Sustainable Rivers Program

National Lock and Dam Meeting

Summary Report

Lake sturgeon spawning below Melvin Price Locks and Dam, Mississippi River (photo by Ryan Swearingin, USACE).

Prepared by: U.S. Army Corps of Engineers, St. Louis District
1222 Spruce Street
St. Louis, Missouri, 63103

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1 Introduction

On May 24-26, 2022, USACE hosted a National Lock and Dam (L&D) meeting in Pittsburgh focused on applications of Sustainable Rivers Program (SRP) strategies to locks and dams managed by the U.S. Army Corps of Engineers (USACE) across the country. The meeting was primarily an information exchange between professionals involved with navigation-oriented and other reservoirs with a focus on environmental benefits and related operational opportunities and concerns. It was convened to help participants be as effective as possible in their work and to promote similar efforts within SRP and beyond across the country.

Meeting goals were to:

1. Increase knowledge of water level management (WLM) capabilities related to USACE infrastructure.
2. Identify more sustainable ways to manage river infrastructure to maximize benefits for people and the environment.
3. Discuss successful and potential WLM opportunities.
4. Further WLM implementation at USACE infrastructure.

Meeting objectives were to:

1. Identify operational opportunities and constraints.
2. Identify specific implementable locations for WLM.
3. Identify information/data gathering tasks at implementable locations.

Overall, 38 people from 5 USACE divisions and 11 districts attended the workshop. Attendees varied in their level of experience with SRP projects which provided a mix of fresh perspectives and opportunities for sharing knowledge and ideas. Workshop agenda provided in Appendix A.

2 SRP Overview

The SRP is a national partnership between USACE and The Nature Conservancy. The mission of SRP is to improve the health and life of rivers by changing water management infrastructure operations to restore and protect ecosystems, while maintaining or enhancing other authorized project purposes.

The meeting began with an overview of SRP, the multi-step process utilized at proposed projects (i.e., advance, implement, and incorporate; Table 1), the types of projects that have been evaluated, implemented, or proposed (Figure 1; Figure 2) and the current priorities for the program (Table 2).

Table 1. Sustainable Rivers Program multi-step process.

Sustainable River Program - Multi-step process	
Advance	Engaging stakeholders in a science-based process to define the flow needs of river ecosystems
Implement	Testing the effectiveness and feasibility of the defined flows
Incorporate	Including environmental flow strategies in operations policy such as water control manuals, SOPs, or other local process for integrating environmental flows into standard operations during relevant periods of time.

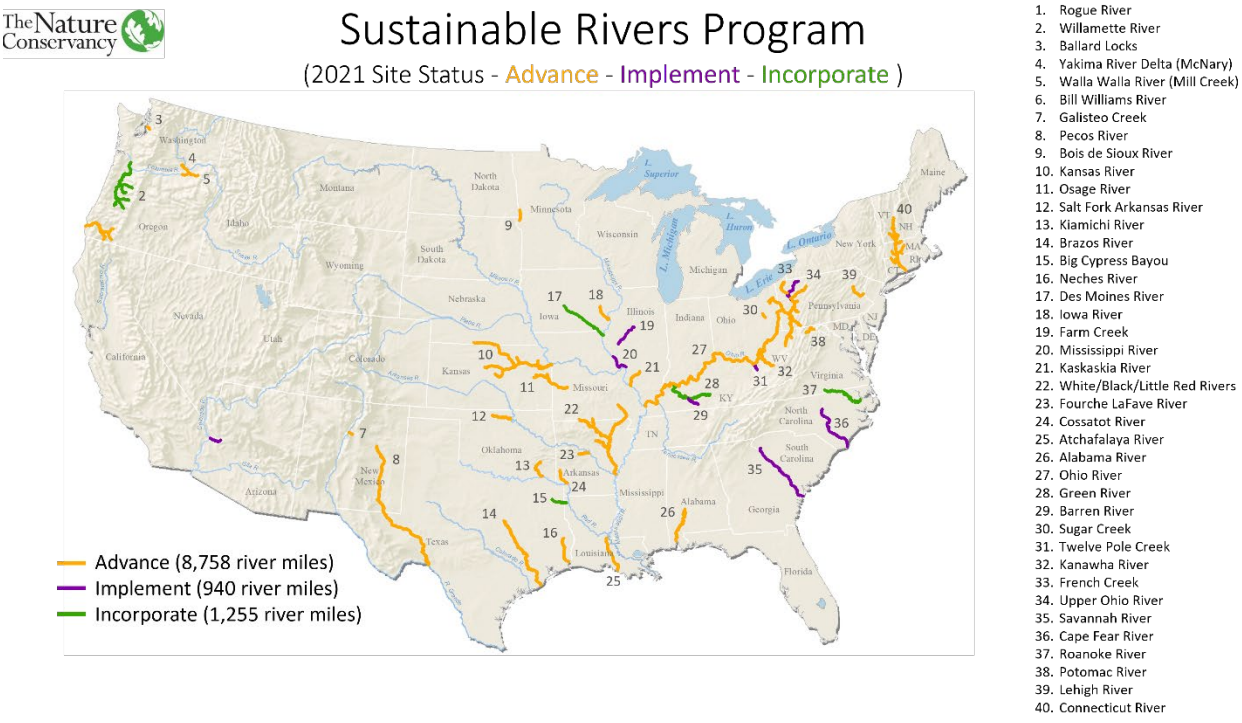


Figure 1. SRP project locations through 2021.

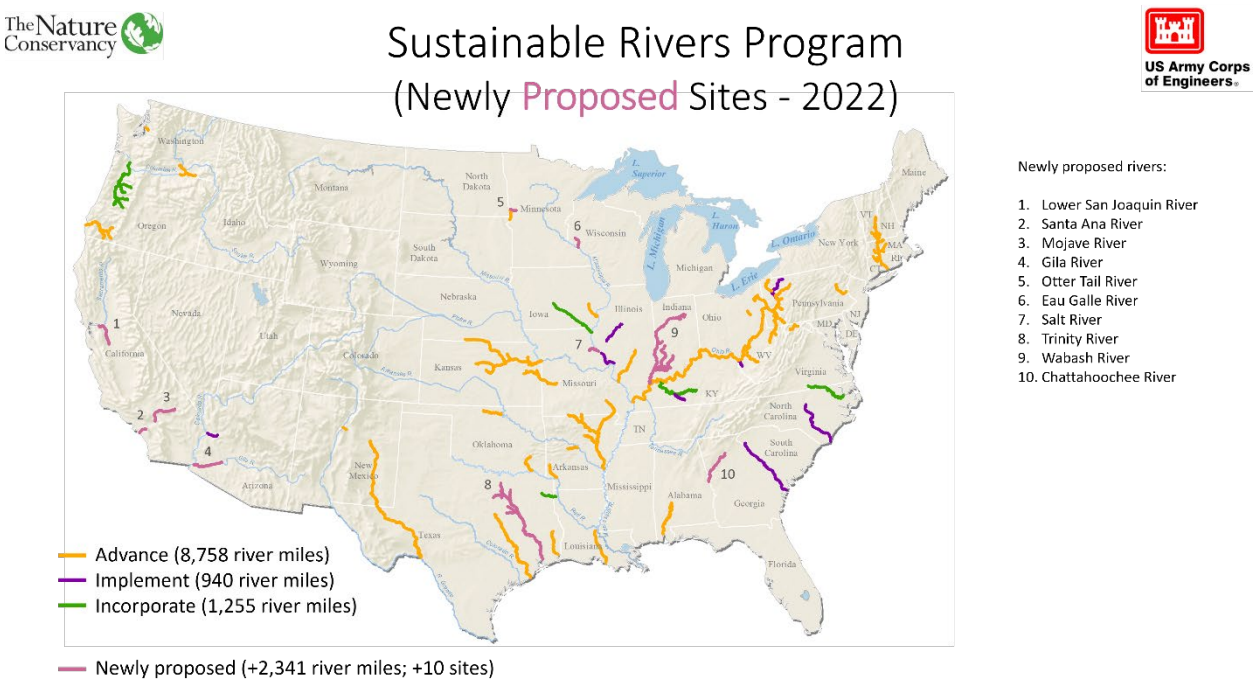


Figure 2. Proposed new SRP project locations in 2022.

Table 2. Sustainable Rivers Program 2022 program strategic objectives for potential projects.

Sustainable River Programs - Strategic objectives
1. Expand SRP strategically and geographically
2. Accelerate "Implementation and Incorporation" of SRP recommendations into infrastructure operations plans
3. Continue to apply SRP with other infrastructure types
4. Develop performance metrics that convey true impact of SRP activity

A focus of the workshop was to engage districts that manage locks and dams, facilitate sharing of project successes and lessons learned across districts, and generate potential projects across multiple districts. The importance of SRP implementation goes beyond the localized benefits in our districts. The SRP program has the potential to modernize dams and infrastructure to achieve environmental benefits which can lead to improvements for both nature and people. Additionally, SRP encourages collaboration between USACE districts as well as other agencies across the nation. This collaboration can result in broader-scale adoption and modifications to management which result in positive changes for the environment while still fulfilling the original authorized purposes of USACE infrastructure.

3 Successful Implementation Examples

The Sustainable Rivers Program has numerous projects that are navigating the advance – implement – incorporate process (Table 1). At the workshop, several SRP team leads presented their projects and discussed lessons learned at the USACE infrastructure they are involved with.

3a Pools 24, 25, and 26 Environmental Pool Management (EPM)

All of the locks and dams within the St. Louis District are hinge point operated projects – meaning that the L&Ds are operated to target pool levels based on river stages at points upstream of the dams. For each L&D, levels are managed such that stage at that point remain within a specific range to prevent the river from inundating land outside of federal easements and to maintain a 9-foot navigation channel, as much as possible (Figure 3). Under this management type, water fluctuations occur in the lower pool as a result of changes in inflows. These fluctuations can expose shoreline and island border mudflats near the dam for parts of the year. Under early dam management methods, exposure occurred for only short periods of time, which reset any vegetation that established.

