Grand River Ecosystem Restoration Study

Final Integrated Feasibility Report and Environmental Assessment

Appendix L: Monitoring, Adaptive Management, and Operations & Maintenance Plan

October 2020

US Army Corps of Engineers ®
Kansas City District

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ACRONYMS

AM	Adaptive Management
CE/ICA	Cost Effectiveness / Incremental Cost Analysis
CFS	Cubic Feet per Second
CY	Cubic Yard
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
FG	Fountain Grove
FWP	Future With Project
FWOP	Future Without Project
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center, River Analysis System
HH	Hydrology & Hydraulic
IG	Implementation Guidance
LC	Locust Creek
LIDAR	Light Detection and Ranging
MDC	Missouri Department of Conservation
MoDNR	Missouri Department of Natural Resources
NER	National Ecosystem Restoration
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
O&M	Operation and Maintenance
OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
PGN	Planning Guidance Notebook
P&S	Plans & Specifications
QHEI	Qualitative Habitat Evaluation Index
RGC	Railroad Grade Control
SDB	Sediment Detention Basin
TSP	Tentatively Selected Plan
UBEC	Upper Basin Erosion Control Sites
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
WRDA	Water Resources Development Act
YC	Yellow Creek

REFERENCES

USACE 2000	Planning Guidance Notebook
EPA 2006	Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)
WRDA 2007	Implementation Guidance for Section 2039 of the Water Resources Development Act
USACE 2009	Monitoring of Ecosystem Restoration
USACE 2017	Implementation Guidance for Section 1161 of the Water Resources Development Act
MDNR 2018	Missouri Rapid Assessment Method for Wetlands Operation Manual

1.0 INTRODUCTION

This appendix presents the Monitoring, Adaptive Management (AM), and recommended Operation and Maintenance (O&M) features, processes and actions to be used with the U.S. Army Corps of Engineers (USACE) portion of the proposed Grand River Ecosystem Restoration Project. Based on results of the feasibility study, the overall Federal project includes recommended restoration actions in the upper basin, within Pershing State Park, at the Fountain Grove Conservation Area, and on U.S. Fish and Wildlife Service (USFWS) property at the Swan Lake National Wildlife Refuge (NWR). This plan will cover restoration features and actions to be implemented by USACE and the Non-Federal Sponsors in the upper basin, at Pershing State Park, owned by Missouri Department of Natural Resources (MoDNR), and in the Fountain Grove Conservation Area, owned by Missouri Department of Conservation (MDC). The USFWS would implement similar AM and O&M actions at the Swan Lake NWR.

This plan presents the initial framework for the above project areas and will also continue to evolve as the Grand River Ecosystem Restoration Project progresses into future levels of design and construction. As the project evolves, details associated with recommended monitoring metrics, performance criteria, and AM/O&M actions will also be refined in collaboration with the Non-Federal Sponsor, as well as per requirements issued in any of the project's environmental permits. Therefore, this draft plan should be considered as a living document that will be revised as necessary during project design, throughout construction, and throughout the 50-year period of analysis to improve ecosystem performance and minimize risks.

2.0 USACE GUIDANCE

Monitoring and AM guidance for USACE projects was detailed in Engineering Regulation 1105-2-100 and Planning Guidance Notebook (PGN) (USACE 2000). Since then, Implementation Guidance (IG) for Section 2039 of the Water Resources Development Act (WRDA 2007), Monitoring of Ecosystem Restoration (USACE 2009) was issued and supersedes the 2000 guidance. In addition, the IG for Section 2039 of 2007 was replaced by the IG for Section 1161 of WRDA 2016, dated 19 October 2017. This Monitoring, AM, and O&M Plan was developed based on the 2017 guidance as well as language in the PGN, Appendix C, Environmental Evaluation and Compliance. The 2017 guidance states that a plan for monitoring ecological success must be included in the decision document. The plan must include the rationale for monitoring, the criteria needed for success, identify key project-specific performance parameters, and determine when AM or O&M actions are required to achieve desired outcomes.

For planning purposes, a 50-year period of analysis was used for the Grand River Ecosystem Restoration Project to estimate AM and O&M costs. Based off guidance, the duration of cost-shared monitoring and AM will be based on a determination of "ecological success" of the project (USACE 2017) and cannot exceed 10 years. The non-Federal responsibility for Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) activities for structural and non-structural project measures will continue as outlined in the OMRR&R Manual for the project. Therefore, depending on future outcomes and project performance, some monitoring and AM actions may no longer be required following ecological success determinations. However, it is extremely important to note that due to the nature of the Grand River Ecosystem Restoration Project as a structural project designed primarily to reduce sedimentation and woody debris inputs from upstream sources, that long-term Non-Federal Sponsor OMRR&R activities will likely be needed to maintain project performance even after ecological success determinations have been made and the 10-year cost-shared monitoring and AM period has expired. The Kansas City District USACE and Non-Federal Sponsors developed the proposed monitoring, AM, and OMRR&R actions, projected costs and schedules as identified in this report; with the understanding that information will be further developed in the following project phases and in the OMRR&R Manual.

All proposed project features of the Grand River Ecosystem Restoration Project are considered structural in nature and are required to achieve and maintain ecological success by reducing future floodplain sedimentation, in-stream aggradation, avulsions, and woody debris inputs within the three project areas. No non-structural or non-mechanical features such as constructed wetlands, tree plantings, grass-seeding or other similar project components are part of the project areas. As issues are addressed with the proposed structural project components, the ecosystem and associated habitats are projected to increase in quality and quantity without the need for non-structural restoration actions. However, if these structural project features are not properly monitored, maintained, and operated into the future, then restored habitats may be lost to future flooding, sedimentation, avulsions, and logjams. Further guidance for Non-Federal Sponsor responsibility for OMRR&R will be further outlined in the OMRR&R Manual for the project, which will be developed based on information from the Feasibility Report and as project plans, specifications and construction details are developed.

Based on the USACE PGN, total project monitoring costs shall not exceed 1% of the total first cost of ecosystem restoration features. Monitoring costs shall be included in the total project costs and cost shared with the Non-Federal Sponsor. The cost of required AM actions will be limited to 3% of the total project cost excluding monitoring costs, and cost shared with the Non-Federal Sponsor. Locust Creek has an estimated $82M total first cost of ecosystem restoration features (not including the AM Costs). Fountain Grove has an estimated $32M total first cost of ecosystem restoration features (not including the AM Costs). This results in an approximate total monitoring budget of $820K for Locust Creek and $320K for Fountain Grove. The AM budget for Locust Creek is approximately $2.46M, and $1.00M for Fountain Grove. Any required monitoring, AM, or O&M costs at the Yellow Creek study area would be the responsibility of the USFWS.

3.0 PURPOSE OF THE PLAN

The overall purpose of the plan is to provide a structured, iterative process for decision making to ensure continued ecological success of proposed restoration measures and actions. This success is measured by establishing monitoring metrics and performance targets that are specifically tied to restoration goals and objectives. The plan would also identify what additional monitoring, AM actions, and/or O&M requirements are needed if performance targets are not met. Secondary goals of the plan are to monitor, modify, and adjust existing project features to avoid costly repairs, minimize long-term O&M costs, and advance the science and knowledge of the Grand River ecological system.

The plan is comprised of monitoring, AM, and O&M phases (**Table 1**) that are interrelated and required to optimize short-term and long-term wet prairie, emergent wetland, hardmast forest, and aquatic riverine habitat restoration goals and objectives. Project monitoring, AM, and O&M would be conducted at different frequencies over the period of analysis. Monitoring and AM actions would be cost-shared and included in total project costs to optimize project performance from Year 0 through Year 10. Year 0 would document baseline conditions prior to initiation of construction activities. Year 1 assessments could also be conducted to document baseline conditions after completion of construction. Follow-on assessments through Year 10 could be compared to Year 0 and Year 1 conditions to identify development and change in project features and habitat. Actions required to maintain project performance after Year 10 should be considered as an OMRR&R requirement and would be the responsibility of the Non-Federal Sponsor. Due to phased construction activities and different construction completion dates, proposed project features and areas will likely have different starting and ending dates for the AM and O&M periods.

Table 1. Monitoring, AM, and O&M Project Framework.

Project Phase	Length of Time	Description	Funding
Monitoring	Year 0-10	To determine the degree to which the project components are or are not meeting the success criteria and project performance targets. Would help inform the need for potential AM decisions. Based on guidance, monitoring actions will be continued until ecological success is determined. Once ecological success has been documented by the District Engineer in consultation with federal and state resource agencies, and a determination has been made by the division commander that ecological success has been achieved (which may be less than ten years), no further monitoring will be required. Ecological success will be documented through an evaluation of the predicted outcomes as measured against the actual results. The law allows for but does not require a 10-year cost shared monitoring plan. Necessary monitoring for a period not to exceed 10 years will be considered a project cost and will be cost shared as a project construction cost and funded under construction. Costs for monitoring beyond a 10-year period will be a non-federal responsibility.	Project Cost Shared
Adaptive Management	Year 1-10	Provides a process for making decisions in the face of uncertainty and learning from outcomes of management actions; may improve the performance of a designed construction measure that is not meeting performance criteria and targets. If needed, structural project components can be modified as outlined in the AM actions to optimize sediment/woody debris capture and retention, provide required downstream flows, reduce flooding impacts, and thereby improve ecosystem form and function. The proposed AM actions are recommended to maintain project performance during the first 10 years of the project and identify any actions that should be continued as O&M actions to maintain long-term project performance.	Project Cost Shared
Long-Term OMRR&R	Beyond Year 10	Long-term project operation and maintenance requirements needed to maintain day-to-day project performance and success. Some OMRR&R actions may be required at Year 1. Other actions to include continued monitoring may be needed to inform long-term O&M and AM decisions after Year 10. Based on guidance, ten years after ecological success has been determined, the responsibility of a non-federal sponsor to conduct OMRR&R activities on nonstructural and nonmechanical elements of an ecosystem restoration project (or component of a project) will cease. Since the Grand River Ecosystem Restoration Project features are all structural or mechanical in nature, this guidance is not applicable. OMRR&R of structural and mechanical elements of an ecosystem restoration project (or component of a project) will continue as outlined in the OMRR&R Manual for the project. The long-term risk to ecological success, sustainability, and function if structural or mechanical project features are not maintained is very high due to continued upper basin inputs of sediment and woody debris.	Non-Federal Sponsor

4.0 STUDY AREAS

This section provides a brief summary of the study areas, problems, goals, objectives, and recommendations from the Grand River Ecosystem Restoration Feasibility Study. Please see the main report text and **Appendix D**, Habitat Evaluation and Quantification, for additional information regarding the ecosystem problems and key habitats that were modeled. Please see the main text and **Appendix G**, Plan Formulation and Cost Effectiveness / Incremental Cost Analysis (CE/ICA), for additional information regarding the assessment of proposed restoration measures, identification of the Tentatively Selected Plan (TSP), and Recommended Plan selection.

The Grand River Ecosystem Restoration Study was authorized by the 108th Congress 2nd Session on 23 June 2004. The overall purpose of the Grand River Ecosystem Restoration Study is to identify a plan that contributes to the

National Ecosystem Restoration (NER) objective, reverses ecosystem degradation trends, and achieves ecosystem lift by increasing the net quantity and/or quality of desired ecosystem resources.

The geographic scope of the study authorization includes the entire Grand River Watershed (**Figure 1**). The watershed drains approximately 7,900 square miles in north central Missouri and southern Iowa. Following discussions with study sponsors and in consideration of schedule and budget, the study focus was narrowed to the Lower Grand River Watershed (**Figure 2**). This area is referred to as the detailed study area and consists of Pershing State Park, Fountain Grove Conservation Area, Swan Lake NWR, Yellow Creek Conservation Area, and surrounding public and private lands. Monitoring, AM and O&M activities will only be conducted on real estate interests the non-federal sponsor owns in fee or is acquiring for the proposed recommended plan actions.

Figure 1. Location of the Grand River Watershed, Missouri and Iowa.

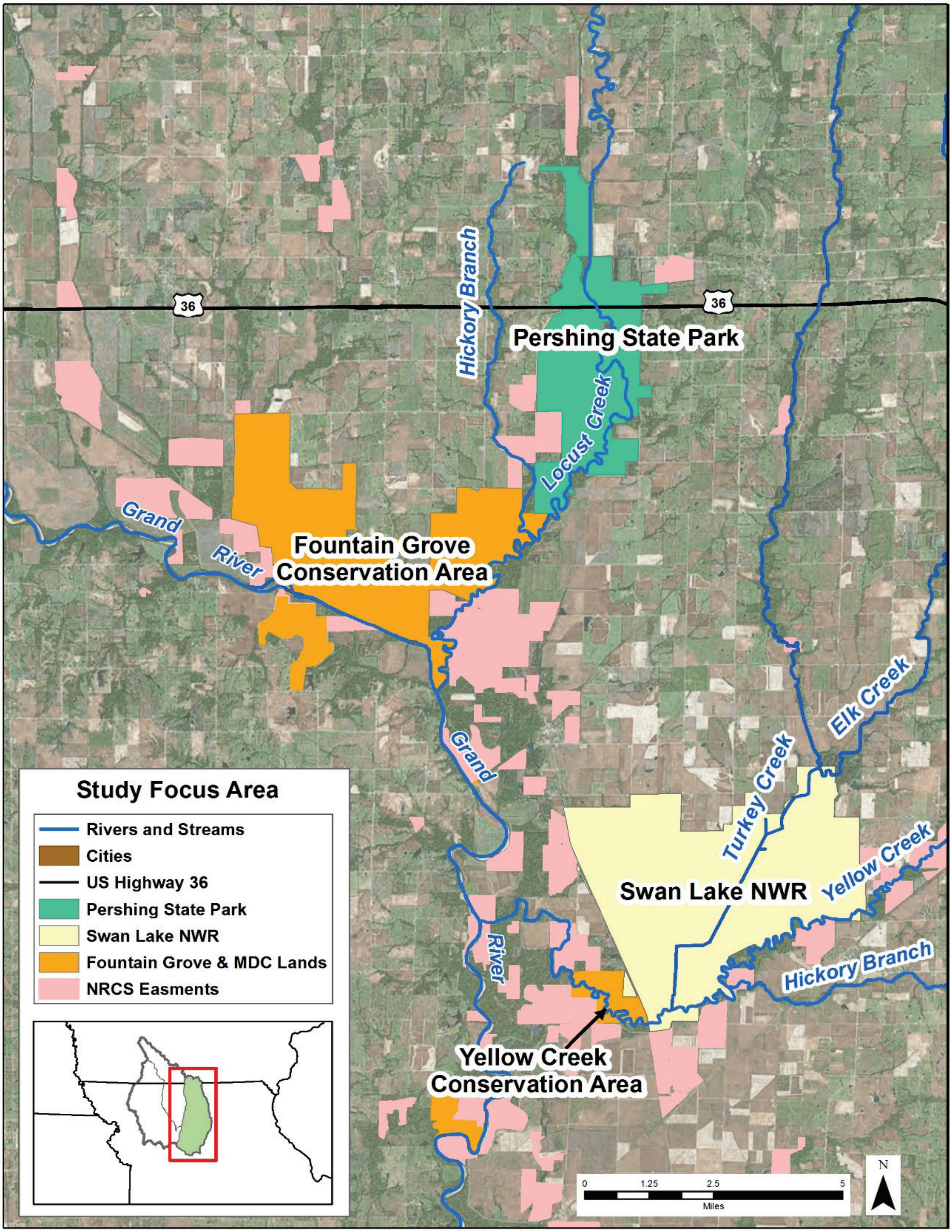

Figure 2. Detailed study areas consisting of Pershing State Park, Fountain Grove Conservation Area, Swan Lake National Wildlife Refuge (NWR), and Yellow Creek Conservation Area.

The Grand River Watershed has been negatively impacted by major land use changes and stream channel alternations since the mid-1800's. These changes have resulted in direct and indirect effects to the natural tallgrass prairie, emergent wetland, bottomland forest, wet prairie, and aquatic riverine habitats of the watershed. Unanticipated consequences of this development have resulted in overall watershed instability with an increase in flood frequency and intensity in recent years. As the watershed has evolved and tried to self-correct, problems manifested in the Lower Grand River Watershed and Locust Creek (LC), Yellow Creek (YC), and Fountain Grove (FG) study areas have included:

- Streambank erosion, loss of riparian vegetation, excessive woody debris, and log jams.
- Aggradation, loss of channel capacity, increased flooding, and increased avulsion potential.
- Floodplain sedimentation, loss of habitat quality/quantity, and reduced habitat value to resident and migratory species.
- Decreased water quality impacts to public/private infrastructure, and reduced recreation value.

4.1 Locust Creek (LC) – Most of the LC study area consists of Pershing State Park, which is passively managed for recreation and wildlife habitat. Additional privately-owned properties and land with Natural Resources Conservation Service (NRCS) easements are located around and adjacent to the park. For all properties within the LC study area, the primary problem to be addressed is excessive sedimentation on the floodplain, which is currently burying existing habitats and converting the existing bottomland hardmast and wetland landscape to a riparian forest and invasive reed canary grass monoculture. Associated issues from sedimentation also include increased aggradation, log jams and high avulsion potential, which has resulted in the de-watering of high-quality aquatic reaches under base flow conditions. See **Appendix D** of the feasibility report for additional information, figures, and photographs of problems within the LC study area.

4.2 Fountain Grove (FG) – Property within the FG study area primarily consists of Missouri Department of Conservation (MDC) managed wetland cells, rotational wetlands, and riparian corridor habitat. The wetlands at FG are managed specifically for migratory waterfowl, shorebirds, and local wildlife species such as fish, reptiles and amphibians. Waterfowl and shorebirds use the wetlands as an important stopover point and food source during their migration seasons. Increased flooding, inundation, and sedimentation have decreased habitat quality and quantity at FG and the ability to effectively manage the system for optimal habitat value. Increased sedimentation from Parsons Creek and Grand River backwater has impacted wetland cell contours by decreasing depth diversity, converting fringe wetland habitat to terrestrial, and impacting existing hardmast forest species. In addition, the current configuration of wetland cells at FG do not allow for independent filling and draining, which impacts management flexibility, the ability to rotate wetland cells, the ability to maximize the quality of edge habitat, and the ability to meet migration timing patterns. The ability to manage all of the wetland cells diminishes during and after flood events. Spring and summer flooding are especially harmful because it hinders the ability to conduct necessary maintenance and plantings that are needed to provide natural habitat quality, quantity, and diversity. See **Appendix D** of the feasibility report for additional information, figures and photographs of problems within the FG study area.

4.3 Yellow Creek (YC) – The YC study area primarily consists of managed habitat on USFWS NWR lands at Silver Lake and Swan Lake, private property developed for agriculture, and NRCS easements (i.e., Wetlands Reserve Easements, ACEP-WRE). Within the YC study area, the primary issue is high inundation extents, durations and depths, which have resulted in continual poor hardmast recruitment and long-term declines in hardmast forest health and coverage. Some sedimentation issues are also present within the YC corridor below Swan and Silver Lakes, which has also resulted in habitat degradation for emergent wetland, wet prairie, and bottomland forest habitats. See **Appendix D** of the feasibility report for additional information, figures and photographs of problems within the YC study area. Monitoring, AM, and O&M-related actions at YC would be included in future USFWS documentation.

