bottomland oaks and hickories) and early successional species, such as Cottonwood and Sycamore (*Platanus occidentalis*) without providing the conditions necessary for regeneration to occur. Project features of TSI are expected to increase the quality of floodplain forest in Yorkinut Slough.

4) **Methodology:** Tree planting survival in TSI stands will follow methodology outlined in tree planting section above. Regeneration monitoring will involve stand monitoring by USACE River Project Office foresters as part of UMRS forestry monitoring efforts.
5) **Success Criteria:** Tree planting survival in TSI stands will follow success criteria outlined in tree planting section. Average sapling cohort regeneration numbers for trees less than 4 inches in diameter will be used to assess stand development in response to treatment. Some stands may be higher or lower than the 150 stems per acre minimum metric based on stand prescriptions and desired target forest community. Stand prescriptions and regeneration targets would be refined for individual stands to reflect variation in conditions and stand potential during planning.
6) **Adaptive Management Trigger and Measure:** If monitoring results indicate an inability to reach 150 stems per acre (or individual stand regeneration density prescription if different from average) by year 8 in TSI stands, then the USACE and the sponsor would conduct additional TSI to encourage appropriate regeneration rates.

4.4 Hydrology Improvements

1) **Objective supported:** All
2) **Performance Indicators:**
    - **a.** Meet flow and fill capacities of designed structures across study area.
    - **b.** Forest inundation duration
3) **Rationale:** Ability to reach target seasonal water levels is a limiting factor for emergent wetland management for waterfowl, shorebirds, and wading birds. Many moist-soil species need a minimum of 60-90 growing season days to produce seed for waterfowl forage. The ability to achieve target water levels for the season is critical after flood events to reduce stress on tree resources and allow management of wetlands for emergent vegetation. The hydrology improvement measures are designed to reduce the time in which water travels throughout the study area, thereby reducing the number of days to drain and fill. Inundation duration during the growing season is a limiting factor for hard mast species in floodplain forest (i.e. <21 days), and also impacts diversity and survivorship of moist-soil species.
4) **Methodology:** The surface water hydrology will be assessed by determining whether target water levels can be achieved in <10 days in the study area after flood events caused by overtopping of berms or from upland runoff.

The specific yearly guidelines are set annually based on unit conditions and management needs and therefore may vary across years. The ability to reach target water levels is dependent on Illinois River water elevations, and therefore functional assessment of water level management may not apply to all flood events.

Hard mast planting areas will be assessed annually to estimate total number of days inundated during the growing season (i.e. <21 days) to ensure proper species selection occurred. Survival as assessed in the tree planting category would also be used to assess hydrological improvements and forestry measure success.

5) Success Criteria:

Criterion 1: Berm modification measures will be considered successful if the study area is able to drain/fill in ≤10 days.

Criterion 2: Water Control structure modifications will be considered successful if the study area is able to drain/fill in ≤10 days.

Criterion 3: Tree planting sites inundated for less than 21 days of growing season annually and >75% survival will be considered appropriate for hard-mast plantings.

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.** Regular and reoccurring inability to drain/fill the study area in 10 days.
- **b.** If areas planted with hard-mast species are flooded for over 21 growing season days on average more frequently than anticipated, then the area will be replanted in species with greater flood tolerance.

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

Documentation, Reporting, and Coordination. The District 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. The first performance evaluation report will be completed approximately 5 years after Project completion and evaluate which Project goals and objectives have been achieved, which are progressing towards targets, and which may require adaptive management measures to be fully successful. The final performance evaluation report will be completed approximately 10 years after Project completion.

Cost. The costs associated with implementing MAM measures were estimated based on 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 AM 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 USFWS will be responsible for monitoring berm functionality, structure capacities, well water availability for the study area, and emergent wetland vegetation monitoring. The sponsor and USACE will be responsible for tree planting and TSI monitoring, 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 O&M into the future

6 REFERENCES

USACE. 2012. Upper Mississippi River Restoration Environmental Management Program Environmental Design Handbook, U.S. Army Corps of Engineers, Rock Island District, Rock Island, IL