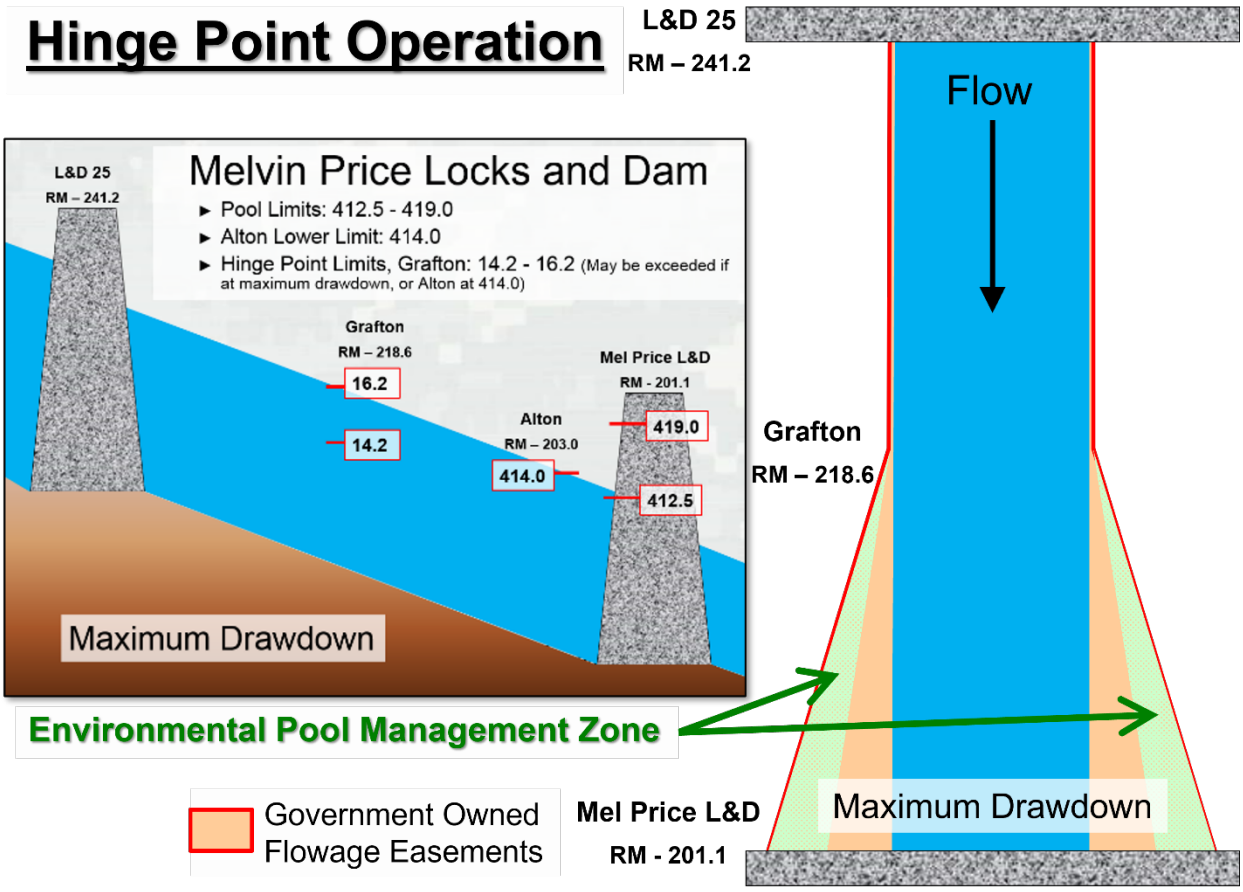


Figure 3. Schematic of hinge point dam operation and environmental pool management, Mississippi River, St. Louis District.

Each year the St. Louis District holds an annual coordination meeting with resource agencies, NGOs, and other stakeholders that is centered on Upper Mississippi River issues, solutions, and ongoing actions. EPM within the St. Louis District began in 1994 at the request of state natural resource agencies during an annual coordination meeting. The idea behind EPM was an evolution of previous agency requests to modify the way dams were operated to better support aquatic vegetation. Prior requests involved more significant drawdown depths and longer durations that were not feasible while maintaining the primary project purpose of a safe, dependable navigation channel. The frequent coordination helped create an opportunity where water managers could better understand limiting factors and minimum needs of ecological resources, communicate what may be possible to implement while maintaining a navigable channel, and provide resource agencies an opportunity to share feedback. This coordination helped to identify a potential solution that balanced the desired benefits while maintaining navigation.

In 1994, the district made its first attempt to draw down several L&D pools along the Mississippi River for at least 0.5 ft over 30 consecutive days in the growing season (Figure 4). Initially, the navigation industry was against the prospect of this program, but concerns were reduced through coordination and implementation of a drawdown. The trial showed that the navigation channel could still be maintained while managing for conditions needed to support aquatic vegetation establishment and growth. During implementation, environmental pool management exposes a fringe of island shoreline and bankline primarily in the lower portion of the pool. Management during the growing season attempts to reduce the rate of water level fluctuations in this exposed fringe when it is possible to achieve without impacts to navigation. If the pool must be raised due to a change in inflows, Water Control attempts to make adjustments gradually (1 inch per day) to continue supporting plant development as long as navigation is not impacted.

Close coordination with a diversity of stakeholders (barge industry, natural resource agencies, recreational users, etc.) helps USACE fulfill multiple purposes while ensuring a navigable channel is maintained. Stakeholders can also provide input during implementation about conditions, needs, etc.

Being open to trying something new allowed EPM to happen and evolve with stakeholder input over time. Resource agency willingness to try the smaller scale drawdown, which was less than their earlier requests, created more favorable conditions for implementing a trial and refining the methodology over time based on results and experience.

Coordination with agencies on EPM continues -- even after more than 25 years of implementation -- to ensure changing conditions are accounted for in the decision-making process. Over the years, the district has found that the best results happen as a result of close coordination with resource managers in the field that can provide “on the ground” insight on environmental conditions and needs.

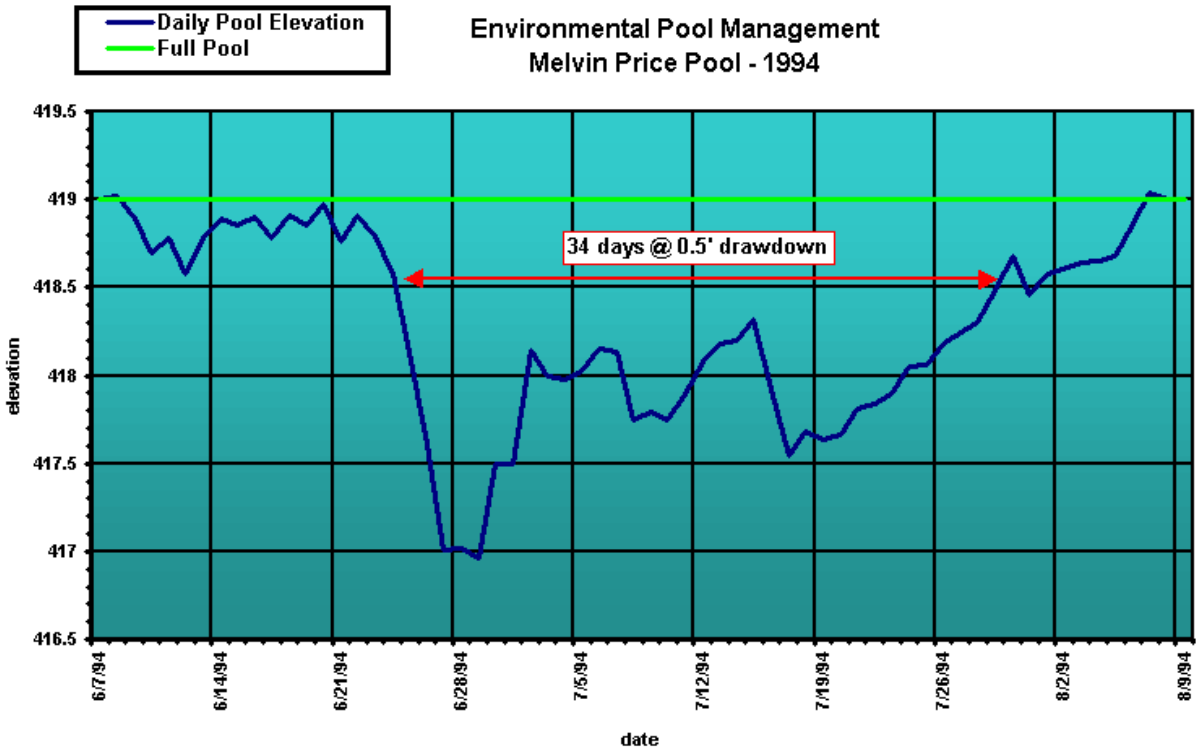


Figure 4. Example of initial environmental pool management minimum depth and duration targets.

In 2015, there was a request by The Nature Conservancy to evaluate a lengthening of the EPM period to 120 days. This resulted in an increase, in perennial aquatic species (e.g. arrowhead, lotus, and spatterdock) growing along the shoreline in parts of the pool. These perennial species were formerly more widespread but were greatly reduced after the historic 1993 and 1995 flood events.

3b Environmental Pool Management for the Kaskaskia River

The Jerry Costello Lock and Dam (Costello L&D) is managed as a hinge point operated dam like all other L&D in St. Louis District. In 2020, at the "SRP Environmental Opportunities for Rivers and Reservoirs in the Upper Midwest" meeting, MVS identified the Kaskaskia River system as a potential location for evaluating pool level management for wetland plant communities at three USACE infrastructure locations, Costello L&D, Carlyle Lake, and Lake Shelbyville. At that time, the district was uncertain whether drawdowns could be implemented on the Kaskaskia River.

Over the next year, the St. Louis District performed a 21-year retrospective analysis with SRP support to determine how frequently the Costello L&D pool and reservoirs along the Kaskaskia River could be managed for a drawdown of at least 30 days. The analysis found that in dry years no EPM would occur at Costello L&D but the Carlyle and Shelbyville reservoirs had a

higher likelihood of having successful EPM. In wet years, Costello L&D would likely have favorable conditions for EPM but the reservoirs would not have favorable conditions for EPM.

Overall, the 21-year evaluation of historic conditions showed that some years are not going to provide ideal conditions for EPM drawdowns while others are going to be near optimal. This natural variation should help to reset vegetation that may start undergoing successional changes to shrubland or forest communities if the conditions were the same each year.

The analysis suggested that drawdowns could occur within existing water management limits while not impacting navigation or any other project purposes at the Kaskaskia projects. As a result, implementation of EPM drawdowns would pose no additional cost to the district while maintaining navigation and improving habitat conditions.

During the 2021 season, the St. Louis District planned to attempt a drawdown at all three locations on the Kaskaskia River if forecasts were favorable. Prior to the environmental pool management season (i.e., the growing season), the district held a public meeting at each location to share information on what environmental pool management is and is not, when it could occur, and what the ecological response and benefits could be. Overall, the public response was mostly supportive of attempting environment pool management. Some businesses and a few recreational users voiced potential concerns with access. Concerns were partially alleviated by adjusting the timing of the drawdown until after July 4th weekend.

In 2021, MVS managed water levels at 0.5 ft below the maximum regulated pool level (i.e., drawdown) for 61 days at Costello L&D. This resulted in significant vegetative growth in areas that are normally underwater. In that same season, Carlyle Lake was at drawdown late in the growing season for approximately 30 days and showed a promising vegetative response. No drawdown was attempted at Lake Shelbyville due to unfavorable conditions.

Across the three locations on the Kaskaskia River, the following EPM success rates were estimated from the 21-year retrospective analysis:

- Costello L&D - 57%
- Carlyle Lake - 29%
- Lake Shelbyville - 43%

It will likely be more challenging to have appropriate conditions to implement EPM at all three sites in a given year, but it should be possible to implement at one or more sites during most years.

3c Cape Fear River

The Cape Fear River was added to SRP in 2016 after concerns over several ecological impacts were raised. The river hosts a diverse assemblage of species and has strong stakeholder engagement. It was listed as one of North America's top 10 most endangered rivers by American Rivers in 2017 due to historic and current industrial use and operations, urbanization,

and agricultural use in the basin. In addition to these general stressors that are present in the basin, the three USACE dams impede diadromous fish movements and create water quality issues in the river due to reduced velocities. The Jordan Dam flood operations reduce the natural variability that was historically present in the floodplain.

The basin is 9,100 square miles and contains 4 district projects: Jordan Dam located below Jordan Lake, and 3 lock and dams (L&D) along the Cape Fear River in North Carolina. Jordan Dam has 5 project purposes, including: flood risk management, water supply, water quality, recreation, and fish and wildlife. All the dams are an impediment to fish passage (about 11 ft of head between each) and management has become more difficult as the infrastructure has aged.