5.0 RECOMMENDED PLAN

The overall purpose of the Grand River Ecosystem Restoration Study is to identify a plan that contributes to the NER objective, reverses ecosystem degradation trends, and achieves ecosystem lift by increasing the net quantity and/or quality of desired ecosystem resources. The overall study objectives at all study areas included:

- Increase quality and quantity of bottomland forest, in-stream aquatic habitat, wet prairie, and emergent wetlands in the Lower Grand River watershed for at least the next 50 years.
- Additional benefits to infrastructure, agriculture, water quality, recreation, and flood risk reduction in association with habitat improvement within the Lower Grand River Basin for at least the next 50 years.

The Recommended Plan for the Grand River Ecosystem Restoration Study includes restoration measures within the Pershing State Park and Fountain Grove Conservation Area (**Figure 3**). In addition, upstream issues and potential actions in the full watershed are also considered and addressed in the feasibility report and Recommended Plan relative to benefits to the Lower Grand River Watershed, particularly for reduced sedimentation and accumulation of woody debris.

5.1 Locust Creek (LC) – LC 15 (see **Figure 4** for proposed measures) was the most effective plan at achieving the LC planning objectives of improving hydraulic connectivity while maintaining floodplain connectivity, reducing sediment deposition on the floodplain, reducing potential for log jams, and increasing habitat quantity and quality within the study area. The Recommended Plan for the LC study area is LC 15.25, which includes LC 15 plan components (**Figure 4**) and up to 316 upstream bank stabilization projects to achieve a 14% reduction in quantified downstream sedimentation risk. Components of LC 15.25 are outlined in **Figure 4** and detailed in Sections 5.1.1 – 5.1.4: Upper Basin Erosion Control (UBEC) sites, a Sediment Detention Basin (SDB), Railroad Grade Control (RGC), and LC restoration measures located below Highway 36.

5.1.1 Upper Basin Erosion Control Sites (UBEC) – An estimated number of up to 316 UBEC sites were identified through a risk-based analysis that is further described in the main text of the Feasibility Report and Appendix D. The implementation of up to 316 upper basin erosion control sites would be conducted to address the primary source of sedimentation to the lower basin and Pershing State Park. UBEC actions would consist of erosion control measures that are specific to the extent of the problem, available lands, and any upstream/downstream resources (i.e., bridges, infrastructure, etc.). It is anticipated that structural measures such as native rock rip rap, bench cuts, bank sloping, tree revetments, and native plantings would be utilized to reduce streambank erosion and inputs of sediment to the stream system.

It is likely that other resource agencies, their projects, and site specific erosion control and prevention actions would be implemented over the next 50 years to further reduce downstream sedimentation risk, ensure downstream habitat benefits, restore upper basin habitat values, reduce losses to agricultural lands, improve water quality in the basin, and ensure longevity of the SDB.

5.1.2 Sediment Detention Basin (SDB) – The sediment detention basin is the primary structural restoration feature, within the northeastern portion of the LC study area. The goal of the SDB is to collect and trap sediment and woody debris from upstream sources, thereby reducing detrimental impacts to downstream habitats. Components of the SDB include an upstream structure, a basin pilot channel, spillway, exterior levees, interior levees, SDB outfall, and access roads **(Figure 4).**

The risk of habitat loss or the need for costly dredging of the SDB is higher in later years if sediment loads become worse over time, are consistently much greater than what was originally modeled, or are much higher with extreme flood events. Therefore, monitoring of sediment composition, loads, movement, and deposition are critical components of the LC study area. Adaptive Management features and potential O&M actions that are developed from this knowledge would be important for long-term optimization and management of sediment in the SDB. Evolution of existing avulsion pathways and development of new avulsions would also be important to monitor **(Figure 5**).

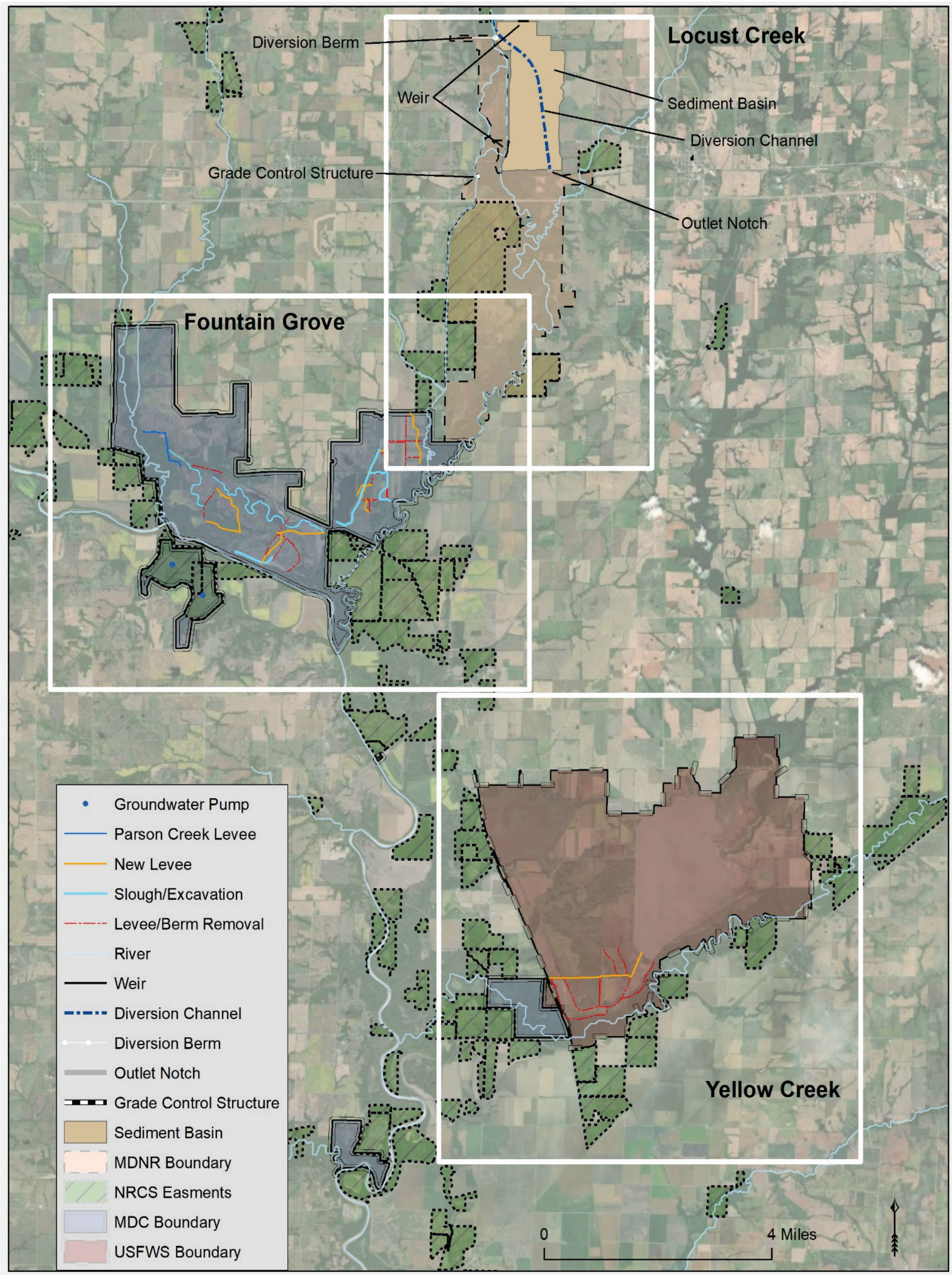

Figure 3. Restoration Measures in the Tentatively Selected Plan at each Study Area.

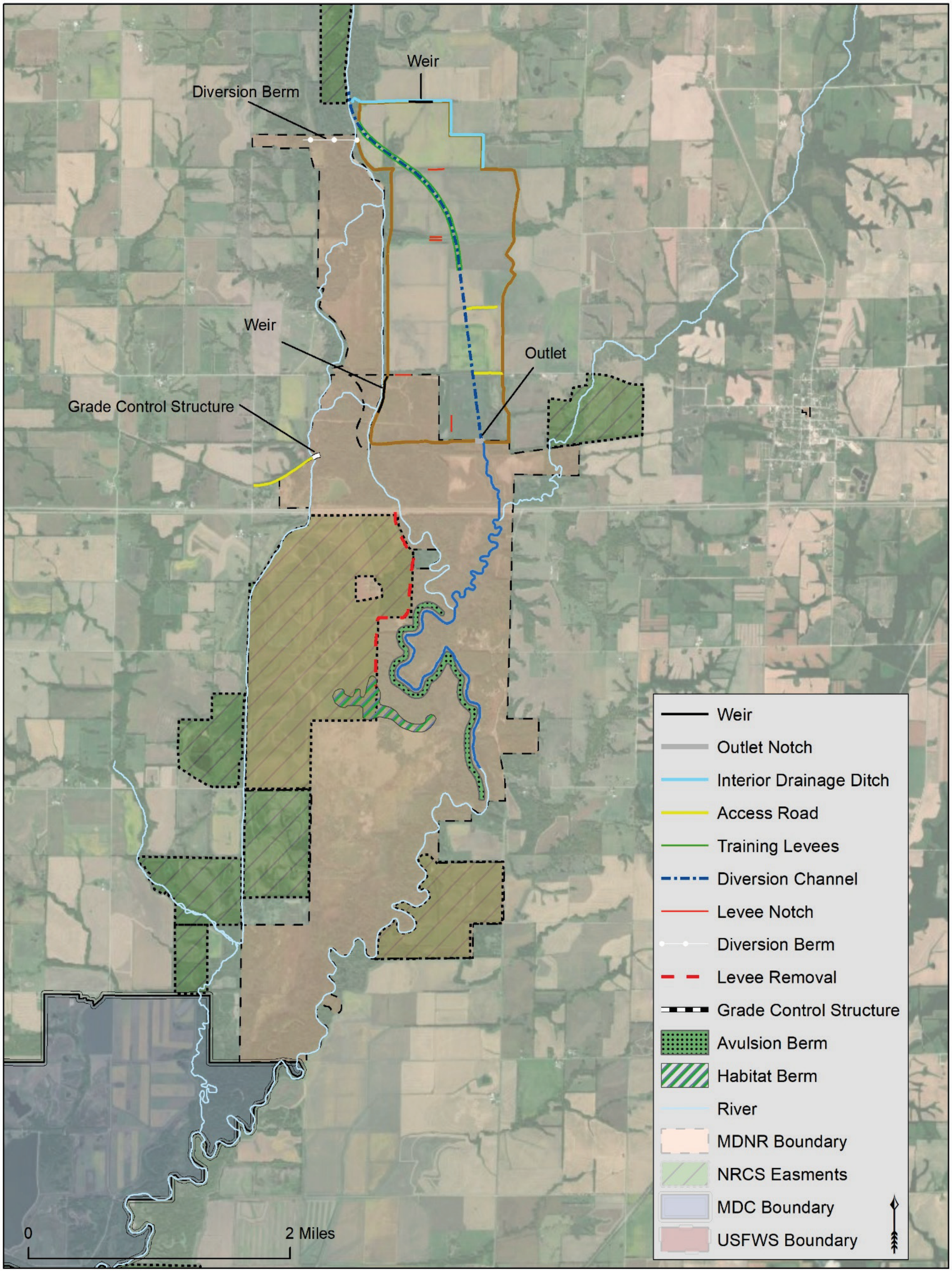

Figure 4. Restoration Measures Within the Locust Creek (LC) Study Area.

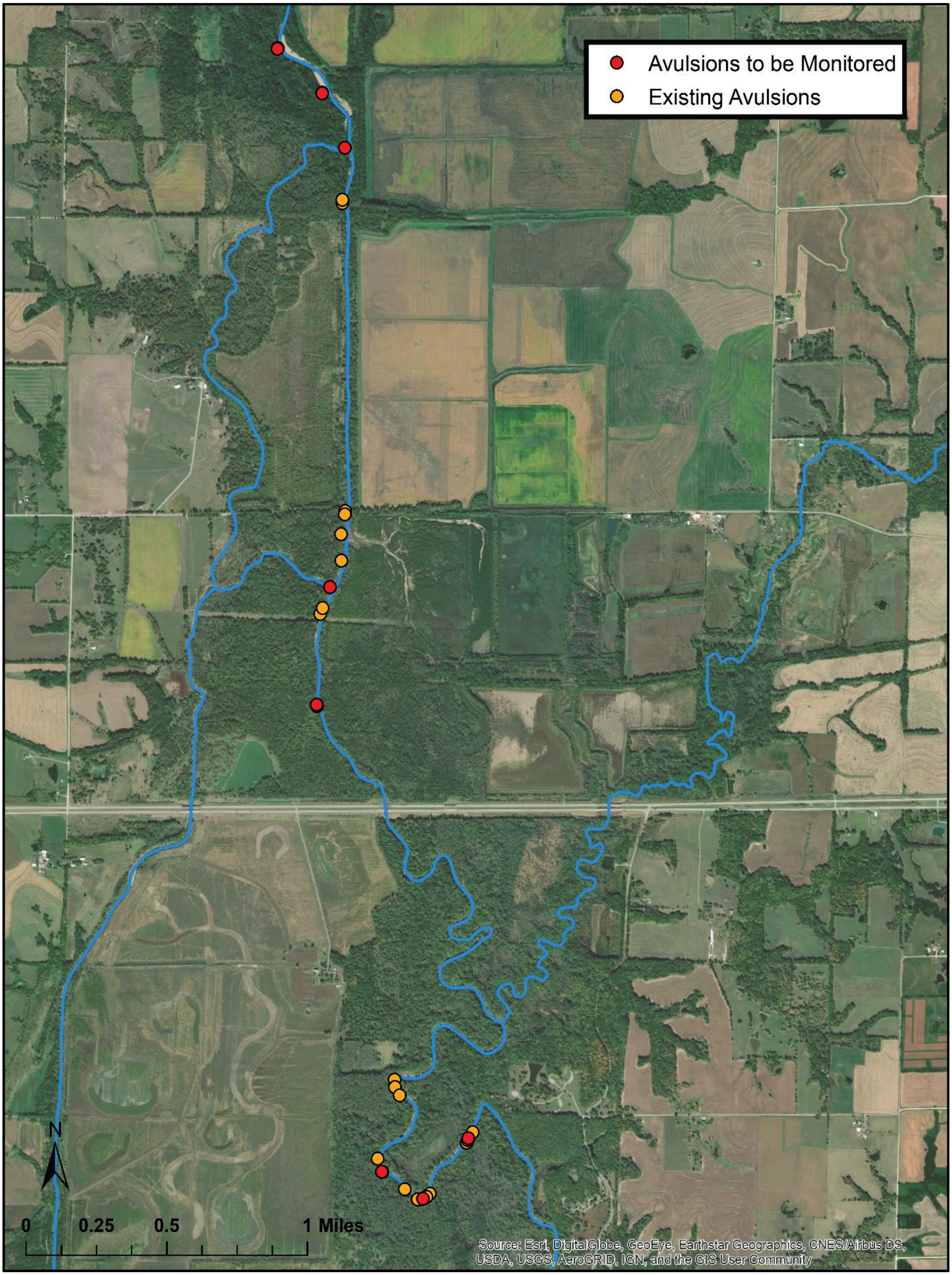

Figure 5. Location of avulsion pathways in the Locust Creek (LC) Study Area.

5.1.3 Railroad Grade Control (RGC) – Another important LC project feature includes the RGC structure. The abandoned railroad berm that runs from Higgins Ditch east to the SDB would be extended, including the existing Higgins Ditch channel, to reduce downstream migration of sediment and woody debris on the western portion of the LC floodplain **(Figure 4).**

Monitoring of sediment deposition on the western portion of the LC floodplain would be important to assess changes in water storage capacity and potential future flooding to adjacent and upstream properties. Adaptive management, such as notching the RGC or O&M actions such as dredging, would be examples of available future actions that could be used if needed. Habitat on the western floodplain and above Highway 36 has been severely impacted by sedimentation and would continue to be impacted as future sediment deposits. Monitoring of existing habitat types and associated species that are tolerant of flooding and high amounts of sedimentation may still be valuable to understand species tolerances and thresholds to these types of disturbances.

5.1.4 Locust Creek (LC) Restoration Below Highway 36 – Base flows would be restored to the LC channel, located below Highway 36 and the proposed SDB outfall. High water events would discharge excess flows through the SDB spillway into LC above Highway 36. To increase channel conveyance for base flows and maintain structural performance, the lower portion of Muddy Creek and the LC channel below Highway 36 would be dredged (**Figure 4**).

The habitat types located below Highway 36 are largely intact and have relatively high quality, form and function. The proposed SDB and RGC project features above Highway 36 would help preserve and restore emergent wetland, wet prairie, and bottomland hardwood habitats that are currently being impacted by excess flooding and sedimentation. Base flows would be restored to LC from Highway 36 to the confluence with Hickory Branch. Monitoring the potential change in sedimentation and habitat quality and quantity below Highway 36 would be important as detrimental effects are reduced. There may also be opportunities for expansion and establishment of habitat through more traditional approaches such as land contouring, invasive removal, and plantings that would have previously been subject to these same detrimental effects.

5.2 Fountain Grove (FG) – The Recommended Plan for the FG study area is FG 37.5 (**Figure 6**), which was the most effective plan at achieving the FG planning objectives of maximizing management capability, providing operational ability to drain water efficiently from the site, limiting sediment deposition on the site, and increasing the quality and quantity of emergent wetlands and bottomland hardwoods.

The FG 37.5 plan includes restoration measures within East FG, West FG, and South FG that consist of levee modifications, groundwater pumps, water control features, and microtopography work. Plan components of FG 37.5 are outlined in **Figure 6**, and described further in Sections 5.2.1, 5.2.2 and 5.2.3 below.

5.2.1 East FG – Includes a setback of the existing East FG levee to reduce future damage and failure due to Hickory Branch flows. Microtopography work would increase emergent wetland habitat quality in existing wetland cells. Would also include infrastructure improvements to existing water control feature, channels, and berms to improve the flow of water and decrease long-term O&M costs **(Figure 6).**

5.2.2 West FG – Several restoration measures were identified for the West FG study area to improve emergent wetland and bottomland hardmast habitat quality and quantity, reduce negative effects from flooding and sedimentation, improve independent wetland cell utility, and decrease long-term O&M costs. Improvements to existing infrastructure would include new water control structures, abandoned railroad berm removal, channel excavation, levee modifications, and new drainage ditches. Microtopography work would create new boat lanes and improve habitat quality in slough areas (**Figure 6**).