The 3 L&Ds were built for commercial traffic but no barges have come through them in the last decade (Figure 5). Over the years, Wilmington District attempted to lock the fish through, just as they would boats. After recent historic flood events, however, gates are no longer operational at L&D 2 or L&D 3 which limits management capabilities for aquatic resources. Constructed rock rapids at the site of Lock and Dam 1 now improve conditions for movement of migratory fish upriver on the lowest portion of the Cape Fear River.

Other challenges to management of the L&Ds also exist. Water supply is not classified as a project purpose, but water supply intakes have been installed upstream of each structure which complicates future management and options.

SRP Process

The initial steps of bringing the river system into SRP included launching a meeting to identify the factors that were threats and opportunities in the basin (Figure 6). The identified challenges and impacts associated with the 3 locks and dams included fish passage and their influence on factors that intensify or dampen harmful algal bloom conditions. The Jordan Dam was also identified for its negative impact on floodplain connectivity, which was historically important for seed and sediment distribution, nutrient cycling, and groundwater recharge.

A literature review was then conducted to determine the state the of the science surrounding the ecology and hydrology of the Cape Fear River. At the meeting experts representing a variety of disciplines worked together to better understand current management of the infrastructure as well as identify the hydrological conditions needed to better support more natural conditions and functions (i.e., improve fish movements, floodplain connectivity, and water quality). The groups used the Regime Prescription Tool (RPT) to evaluate three reaches under 3 different conditions (wet, average, and dry), and the flows necessary to address the 3 focal issues (fish passage, floodplain connectivity and function, and water quality). The end goal of the workshop was to develop a “perfect hydrograph”, or “environmental flows” (e-flows, that would determine if and how Jordan Dam releases could be tailored to assist fish movement and reduce potential for hazardous algae blooms.

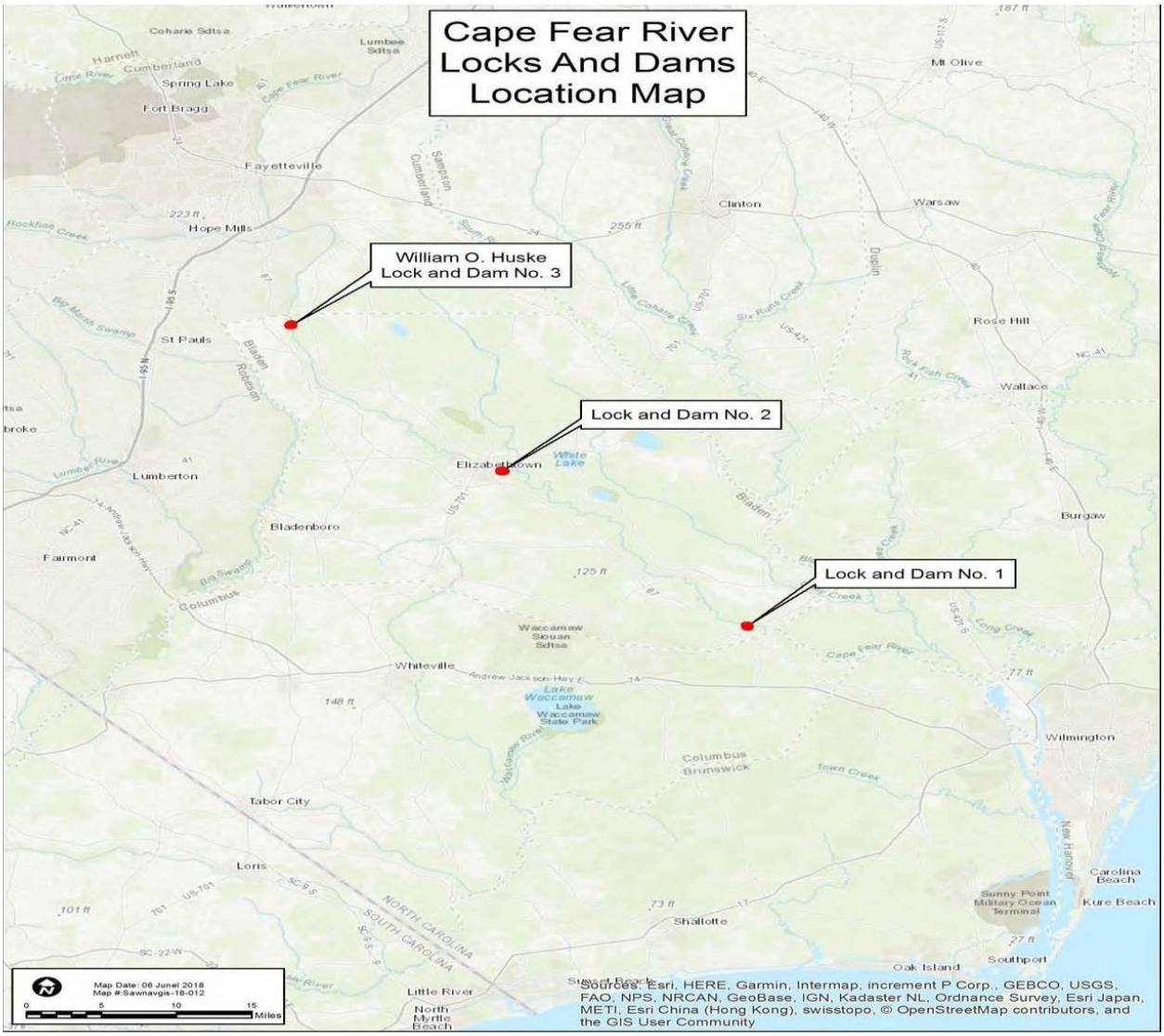


Figure 5. Location of locks and dams 1-3 on the Cape Fear River.

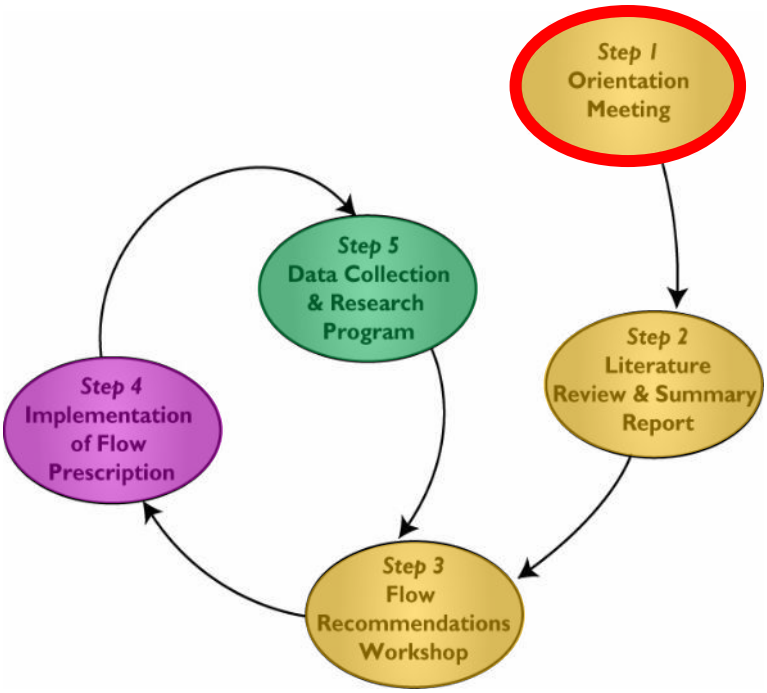


Figure 6. Steps taken by the Cape Fear team during early project development as part of SRP.

The result of the workshop was the development of potential releases from Jordan Dam that could be modified to more closely meet target conditions for various environmental purposes such as supporting diadromous fish movement and reducing the potential for algal blooms under certain conditions (Figure 7).

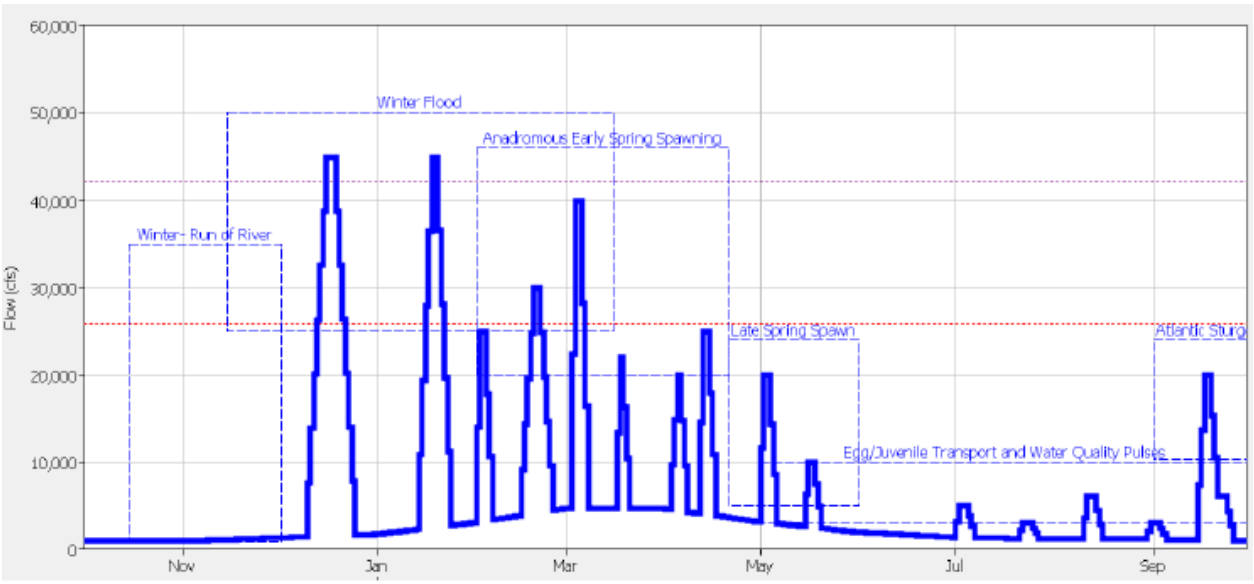


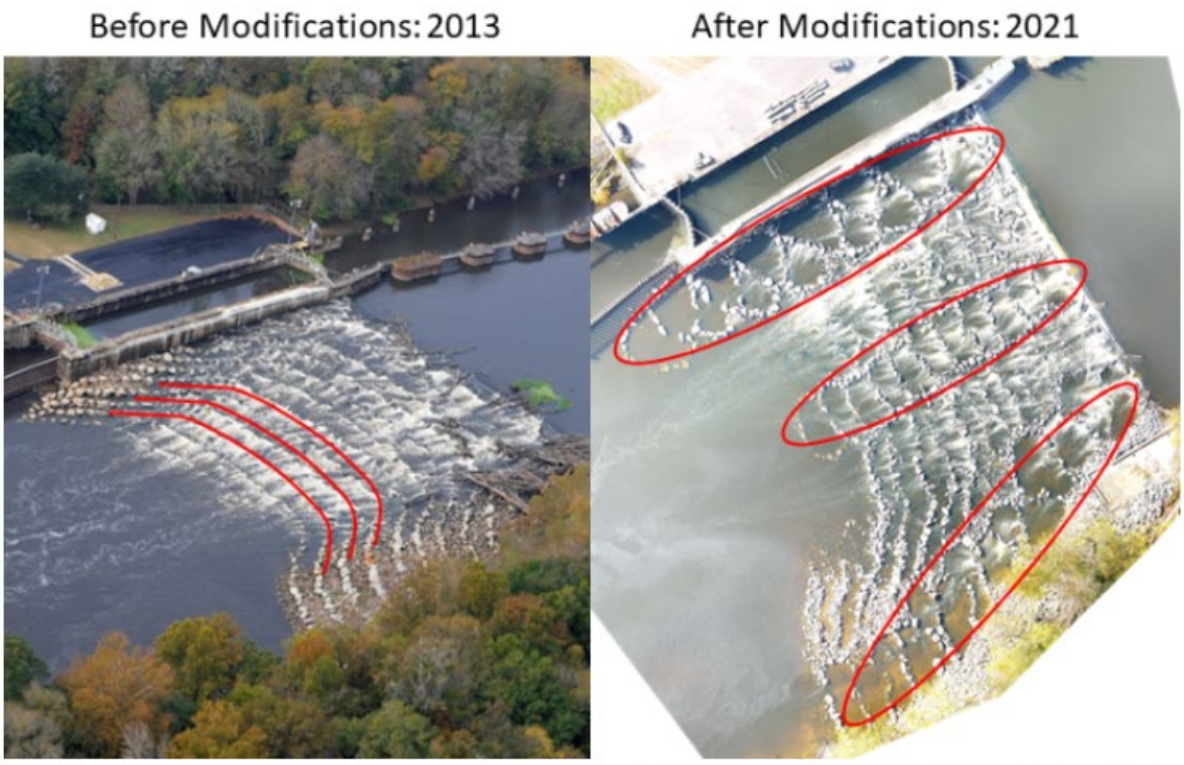
Figure 7. Example taken from e-flow workshop showing target periods for specific life cycle stages when conditions allow.

Implementation

In 2020, implementation began with several e-flow pulses conducted to reduce water quality issues. Covid restrictions limited monitoring but set a solid foundation for future monitoring. In 2021, pulses were implemented again with more robust monitoring. Acoustic telemetry, traditional electrofishing, and eDNA sampling were initiated; water quality monitoring was expanded; and one fish pulse was implemented. The pulse for fish was successful but not long enough for fish to clear all three locks and dams. Unfortunately, additional pulse implementation for fish and water quality were put on hold due to drought conditions.

In 2022, two pulses were coordinated and conducted to improve fish movement through the dam. The next step evaluated if they needed to modify the dams to allow for fish passage or if they could use the locks to allow the fish passage through.

To test if they could use the dams as they are, rapids were constructed at LD 1 (Rock Rapids) to mimic how the river acts in the middle of the basin (Figure 8). The rapids were originally constructed in 2012 but fish passage was limited to a few species. In 2021, a new slope was designed, and new pathways were added along with notches to guide fish to the pathways. Ongoing USACE telemetry studies will determine if the new design is more effective.



Aerial view of the original nature-like fishway at Cape Fear Lock and Dam Number 1 in 2013, and the modified nature-like fishway in 2021. The red lines indicate the rock arches constructed below the crest of the dam structure. The red circles indicate the staggered pools which form three pathways through the fishway. Credit: U.S. Army Corps and Cape Fear River Watch.

Figure 8. Aerial image of rock rapid structure at Lock and Dam 1 on the Cape Fear River.

To test the viability of passing fish through the locks, pulses were attempted in the springs of 2021 and 2022 focused on sturgeon, shad, and striped bass (Figure 9; Figure 10). A successful pulse was achieved in 2021 but it was not long enough to get fish through all the L&Ds. In the spring of 2022, two successful pulses created conditions for fish to pass beyond L&D 3. Telemetry is still being analyzed, and eDNA data will be analyzed at the end of the year to give a better picture of how many fish passed through. HR3 array gear was used to track the fish through the locks, and it was determined that the amount of flow needed to allow the fish through was 3,000 cfs less than anticipated (17,000 cfs instead of 20,000 cfs; Figure 11).

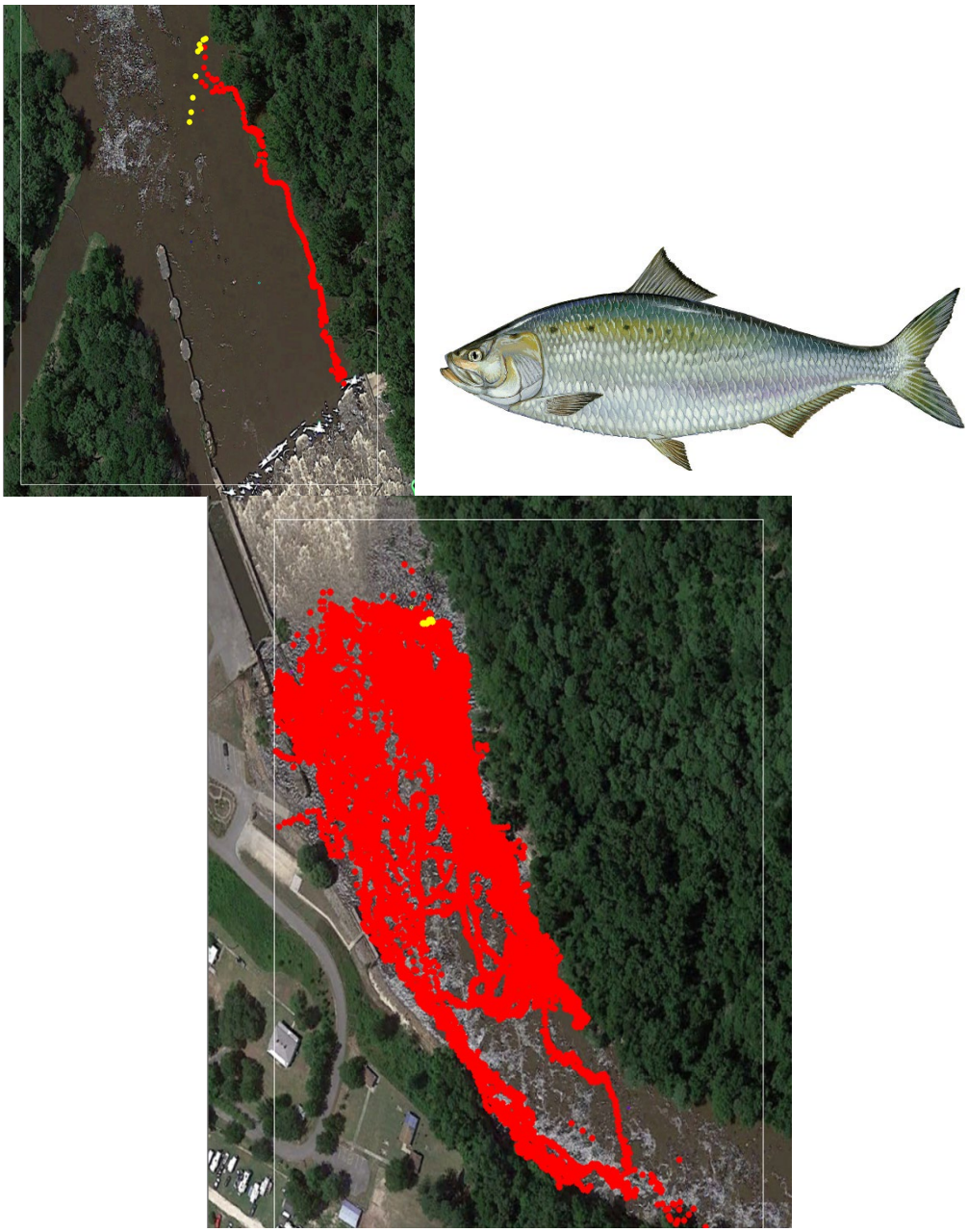


Figure 9. American shad telemetry from April 13, 2021, monitoring by Clemson University. Fish navigated the rock ramp in 21 minutes.

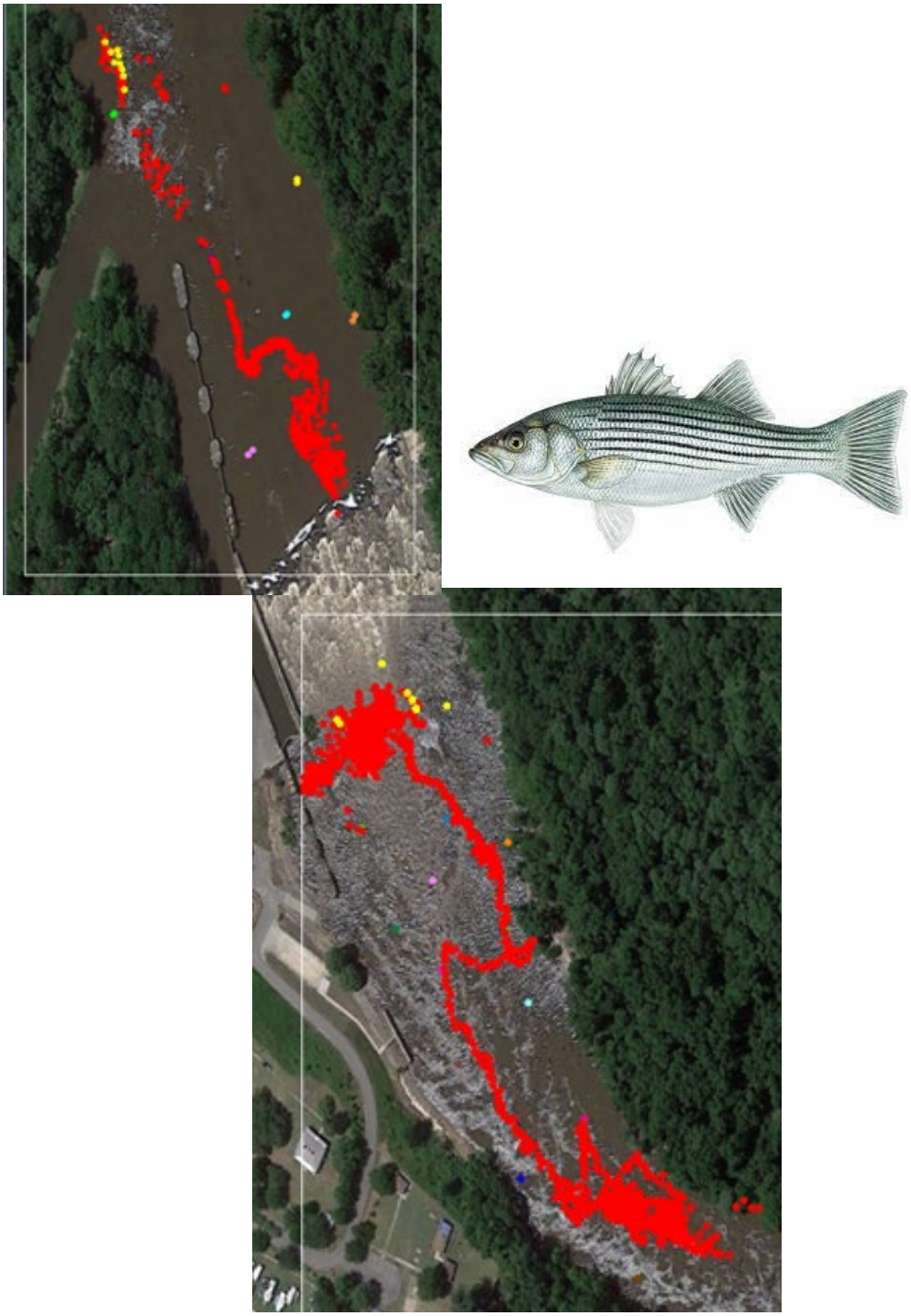


Figure 10. Striped bass telemetry from May 30, 2021, monitoring by Clemson University. Fish navigated rock ramp in 48 minutes.