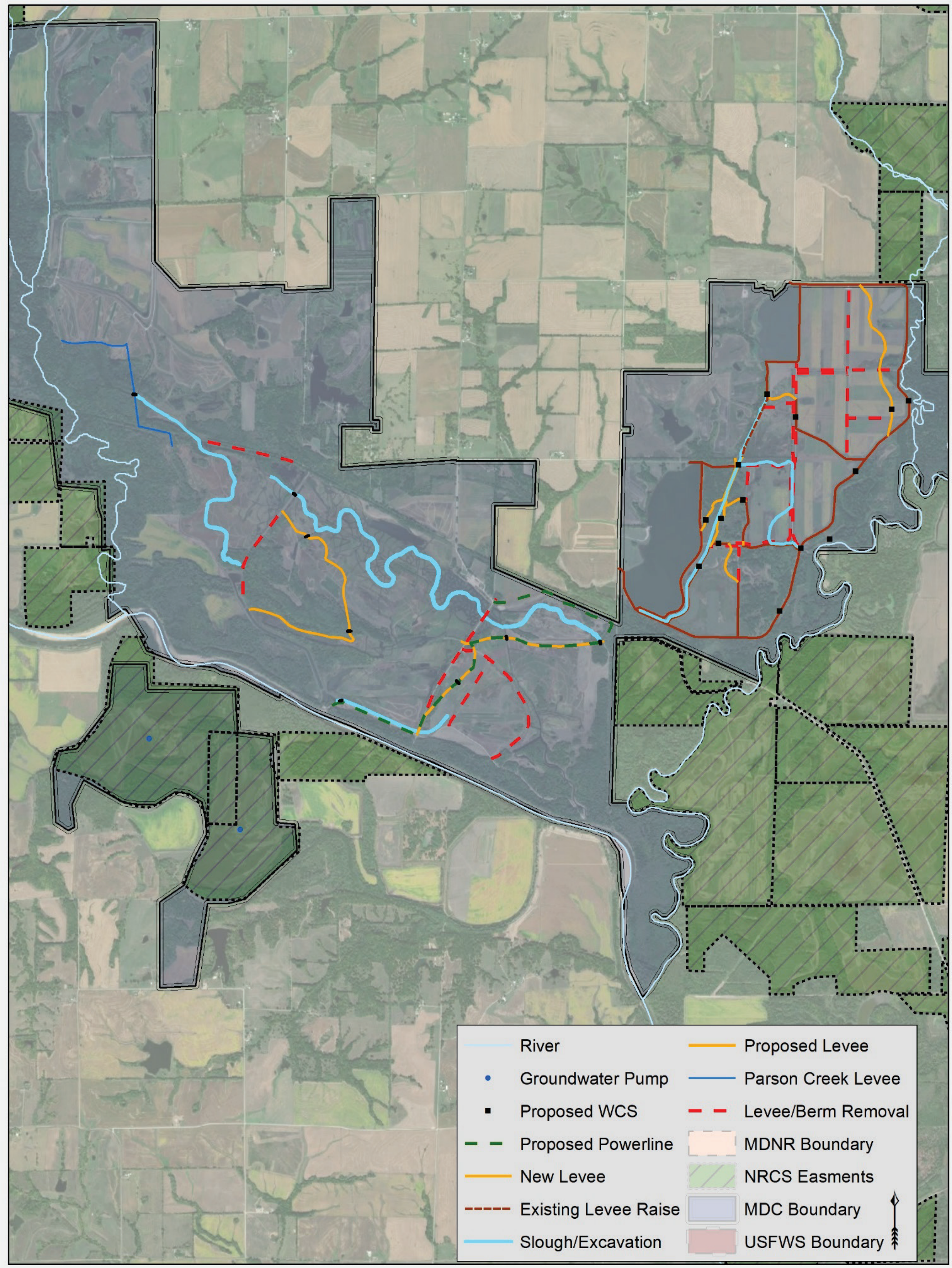

Figure 6. Restoration Measures Within the Fountain Grove (FG) Study Area.

5.2.3 South FG – Would include the installation of groundwater pumps to provide a consistent and reliable source of water for existing emergent wetland cells. Electrical lines from the existing West FG pump station would be installed to provide power to the groundwater pumps (**Figure 6**).

5.3 Yellow Creek (YC) – The Recommended Plan for the YC study area is YC 11, which includes a levee setback on the USFWS Swan Lake NWR levee (Area D). Setback Area D also includes stabilization of an adjacent levee and removal of some existing infrastructure (**Figure 7**).

5.3.1 USFWS Levee Setback – Habitat within setback Area D would remain relatively the same but would move from being levee protected, managed habitat to riverward land that is more susceptible to YC flows. The setback would help reduce backwater and sedimentation effects that are driving degradation of nearby bottomland hardmast trees, agricultural lands, and Swan Lake NWR infrastructure.

The USFWS would develop the decision tree and details associated with monitoring, AM, and O&M for the YC study area. Actions may include monitoring and inspection of the levee setback area, long-term Light Detection and Ranging (LIDAR), drone aerial photography, and habitat assessments.

6.0 TYPES OF PROJECT MONITORING AND INSPECTIONS

Per Section 1161 of WRDA 2016, upon completion of construction of an ecosystem restoration project (or component of a project), monitoring for ecological success will be initiated to determine project ecological success. "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 AM measures are necessary to ensure that the project will attain project benefits." This section summarizes the resource monitoring, inspections, and data collection recommendations. Due to the complexity, high level of unknowns, and structural nature of the project, it is recommended that monitoring occur for 10 years following construction to determine the degree to which the project is meeting success criteria and for informing potential AM decisions. Any long-term performance reporting would commence following the 10-year monitoring and AM period. Long-term performance monitoring would be conducted by the Non-Federal Sponsor beyond Year 10 to continue to help meet project success criteria, inform any needed O&M adjustments, and provide basic data for long-term planning purposes. The OMRR&R actions that are necessary after the determination of ecological success and/or beyond Year 10 are outlined in Table 7 below, and will be further described in the OMRR&R Manual as a non-Federal responsibility. Additional details on monitoring and AM are provided in **Section 9.0**, **Tables 2 and 3**, and in **Attachment A**.

Monitoring typically consists of periodic inspections and observations of restoration features and key project areas to check the function, progress, or quality of the feature or area over a defined period. Monitoring information provides critical data and information for use in the AM and O&M decision making processes. The Grand River study areas are expected to be dynamic and evolve over time due to natural precipitation variability in the watershed, evolution of the upper basin, and from proposed restoration features. Establishment of strict parameters and predetermined "performance standards" may not necessarily predict the success or reveal the failure of proposed restoration efforts. Project monitoring and evaluation should focus on determining whether the overall project objectives are being satisfied. Most of the monitoring data and results would help assess the unpredictable evolution and development of project sites. Only some of the monitoring efforts and associated AM measures would be based on specific performance targets and thresholds. All monitoring and inspections would be performed by qualified scientists and engineers.

6.1 Short-Term Monitoring – Would be conducted annually or multiple times, including after significant runoff events, during the first five years of the analysis period. This type of monitoring would be used to confirm or contradict the anticipated performance of key restoration features and areas, with the intent to identify any major issues or problems early in the analysis period. A portion of this period may also be

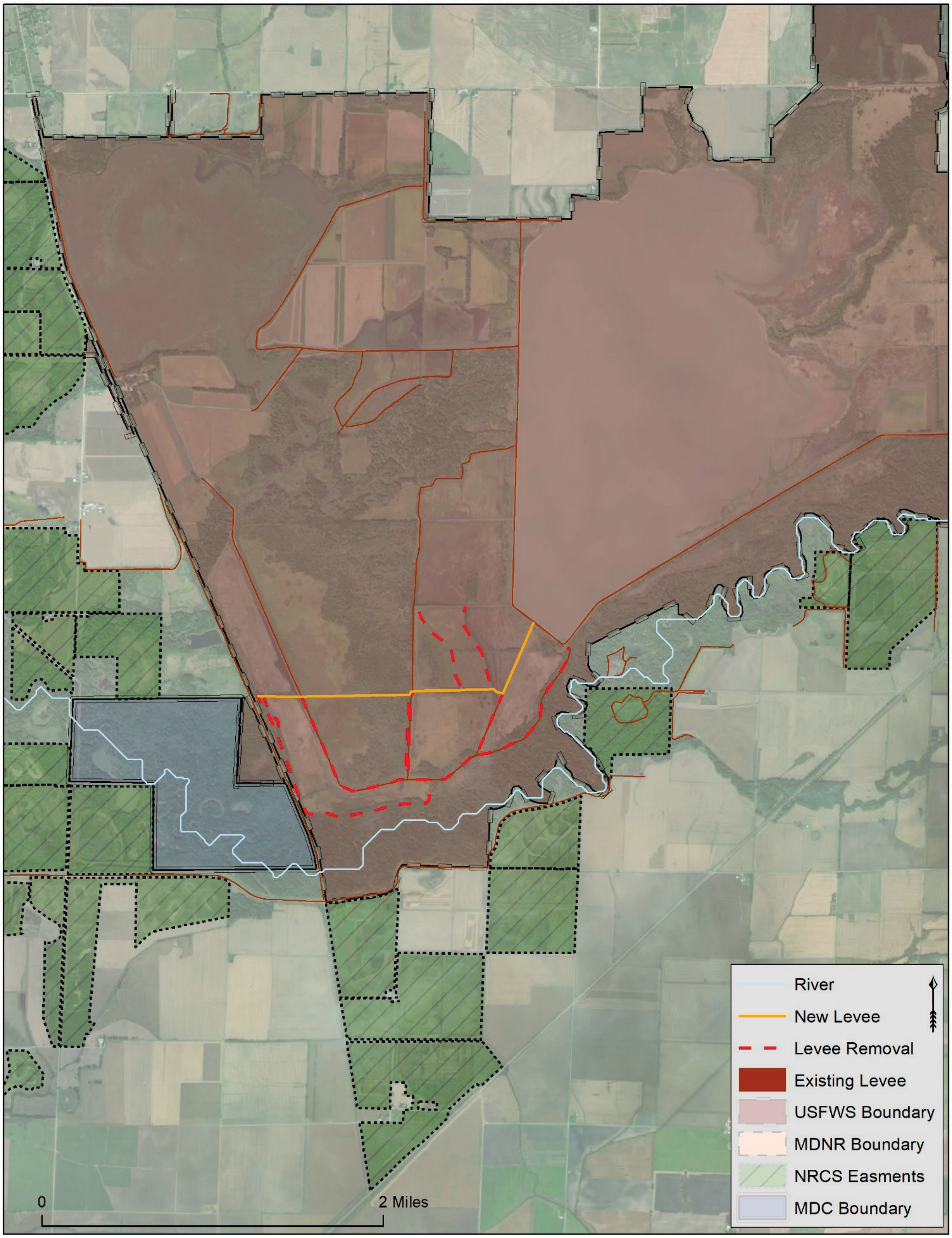

Figure 7. Restoration Measures Within the Yellow Creek (YC) Study Area.

considered as the warranty period of the project, where major issues in design or constructed-related issues may be cost-shared or the responsibility of the construction contractor. Methods to collect short-term data would include field site inspections, collection of existing gauge data, use of sampling probes at key locations, and measurements at existing hydraulic cross sections. Short-term monitoring within the study areas may include:

- UBEC sites would be assessed for stability, with the intent to monitor and inspect all sites within the first 10 years of the analysis period and following major runoff events during the AM period. Due to phased construction activities and different construction completion dates, proposed UBEC sites will have different starting and ending dates for the 10-year AM and long-term O&M periods.
- For the LC study area, existing hydraulic cross-sections, topography, turbidity sondes, and gauge data would be assessed with short-term monitoring in key areas and reaches to include above and below the LC flow diversion structure, within the SDB, above/below the SDB spillway, below the SDB outfall, within Higgins Dich below the existing avulsion, at the Higgins Ditch RGC, and in reaches with existing avulsions.
- For the FG study area, key features and areas that should be inspected include the levee setback area, exterior levees, water control structures, and outlets to the Grand River.

6.2 Long-Term Monitoring – Would be conducted at 5-10-year increments over the analysis period. This type of monitoring would be used to assess long-term trends or shifts in the performance of the project, with the intent to make minor adjustments to routine operations in order to achieve long-term habitat goals or avoid future risks. For example, the LC SDB outfall may be modified by narrowing or widening existing notches with the addition or removal of rock riprap to increase or decrease downstream flows and sedimentation, which in turn could affect long-term floodplain sedimentation, downstream channel morphology, and quality of habitats. These types of outfall modifications would be used to affect the long-term performance of the SDB and optimize downstream flows and channel conditions. It is anticipated that these outfall modifications would be needed infrequently after major flood events or following collection of several years of monitoring data that indicates that a modification is necessary.

Methods would include field assessments at established habitat monitoring locations, measurements at existing hydraulic cross sections, collection of existing gauge data, use of sampling probes at key locations, use of LIDAR data, and review aerial drone mapping.

For all study areas, wet prairie, emergent wetland, bottomland forest, and aquatic riverine monitoring sites would be established to assess changes in habitat quality and quantity. Forest recruitment and survival would be assessed for short-term changes in bottomland hardwood and riparian riverfront forests. Aquatic riverine habitat features, such as instream habitat (rootwads, aquatic vegetation, woody debris, etc.) would be assessed for potential short-term changes; habitat features, such as channel width, depth and sinuosity, likely evolve over longer periods of time and could be sampled less frequently. Long-term sampling would be used with short-term monitoring for up to seven different times over the analysis period. Short-term and long-term monitoring results may also dictate the need for more or less sampling in subsequent years pending data results.

- Year 0 (baseline, just prior to initiation of project construction)
- Year 1 (baseline, just after completion of project construction)
- Year 5
- Year 10
- Year 25
- Year 35
- Year 45

6.3 Event-Based Flood Monitoring – Would be conducted at key project locations during and after certain magnitude flood events. The primary intent of this type of monitoring would be to allow assessment of net change in habitat or project features following a flood event; to obtain real-time flood data for refinement of existing flows, movement of woody debris, and sediment; and to decrease risk and optimize project performance through refinement of project operations prior to, during, and following a flood event. Potential event-based flood events include:

- 2 Year Event
- 5 Year Event
- 10 Year Event
- 50 Year Event
- 100 Year Event

7.0 ADAPTIVE MANAGEMENT (AM) CONSIDERATIONS

For the Grand River Ecosystem Restoration project, AM actions are considered between Year 0 and Year 10 along with monitoring data to fine-tune and optimize the performance of the project structural components. AM can be structured actively and/or passively to accrue information that is needed to reduce uncertainty, aid decision making, and improve long-term management outcomes. Both approaches depend on the previously described monitoring framework to collect data that must be interpreted to determine future management steps or actions.

7.1 Passive AM – Is more reactionary and typically involves monitoring (with or without implemented actions) to identify unknowns in a system with a high degree of uncertainty. Most of the AM for the Grand River Ecosystem Restoration study would be centered around passive data collection to help fine-tune and adjust project features for optimal performance over the analysis period. Routine collection of stream bank erosion data at Upper Basin sites followed by an AM decision to increase riprap armoring due to excessive erosion trends would be an example of passive AM.

7.2 Active AM – Includes measures that are typically proactive and designed around a hypothesis to address known unknowns in a system and determine if an assumed outcome is correct or not. The outcome may not necessarily be negative to project goals and objectives and therefore require an AM action. If an outcome is negative and AM is needed, additional research steps may be needed to identify an appropriate solution. An example of active AM would be to collect data in a specific location as part of a field research study to help identify unknows associated with invasive vegetation rates and types. The data would help identify future management needs relative to the identified species and levels of invasion.

Potential active AM measures for the Grand River Ecosystem Restoration study could include hypotheses associated with the evolution of the SDB (i.e., habitat conversion from row crop to a more natural ecosystem); the implementation of pilot projects to assess their effectiveness (i.e., bed-load sediment collectors); or the factors that are important to the formation and location of log jams. Like passive AM, a decision tree can be established based on the results of the studies. Data would be collected to help answer the hypotheses, and depending on the results, several follow-on actions could occur: 1) additional study/modeling to further address the hypotheses, 2) the need for new/revised hypotheses and additional questions/monitoring, or 3) execution of new project measures and associated passive AM.

7.3 AM Decision Tree – Both passive and active AM would have decision trees based on the performance of project features that can be used to identify minor modifications to the project (i.e., adaptive management) to improve or correct on-the-ground results (i.e., project performance). The decision tree would be based on a project feature/location, a performance question, monitoring data, a description of performance based on the data, and when applicable a pre-determined AM decision associated with the data/answer to the question. The decision tree should be specific to the designed features or critical areas, the monitoring data to assess the feature/area, and implementable future adjustments. Pre- and post-mapping of key project features/areas should be used to help demarcate data collection points, reaches, and areas.

The below AM components and generic decision tree is an example of what would be used for the Grand River project. This template would apply to all proposed Grand River monitoring, AM, and O&M actions. Sampling protocols, timelines, and data to be collected would vary depending on the requirements associated with each individual project objective. See **Section 9.0** text and **Attachment A** for detailed information on all proposed Grand River monitoring, AM, and O&M project components.

- **Project Objective –** States the desired objective of proposed restoration measures.
- **Project Location –** The location within each study area of the restoration measure, monitoring site, or habitat to be assessed.
- **Assessment Tools and Metrics –** Identify the technologies to be used for assessment of restoration performance, success, and change. Monitoring and inspection results would be compared over time to determine if restoration features are performing as designed. Standardized field data collection sheets would be developed for all monitoring.
- **Assessment Frequency –** Monitoring and inspections would be conducted at short-term (continually, annually, multiple times in the first 5-10 years), long-term (every 5 to 10 years), and event-based (after 2-year or greater flood events) frequencies by restoration measure, site or habitat type. The number of field trips for out-year assessments (Year 15, 25, 35 and 45) are outlined in Table 7 below, and would be further defined in the OMRR&R Manual, with associated costs and actions a non-Federal responsibility. Only data associated with high-risk sites based on previous assessment data would be collected in out-years.
- **Performance Outcomes and Targets –** Several different potential performance outcomes could occur at project locations and restored sites; requiring different levels of follow-on monitoring, AM, or O&M work. Performance outcomes would be determined by using targets or thresholds that are specific to the restoration measure, site, design standard, and project objective. Potential performance outcomes could include:
    - Acceptable, the project features are performing as designed, no AM is recommended. Continue monitoring as scheduled if the site has a high risk of potential future issues.
    - Acceptable, the project features are performing as designed, no AM is recommended. Discontinue or reduce frequency of monitoring if the site has a low risk of future issues.
    - Inconclusive, only minor issues are identified, or a portion of a site is unacceptable. No AM is recommended but conduct continued or increased frequency of monitoring to determine if performance trends become established.
    - Unacceptable, the project features are not performing as designed, AM is recommended. Continue monitoring to determine if issues are resolved.
- **AM Measures –** If unacceptable project conditions are occurring based on exceeded performance targets, identify the reason for the issue, identify the appropriate AM action(s), implement the corrective action, and continue monitoring to determine if the issue is resolved appropriately.
- **Long-Term O&M –** Long-term O&M, to include continued monitoring, inspections, or corrective actions, would be conducted by the Non-Federal Sponsor following the initial 10-year monitoring and AM period. Similar to the outcomes described for AM, associated O&M corrective actions could include the same four decision pathways as described above. It is the intent that during the first 10-years, that project features and areas needing long-term monitoring, corrective actions, and O&M are identified to maintain long-term project performance.

The main challenge of any AM approach is often finding the correct balance between short-term actions to obtain knowledge and implementation of long-term management actions that meet restoration goals. Another key consideration for a successful AM approach is that it must be flexible and robust enough to deal with systems that have many variables, are constantly changing, have a large degree of unknowns, and typically have highly constrained management options.

The Grand River AM plan identifies proposed actions and procedures to ensure long-term success of the project based on the problems within the Grand River Watershed, the proposed objectives and goals for the three study areas (UBEC sites, LC, FG), and the individual restoration measures identified in the Recommended Plan. Both passive and active AM measures are described within this plan to ultimately improve success of proposed ecosystem restoration measures and ensure long-term management success of key habitat types (wet prairie, emergent wetland, aquatic riverine, and hardmast forest).

The Grand River AM framework was developed based on existing data, perceived existing/future risks, anticipated future monitoring information as outlined above, and budgetary constraints. Project decision trees by objective are provided in **Attachment A**, which identifies recommended courses of action pending potential future outcomes. Due to the high level of uncertainty, it is anticipated that the AM process would be adjusted as the project matures and foreseen and unforeseen events and outcomes occur; this includes potential changes and modifications to the above decision tree and associated performance targets, metrics, and AM measures. The high degree of proposed monitoring, inspections and future data collection should help reduce overall risk and project uncertainty.

8.0 OPERATION & MAINTENANCE (O&M) ACTIONS

The Non-Federal Sponsor is responsible for all long-term project OMRR&R. Some actions may be needed following initial construction, such as gate operations, routine equipment maintenance, and required vegetation management. Some actions may be the responsibility of the construction contractor, such as vegetation warranty periods, then become the responsibility of the Sponsor when they expire. Other actions may be identified for continuation following the initial 10-year monitoring and AM period, such as sediment monitoring. Long-term O&M does not include acts of God that may require additional cost-share agreements to address. A primary goal or consideration of the Grand River Ecosystem Restoration feasibility study was to identify project measures that avoid high O&M costs that the Non-Federal Sponsor would assume. This plan identifies and includes the major O&M actions required in the three project areas. Several O&M levels can be considered for the proposed project:

8.1 Maintenance Actions – Are required to maintain desired or engineered performance of a restoration feature. For example, keeping access roads clean and clear of woody debris; maintaining proper vegetation on levees, berms, and grade control structures; and repair of project features damaged by floods. Routine inspections are also typically associated with required maintenance actions to identify any damage and/or needed repairs.

8.2 Operational Actions – Are used to optimize the flow of water, movement of sediment, maximize habitat quality, or to minimize project-related risks. For example, water control structures can be operated as open, partially open, or closed at different flow conditions to help achieve desired upstream and downstream conditions. At FG, many operational decisions are based on the timing of water pumps, water control features, and outlet structures to control the depth of water for optimal submerged littoral habitat or exposure of mud flats that benefit migratory waterfowl and shorebirds.

8.3 Long-Term Actions – For some project features and areas, there may be O&M modifications or adjustments that are newly identified during the initial 10-year period. Likewise, there may be initial monitoring or AM actions that are recommended for long-term continuation beyond Year 10. It is anticipated that any long-term monitoring and AM needs would be considered as O&M actions after Year 10. Ideally, all the long-term O&M actions would be identified at the end of Year 10 and included in the project OMRR&R Manual, however, there may be additional O&M needs that are identified between Year 10 and Year 50. These newly identified actions would also be classified as part of long-term O&M.

9.0 PLAN IMPLEMENTATION

Due to the high degree of unknowns associated with future flooding events, sedimentation levels, and woody debris amounts, the Grand River project would utilize the monitoring and inspection methods described in **Section 6.0** to collect data, which would help identify and inform the study team for potential follow-on AM and O&M methods (**Sections 7.0 and 8.0**). Adaptive Management measures would be implemented if the monitoring and inspection program (or any other documented observations by qualified personnel) indicates that performance targets are not being met and cannot be explained by extraneous variables. The USACE and the Non-Federal Sponsors, in coordination with regulatory and funding agencies, would then assess monitoring parameters and initiate corrective actions to address the identified issue(s). The monitoring tools and AM measures outlined below are based on a presumption that some flood damage should be anticipated as the river adjusts to the large-scale project and that some additional work may be needed to move the site toward full sustainability. The AM measures have been developed to address moderate flood damage from occasional large floods, not catastrophic damage from extreme floods. Damage to the site from catastrophic flooding (including the levees) would likely be addressed using other programs or through additional cost-share agreements.

The work to complete AM and O&M measures would be directly informed by monitoring and inspection data and include development of a simplified design by the USACE and Non-Federal Sponsor based on field conditions. Work would likely consist of rough grading activities involving manipulation of on-site materials with heavy equipment (300 series excavators, off road dump trucks, D-8 dozers, etc.). It is reasonable to assume that management measures would be utilized in a single maintenance cycle. It is also assumed that routine O&M would be addressed by the Non-Federal Sponsor throughout the project study life to include actions that are deemed necessary for long-term inclusion after the 10-year monitoring and AM period is completed.

9.1 Monitoring Tools, AM Considerations, and O&M Actions – A variety of monitoring technologies and tools are proposed to obtain data and information for use in the AM and O&M project phases. **Tables 2 and 3** below and **Attachment A** provide summaries of proposed monitoring, AM, and O&M measures by study area and proposed restoration measures/objectives, performance targets, and estimated costs. **Section 10.0** provides information on initial monitoring, AM, and O&M project schedules and budgets. **Section 11.0** identifies the responsible parties for implementation of proposed monitoring, AM, and O&M actions.

9.1.1 UBEC Sites: Following implementation of future with project (FWP) restoration measures, stable streambanks with normal sediment inputs into the river would be the desired objectives and target conditions. Monitoring would be used to document potential change in streambank erosion and channel morphology at UBEC sites by measuring exposed rebar stakes and inspecting channel conditions over time. If available, existing LIDAR, aerial mapping, and HH (Hydrology & Hydraulic) cross-section data would be used to help detect landform change between assessment periods.

Permanent monitoring stakes (rebar or similar item) would be evenly spaced every 50 feet at each UBEC site. Stakes would contain an etched hatch mark of “0” at the mid-point of each 6 ft stake. At the time of establishment, stakes would be driven into the ground so that “0” lies at ground level (3 ft above ground and 3 ft below ground). Future site visits would measure from the top of the stake to ground level. The amount of erosion or sedimentation between sampling periods would be calculated by subtracting the current site visit measurement from the previous site visit measurement. For stakes that may receive more than 4 ft of erosion or sedimentation, new monitoring stakes would be installed.

The 316 proposed UBEC sites would be grouped into categories based on similar restoration efforts, locations, and/or issues. Monitoring at Year 1, 5, 10, and after recommended event-based floods would be conducted to assess change in streambank erosion/sedimentation, channel morphology, and habitat conditions using riparian and aquatic riverine modeling (similar to methods described in **Section 9.1.4**). Five percent of the 316 UBEC sites would be assessed for habitat conditions at Year 1, 5, 10, 25, and 45. Approximately \$79,000 and \$69,504 would be needed for sediment and habitat assessments, respectively. If needed, additional event-based flood assessments would increase these costs. Out-year assessments (Year 25 and 45) would likely only assess high risk UBEC sites, based on previous assessment data. If streambanks are eroding or the channel is aggrading/degrading, performance targets would be assessed, which would be specific to the erosion measures implemented at each site (i.e., rock armoring, channel widening, bench cuts, tree revetments, willow plantings, etc.). For AM costing purposes, an estimate of 50% of the UBEC sites was used and 20% for long-term O&M actions, with $3,000 per site for implementation of erosion control modifications. AM and O&M costs for long-term invasive weed control and re-plantings of riparian corridor vegetation were also estimated for UBEC sites.

9.1.2 Light Detection and Ranging (LIDAR): This technology would be used to help assess short- and long-term changes and shifts in floodplain habitats, river channel morphology, floodplain elevations, eroding reaches, new and existing avulsions, and areas with woody debris accumulation. The most recent LIDAR and mapping data would be used to document Year 0 (just prior to initiation of construction) baseline conditions for all study areas (LC, FG, and YC). Year 1 (post construction), Year 5 (midpoint of AM period) and Year 10 (end of AM period) LIDAR would be used to compare with baseline data to assess changes in project conditions. Approximately $120,000 would be needed for at least three LIDAR assessments from Year 1 to Year 10. LIDAR mapping at Year 25 and 45 was estimated at $80,000 as outlined in Table 7 below, and will be further defined in the OMRR&R Manual as a long-term O&M cost and non-Federal responsibility. No direct AM actions are associated with this measure.

9.1.3 Aerial Drone Photography: This technology would be used with LIDAR to help map and assess long-term changes and shifts in floodplain habitats, river channel morphology, eroding reaches, new and existing avulsions, and areas with woody debris accumulation. The most recent photography data would be used for Year 0 (just prior to initiation of construction) mapping to document baseline conditions for all study areas (LC, FG, and YC). Year 1 (post construction), Year 5 (midpoint of AM period) and Year 10 (end of AM period) mapping would be used to compare with baseline data to assess changes in the desired project parameters listed above. An estimate of approximately $60,000 would be needed for up to three aerial mapping periods from Year 1 to Year 10. Aerial mapping at Year 25 and 45 was estimated at $40,000 as outlined in Table 7 below, and will be further defined in the OMRR&R Manual as a long-term O&M cost and non-Federal responsibility. No direct AM actions are associated with this measure.

9.1.4 LC Habitat Assessments: Evaluating the evolution of restored wet prairie, emergent wetland/marsh, bottomland hardwood forest, riparian riverfront forest, and aquatic riverine habitats is the focus of the Grand River study and would consider both the quality (ecological form and function) and quantity (habitat extent) of targeted areas. Additional HH, soil, and adjacent buffer data would also be collected to provide information for proposed habitat modeling. Year 0 habitat assessments would be conducted to provide pre-construction baseline data for comparison with future assessments. Year 0, baseline habitat monitoring could be completed as part of the design effort, prior to ground disturbing actions. Year 1, 5, and 10 post-construction assessments and recommended event-based flooding would be conducted during the AM period. Long-term habitat assessments would be conducted at Year 25 and 45 and following recommended event-based flooding. Habitat assessment and modeling after Year 10 would be defined in the OMRR&R Manual as long-term O&M, with associated costs and actions a non-Federal responsibility. The same models and protocols should be used for all phases of monitoring so that consistent data can be obtained and compared with pre- and post-construction conditions. Several models (i.e., Missouri Floristic Indices, Missouri Rapid Wetland Assessment, and those used in the Feasibility Study) and strategic habitat assessment locations were assessed by the Non-Federal Sponsor. The primary goal of the LC study area is to reduce sediment deposition, woody debris accumulation and avulsions, thereby increasing long-term habitat quality and quantity. Recommended AM and O&M actions that may be used to improve project function and to optimize habitat outputs are outlined in the below HH and sediment sub-sections. No direct AM actions are associated with these measures.

9.1.4.1 Terrestrial Habitat Sites. Terrestrial habitat monitoring would be based upon the Missouri Rapid Assessment Method for Wetlands Operation Manual (Missouri Department of Natural Resources, MoDNR 2018) https://dnr.mo.gov/geology/wrc/docs/moramoperationsmanual.pdf. Modeling would provide ranks/scores of each designated habitat site based on the categories of vegetation, soils, hydrology, and buffers. A total of 10 habitat assessment plots have been proposed, 2 north of U.S. Highway 36 and 8 south of U.S Highway 36 (colored dots in **Figure 8**). The proposed survey locations include areas of remnant and recreated wetland communities in areas that are expected to have a large amount of sedimentation under Future Without Project (FWOP) conditions; but are now expected to have a range of sediment deposition from high to none under FWP conditions. These survey locations are to be placed in representative sites of wet prairie, emergent marsh, bottomland hardwood forest, and riparian riverfront forest. The ten designation survey locations coincide with proposed sediment monitoring locations (black dots in **Figure 8**). To support terrestrial habitat assessments, physical substrate samples, HH information, and buffer zone data would be collected at the proposed locations for Year 0, 5, 10, 25 and 45. Similar to the methods described in **Section 9.1.1**, rebar stakes would be permanently installed, and erosion/sedimentation rates would be measured. Using the standard methods proposed in the Wetlands Operation Manual, sixteen 1 square meter quadrats would be sampled in each habitat assessment plot, for a total of 160 quadrats. Vegetation monitoring is scheduled for years 0, 1, 5, 10, 25 and 45, with additional event-based flooding if necessary. Collection of terrestrial data, soil samples, HH data, and buffer zone data at monitoring sites would be approximately $43,444 for the first ten years; and approximately $35,277 for Year 25 and 45 assessments (Table 7).

9.1.4.2 Aquatic Riverine Habitat Sites. Variables associated with the Grand River Qualitative Habitat Evaluation Index (QHEI) model (Environmental Protection Agency, EPA 2006) would be collected within proposed HH cross-section data collection reaches. Changes in channel morphology along with in-stream habitat such as root wads, log complexes, aquatic vegetation, substrate, and other variables would be measured and inputted in the QHEI model to assess changes in habitat quality over time. Similar to terrestrial habitat monitoring, aquatic riverine habitat would be assessed at Year 1, 5, 10, 25 and 45, with additional event-based flood sampling as needed. Costs for QHEI assessment work is included in the HH cross-section work effort (**Section 9.1.6** below).

9.1.5 LC Sediment Loads: Suspended sediment loads, deposited sediment amounts, and soil characteristics would be measured within the LC study area. See **Figure 9** for sediment-related monitoring work efforts within the LC study area. Suspended sediment levels would be collected at the Linneus United States Geological Survey (USGS) gage for five years following completion of LC construction (Year 1-5) to better document existing suspended sediment loads and improve sediment modeling. Annual physical samples of sediment would also be collected to assess sediment types, size, and gradation within the Linneus to SDB reach. Turbidity sondes would be established at key locations (above/below the SDB diversion structure, below the SDB spillway and outfall) to measure turbidity for up to 4 months of continuous sampling at Year 0, 5 and 10 during the AM period; with long-term data collection during the O&M period at Year 15, 20, 25, 20, 35, 40, 45 and 50. Estimated costs for sediment-related data collection efforts include USGS data collection and analysis ($180,000); AM turbidity assessments ($109,244) and long-term O&M turbidity ($253,311). Long-term O&M activities are included in Table 7 below, and will be further defined in the OMRR&R Manual as a non-Federal responsibility. Sediment data would help guide decisions on future AM and O&M decisions regarding the amount of flow/sediment to allow into the SDB and the amount of flow/sediment to pass through the SDB outfall at the downstream end of the SDB. No direct AM actions are associated with these measures.

9.1.6 LC HH Cross-Sectional Data: Field survey crews would conduct site visits to established HH cross-sections to measure river and floodplain parameters. See **Figure 9** for a description of sediment-related monitoring work efforts within the LC study area. Up to 539 riverine cross sections could be collected on LC, Higgins Ditch, avulsions, Muddy Creek, and the Diversion Channel. Cross-sectional data would be used with LIDAR, aerial mapping, and Hydrologic Engineering Center, River Analysis System (HEC-RAS) models to assess how the rivers and reaches are responding to flow/sediment diversions, dredging, sedimentation in the basin, and grade control structures.

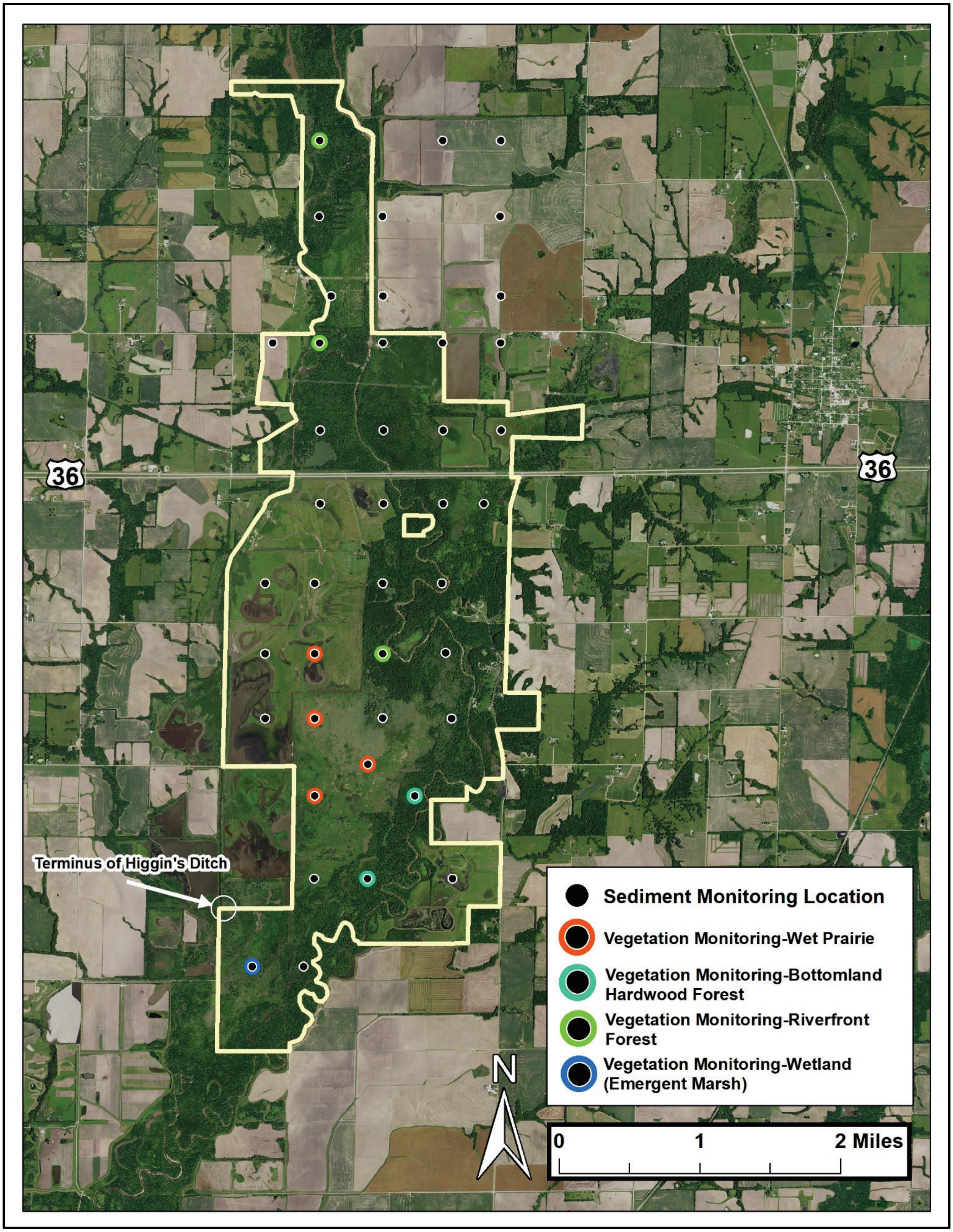

Figure 8. Proposed Habitat and Sediment Monitoring Locations within the LC Study Area.