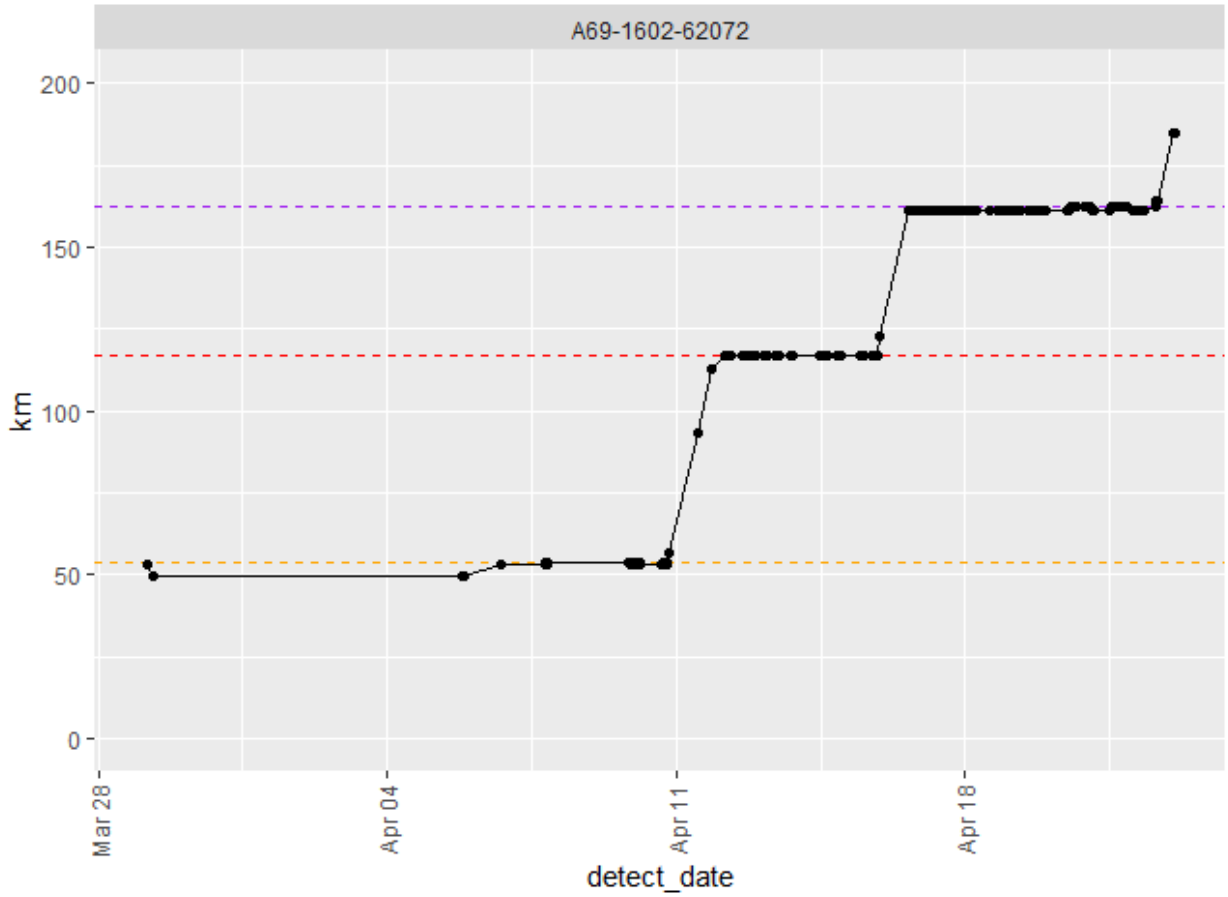


Figure 11. Telemetry array results for fish passage from below L&D 1 over L&D 3.

Attempts to implement pulses and evaluations of fish passage improved Wilmington District's understanding of infrastructure management and biological needs for some target species. The minimum pulse required to allow fish to pass the dams/rapids was slightly lower than originally thought which increases the amount of time that management can be effective at increasing fish passage. The multi-organizational monitoring showed that fish passage could occur at L&D 1-3 on the Cape Fear with suitable pulses and also helped the district evaluate changes to the rock rapids at L&D 1.

- Water Quality

Concern around development of harmful algal blooms (HABs) during low flow months led the team to evaluate use of pulses to mix the water column during warm months to improve water quality.

Multiple pulses were accomplished in 2020 and monitored with remote sensing equipment, real time sensors, autonomous underwater vehicle runs, and gages. Monitoring efforts were

focused near L&D 1. In 2021, these pulses occurred again with the same equipment in place and expanded upstream to the confluence. Pulses out of the dam were limited by drought, however. In summer of 2022, more pulses occurred with expanded monitoring in place.

The water quality monitoring component of the project involves an interagency collaboration.

USGS has deployed an autonomous underwater vehicle (AUV) tech which provides information about the water column (Figure 12). The AUV has real time water quality data collected along with chlorophyll-a and other algae numbers. AUV monitoring by the USGS helps to provide a map of conditions throughout the water column (e.g., temperature, dissolved oxygen, specific conductance, turbidity, pH, blue-green algae) as well as collect bathymetry in target locations. This results in real-time water gage data gathered at target locations along the Cape Fear River to corroborate other water quality monitoring.

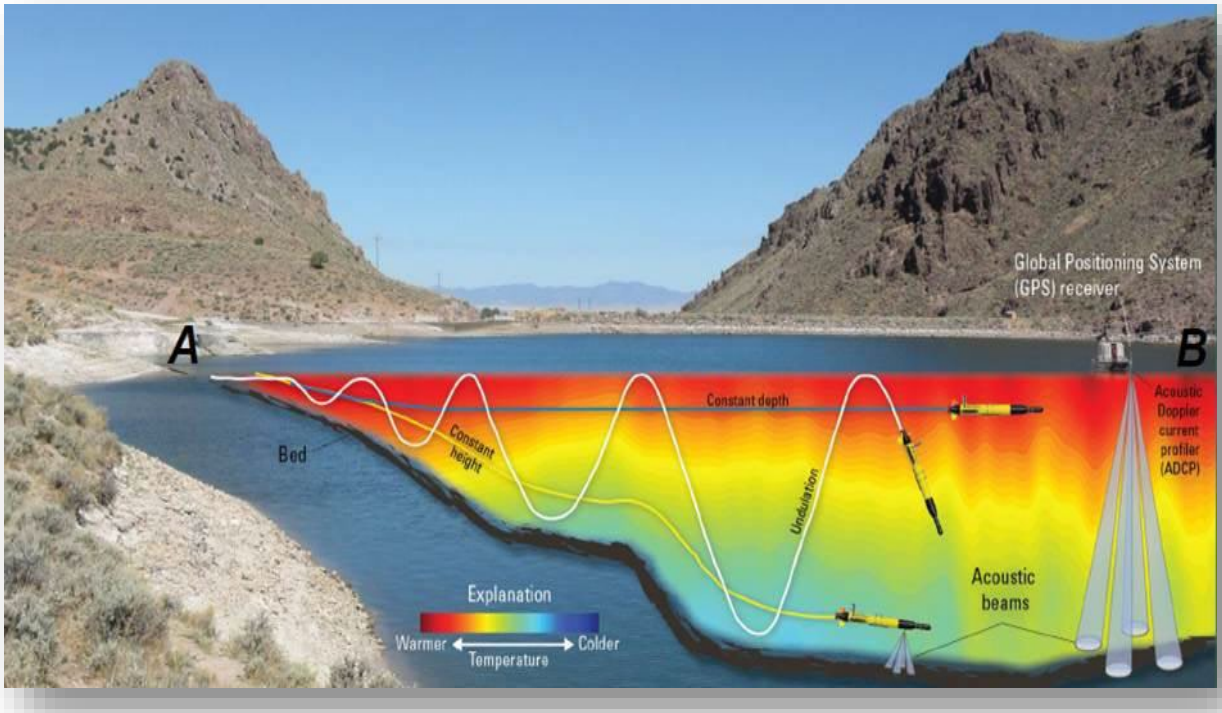


Figure 12. Example of autonomous underwater vehicle (AUV) capabilities.

TNC utilizes the remote sensing equipment “Gybe” to provide water quality data through the combination of a local sensor working with satellite data to generate time-series data and maps of water quality information on parameters such as chlorophyll-a, turbidity, and colored dissolved organic matter (CDOM; Figure 13).

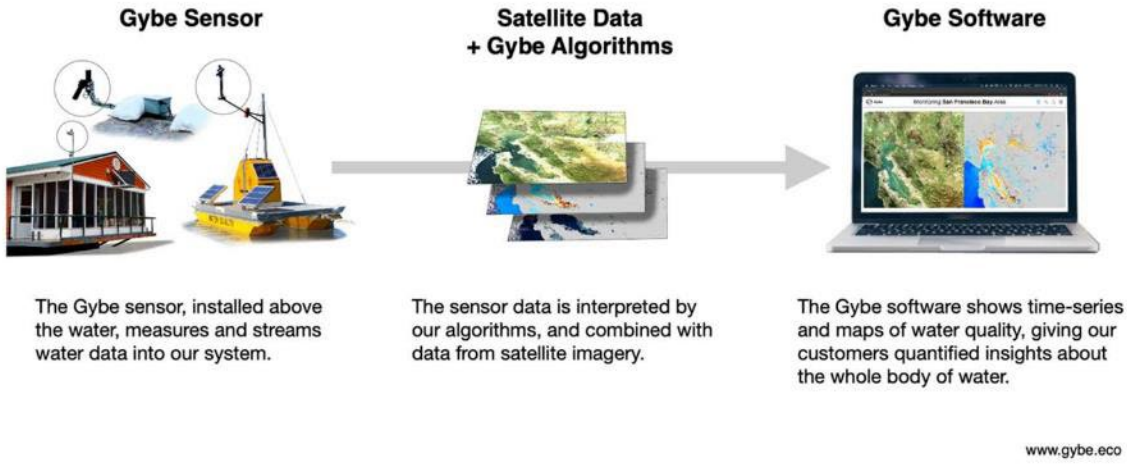


Figure 13. Gybe remote sensing system.

In addition to the previous partners that gather data on the river, UNC Chapel Hill deploys acoustic doppler current profilers (ADCP), a variety of thermistors, and YSI 6600 optical sensor, and gathers chlorophyll a, phycocyanin, and other pigments; CDOM; total suspended solids (TSS), Secchi disk depth data, high and low flow temperature, dissolved oxygen, pH, conductivity, and photosynthetically available radiation (PAR).

Overall, water quality data for the project was gathered utilizing a variety of technologies that work to both enhance results and verify accuracy of results which helps to export methodologies to other districts. In 2022, water quality monitoring expanded near the confluence of the Deep and Haw Rivers, with plans to do AUV runs in Jordan lake as well. A grant was added to continue monitoring research. The SRP effort worked to evaluate pulse effectiveness, refine pulses and protocols; investigate options for LD structures; and reengage stakeholders to share results. The goals of the water quality initiative were to incorporate environmental flows into normal operations and share SRP science.