Item #	Description	Assessment	Frequency
A	Sediment reduction measures	Visual inspection plus erosion determination	Standard
B	Linneus gage	Sediment load	During PED, construction, & adaptive management
C	Locust Creek upstream of diversion	Cross sections	Standard
D	Diversion structure and floodplain berm	Visual assessment, cross section	Annual
E	West side floodplain	LIDAR or similar	Standard
F	Higgins grade control and rail road berm	(1) Visual inspection; (2) Topographic survey	(1) Annual; (2) Standard
G	Pilot channel	Cross sections	Standard
H	Exterior levees	Visual inspection	Annual
I	Sedimentation basin	LIDAR or similar	Standard
J	Basin outlet	(1) Visual inspection; (2) Topographic survey	1) Annual; (2) Standard
K	HWY 36 bridge openings	(1) Visual inspection; (2) Cross section	1) Annual; (2) Standard
L	Muddy Creek and Locust Creek DS of HWY36	Cross sections	Standard
M	Avulsion berm	(1) Visual inspection; (2) Topographic survey	1) Annual; (2) Standard

Standard Frequency	Year 0 (As built) Year 5 Year 15 Year 25 Year 35 Year 45

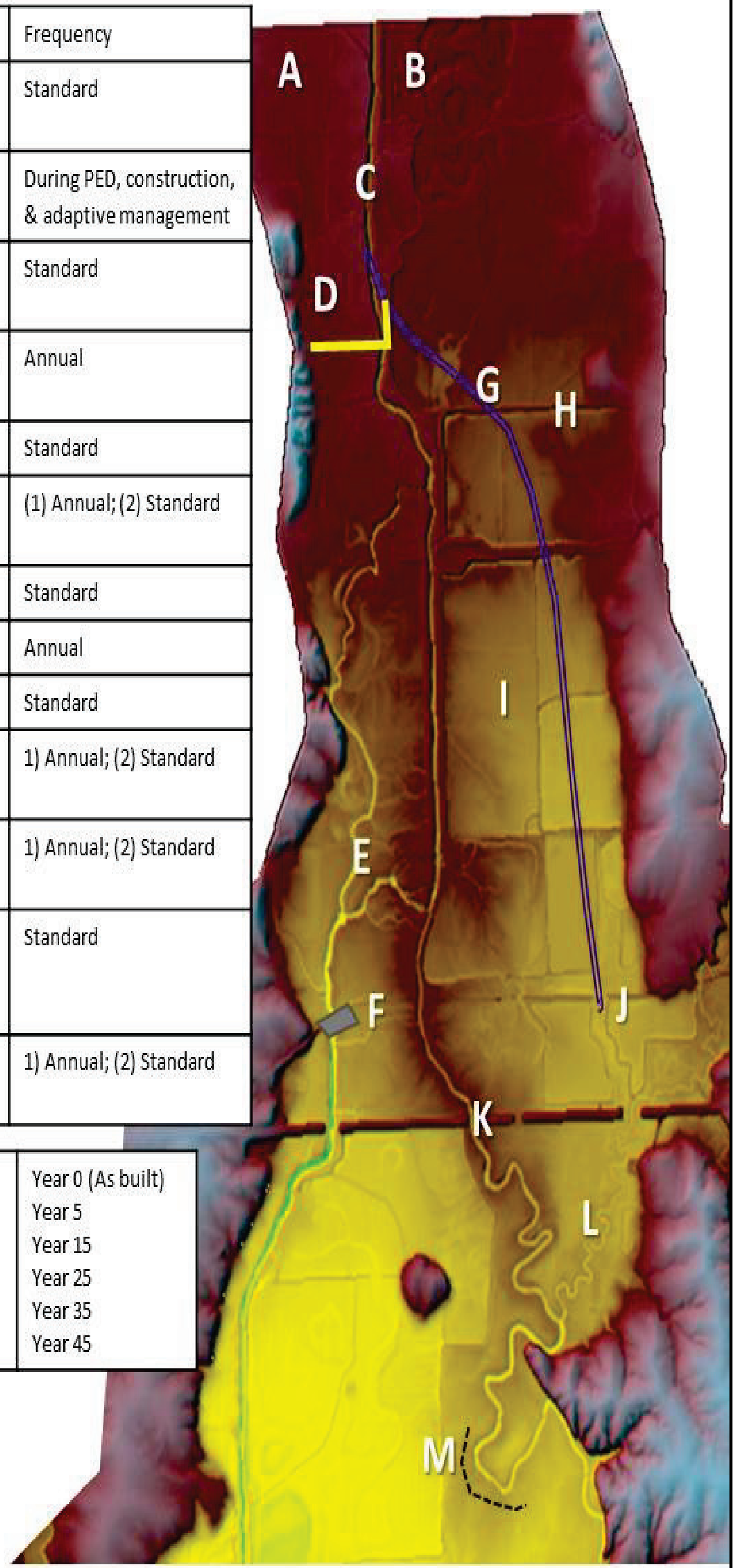

Figure 9. Sediment-Related Monitoring Work Efforts within the LC Study Area.

Cross-sections on LC downstream of the Muddy Creek confluence would assess channel capacity, which would help guide decisions on how much flow should be passed downstream from the proposed sediment detention water outlets. Year 0 (just prior to initiation of construction) and Year 1 (just after completion of construction) data would be used to document baseline conditions for strategic locations within the two study areas (LC and FG). Year 5 (midpoint of AM period) and Year 10 (end of AM period) data would be collected and used to compare with baseline data to assess changes in project parameters. Eight weeks of labor was used to estimate costs for field work and required follow-on data processing costs for 4 sampling periods (approximately $192,000) through Year 10 to include collection of QHEI habitat data within assessed reaches. The number of strategic locations and frequency of sampling after Year 10 are outlined in Table 7 below, and will be further defined in the OMRR&R Manual, with associated costs and actions a non-Federal responsibility. It is recommended that long-term Sponsor assessments be conducted at Year 15, 25, 35, and 45, with 50% less HH cross-sections. Long-term O&M-related assessment costs were estimated at $120,000. No direct AM actions are associated with these measures, individual reach AM recommendations are provided below. **Tables 4-7** provide monitoring, AM, and O&M cost information.

9.1.6.1 LC Reach, Linneus to SDB Diversion Structure. The USGS gage at Linneus and sparse historic cross sections have indicated that the reach from Linneus to the proposed SDB diversion structure is generally aggradational. This aggradation may have been exacerbated by backwater effects from log jams. The removal of log jams, the opening up of the diversion channel through the sedimentation basin, and upstream sediment reduction measures may decrease or reverse the aggradation. In addition, the 2019 flood events and future events may mobilize additional material in the upper watershed, which has not yet reached this reach. If future log jams and avulsions develop upstream from the SDB diversion structure that have the potential to negatively impact the LC restoration project, then corrective measures should be considered. The proposed SDB berm that crosses the western portion of the floodplain at the SDB Diversion Structure was designed to help address potential flanking from upstream avulsions. If LIDAR, aerial photography, or HH cross-section modeling indicate that channel capacity has decreased more than 20%, corrective actions may be needed to ensure conveyance into the sediment detention basin. Design modifications may require channel modifications to increase channel capacity into the basin and the potential need for additional UBEC sites to reduce sediment inputs. Due to the high level of unknowns associated this reach and the potential future need for private land agreements, this reach was flagged for monitoring during the AM and O&M periods to assess potential future risk. Any required future corrective actions and associated costs would be coordinated between the USACE, Sponsor, and any required third parties.

9.1.6.2 LC Reach, SDB Diversion Structure. Hydraulic conditions at engineered flow splits favor sediment deposition and woody debris accumulation. It is recommended that measurement of sediment and wood debris be taken annually at the diversion structure. Significant accumulation of woody debris that negatively impacts project performance should be promptly removed with AM or O&M actions. If sediment has deposited more than 1 foot, the potential for adverse impacts to the function and efficiency of the diversion structure would be assessed and removal methods for deposited sediment would be considered. An estimate of 6,000 cubic yards of excavation was used for AM and 24,000 cubic yards for long-term O&M actions for the SDB diversion structure area.

9.1.6.3 SDB Reach, Diversion Channel. The SDB diversion channel was designed as a straight channel that is sufficiently wide to prevent deposition of woody debris until reaching the downstream end of the channel. Towards the downstream end, a meander bend and a channel width constriction would encourage sediment deposition, woody debris accumulation, and the initiation of channel meandering. Significant sedimentation is expected in the basin over the analysis period. Cross-sections in the diversion channel would augment LIDAR collection to produce digital terrain mapping of the basin. If volume estimates indicate accelerated filling, the discharge from the downstream SDB outfall could be increased to decrease residence time, or sediment could be mounded within the basin to provide additional storage volume at moderate discharges. An estimate of 4,000 cubic yards of sediment mounding was included for AM and 8,000 cubic yards for long-term O&M actions over 50 years, with SDB outfall operations (part of normal Non-Federal Sponsor park operational duties).

9.1.6.4 SDB Reach, SDB Outfall to Highway 36. Downstream of the SDB and SDB outfall, the diversion channel is expected to enlarge in response to the higher flows and lower sediment loads. Grade control would be designed to protect against expected scour and provide a gradual transition for fish movement and passage. If cross-sections indicate that excessive downstream degradation has occurred, additional grade control would be implemented while also considering for fish passage requirements. An estimate of 1,600 tons of riprap grade control was included for AM and 6,400 tons for long-term O&M actions over 50 years.

9.1.6.5 LC Reach, SDB Diversion Structure to SDB Spillway: Historic cross-sections indicate that this reach has significantly aggraded in the past. This aggradation was exacerbated by backwater effects from log jams and flow reductions from avulsions. The effects of the flow/sediment diversion on sedimentation in this reach are currently unknown. As flows are diverted to the SDB, less water and sediment would enter this reach. If cross-sections indicate that the channel has degraded more than 3 feet, the SDB diversion berm would be assessed to determine if additional rock armoring would be needed on the downstream slope. An estimate of 1,400 tons of riprap grade control was included for AM and 5,600 tons for long-term O&M actions over 50 years.

9.1.6.6 LC Reach, SDB Spillway to Muddy Creek Confluence. Historic cross sections indicate that this reach has significantly aggraded in the past. This aggradation was exacerbated by backwater effects from log jams and flow reductions from avulsions. Under the FWP condition, this reach would be expected to degrade as it accepts sediment-poor-water from the SDB spillway (under high flows) and diverted sediment/flows through the SDB. Below the spillway, water would continue to flow down existing Higgins Ditch and LC pathways. If cross-sections indicate that channel degradation has occurred in LC and avulsions have aggraded to the point that water no longer flows down Higgins Ditch, the flow change implications would be assessed, and grade control would be considered as an AM measure. An estimate of 1,200 tons of riprap grade control was included for AM and 4,800 tons for long-term O&M actions over 50 years.

9.1.6.7 LC Reach, Downstream from the Muddy Creek Confluence. Historic cross-sections have indicated significant aggradation and loss of conveyance in this reach. This aggradation was exacerbated by flow reductions from avulsions. The additional flow and relatively low-sediment-water that would be returned to this channel under the FWP condition is expected to enlarge LC downstream from the Muddy Creek confluence. If cross-sections indicate that the channel has enlarged, additional flow could be released downstream with the goal of further enlarging the reach to its estimated historic bankfull capacity of 6,000 cubic feet per second (cfs). If cross-sections indicate that LC has further aggraded, actions such as plugging existing avulsions, installation of bedload traps, and excavation of the channel bottom would be considered. For cost estimating, an estimate of 4,000 cubic yards of excavation with avulsion bank packing, along with SDB outfall adjustments was included for AM and 16,000 cubic yards for long-term O&M actions over 50 years.

9.1.6.8 Higgins Ditch Reach, From Initiation to RGC Structure. Initiation refers to the existing location of the Higgins Ditch avulsion point that diverts water from LC through Higgins Ditch. Historic observations on Higgins Ditch indicate significant channel enlargement as Higgins Ditch has captured more and more flow from LC. Under FWP conditions, the grade control structure and flow diversion into the SDB are expected to reduce further enlargement of Higgins Ditch, resulting in gradual deposition and a smaller channel over time. No AM measures are anticipated for this this reach.

9.1.6.9 Higgins Ditch Reach, RGC Structure to Terminus of Higgins Ditch. The RGC structure would be extended across Higgins Ditch to increase sediment deposition in the western portion of the LC study area. Historic observations on Higgins Ditch have indicated significant channel enlargement as Higgins Ditch captured more and more flow from LC. Under the FWP conditions, Higgins Ditch would capture significantly less flow, particularly low and moderate flows, but should also transport less sediment due to increased deposition above the RGC and in the SDB. Therefore, variable levels of aggradation, degradation, channel development, and meandering are likely to occur in the future. Higgins Ditch may take a long time to evolve into a new climax condition as it receives lower flows with less sediment. The proposed Higgins Ditch RGC structure should be inspected and monitoring for potential scouring and degradation that could lead to structural failure. If cross-sections indicate more than 3 feet of degradation has occurred, AM actions such as adding rock to the downstream side of the RGC structure south to the terminus of Higgins Ditch (as shown in Figure 8), or installation of an additional downstream grade control structure to create a backwater effect, should be considered. An estimate of 100 tons of grade control was included for AM and 400 tons for long-term O&M actions over 50 years.

9.1.7 LC Log Jams and Woody Debris: Where and how much woody debris deposits in the LC floodplain, river channels, avulsions, and SDB is a known risk and uncertainty that would be handled with collection of HH cross-section data and review of long-term LIDAR and aerial mapping. This measure would include collection and review of mapping to identify any potential issues associated with accumulation of woody debris within the Pershing State Park. Critical areas would include aggradation reaches, existing avulsions, near the flow diversion structure, basin spillway, and SDB outfall. The cost for monitoring work is included in the above cost estimates. Annual inspections of the LC study area would occur with routine Non-Federal Sponsor park maintenance activities. If results identify woody debris issues, manual log removal and mulching AM measures would be considered based on the distance from access roads and on-the-ground conditions. If needed, notching of interior SDB levees/berms could be used as an AM measure to help promote the movement of flows/logs/sediment to other areas of the basin. Mounding of sediment/debris and creation of low spots (i.e., sediment/log traps) could be used to promote accumulation in desired areas of the SDB. Bank-packing and placement into existing avulsions would also be considered depending on the location where the accumulation occurs. Estimates of 5,000 and 20,000 cubic yards of log material for bank or avulsion packing was used for AM and long-term O&M costs, respectively. **Tables 4-7** below provide estimated monitoring, AM, and O&M cost information.

9.1.8 LC SDB Vegetation: The upper area of the SDB, diversion structure, spillway, and SDB outfall should be routinely monitored and inspected to identify any issues associated with excessive vegetation growth. It is anticipated that high densities of early successional species such as willow, cottonwood, silver maple, and invasive communities like reed canary grass would occur in depositional areas of the SDB during the first 10 years. Review of aerial mapping, habitat assessments, and HH cross-section data should be used together to help identify any potential issues with vegetation as the basin evolves from row crop to a more natural condition. The cost for monitoring work is included in the above cost estimates. Annual inspections of the LC study area would occur with routine Non-Federal Sponsor park maintenance activities. Monitoring should help identify any AM/O&M needs associated with care of vegetation to include mowing, thrashing, and burning. An estimate of 200 and 800 acres of mowing within SDB areas was used for AM and long-term O&M costs, respectively. **Tables 4-7** below provide estimated monitoring, AM, and O&M cost information.

9.1.9 LC and FG Levees and Berms: There are many levees and berms within the LC and FG study areas. Structures adjacent to and downstream of proposed FWP measures, and those required for continued success of proposed restoration features should be routinely monitored and inspected to identify any erosion concerns, sloughing, detrimental vegetation growth, animal burrows, or damage from periodic flooding. Field trips for collection of HH cross-section data and habitat assessments could be used to also inspect berms and levees. Some of the levee/berm crests would be wide enough to allow for easy inspection access and for maintenance access. The cost for monitoring work is included in the above cost estimates. Annual inspections of the LC study area would occur with routine Non-Federal Sponsor park maintenance activities. Routine O&M mowing, thrashing, or burning may be necessary to maintain vehicle access and dense vegetation coverage on levees and berms to help limit potential erosion. Adjustment and modification of interior berms within the SDB such as notching, could be used to help divert flows and reduce erosional impacts. An estimate of approximately 5,000 acres of mowing was used for long-term O&M of levees and berms to maintain access roads and areas at LC and FG. **Tables 4-7** below provide estimated monitoring, AM, and O&M cost information.

9.1.10. LC SDB Active AM Opportunities: There would be an opportunity for additional HH, ecosystem, and biological research and the use of Active AM measures within the SDB as the existing row crop land use evolves into a more natural condition. Research projects that assess changes in vegetation communities, invasive species invasion rates, shifts in plant and animal communities, water quality benefits, changes in diversity and species abundance, trends in abiotic conditions, and many more could be implemented. Vegetation information from Section 9.1.8 monitoring activities could provide baseline data for use with any future research projects or basin management actions. The current AM Plan does not specifically identify or fund these types of research-related studies. Implementation of future projects would be at the discretion of the Non-Federal Sponsor and identification of cooperative opportunities with USACE, other resource agencies, and universities.

9.1.11 FG Wetland Cells: Event-based monitoring and inspection of the East, West, and South FG levees, berms, water control structures, and access roads to identify any changed conditions, damage and/or needed repairs. Annual inspections of critical FG infrastructure would occur through routine Non-Federal Sponsor operations and maintenance activities.

Long-term data collection (Year 0, 1, 5, 10, 25, and 45) using sediment stakes as described in **Sections 9.1.1 and 9.1.4.1** would be approximately $50,000. Use of site visits, habitat modeling, review of sediment data, and LIDAR/aerial photography would be used to assess changes in habitat conditions at FG. The quality and quantity of emergent wetland and hardmast forest habitats would be tracked over time by comparing baseline model results with long-term changes in vegetation communities. Field work with follow-on data processing for up to 10 habitat plots during the first 10 years would be approximately $43,444; and $35,277 for Years 25 and 45.

LIDAR and drone aerial photography would be reviewed to help assess habitat changes, avulsions, log jams, and wetland cell sedimentation. LIDAR and aerial mapping costs are included in the above cost estimates. Use of short-term and long-term operational data from routine FG management activities would also be used to help identify potential modifications to gates, piping, berms, channels, microtopography, pumps, etc. AM actions for FG may include similar actions as described above for the LC study area, such as erosion control measures, grade control, channel excavation, sediment mounding, bed-load traps, log removal with bank/avulsion packing, and operation of wetland water control structures during flood events. **Tables 4-7** below provide estimated monitoring, AM, and O&M cost information.

Where and how much woody debris deposits in the FG study area is a known risk and uncertainty that would be handled with routine inspections and review of long-term LIDAR and aerial mapping. Potential areas may include Jackson's Ditch to the east and within FG after high flood events. The levee setback measure along the northeast portion of FG should help alleviate current erosion and sloughing concerns associated with the current levee alignment. Data and mapping would be reviewed for potential levee issues associated with the new alignment. The cost for monitoring work is included in the above cost estimates. Annual inspections of the FG study area would occur with routine Non-Federal Sponsor maintenance activities. If results identify woody debris issues, manual log removal would be considered based on the distance from access roads and on-the-ground conditions. Estimates of 500 cubic yards of log material for manual removal was used for AM and long-term O&M costs. **Tables 4-7** provide estimated monitoring, AM, and O&M cost information.

9.1.12 YC Levee Set-Back: Any required monitoring, AM, or O&M actions and associated costs at the YC study area would be the responsibility of the USFWS. Similar actions as outlined above would likely be used to identify AM actions and long-term O&M requirements for the proposed levee set-back area along Yellow Creek. Inspection of critical USFWS infrastructure, assessment of habitat quality and quantity, and changes in local sedimentation would be important project components to assess over time.

Table 2: Summary of Proposed Monitoring and Long-Term O&M Actions for Grand River Study Areas.

Project Location / Work Effort	Method / Measurement	Monitoring Period					Long-Term O&M Period			
		Annually	Year 0 w/o Alt	Year 1 w/ Alt	Year 5 w/ Alt	Year 10 w/ Alt	Year 15 w/Alt	Year 25 w/ Alt	Year 35 w/Alt	Year 45 w/ Alt
9.1.1 UBEC Sites Erosion Rates Habitat Assessments	Field trips to measure rebar stakes (erosion rates) and collect aquatic riverine and riparian corridor data, habitat acres.		Pre-construction design information.	Group similar sites into categories and assess a portion each time period (50% erosion, 5% habitat). If needed, conduct event-based flood assessments for -10 year or greater events.			Non-Federal Sponsor can assess high risk sites (20% erosion, 5% habitat) at Year 25 and 45, to be included in the OMRR&R Manual; plus, any desired event-based flood assessments.			
9.1.2 LC & FG Study Areas LIDAR Mapping	LIDAR, with GIS mapping.		Includes most recent LIDAR.	X	X	X		X		X
9.1.3 LC & FG Study Areas Aerial Drone Photography	Aerial photography, with GIS mapping.		Includes previous Feasibility data.	X	X	X		X		X
9.1.4 LC & FG Study Areas Habitat Assessments	Field trips to collect wet prairie, emergent wetland, hardmast forest model data, habitat acres at **Figure 8** monitoring sites. Aquatic riverine data would be collected with HH cross-sectional sampling efforts.		X	X	X	X	Year 25 and 45 by the Non-Federal Sponsor, to be included in the OMRR&R Manual.			
9.1.5 LC & FG Study Areas Sediment Loads	USGS gauge data, field trips to collect physical sediment data, and installation of turbidity sondes.	X	USGS gauge suspended sediment monitoring with annual physical samples for Linneus to SDB reach for five years following completion of construction. Turbidity sondes would collect continuous turbidity data for six months at Year 0, 5 and 10 above/below the SDB diversion structure, below the SDB spillway, and below the SDB outfall.				Continuation of turbidity sonde data collection for six months every 5 years by the Non-Federal Sponsor, to be included in the OMRR&R Manual.			
9.1.6 LC & FG Study Areas HH Cross-Sectional Data Aquatic Riverine Habitat Data LIDAR and Aerial Mapping	Field trips to measure change in HH cross-sections (sediment aggradation, degradation) and to collect aquatic riverine model data. Review of LIDAR and drone aerial data with terrain mapping to assess change in floodplain, SDB elevations (sediment deposition, erosion).		Feasibility data.	X	X	X	By Non-Federal Sponsor at Year 25 and 45, to be included in the OMRR&R Manual.			
9.1.7 LC Study Area Log Jams and Woody Debris	Inspections of key study reaches and avulsions (**Figure 5**).	X	Would occur with annual HH data collection activities and review of HH cross-section data, LIDAR and aerial mapping to identify potential problem areas.				Annual inspections of the SDB would occur with routine Non-Federal Sponsor park maintenance.			
9.1.8 LC Study Area SDB Vegetation	Inspect SDB for issues with high densities of vegetation growth that could impact flow of water, sediment, and woody debris. Review of aerial mapping, habitat assessment data, and HH cross-section data.	X	Would occur with annual HH data collection activities and review of HH cross-section data, LIDAR and aerial mapping to identify potential problem areas.				Annual inspections of the SDB would occur with routine Non-Federal Sponsor park maintenance.			
9.1.9 LC & FG Study Areas Levees and Berms	Inspections to identify any erosion concerns, sloughing, detrimental vegetation growth, animal burrows, or damage from periodic flooding. Field trips for collection of HH cross-section data and habitat assessments could be used to also inspect berms and levees.	X	Would occur with annual HH data collection activities and review of HH cross-section data, LIDAR and aerial mapping to identify potential problem areas.				Annual inspections of the SDB would occur with routine Non-Federal Sponsor park maintenance.			
9.1.10. LC Study Area SDB Active AM Opportunities	Opportunity to study vegetation shifts, invasive rates, wildlife shifts, water quality benefits, changes in diversity and species abundance, trends in abiotic conditions, and many more research-related areas.	Currently not scheduled or budgeted. Would be dependent on interest from Non-Federal Sponsor, USACE Engineer Research and Development Center (ERDC), and natural resource agencies.								
9.1.11 FG Study Area Levee Set-Back Site Water Infrastructure Wetland and Hardmast Habitat Grade Control and Sediment	Potential levee and water infrastructure issues would be assessed through annual inspections and with designed standards. Wetland and hardmast forest habitat based on modeling data and habitat acres. Change in erosion, avulsions, woody debris, and sedimentation rates would be assessed through routine inspections, sediment stakes, and review of LIDAR / aerial mapping.	Infrastructure, habitat, woody debris, and sediment would be monitored and assessed annually and at Year 0, 1, 5, 10, 25 and 45 with routine Non-Federal Sponsor operations and maintenance activities. Some additional funding is estimated for additional turbidity sondes, habitat assessment, and inspection work efforts. Review of design data, LIDAR and aerial mapping to identify potential problem areas.								
9.1.12 YC Study Area Levee Set-Back Site	Inspection of levees, habitat assessments, and changes in inundation/sedimentation levels.	Monitoring, AM, and O&M actions would be conducted by the USFWS as the Federal lead for property at the Swan Lake National Wildlife Refuge. Potential monitoring actions could include Inspections of critical USFWS infrastructure, assessment of habitat quality and quantity, and changes in local sedimentation rates.								

Table 3: Summary of Proposed AM and O&M Actions for Grand River Study Areas.

Project Location	AM Objective / Performance Targets	AM Period			O&M Period			
		Year 1 w/ Alt	Year 5 w/ Alt	Year 10 w/ Alt	Year 15 w/Alt	Year 25 w/ Alt	Year 35 w/Alt	Year 45 w/ Alt
9.1.1 UBEC Sites	Stable to aggrading streambank and channel morphology. Established site-by-site based on channel configuration, upstream & downstream conditions, and the design standards associated with the restoration measures to be employed.	Rock armoring, channel widening, bench cuts, tree revetments, willow plantings, channel grade control, and bank sloping.			Similar repair and replacement actions would be conducted by the Non-Federal Sponsor after Year 10 as part of long-term O&M, to be included in the OMRR&R Manual.			
9.1.1 and 9.1.4 LC, FG & UBEC Sites	Increased habitat quality & quantity over time. Improved habitat values. Stable to increasing acreages.	If habitat values or acreages are decreasing, identify issue and develop AM action(s) such as plantings, erosion control, grade control, operational adjustment, or modification to infrastructure.			Similar actions would be conducted by the Non-Federal Sponsor after Year 10 as part of long-term O&M, to be included in the OMRR&R Manual.			
9.1.5 and 9.1.6 LC & FG Study Areas	Stable channel morphology, decreasing sediment loads and turbidity levels. Informed by HH and sediment model outputs. Channel instability that threatens habitat outputs or the performance of key project features/areas.	Modify SDB diversion structure and/or SDB outfall to adjust flow/sediment into and out of the SDB. Implement additional upstream sediment reduction measures, bedload traps, or channel excavation.			The Non-Federal Sponsor would continue SDB diversion structure and SDB outfall operations as informed from LIDAR, aerial photography, HH, sediment, and habitat data outputs; as outlined in the OMRR&R Manual.			
9.1.6.2 LC Reach, SDB Diversion Structure	No woody debris accumulation, minimal sediment deposition. Sediment Deposition – no more than 1 foot. Any accumulation of woody debris.	Sediment removal methods such as channel excavation and bed-load collectors. Any woody debris accumulation should be promptly removed with mulching or manually.			Continue similar long-term sediment or woody debris removal at the SDB diversion structure by the Non-Federal Sponsor, to be included in the OMRR&R Manual.			
9.1.6.3 SDB Reach, Diversion Channel	Maintain long-term SDB storage volume and capacity. Informed by HH model outputs. Actions may be required if the SDB fills in with sediment too quickly or if FRM issues arise.	Adjust SDB flow discharges to decrease sediment residence time, mound sediment within the basin to provide additional storage volume with moderate discharges, manual sediment removal, expansion of SDB boundaries, and RGC notching.			As part of the OMRR&R Manual, similar O&M actions would be employed by the Non-Federal Sponsor; primarily adjustment of SDB flow discharges.			
9.1.6.4 SDB Reach, SDB Outfall to Highway 36	Stable channel capacity and conveyance. Expected channel enlargement and scouring in response to higher flows and lower sediment loads.	If HH cross-sections indicate excessive downstream degradation and scouring, additional grade control would be used while providing for a gradual transitioning slope for fish passage.			Similar grade control actions for long-term O&M.			
9.1.6.5 LC Reach, SDB Diversion Structure to SDB Spillway	Stable channel capacity and conveyance. Less water and sediment would enter this reach in the future. Channel degradation of more than 3 feet.	Assess the diversion channel to determine if rock armoring is needed on the downstream slope of the structure and spillway.			Similar grade control actions for long-term O&M.			
9.1.6.6 LC Reach, SDB Spillway to Muddy Creek Confluence	Stable channel capacity and conveyance. Channel degradation in LC and aggradation in avulsions, with now water flow down Higgins Ditch.	Flow change implications would be assessed, and grade control would be considered as an AM measure.			Similar grade control actions for long-term O&M.			
9.1.6.7 LC Reach, Downstream from Muddy Creek Confluence	Channel enlargement and increased capacity. Expect enlargement of LC downstream from the Muddy Creek confluence. Avoid conditions resulting in aggradation.	Modify flow releases to enlarge the reach to estimated historic bank full capacity of 6,000 cfs. For aggradation, actions such as plugging existing avulsions, installation of bedload traps, and excavation of the channel bottom could be considered.			Similar flow adjustments and aggradation actions for long-term O&M.			
9.1.6.8 Higgins Ditch Reach, From Initiation to RGC Structure	Sediment deposition and a smaller channel over time.	No AM measures are anticipated in this reach.			No long-term O&M measures are anticipated in this reach.			
9.1.6.9 Higgins Ditch Reach, RGC Structure to the Terminus of Higgins Ditch	Sediment deposition and a smaller channel over time. HH cross-sections with more than 3 feet of degradation.	Add rock to the downstream side of the grade control structure, or installation of an additional downstream grade control structure along Higgins Ditch to the terminus to create a backwater effect.			Similar grade control actions for long-term O&M.			
9.1.7 LC Log Jams and Woody Debris	Decreased frequency and amount of log jams. Any excess accumulation of woody debris and formulation of log jams. This measure would include identification and removal of woody debris within the Pershing State Park or waters bordering the park.	Manual log removal, mulching, notching of interior SDB levees, sediment/debris mounding in SDB, creation of sediment/log traps in SDB, bank-packing, and placement of logs into existing avulsions.			Similar actions could be used for long-term O&M needs. The type of O&M measure would be based on the distance from access roads and on-the-ground conditions.			
9.1.8 LC SDB Vegetation	Maintain designed flow of water, sediment, and woody debris into the SDB. High densities of vegetation impacting flow of water, sediment, or woody debris into the SDB.	Monitoring will help identify any AM needs associated with care of vegetation to include mowing, thrashing, and/or burning.			Similar actions could be used for long-term O&M needs. The type of O&M measure would be based on the distance from access roads and on-the-ground conditions.			
9.1.9 LC & FG Levees and Berms	Maintain designed levee performance standards. Any erosion concerns, sloughing, detrimental vegetation growth, animal burrows, or damage from periodic flooding.	Adjust levee contours, heights, widths, etc., based on Year 1-10 performance. Adjust and modify interior berms within the SDB such as notching, if needed.			Mowing, thrashing, or burning may be necessary to maintain vehicle access and proper vegetation coverage.			
9.1.10 LC SDB Active AM Opportunities	Identify Active AM plans, dependent on individual research/active AM objectives.	Implementation of future projects would be dependent upon identification of cooperative opportunities with USACE, other resource agencies, and universities.						
9.1.11 FG AM and O&M Considerations	Infrastructure design standards. Increasing habitat units and/or acreages. Stable streambanks and channel morphology. Continued independent filling and drainage ability of designed wetland cells.	Maintain designed infrastructure standards and adjust as needed based on Year 1-10 performance. If habitat values decrease, identify issue and develop AM operational action(s) such as infrastructure adjustments, erosion control actions, grade control, etc. Operational protocol for water inlet/outlets and features to decrease sediment deposition, accumulation of woody debris during flood events.			Use of operational data from FG management to identify potential modifications to gates, piping, berms, channels, microtopography, etc.			
9.1.12 YC AM and O&M Considerations	Similar objectives, performance targets and AM actions as outlined above could be used for the proposed levee set-back area along Yellow Creek. Any required AM or O&M actions and associated costs would be the responsibility of the USFWS. Inspection of critical USFWS infrastructure, assessment of habitat quality and quantity, and changes in local inundation and sedimentation levels would be important project components to asses over time.							

10.0 SCHEDULE & BUDGET INFORMATION

At this time, it is assumed that personnel from both the USACE and Non-Federal Sponsor would lead and conduct both monitoring and any required AM construction using existing equipment or through contracts if needed. For study areas with multiple potential AM actions, unknown types and frequencies of future issues, and uncertain on-the-ground conditions, a gross estimate of potential AM and O&M costs was used relative to available funding. The FY20 based cost estimates in **Tables 4-7** are preliminary and include an approximate 10% cost contingency reflected in increased cost units and quantities; estimates do not include design costs, and are escalated over time for inflation or depreciation of scope. Costs for proposed vegetation and sonde survey actions include current and projected salaries of state employees and current and expected contract labor costs. A detailed project OMRR&R Manual will be developed during the Plans and Specification phase of the project, which would outline routine activities, and additional monitoring actions. The Grand River study has multiple Non-Federal Sponsors, as such total costs for monitoring, AM, and O&M will be funded and cost shared by MoDNR for the LC study area and by MDC for the FG study area. A 10-year monitoring and AM period as well as a 50-year project analysis period was assumed for plan formulation and cost estimating purposes. Actual time periods and costs will be based on ecological success determinations, future flood events, and levels of future upper basin restoration.

Table 4. Summary of Total Estimated Grand River Monitoring, AM, and O&M Costs.

Location / Work Effort	Non-Federal Sponsor	Year 0-10 Monitoring	Year 1-10 AM	Year 10-50 Monitoring	Year 1-50 O&M
9.1.1 UBEC Sites HH/Sediment	MoDNR	$79,000	$474,000	$31,600	$189,600
9.1.1 UBEC Sites Habitat*	MoDNR	$69,504	$31,600	$69,504	$12,600
9.1.2 LIDAR	MDC, MoDNR	$120,000	$0	$80,000	$0
9.1.3 Drone Aerial Photography	MDC, MoDNR	$60,000	$0	$40,000	$0
9.1.4.1 LC Terrestrial Habitat Assessments**	MoDNR	$43,444	$0	$35,277	$0
9.1.5 USGS Turbidity & Sediment	MoDNR	$180,000	$0	$0	$0
9.1.5 LC SDB Turbidity & Sediment	MoDNR	$109,244	$0	$253,311	$0
9.1.6 LC HH Cross-Sections***	MoDNR	$192,000	$0	$120,000	$0
9.1.6.1 LC Reach, Linneus to SDB Diversion Structure	MoDNR	$0	$250,000	$0	$1,000,000
9.1.6.2 LC Reach, SDB Diversion Structure	MoDNR	$0	$300,000	$0	$1,200,000
9.1.6.3 SDB Reach, Diversion Channel.	MoDNR	$0	$100,000	$0	$400,000
9.1.6.4 SDB Reach, SDB Outfall to Highway 36	MoDNR	$0	$128,000	$0	$512,000
9.1.6.5 LC Reach, SDB Diversion Structure to SDB Spillway	MoDNR	$0	$112,000	$0	$448,000
9.1.6.6 LC Reach, SDB Spillway to Muddy Creek Confluence	MoDNR	$0	$96,000	$0	$384,000
9.1.6.7 LC Reach, Below Muddy Creek Confluence	MoDNR	$0	$400,000	$0	$1,600,000
9.1.6.8 Higgins Ditch, From Initiation to RGC Structure	MoDNR	$0	$0	$0	$0
9.1.6.9 Higgins Ditch, RGC to Terminus of Higgins Ditch	MoDNR	$0	$8,000	$0	$32,000
9.1.7 LC Log Jams and Woody Debris	MoDNR	$0	$500,000	$0	$2,000,000
9.1.8 LC SDB Vegetation	MoDNR	$0	$3,550	$0	$14,200
9.1.9 LC & FG Levees and Berms	MDC, MoDNR	$0	$0	$0	$88,750
9.1.10 LC SDB Active AM Opportunities	MoDNR	$0	$0	$0	$0
9.1.11 East, West, South FG Infrastructure****	MDC	$0	$0	$0	$0
9.1.11 East, West, South FG Sediment	MDC	$18,000	$100,000	$32,000	$400,000
9.1.11 East, West, South FG Grade Control	MDC	$0	$160,000	$0	$160,000
9.1.11 East, West, South FG Habitat*	MDC	$43,444	$40,000	$35,277	$32,000
9.1.11 East, West, South FG Woody Debris	MDC	$0	$50,000	$0	$200,000
9.1.12 YC Levee Set-Back*****	USFWS	$0	$0	$0	$0
Upper Basin Sites (MoDNR)		**$148,504**	**$505,600**	**$101,104**	**$202,200**
Locust Creek Study Area (MoDNR)		**$614,688**	**$1,897,550**	**$468,588**	**$7,634,575**
Fountain Grove Study Area (MDC)		**$151,444**	**$350,000**	**$127,277**	**$836,375**
Total Costs (in FY20 price level)		**$914,636**	**$2,753,150**	**$696,969**	**$8,673,150**

*Estimated AM/O&M-related costs for potential invasive weed control and re-plantings of riparian corridor vegetation.

**Includes sediment, HH, soils, and buffer area data collection efforts to support terrestrial vegetation modeling.

***LC aquatic riverine habitat assessment costs are included in total 9.1.6 HH Cross-Section monitoring costs.

****Assumes that inspections of newly created FG infrastructure would not result in additional costs based on current routine costs.

*****Monitoring, AM, or O&M actions and associated costs at the YC study area would be the responsibility of the USFWS.

10.1 Project Monitoring Costs – There is some uncertainty in how the study areas will evolve over time, therefore the monitoring as described above would be necessary to identify actions to optimize project features and outcomes. The first round of monitoring data would utilize existing information collected during the Feasibility study. The second round would occur during project design to obtain pre-construction (Year 0) project conditions, which would serve as a baseline for comparison with future assessments. Year 1-50 assessments would be conducted to provide comparisons with baseline and future assessments. Monitoring would be conducted as described above, in **Table 2**, and in **Attachment A**. The monitoring data would be evaluated to determine if AM and long-term O&M actions would be required. Costs for monitoring to determine the degree that the project is meeting the success criteria and for informing potential AM actions are summarized in **Table 5** by total and Non-Federal Sponsor. Site monitoring costs include procurement of additional LIDAR and aerial photography needed to assess project areas, site visits to inspect key project areas, routine collection of data from gauges and sonders, and associated report preparation to convey monitoring data. Cost-shared monitoring would occur from Year 0 through 10. A 10-year monitoring period was assumed for plan formulation and cost estimating purposes. Actual time periods and costs will be based on ecological success determinations, future flood events, and levels of future upper basin restoration.