In sum, the Cape Fear Team leveraged SRP funding to develop a diverse monitoring and research group comprised of several universities, NGOs, state, and federal agencies. This multiagency collaboration increased learning opportunities and led to successful implementation of pulses on the Cape Fear River to improve fish migration, longitudinal connectivity, and address a water quality concern in the system.

3d Green River, KY

The Louisville District's Green River Project was the first SRP project and was initiated in partnership with TNC in the early 2000s to improve water management to better support species within a high biodiversity river system. The district worked to improve flows by partially mimicking natural pulses down the river using reservoir releases. These trials determined that

extended drawdown rates improve water quality. They also brought the Water Quality team in with the Water Managers to teach them how to better run CWMS and better understand water control operations, leading to better collaboration and better reservoir operations.

Since involvement and support from the SRP program for the initial efforts, locks and dams on the Green River have continued to age, leading to the removal of several dams and potential for removal of others on the Green River. Louisville District has been evaluating existing structures within the basin and determined it would cost roughly two million dollars to remove one particular dam, and they would need to partner with local agencies to accomplish it.

The Louisville District has started to reassess how the reservoirs with the Green River Basin are operated with the intent of maintaining flood control capabilities while expanding environmental opportunities and benefits.

Additional discussion and examples of water management changes to improve environmental benefits can be found in Appendix B.

3e Ohio River navigation system

In 2022, Pittsburgh, Huntington, and Louisville districts conducted a system analysis of the Ohio River navigation system which includes 19 Locks and Dams and 981 river miles of commercially navigable channel (Figure 14). The project identified environmental problems and objectives that could potentially be addressed through water management changes; identified opportunities, considerations, and constraints in the system; summarized existing conditions; developed a list of potential measures; analyzed and ranked measures potential throughout the system; and identified future analyses and steps that would be needed to implement a project.

The Ohio River System problem statement included:

Altered hydrology continues to threaten the ecological sustainability of the Ohio River by affecting water quality, sediment transport and distribution, floodplain connectivity, and availability of/access to critical habitats.

Project objectives included:

1. Inventory and baseline conditions within the Ohio River.
2. Characterize critical aspects of basin-level hydrology and identify additional hydrologic modeling and tools that may be needed to inform a systems approach to sustainable water management.
3. Identify potential opportunities and measures to maximize ecological sustainability through reservoir and navigation system operations.
4. Engage regional stakeholders to develop a coordinated approach to further study and potential implementation of the ecological measures identified under the current study.

The Ohio River system team identified a process for addressing project objectives and problems (Figure 15).

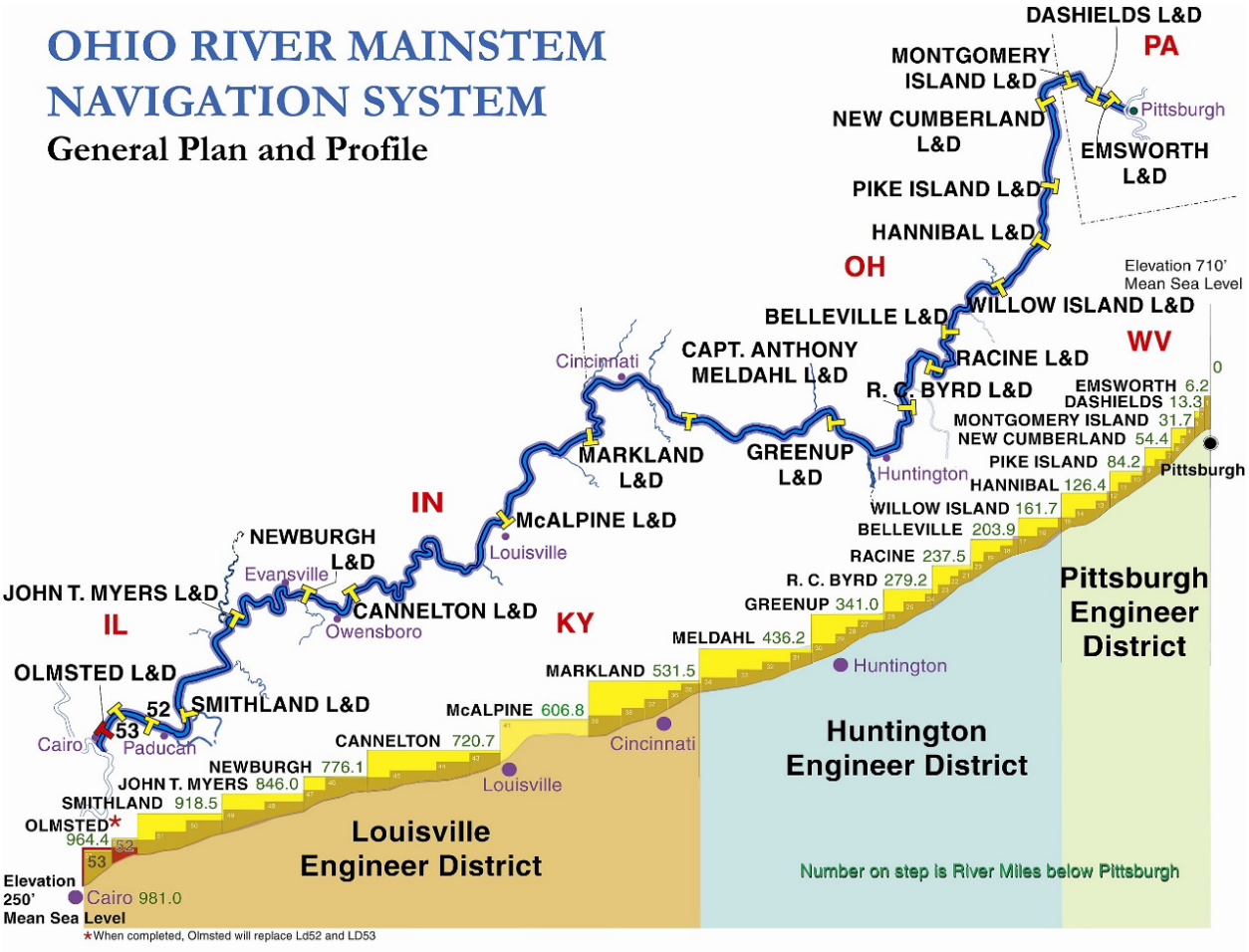


Figure 14. USACE districts and locks and dams of the Ohio River navigation system.

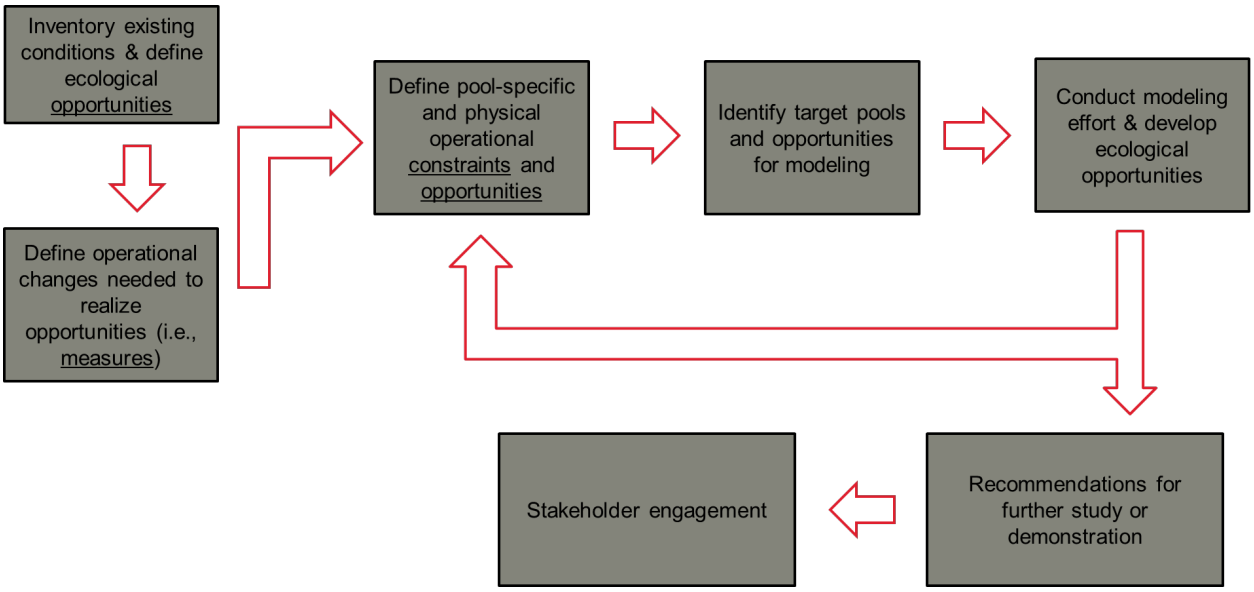


Figure 15. Study approach for SRP Ohio River project.

The inventory of existing conditions for the Ohio River system included evaluations of the following environmental resource categories:

- Climate
- Land use
- Navigation infrastructure and channel
- Other infrastructure
- Biological communities
    - Fish
    - Mussels
    - Threatened and endangered species
    - Aquatic and terrestrial invasive species
- Water quality
- Aquatic habitat
- Riparian and floodplain habitats
- Wildlife refuges and other protected ecosystems

The Ohio River SRP team then identified applicable opportunities, management options at existing locks and dams, and constraints that could be used to help prioritize the most feasible measures for improving ecological conditions (Table 3).

The Ohio River team next identified and assessed a variety of measures that could potentially be utilized at one or more locations on the Ohio River to potentially address project problems, objectives, and opportunities. The measures included:

1. Temporarily raising pool elevation
2. Temporarily lowering pool elevation
3. Flow manipulation for habitat improvement
4. Selective withdrawal retrofits for Flood Risk Management structures
5. Structural changes
6. Island restoration
7. Invasive species control
8. Modification of hydropower Operating Agreements
9. Rapid watershed assessment for tributaries
10. Conservation lockages

Table 3. Opportunities and constraints for the Ohio River system.

Opportunities	Constraints	Considerations
1. Restoration of more natural hydrologic and hydraulic regimes 2. Improvement in water quality 3. Improvement in quality and diversity of habitats 4. Improvement in connectivity of habitats 5. Improvement in quality of aquatic communities	1. L&D type and construction 2. Depths required to maintain navigation 3. Presence of other infrastructure along the river 4. Travel times 5. Legal obligations 6. Potential impacts to threatened or endangered species	1. Authorized purposes 2. Major tributaries 3. Presence of wildlife refuges 4. Potential impacts to invasive species 5. Potential impacts to non-target species 6. Potential impacts to erosion or sedimentation 7. Current water control manuals and guide curves 8. Timeframe for analysis

During the analysis of considered measures, sites were ranked into categories based on pool resources, potential benefits or limitations, and degree of operational constraints. Recommendations were developed for each of the 10 evaluated measures and a summary of the recommendations were discussed at the L&D workshop for 3 of the 10 evaluated measures. The three measures discussed in greater detail included 1) temporarily lowering pool elevation, 2) flow manipulation for habitat improvement, and 3) island restoration.