Table 5. Estimated Total Monitoring Costs by Study Area and Work Effort.

Monitoring Location / Work Effort	Non-Federal Sponsor	Unit Cost	Frequency (Year period)	Quantity	Item Cost
9.1.1 UBEC Sites HH/Sediment*	MoDNR	$500/site	1, 5, 10	158 sites	$79,000
9.1.1 UBEC Sites Habitat**	MoDNR	$4,344/site	1, 5, 10	16 sites	$69,504
9.1.2 LIDAR	MDC, MoDNR	$40,000/flight	1, 5, 10	LC and FG	$120,000
9.1.3 Drone Aerial Photography	MDC, MoDNR	$20,000/flight	1, 5, 10	LC and FG	$60,000
9.1.4.1 LC Terrestrial Habitat – Vegetation**	MoDNR	$33 -$39/hour	0, 1, 5, 10	10 sites, 640 hours	$23,113
9.1.4.1 LC Terrestrial Habitat – Sediment*	MoDNR	$33 -$39/hour	0, 1, 5, 10	10 sites, 280 hours	$9,959
9.1.4.1 LC Terrestrial Habitat – HH Data	MoDNR	$33 -$39/hour	0, 1, 5, 10	10 sites, 40 hours	$1,414
9.1.4.1 LC Terrestrial Habitat – Soils Data	MoDNR	$33 -$39/hour	0, 1, 5, 10	10 sites, 240 hours	$7,544
9.1.4.1 LC Terrestrial Habitat – Buffer Data	MoDNR	$33 -$39/hour	0, 1, 5, 10	10 sites, 40 hours	$1,414
9.1.5 USGS Turbidity & Sediment	MoDNR	$54,000/year	Annually, 1-5	USGS gauge	$180,000
9.1.5 LC SDB Turbidity & Sediment	MoDNR	$36,415/site	Every 5 years	3 sites	$109,244
9.1.6 LC HH Cross-Sections	MoDNR	$60,000/period	0, 1, 5, 10	Multiple reaches	$192,000
9.1.6.1 LC Reach, Linneus to SDB Diversion	MoDNR	Monitoring costs are included in the above cost estimates.			
9.1.6.2 LC Reach, SDB Diversion Structure	MoDNR				
9.1.6.3 SDB Reach, Diversion Channel	MoDNR				
9.1.6.4 SDB Reach, WCS to Highway 36	MoDNR				
9.1.6.5 LC Reach, SDB Diversion to Spillway	MoDNR				
9.1.6.6 LC Reach, SDB Spillway to Muddy	MoDNR				
9.1.6.7 LC Reach, Below Muddy Creek	MoDNR				
9.1.6.8 Higgins Ditch, From Initiation to RGC	MoDNR				
9.1.6.9 Higgins Ditch, RGC to Terminus of HD	MoDNR				
9.1.7 LC & FG Log Jams and Woody Debris	MDC, MoDNR				
9.1.8 LC SDB Vegetation	MDC				
9.1.9 LC & FG Levees and Berms	MDC, MoDNR				
9.1.10 LC SDB Active AM Opportunities	MoDNR	Will be outlined in the OMRR&R Manual, if needed in the future.			
9.1.11 East, West, South FG Infrastructure	MDC	Assumes no additional project costs to existing routine FG inspections.			
9.1.11 East, West, South FG Sediment*	MDC	$100/hour	Annually, 1-10	180 hours	$18,000
9.1.11 East, West, South FG Grade Control	MDC	Assumes no additional project costs to existing routine FG inspections.			
9.1.11 East, West, South FG Habitat**	MDC	$4,344/site	0, 1, 5, 10	10 sites	$43,444
9.1.12 YC Levee Set-Back	USFWS	To be determined as part of the USFWS project.			
				Upper Basin Sites (MoDNR)	**$148,504**
				Locust Creek Study Area (MoDNR)	**$614,688**
				Fountain Grove Study Area (MDC)	**$151,444**
				TOTAL COST	**$914,636**

*Includes 100 hours for initial Year 0 rebar stake installation.

**Based on similar plot-based vegetation work contracted in 2019 by MoDNR at $5,000 per plot.

10.2 Project AM Costs – If AM actions are needed to maintain project performance, it is assumed that they would be implemented within approximately a 1-2-year window after discovery to allow time for any needed permitting and design work. It is assumed that flooding in the study areas would continue in the future and may necessitate some amount of AM to optimize project functions to allow for a fully sustainable condition 10 years from project completion. After 10 years, routine O&M would be conducted by the Non-Federal Sponsor to address long-term OMRR&R requirements as defined in the OMRR&R Manual. The expected stabilization resulting from revegetation of disturbed areas, the entrapment of sediment and woody debris, and evolution of undersized reaches should reduce the need for AM over time. At this time, it is assumed that personnel from both the USACE and Non-Federal Sponsor would lead and conduct both monitoring and any AM construction using existing equipment or thorough contracts if needed. For study areas with multiple potential AM actions, an unknown type and frequency of future issues, and uncertain future on-the-ground conditions; a gross estimate of one type of potential AM was used to estimate quantities and costs. The cost estimates in **Tables 6** are very preliminary, do not include design costs, and are not escalated over time for inflation or depreciation of scope. A 10-year AM period was assumed for plan formulation and cost estimating purposes. Actual time periods and costs will be based on ecological success determinations, availability of Non-Federal Sponsor funds, future flood events, and levels of future upper basin restoration.

Table 6. Estimated Total AM Costs by Study Area and Work Effort.

Monitoring Location / Work Effort	Non-Federal Sponsor	AM Type	Assumptions	Quantity	Item Cost
9.1.1 UBEC Sites – Infrastructure	MoDNR	Multiple	Erosion control on 50% of sites	$3,000/site	$474,000
9.1.1 UBEC Sites – Habitat*	MoDNR	Multiple	Plantings on 50% of sites	$200/site	$31,600
9.1.2 to 9.1.6 LC and FG Study Areas	MDC, MoDNR	No AM costs associated with Lidar, aerial photography, habitat, HH, and sediment data collection monitoring.			
9.1.6.1 LC Reach, Linneus to SDB Diversion Structure	MoDNR	Excavation	Manual removal, $50/cy	5,000 cy	$250,000
9.1.6.2 LC Reach, SDB Diversion Structure	MoDNR	Excavation	Manual removal, $50/cy	6,000 cy	$300,000
9.1.6.3 SDB Reach, Diversion Channel	MoDNR	Excavation	Sediment mounding, $25/cy	4,000 cy	$100,000
9.1.6.4 SDB Reach, SDB Outfall to Highway 36	MoDNR	Grade control	Riprap stone, $80/ton	1,600 tons	$128,000
9.1.6.5 LC Reach, SDB Diversion to Spillway	MoDNR	Grade control	Riprap stone, $80/ton	1,400 tons	$112,000
9.1.6.6 LC Reach, SDB Spillway to Muddy Creek	MoDNR	Grade control	Riprap stone, $80/ton	1,200 tons	$96,000
9.1.6.7 LC Reach, Below Muddy Creek	MoDNR	Excavation & bank packing	Manual removal, $100/cy	4,000 cy	$400,000
9.1.6.8 Higgins Ditch, From Initiation to RGC	MoDNR	None required at this time.			
9.1.6.9 Higgins Ditch, RGC to Terminus of HD	MoDNR	Grade control	Riprap stone, $80/ton	100 tons	$8,000
9.1.7 LC Log Jams and Woody Debris	MoDNR	Bank packing	Remove & place, $100/cy	5,000 cy	$500,000
9.1.8 LC SDB Vegetation	MoDNR	Mowing	Annually if blockage	200 acres	$3,550
9.1.9 LC & FG Levees and Berms	MDC, MoDNR	O&M actions only.			
9.1.10 LC SDB Active AM Opportunities	MoDNR	None identified at this time.			
9.1.11 FG AM Considerations**	MDC	Excavation (200 cy), grade control (200 tons), plantings (40 acres), woody debris (500 cy)			$350,000
9.1.12 YC AM Considerations	USFWS	To be identified by USFWS.			
				Upper Basin Sites (MoDNR)	**$505,600**
				Locust Creek Study Area (MoDNR)	**$1,897,550**
				Fountain Grove Study Area (MDC)	**$350,000**
				TOTAL COST	**$2,753,150**

*Estimated AM/O&M-related costs for potential invasive weed control and re-plantings of riparian corridor vegetation.
**Estimated FG AM costs for excavation and mounding of sediment, grade control, woody debris management, and vegetation plantings.

10.3 Long-Term O&M Cost Considerations – Costs for long-term project O&M actions are summarized in **Table 7**. Costs include new or continued long-term inspections, monitoring, or AM actions that are recommended to meet project success criteria, inform future project adjustments, and provide basic data for long-term planning. O&M actions include projected repair, rehabilitation, or replacement actions over the 50-year period of analysis. Long-term O&M starts after the AM period. Proposed project measures have been designed to ensure low annual O&M requirements. O&M may include performing inspections of avulsion sites, debris removal at levee setback areas, removal of log jams at critical project areas, or continued sediment monitoring. Initial quantities and costs may change during project design and construction phases. A complete list of O&M needs will be provided in an OMRR&R Manual following completion of construction and preparation of as-built drawings, and prior to transferring the project to the Sponsors. For plan formulation and cost estimating purposes, long-term O&M would occur after the monitoring and AM periods. Actual time periods and costs will be based on ecological success determinations, future flood events, and levels of future upper basin restoration.

Table 7. Estimated Total O&M Costs by Study Area and Work Effort.

Monitoring Location / Work Effort	Non-Federal Sponsor	O&M Type	Frequency (Year period)	Quantity	Item Cost*
9.1.1 UBEC Sites HH/Sediment	MoDNR	Monitor – $500/site Erosion – $3,000/site	25, 45 10-50	63 sites 63 sites	$31,600 $189,600
9.1.1 UBEC Sites Habitat	MoDNR	Monitor -$4,344/site Plantings – $200/site	25, 45 10-50	16 sites 63 sites	$69,504 $12,600
9.1.2 LIDAR	MDC, MoDNR	Monitor – $40,000/flight	25, 45	LC and FG	$80,000
9.1.3 Drone Aerial Photography	MDC, MoDNR	Monitor – $20,000/flight	25, 45	LC and FG	$40,000
9.1.4.1 LC Terrestrial Habitat – Vegetation	MoDNR	Monitor – $48-$66/hour	25, 45	320 hours	$18,608
9.1.4.1 LC Terrestrial Habitat – Sediment	MoDNR	Monitor – $48-$66/hour	25, 45	120 hours	$6,667
9.1.4.1 LC Terrestrial Habitat – HH data	MoDNR	Monitor – $48-$66/hour	25, 45	20 hours	$1,145
9.1.4.1 LC Terrestrial Habitat – Soils data	MoDNR	Monitor – $48-$66/hour	25, 45	120 hours	$7,712
9.1.4.1 LC Terrestrial Habitat – Buffer data	MoDNR	Monitor – $48-$66/hour	25, 45	20 hours	$1,145
9.1.5 USGS Turbidity & Sediment	MoDNR	Long-term USFGS gauge monitoring is not included.			
9.1.5 LC SDB Turbidity & Sediment	MoDNR	Monitor – $84,437/site	Every 5 years	3 sites	$253,311
9.1.6 LC HH Cross-Sections	MoDNR	Monitor – $30,000/period	15, 25, 35, 45	Multiple	$120,000
9.1.6.1 LC Reach, Linneus to SDB Diversion	MoDNR	Excavation, $50/cy	10-50	20,000 cy	$1,000,000
9.1.6.2 LC Reach, SDB Diversion Structure	MoDNR	Excavation, $50/cy	10-50	24,000 cy	$1,200,000
9.1.6.3 SDB Reach, Diversion Channel	MoDNR	Mounding, $50/cy	10-50	8,000 cy	$400,000
9.1.6.4 SDB Reach, WCS to Highway 36	MoDNR	Riprap, $80/ton	10-50	6,400 tons	$512,000
9.1.6.5 LC Reach, SDB Diversion to Spillway	MoDNR	Riprap, $80/ton	10-50	5,600 tons	$448,000
9.1.6.6 LC Reach, SDB Spillway to Muddy	MoDNR	Riprap, $80/ton	10-50	4,800 tons	$384,000
9.1.6.7 LC Reach, Below Muddy Creek	MoDNR	Bank Packing, $100/cy	10-50	16,000 cy	$1,600,000
9.1.6.8 Higgins Ditch, Initiation to RGC	MoDNR	None required at this time.			
9.1.6.9 Higgins Ditch, RGC to Terminus of HD	MoDNR	Riprap, $80/ton	10-50	400 tons	$32,000
9.1.7 LC Log Jams and Woody Debris	MoDNR	Bank Packing, $100/cy	10-50	20,000 cy	$2,000,000
9.1.8 LC SDB Vegetation	MoDNR	Mowing – $17.75/acre	10-50	800 acres	$14,200
9.1.9 LC & FG Levees and Berms	MDC, MoDNR	Mowing – $17.75/acre	1-50	5,000 acres	$88,750
9.1.10 LC SDB Active AM Opportunities	MoDNR	Will be outlined in the OMRR&R Manual, if needed in the future.			
9.1.11 East, West, South FG Infrastructure	MDC	Assumes no additional project costs to existing routine FG inspections.			
9.1.11 East, West, South FG Sediment	MDC	Monitor – $100/hour Excavation – $50/cy	25, 45 10-50	320 hours 8,000 cy	$32,000 $400,000
9.1.11 East, West, South FG Grade Control	MDC	Riprap, $80/ton	10-50	2,000 tons	$160,000
9.1.11 East, West, South FG Habitat	MDC	Monitor – $48-66/hour Plantings – $200/acre	25, 45 10-50	FG 160 acres	$35,277 $32,000
9.1.11 East, West, South FG Woody Debris	MDC	Removal – $100/cy	10-50	2,000 cy	$200,000
9.1.12 YC Levee Set-Back	USFWS	To be determined as part of the USFWS project.			
				Upper Basin Sites (MoDNR)	**$303,304**
				Locust Creek Study Area (MoDNR)	**$8,103,163**
				Fountain Grove Study Area (MDC)	**$963,652**
				TOTAL COST	**$9,370,119**

*Estimated long-term O&M costs associated with continuation of monitoring are based are the costs outlined in **Table 5**. Routine O&M actions to be conducted by Non-Federal Sponsor staff as a general component of their work duties (or through contract) were not included in the long-term O&M cost estimates.

11.0 RESPONSIBLE PARTIES

The plan may require extensions and changes to the monitoring, inspections, and AM actions outlined above, especially if major changes in the plan are required. As applicable, Corps project biologists and engineers, in consultation with Non-Federal Sponsor personnel, would make monitoring and AM recommendations. The parties responsible for implementation of the restoration plan and any associated contingencies are listed below. **Table 8** provides a summary of the project phases, purposes, and responsibilities associated with proposed monitoring, AM, and long-term O&M actions. Changes in personnel over the remaining project phases should be tracked and the points of contact should be modified as needed to keep the project up to date.

Project Manager: Kaely Megaro
U.S. Army, Corps of Engineers, Kansas City District

Project Manager: Tim Rielly
Missouri Department of Natural Resources

Project Manager: Stuart Miller
Missouri Department of Conservation

Project Biologist: Jeff Tripe
U.S. Army Corps of Engineers, Kansas City District

Project Biologist: Christopher Crabtree
Missouri Department of Natural Resources

Project Biologist: Chris Freeman
Missouri Department of Conservation

Project Engineer: John Shelley
U.S. Army Corps of Engineers, Kansas City District

Project Hydrologist: Erin Reinkemeyer
U.S. Army Corps of Engineers, Kansas City District

Table 8: Project Phases, Purposes, and Responsibilities for the Grand River Ecosystem Restoration Project.

Project Phase	Type of Activity	Purpose	Responsible / Implementing Agency	Funding Source
Feasibility Study	Feasibility-related data collection, mapping, monitoring, and modeling. Part of Year 0 baseline condition information. Conceptual measures and alternatives, at approximately 35% level of design.	Identify and define study problems. Establish need and conceptual effectiveness of proposed project measures. Establishes baseline condition for follow-on AM and O&M project performance evaluations. Provides general location, methods, and costs for potential implementation.	Non-Federal Sponsors USACE	Cost-Shared
Plans & Specifications (P&S)	P&S-related data collection, mapping, monitoring, and modeling. Part of Year 0 baseline condition information. Detailed P&S typically includes sub-phases for development of 35%, 65%, 95%, and 100% designs.	Refines new/changed problems since Feasibility. Establishes baseline condition for follow-on AM and O&M project performance evaluations. Refines proposed project measures to include quantification of project objectives, design of project features, cost refinement, development of OMRR&R Manual and evaluation reports/sampling manuals.	Non-Federal Sponsors USACE USFWS	Cost-Shared USFWS**
Construction	Construction monitoring, quality control and assurance.	Assess potential construction impacts and assures permit conditions are met. Identify any construction improvements or design changes based on current conditions.	Non-Federal Sponsors USACE USFWS**	Cost-Shared USFWS**
AM Phase (Year 1-10)*	Performance evaluation monitoring. Implementation of AM measures. Routine O&M activities.	To identify AM actions for potential implementation, provide real-time data, and to help ensure overall project success. To course-correct for changed conditions that may reduce project effectiveness and success. Should help optimize the project performance and desired outputs. Routine project-related operations, maintenance, repair and replacement activities to maintain designed project performance.	Non-Federal Sponsors USACE USFWS**	Cost-Shared USFWS**
O&M Phase (Year 1-50)*	Continuation of any long-term monitoring, AM, and routine O&M actions.	Same as above, but any required long-term monitoring or AM actions are continued as O&M activities, dependent on requirements as outlined in the OMRR&R Manual.	Non-Federal Sponsors USFWS**	Non-Federal Sponsors USFWS**

* A 10-year monitoring and AM period as well as a 50-year analysis period was assumed for plan formulation and cost estimating purposes. Actual time periods and costs will be based on ecological success determinations, future flood events, and levels of future upper basin restoration.
**Part of the overall Federal Project, which includes actions that may be conducted by USFWS at the Yellow Creek study area.

Attachment A. Summary of Grand River Ecosystem Restoration Study Monitoring, AM, and O&M Plan Components.

Report Section	Locations	Objectives	Assessment Tools	Assessment Metrics	Assessment Frequency	Minimum Performance Targets	Estimated Monitoring and Inspection Costs	AM Actions and Costs	O&M Actions and Costs	Notes
9.1.1 UBEC Sites	Grand River Watershed, Upper Basin Erosion Control (UBEC) Sites	Reduced streambank erosion and stable channel morphology.	Field trips to measure exposed or buried rebar stakes. If available, existing LIDAR and aerial mapping. If available, HH cross-sections.	Erosion, aggradation, and degradation rates. Change in channel morphology.	Year 0, Year 5, Year 10. Event-based flood assessments for 2-year or greater flood events. 316 UBEC sites would be grouped by similarity and a portion of each group would be assessed each period (50% year 0-10, 20% year 10-50).	General performance targets would include stable to aggrading streambank conditions and stable channel morphology. Depending on site specific channel configurations, upstream-downstream conditions, and the restoration measures to be employed, specific performance targets would establish on a site-by-site basis.	Up to four assessment periods with 2 weeks of labor per period within the first 10 years. Approximately $79,000.	Depending on site specific needs and conditions, AM actions could include rock armoring, channel widening, bench cuts, tree revetments, willow plantings, channel grade control, bank sloping, etc.	Anticipate reduced number of field trips for out-year assessments (Year 25 and 45) due to limited resources. Only assess high risk UBEC sites, based on Year 1-10 data. Approximately $31,600 for Year 25 and 45.	Sites should be sampled when flows are at normal base flow conditions. Visual assessment of adjacent private property would also be conducted to identify potential erosion or sedimentation issues.
		Increased aquatic and riparian habitat quality & quantity.	Field trips to collect data for Aquatic Riverine and Riparian Corridor Habitat Models.	Habitat Model Outputs. Habitat Acres.	Year 0, Year 5, Year 10. At least one assessment for 2-year or greater flood events.	Improved HSI values. Stable to increasing acreages.	Two weeks of field work with follow-on data processing for up to six assessment periods during the first 10 years. Approximately $69,504.	If HSIs or acreages are reduced, identify issue and develop AM action(s) such as plantings, erosion control, grade control, etc.	Long-term habitat assessments (Year 25 and 45) by Non-Federal Sponsor. Approximately $69,504 for 2 period assessments.	Several models and strategic habitat assessment locations were assessed by the Non-Federal Sponsor.
9.1.2 Light Detection and Ranging (LIDAR)	Locust Creek (LC) and Fountain Grove (FG) Study Areas	Light Detection and Ranging (LIDAR) to assess changes in lands forms, channel migration, floodplain elevations, woody debris accumulation, and changes to avulsions over time.	LIDAR mapping with Geographic Information System (GIS) assessment.	Change in the parameters listed in the "Objective" column.	Year 0, Year 5, Year 10.	Required LIDAR quality and parameters would be similar to those used for the Feasibility Study.	Initial estimates are $120,000 for up to three LIDAR assessments from Year 0 to Year 10.	LIDAR data and results would be used in conjunction with other datasets and information to support the potential AM and O&M actions listed below.	Long-term habitat assessments (Year 25 and 45) by Non-Federal Sponsor. Out-year LIDAR assessments would be approximately $40,000 per assessment.	The total number of LIDAR flights that can be accomplished will be dependent on total AM cost estimates.
9.1.3 Aerial Drone Mapping	LC and FG Study Areas	Drone aerial photography and mapping to assess change in floodplain habitats, river channel morphology, eroding reaches, new and existing avulsions, and areas with woody debris accumulation.	Aerial drone photography with GIS assessment.	Change in the parameters listed in the "Objective" column.	Year 0, Year 5, Year 10.	Aerial photography quality and parameters would be similar to those used for the Feasibility Study.	Initial estimates are $60,000 for three aerial drone assessments from Year 0 to Year 10.	Photography and mapping would be used in conjunction with other datasets and information to support the potential AM and O&M actions listed below.	Long-term habitat assessments (Year 25 and 45) by Non-Federal Sponsor. Out-year drone aerial mapping would be approximately $40,000 per assessment.	The total number of aerial flights that can be accomplished will be dependent on total AM cost estimates.
9.1.4 Habitat Assessments	LC and FG Habitat Sites	Increased aquatic riverine, wet prairie, emergent wetland, and hardmast forest habitat quality & quantity.	Field trips to collect aquatic riverine, hardmast forest, emergent wetland, and wet prairie habitat model data.	Habitat Model Outputs. Habitat Acres.	Year 0, Year 1, Year 5, Year 10, Year 10, Year 25, Year 45.	Improved HSI values. Stable to increasing acreages.	Field work with follow-on data processing for up to 4 assessment periods during the first 10 years. Approximately $43,444.	If HSIs or acreages are reduced, identify issue and develop AM action(s) such as plantings, erosion control, grade control, etc.	Long-term habitat assessments (Year 25 and 45) by Non-Federal Sponsor. Approximately $35,277 for Year 25 and 45.	Several models and strategic habitat assessment locations were considered by the Non-Federal Sponsor.
9.1.5 Sediment Loads	LC Reach, Linneus to Sediment Detention Basin (SDB) Diversion Structure	Reduced downstream migration of sediment.	SON/Turbidity data from the Linneus USGS gauge. Field trips to collect physical sediment samples from Linneus to SDB diversion structure.	Turbidity levels over time. Sediment concentration and size.	Turbidity - continuously sampled from Year 0 through Year 5. Substrate - at least 12 annual physical samples.	Stable or decreasing sediment loads and turbidity levels.	Estimated cost of installation of sampling probes, data collection and analysis of data are approximately $180,000.	Modify SDB diversion structure and/or SDB outfall to adjust flow/sediment into and out of the SDB. implementation of upstream sediment reduction measures, bedload traps, or channel excavation.	No long-term assessments by Non-Federal Sponsor. Adjustments to SDB outfall.	Potential high first costs but would be primarily labor costs to collect and process data.
	Installation of SON/Turbidity sites at key locations (above/below SDB diversion structure, spillway, SDB outfall).	Measure both event-based floods and acquire time-based (monthly, yearly) turbidity data.	Turbidity sondes.	Turbidity levels over time.	Turbidity sondes would continuously collect turbidity for up to 4 months every 5 years from Year 0 through Year 50.	Data would be used with physical samples, Lidar, aerial mapping, and HH cross-sections to assess change in sediment load over time.	Estimated costs include turbidity equipment and assessments for the first 10 years, approximately $109,244.	Data would be used with physical samples, Lidar, aerial mapping, and HH cross-sections to assess sediment loads in the study areas.	Long-term turbidity assessments would be approximately $253,311 for 6 months of continuous data collection every five years from Year 10 through Year 50.	Long-term data collection would be continued or discontinued as outlined in the project OMRR&R Manual.

Report Section	Locations	Objectives	Assessment Tools	Assessment Metrics	Assessment Frequency	Minimum Performance Targets	Estimated Monitoring and Inspection Costs	AM Actions and Costs (Year 01-10)	O&M Actions and Costs (Year 1-50)	Notes
9.1.6 HH Cross-Sectional Data	9.1.6.1 LC Reach, Linneus to SDB Diversion Structure	Stable channel capacity and conveyance.	Field trips to collect HH cross-sectional data. Review of LIDAR and drone aerial mapping.	Change in HH cross-sections within the reach; particularly aggradation.	Year 1, Year 5, Year 10.	Channel capacity reduction of 20% or more.	Eight weeks of labor was used to estimate costs for field work and required follow-on data processing for 4 sampling periods through Year 10. Total estimated HH cross-section data collection and assessment costs are approximately $192192,000192,000,000 .	Additional upstream sediment reduction measures, bedload traps, channel excavation, and/or adjustments to the SDB diversion structure and SDB outfall. Excavation at $250,000.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor, approximately $120,000. Adjustments to SDB outfall. Excavation at $1,000,000.	Total costs for LIDAR, aerial mapping, and HH cross-sections are included in above and below cost estimates. See Tables 4-7 of main report for long-term monitoring, AM, and O&M costs.
	9.1.6.2 LC Reach, SDB Diversion Structure	No woody debris accumulation and minimal sediment deposition near the diversion structure.	Field trips to collect HH cross-sectional data. Review of LIDAR and drone aerial mapping.	Change in HH cross-sections near the diversion structure; particularly aggradation.	Annual measurements of sediment and woody debris.	Sediment Deposition - more than 1 foot. Any accumulation of woody debris.		Sediment removal methods such as channel excavation and bed-load collectors. Any accumulation of woody debris should be promptly removed with mulching or manual removal. Excavation at $300,000.	Short-term, annual inspections of the SDB diversion structure. HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Adjustments to SDB outfall. Excavation at $1,200,000.	
	9.1.6.3 SDB Reach, Diversion Channel	Maintain Long-term SDB Storage Volume and Capacity.	Field trips to collect HH cross-sectional data. Review of LIDAR and drone aerial mapping.	Change in terrain mapping. Sediment deposition amounts. SDB volume estimates.	Year 1, Year 5, Year 10.	HH and Sediment models could be periodically used to assess remaining SDB storage volume.		Adjust SDB flow discharges to decrease sediment residence time, mounding sediment within the basin to provide additional storage volume with moderate discharges, manual sediment removal, expansion of SDB boundaries. Sediment mounding at $100,000.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Adjustments to SDB outfall. Excavation at $120,000, year 10-50. Sediment mounding at $400,000.	
	9.1.6.4 SDB Reach, SDB Outfall to Highway 36	Stable channel capacity and conveyance.	Field trips. HH cross-section data. LIDAR mapping. Aerial mapping.	Change in HH cross-sections below the SDB outfall; particularly scouring.	Year 1, Year 5, Year 10.	Expected enlargement and scouring in response to higher flows and lower sediment loads. If cross-sections indicate that excessive downstream degradation has occurred, additional grade control would be implemented while also considering fish passage requirements.		If cross-sections indicate that excessive downstream degradation and scouring is occurring, additional grade control would be implemented while providing for a gradual slope for fish movement and passage requirements. Grade control $128,000.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Adjustments to SDB outfall. Additional grade control if needed. Grade control $512,000.	
	9.1.6.5 LC Reach, SDB Diversion Structure to SDB Spillway	Stable channel capacity and conveyance.	Field trips. HH cross-section data. LIDAR mapping. Aerial mapping.	Change in HH cross-sections in LC from the SDB diversion structure to the spillway; particularly degradation.	Year 1, Year 5, Year 10.	Less water and sediment would enter this reach in the future. Channel degradation of more than 3 feet.		If performance targets are exceeded, the diversion channel would be assessed to determine if additional rock armoring would be needed on the downstream slope of the diversion structure and spillway. Grade control $112,000.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Additional grade control if needed. Grade control $448,000.	
	9.1.6.6 LC Reach, SDB Spillway to Muddy Creek Confluence	Stable channel capacity and conveyance.	Field trips. HH cross-section data. LIDAR mapping. Aerial mapping.	Change in HH cross-sections in LC from the SDB spillway to the Muddy Creek confluence; particularly degradation.	Year 1, Year 5, Year 10.	Channel degradation in LC and aggradation in avulsions, to the point that water no longer flows down Higgins Ditch.		Flow change implications would be assessed, and grade control would be considered as an AM measure. Grade control $96,000.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Additional grade control if needed, $384,000.	
	9.1.6.7 LC Reach, Downstream from the Muddy Creek Confluence	Channel enlargement and increased capacity over time.	Field trips. HH cross-section data. LIDAR mapping. Aerial mapping.	Change in HH cross-sections in LC downstream of the Muddy Creek confluence; particularly channel enlargement.	Year 1, Year 5, Year 10.	The additional flow and relatively low-sediment-water that would be returned to this channel under the FWP condition is expected to enlarge LC downstream from the Muddy Creek confluence.		Additional flow could be released to further enlarge the reach to its estimated historic bank full capacity of 6,000 cfs. Aggradation, actions such as plugging existing avulsions, installation of bedload traps, and excavation of the channel bottom would be considered. Log removal with packing $400,000.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Adjustments to SDB outfall, avulsion packing, operation of bed-load collectors/traps, and channel excavation. Log removal with packing $1,600,000.	
	9.1.6.8 Higgins Ditch Reach, From Initiation to RGC Structure	Sediment deposition and a smaller channel over time.	Field trips. HH data. LIDAR mapping. Aerial mapping.	Change in HH cross-sections in Higgins Ditch to RGC.	Year 1, Year 5, Year 10.	Sediment deposition and a smaller channel over time.		No AM measures in this reach are anticipated.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor.	
	9.1.6.9 Higgins Ditch Reach, RGC Structure to Terminus of HD	Sediment deposition and a smaller channel over time.	Field trips. HH cross-section data. LIDAR mapping. Aerial mapping.	Change in HH cross-sections in Higgins Ditch to RGC.	Year 1, Year 5, Year 10.	Inspect and monitor Higgins Ditch grade control structure for potential scouring and degradation that could lead to structural failure. Performance metric of 3 feet of degradation or more.		Consider adding rock to downstream side of grade control structure, or installation of an additional downstream grade control structure to create a backwater effect. Grade control $8,000 year 1-10.	Long-term HH cross-section assessments (Year 15, 25, 35 and 45) by Non-Federal Sponsor. Additional grade control if needed. Grade control $32,000, year 10-50.	

Report Section	Locations	Objectives	Assessment Tools	Assessment Metrics	Assessment Frequency	Minimum Performance Targets	Estimated Monitoring and Inspection Costs	AM Actions and Costs (Year 01-10)	O&M Actions and Costs (Year 1-50)	Notes
9.1.7 Log Jams and Woody Debris	LC floodplain, aggradational reaches, existing avulsions, and within the SDB near the flow diversion structure, basin spillway, and SDB outfall.	Assess change in woody debris accumulation and log jams.	HH cross-section data, LIDAR and aerial mapping.	Data and mapping would be reviewed for potential issues associated with accumulation of woody debris.	Annually.	Impacts to flow of water, sediment, or woody debris within the SDB and at key locations.	The cost for this work is included in the above LIDAR, aerial mapping, and HH cross-section cost estimates.	Manual log removal, mulching, notching of interior SDB levees, mounding of sediment/debris in the SDB, creation of sediment/log traps in the SDB, bank-avulsion packing. $500,000 for log removal with packing, year 1-10.	After Year 10 the Non-Federal Sponsor could use the same AM actions for any long-term O&M needs. $2,000,000 for log removal with packing, year 10-50.	The type of AM/O&M measure would be based on the distance from access roads and on-the-ground conditions.
9.1.8 SDB Vegetation	Upper area of the SDB, diversion structure, spillway, and SDB outfall.	Routinely monitor and inspect areas to identify any issues associated with excessive vegetation growth.	Review of aerial mapping, habitat assessment data, and HH cross-section data.	High densities of willow, cottonwood, silver maple, and reed canary grass could impact flow of water, sediment, and woody debris in the SDB.	Annually.	Impacts to flow of water, sediment, or woody debris within the SDB and at key locations.	The cost for monitoring work is included in the above cost estimates.	Monitoring should help identify any AM needs associated with care of vegetation to include mowing, thrashing, and burning. Mowing at $3,550, year 1-10.	After Year 10 the Non-Federal Sponsor could use the same AM actions for any long-term O&M needs. Mowing at $14,200, year 10-50.	The type of AM/O&M measure would be based on the distance from access roads and on-the-ground conditions.
9.1.9 Levees and Berms	Levees and berms within the LC, FG, and YC study areas.	Maintain levees/berms adjacent to and downstream of proposed FWP measures and those required for continued success of proposed restoration features.	Field trips for collection of HH cross-section data and habitat assessments could be used to also inspect berms and levees.	Identify any erosion concerns, sloughing, detrimental vegetation growth, animal burrows, or damage from periodic flooding.	Annually.	Maintain designed levee/berm performance and standards.	The cost for monitoring work is included in the above cost estimates.	Adjustment and modification of interior berms within the SDB such as notching, could be used to help optimize desired flows, sedimentation, and accumulation of woody debris.	Routine mowing, thrashing, or burning may be necessary to maintain vehicle access and to maintain dense vegetation coverage on levees and berms to help limit potential erosion. $88,750 for mowing, year 1-50.	The type of AM/O&M measure would be based on the designed levee standards and type of performance issue.
9.1.10. Active AM Opportunities	Within the SDB.	HH, ecosystem, and biological research and the use of Active AM measures within the SDB as existing row crop land use evolves into a more natural condition.	Field trips to collect specific data with data assessment. Review of LIDAR, aerial mapping, and HH cross-sections.	Vegetation shifts, invasive rates, wildlife shifts, water quality benefits, changes in diversity and species abundance, trends in abiotic conditions, and many more research-related areas.	Dependent on the research/active AM objective.	Dependent on the research/active AM objective.	The current Monitoring Plan does not specifically identify or fund additional monitoring activities.	The current AM Plan does not specifically identify or fund additional research or active AM-related studies.	Implementation of future projects would be at the discretion of the Non-Federal Sponsor and identification of cooperative opportunities with USACE, other resource agencies, and universities.	
9.1.11 FG Monitoring, AM, and O&M Considerations	East FG, West FG, and South FG	Inspections of critical infrastructure for performance issues. Reduced streambank erosion, decreased sedimentation, and stable channel morphology. Increased emergent wetland and hardmast forest quality & quantity. Long-term LIDAR and drone aerial photography to assess broad changes in vegetation communities, accumulation of woody debris, and sedimentation.	Monitoring and inspections of critical infrastructure. Field trips to collect HH, sediment, and habitat modeling data. Review of LIDAR and aerial mapping to assess landform changes, avulsions, sedimentation, and woody debris accumulation. Use of sediment rebar stakes. Review of FG management data.	Identified infrastructure issues vs. designed standards. Wetland and hardmast forest habitat model outputs and habitat acres. Change in erosion, aggradation, degradation, and sedimentation rates.	Critical infrastructure - annually. Habitat modeling - Year 0, Year 1, Year 5, Year 7, Year 10. HH/Sediment data - Year 1, Year 5, Year 10. LIDAR/aerial mapping - Year 0, Year 5, Year 10 and after at least one event-based flood. Annual review of FG management results.	Minimum infrastructure design standards. Increasing habitat units and/or acreages. Stable streambanks and channel morphology. Continued independent filling and drainage ability of designed wetland cells.	Annual inspections of infrastructure within the first 10 years, approximately $8,000. Habitat assessment periods during the first 10 years, $43,444. LIDAR and aerial mapping costs are included above. Sediment-erosion monitoring, $90,830.	If infrastructure issues, identify AM action dependent on the problem. If HSIs or acreages are reduced, identify issue and develop AM action(s) such as plantings, erosion control, grade control, etc. Estimates for AM period included: Excavation 200 cubic yards, grade control 200 tons, plantings 40 acres, and woody debris removal 500 cy.	Annual inspections of infrastructure from year 10-50, approximately $32,000. Long-term habitat assessments (Year 25 and 45) by Non-Federal Sponsor, $35,277. Use of operational data from FG management to identify potential modifications to gates, piping, berms, channels, microtopography, etc. Sediment-erosion monitoring $32,000. O&M plantings, $32,000. Sediment excavation $400,000, grade control $160,000, and woody debris removal $200,000.	Several models and strategic habitat assessment locations are currently being considered by the Non-Federal Sponsor.
9.1.12 YC Monitoring, AM, and O&M Considerations	Yellow Creek (YC) Levee Set-Back Area	Any required monitoring, AM, or O&M actions and associated costs at the YC study area would be the responsibility of the USFWS.	Similar actions as outlined above would likely be used to identify AM actions and long-term O&M requirements for the proposed levee set-back area along Yellow Creek.	Inspection of critical USFWS infrastructure, assessment of habitat quality and quantity, and changes in local sedimentation would be important project components to asses over time.	Dependent on USFWS resources and funding.	Impacts to infrastructure, improvement in habitat quality and quantity, and decreased flooding/sedimentation.	Any required monitoring, AM, or O&M actions and associated costs at the YC study area would be the responsibility of the USFWS.	Any required monitoring, AM, or O&M actions and associated costs at the YC study area would be the responsibility of the USFWS.	Any required monitoring, AM, or O&M actions and associated costs at the YC study area would be the responsibility of the USFWS.	Part of the overall Federal plan to be implemented by USFWS.