Temporarily lowering pool elevations

The goal of this measure is to expose mudflats and allow increased vegetative growth in newly exposed areas. Identified benefits include: fish attraction, spawning, and nursing; waterfowl and shorebird attraction; growth of emergent vegetation; and improving river habitat and vegetative growth variability. Potential drawbacks that may result from implementation of a

temporary pool elevation lowering include: potential impacts to navigation or hydropower and additional dredging needed to maintain the navigable channel.

Initial feasibility modeling found that the 9-foot navigation channel can potentially be maintained while accommodating a 1-ft drop at all pools. The team recommended that additional analyses be conducted at specific locations prior to implementation to assess potential impacts to navigation. The highest priority location to consider for implementation was J.T. Myers because it had the fewest constraints. Secondary priorities were identified at New Cumberland (LRP), Willow Island (LRH), Markland, Cannelton, Newburgh, and Smithland (LRL). Additionally, there is potential for synergistic opportunities with temporary pool elevation raises when considering this measure for implementation.

Flow manipulation for habitat improvement

This measure works to optimize operation of the locks and dams seasonally, year-round, or in response to maintenance actions to benefit downstream organisms and habitats. Analysis found that modification of the gate operating schedule would have the greatest potential to manipulate habitat downstream.

The team shared an example of an ongoing project at R.C. Byrd Lock and Dam that has implemented changes in management to improve environmental conditions for downstream mussel communities (Figure 16). Gate operation during disposal operations is adjusted to provide clear, oxygenated water flows over mussel beds and guide turbid waters toward the thalweg to reduce impacts.

Figure 16. R.C. Byrd Lock and Dam, where flow manipulation is used as a mitigative measure to protect mussel communities from turbid water generated during in-water placement of dredged material (USACE photo).

Similar benefits may be possible to achieve for mussels near other locks and dams on the Ohio River. The Ohio River team developed a two-tiered screening method to rank locks and dams by degree of potential. First the locks and dams were screened for operational constraints (presence/absence of gates) which removed one lock and dam from consideration. Next locks and dams were ranked by the potential presence of federally protected species. The four locks and dams that had no documented federally threatened or endangered mussel species in their respective pool were screened from consideration. The remaining locks and dams were ranked based on the number of federally listed mussel species occurring within a pool (e.g., 0-5, 5-10, +10 species).

This evaluation strategy identified 8 locks and dams as high priority locations for further study or implementation and included: Greenup, Meldahl (LRH), Markland, McAlpine, Newburgh, J.T. Myers, Smithland, and Olmsted (LRL) locks and dams.

Island Restoration

The last example from the measure analysis conducted as part of the Ohio River System analysis is Island Restoration. Pittsburgh District shared a case study of recent island restoration work on the Ohio River to discuss considerations and coordination required to implement this type of work before providing a summary of the island restoration analysis performed as part of the SRP project.

The case study focused on Georgetown and Phillis islands (LRP) and included beneficial reuse of material that was generated during maintenance dredging in New Cumberland pool. The construction of the islands reduced the cost of disposal compared to upland placement, and restored islands in an area that had islands prior to construction of the locks and dams on the Ohio River. Island restoration requires significant planning, design, and collaboration with USFWS and applicable state agencies. Pittsburgh District plans to investigate other studies to see how different basin environments may affect the results of island restoration methods.

Island restoration was considered as part of the SRP project because islands were historically more abundant throughout the Ohio River System and because they support a diverse variety of habitat types above and below the water surface. The island restoration measure considered the use of dredged material and/or ecosystem restoration authorities to restore Ohio River islands. As part of the analysis the team identified 75 islands across 17 pools to consider for prioritization. Islands were screened based on predominant land use (i.e., industrial, vegetated, or submerged) and then vegetated islands were assessed for potential for long-term protection (federal, state, or other protected land categories). Vegetated islands located within the Ohio River Island National Wildlife Refuge were given the highest priority for restoration.

Recommendation based on presence of ORINWR islands included New Cumberland (LRL), Hannibal (LRL), Willow Island (LRH), Belleville (LRH), Racine (LRH), and Meldahl (LRH) pools.

LRD is aiming to develop a conceptual plan for implementation across the Ohio River Basin and implementation guided by interested partners with similar priorities in the basin. It is anticipated that implementation of island restoration would be achieved through other authorities such as O&M, Section 204 /206, etc.

Overall, the SRP supported analysis for the Ohio River system identified and described ecological conditions, hydrological conditions, ecological opportunities, constraints, and considerations; prioritized ecological measures for specific structures (Table 4); identified future modeling and data needs; and proposed a strategy for stakeholder and partner engagement.

Table 4. Summary of measures analysis for Ohio River system.

Measure	Pool																			
	Emsworth	Dashields	Montgomery	New Cumber.	Pike Island	Hannibal	Willow Island	Belleville	Racine	R.C. Byrd	Greenup	Meldahl	Markland	McAlpine	Cannelton	Newburgh	J.T. Myers	Smithland	Olmsted	Tributaries / Reservoirs
Temporarily raising pool elevation																X	X	X		
Temporarily lowering pool elevation				X			X						X		X	X	X	X		
Flow manipulation for habitat improvement											X	X	X	X		X	X	X	X	
Selective withdrawal retrofits for flood risk																				X
Structural changes (i.e., fishways)	X	X	X	X	X	X	X	X	X	X	X									
Island restoration				X		X	X	X	X			X								
Invasive species control												X	X	X	X	X	X	X	X	
Modification of hydropower Operating Agreements							X	X	X	X	X	X	X	X	X			X		
Rapid Watershed Assessment for tributaries																				X
Conservation lockages																				X

3f Melvin Price L&D - Lake sturgeon spawning

The Missouri Department of Conservation observed spawning of the state-listed lake sturgeon in 2015 and reached out to the Corps to see if the dam could be operated in a way that would produce more favorable conditions for spawning in other years. The critical elements of sturgeon spawning are that the water temperature is about 55 degrees, the time of year is April-mid May, flow velocities are 1.0 to ~1.5 ft/s, and the sturgeon have a rock substrate to lay the eggs on.

SRP provided support to the St. Louis District starting in FY2021 to develop a HEC-RAS 2-dimensional model, develop outreach and education materials, and enhance monitoring of water conditions and fish use of the bankline below Melvin Price Locks and Dam. Model results and field monitoring of bankline flows were used to guide gate management for lake sturgeon spawning. This change in management resulted in documented lake sturgeon spawning in spring of 2022. Future work aims at improving model accuracy and development. St. Louis District is also looking into potential opportunities below Lock and Dam 24 and below the regulation dam at Mark Twain Lake on the Salt River.

4 Opportunities at system-scales and associated technical support

Most L&D are parts of navigation systems. Environmental opportunities exist at local, or project, scales and at system scales. This agenda topic covered geographical resources available nationally, an example effort that explored upscaling from a local to a system scale, and a technical analysis with potential for broader application.

4a Geographical overview of divisions and infrastructure

St. Louis District provided an introduction on the development of geospatial data related to Locks and Dams infrastructure managed by USACE. The purpose of this effort is to identify environmental opportunities at USACE L&Ds and associated limitations that could affect implementation of environmental actions. Information gathered is designed to guide future SRP efforts and complement existing data, specifically from an environmental perspective.

The webmap, as shared at the workshop, contains data from Districts that have already responded to a request to supply information for the development of this data source. Follow up with individual districts will occur after the lock and dam workshop to complete the datasheet.

4b Analysis of EPM Potential at Upper Mississippi River L&Ds

St. Louis District provided an overview of L&D management on the Upper Mississippi River (UMR) and then presented an analysis of potential to implement environmental pool management drawdowns during the growing season to improve vegetation diversity in backwaters and off channel areas of the Upper Mississippi River (Figure 17).

St. Louis District has been implementing environmental pool management (EPM) since the early 1990s. EPM consists of a small-scale drawdown of the pool, which is maintained within existing management limits for sufficient duration (> 30 days) to promote emergent and aquatic vegetation species along bank and island shoreline. Once vegetation establishes, it grows quickly and can tolerate shallow inundation if it isn't overtopped by water. As a result, a slow pool rise can be accommodated once vegetation is well established.

Although L&Ds on the UMR were authorized for commercial navigation, other objectives can be incorporated if they do not compromise the Congressionally authorized project purpose to maintain a navigable channel (Figure 17). This analysis considered modifications to management within authorized regulation limits at all locks and dams managed by St. Paul, Rock Island, and St. Louis districts (Figure 18).

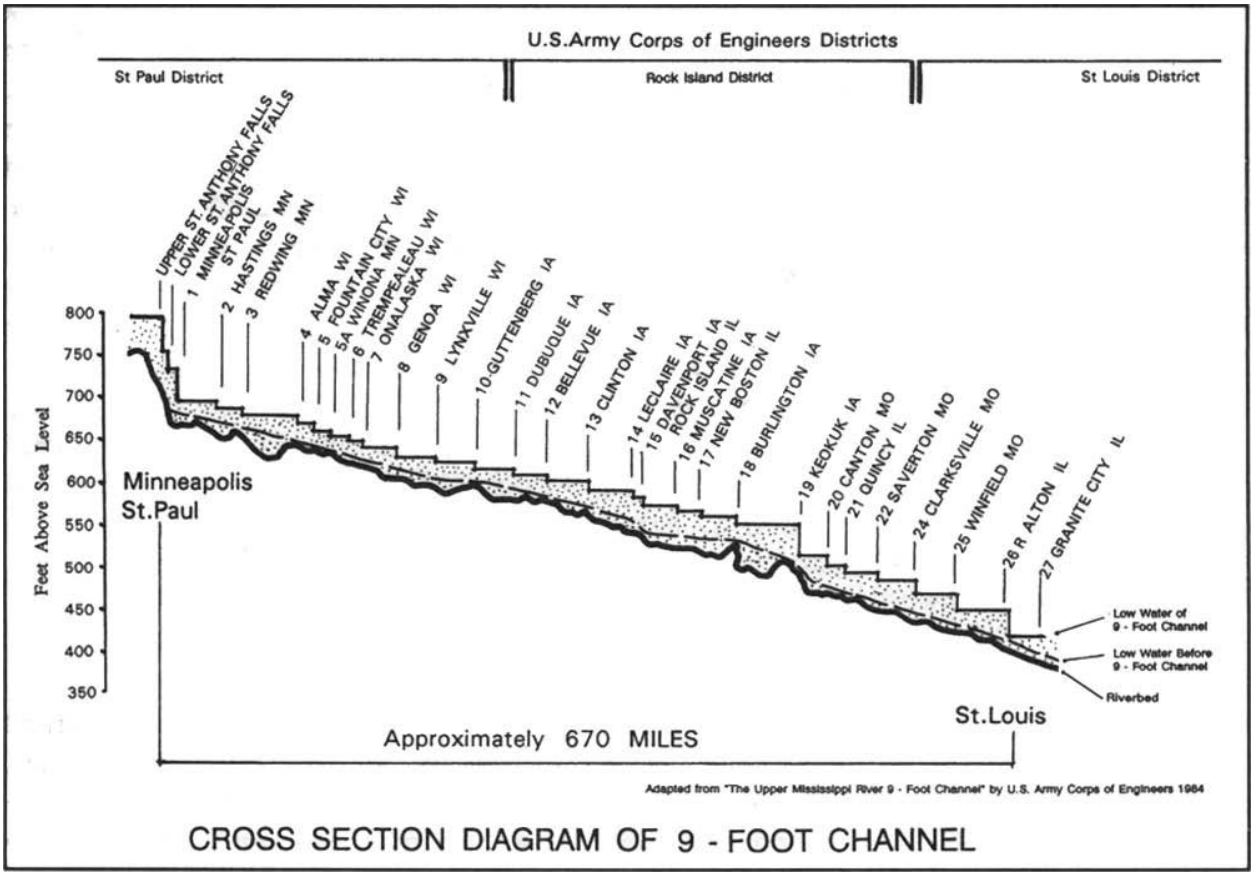


Figure 17. Locations of locks and dams along the Upper Mississippi River by district.

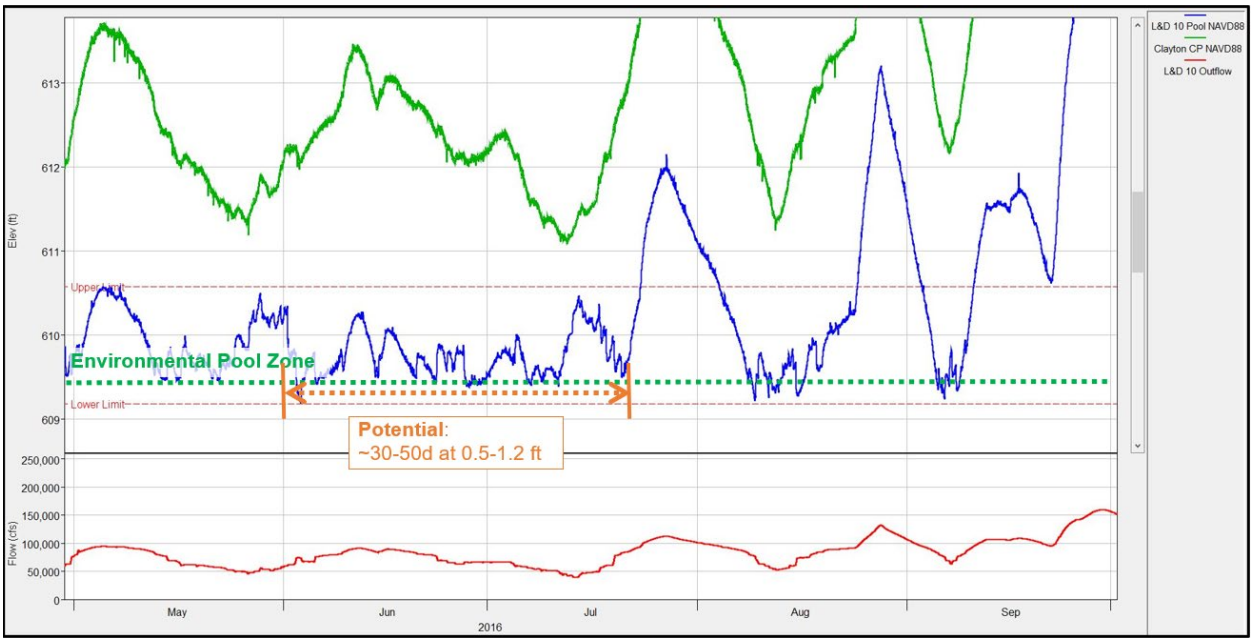


Figure 18. Example drawdown analysis potential at L&D 10 in St. Paul District.

4c Technical support for implementation on the Kaskaskia River System

St. Louis District also presented on a recent analysis of environmental pool management potential on the Kaskaskia River System above Jerry F. Costello L&D (Costello L&D). After providing background on L&D management on the Kaskaskia River system, MVS shared the results of the analysis (Table 5 and Figure 19).

Table 5. Summary of Costello L&D success rate based on data from 2000-2020.

Number of Years	21
Number of EPM Years	11
Success Rate	52%

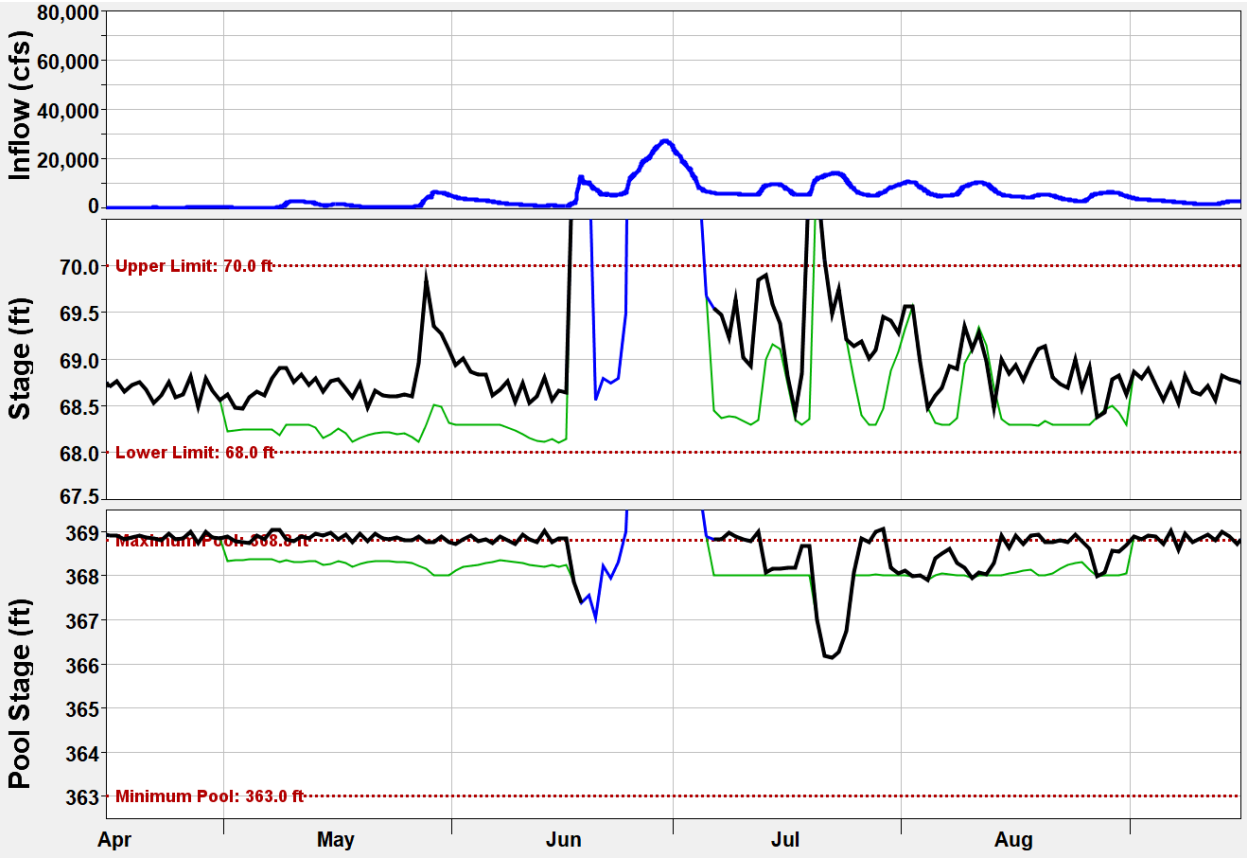


Figure 19. Example drawdown analysis potential at Costello L&D in St. Louis District.

The analysis showed that implementation of an environmental pool management drawdown could be achieved relatively frequently if attempted during the growing season. As a result, in 2021, the district attempted their first environmental pool management drawdown at Costello L&D as well as at Lake Shelbyville and Carlyle Lake (reservoirs also in the Kaskaskia River Basin).

In 2021, MVS was able to achieve a drawdown in the pool above Costello L&D on the Kaskaskia River as well as at Carlyle Lake. Site visits to both locations showed the potential for promising results (Figure 20, Figure 21, and Figure 22). MVS plans to conduct future drawdowns and quantitatively assess the plant response (species response, abundance, and seed production estimation for important emergent plants to migratory waterfowl.

Figure 20. Vegetation growing along fringe of oxbow upriver of Costello L&D, Kaskaskia River, river mile 2 (USACE photo).

Figure 21. First year drawdown plant response in oxbow upriver of Costello L&D, Kaskaskia River, river mile 7.5 (USACE photo).

Figure 22. Drawdown response in a cove of Carlyle Lake near Eldon Hazlet State Park (USACE photo).

5 Lessons learned from areas with successful implementation

Discussions about what steps were taken by teams that have successfully implemented projects fell into several themes, including: Fostering a culture of change in USACE, communication and outreach, and showing benefits.

5a Fostering a culture of change

Developing a culture of change takes time, coordination, and buy-in from leadership. Teams identified the importance of reaching out to leadership and communicating the value of proposed SRP efforts. Having leadership-level support early in the process can be the difference between implementation and not. It is essential to communicate the story to leadership throughout the process to illustrate the value for the environmental resource as well as the relationship with state or federal agencies, and/or other stakeholders.

Teams also identified the importance of developing processes that support innovative thinking for addressing problems at existing USACE infrastructure. A common thread among SRP teams was the importance of considering a wide range of alternatives (i.e., both outside and inside of existing operating

limits) and looking for opportunities to manage differently. Sometimes this may be captured by a proposed alternative and sometimes it starts as an alternative that partially meets a project objective. The key component is a willingness to consider a change and evaluate if it would be feasible to attempt. If it is successfully implemented, then it may lead to later modifications that build on that initial change as more is learned about the actual management flexibility and biological response. Even a small change from current conditions can lead to important learning opportunities and improvements to environmental conditions.

5b Communication and outreach

Several teams noted the importance of starting outreach early and including all potential stakeholders in early discussions. Relevant groups and organizations to coordinate with will vary geographically so it is important to research and identify a range of groups with an interest in the study area. Feedback from these groups will be important to consider through the development of alternatives and may help to identify an action that meets project objectives while having broad support from external groups. Inviting stakeholders with different interests can be an effective way to help identify potential concerns, identify what matters most to the groups, and manage potential conflicts with a proposed action. Regular coordination with stakeholders should continue throughout project development, implementation, and proposed refinements. Consistent meetings help to build trust, identify issue areas before they become problematic, and provide opportunities for communication with USACE when all relevant disciplines are accessible.

5c Identification and communication of relevant benefits

The last lessons-learned theme discussed related to the importance of describing and communicating benefits that result from a change in operations. Teams discussed the importance of identifying what stakeholders care about in their study area and developing a metric or metrics that can be used to evaluate the response of the most important components. Finally, the results from the evaluations should be communicated in a way that is compelling to stakeholders. Being able to tell the story of why a project matters can be the difference between a project that continues on or a project that loses support.

Additional notes from the lessons learned portion of discussions can be found in Appendix C.

6 Lock and dam management by district

Discussions on the first day of the workshop ended with a discussion on operations of L&Ds by district. This provided an opportunity for workshop participants to better understand the opportunities, constraints, and develop a common understanding prior to project idea development in breakout sessions. Details of L&D management discussion by district can be found in appendix D.

7 Breakout Sessions

During the second day of the workshop, the attendees were split into 5 groups by division to discuss potential SRP project ideas. This resulted in identification of at least 20 potential project ideas (Table 6).

Table 6. Potential project ideas by breakout group.

Division	# of Potential Project Ideas
Lakes and Rivers	8
Southwest	2
Northwest	2
South Atlantic	2
Mississippi Valley	6

A summary of project ideas by division is provided below with additional groups notes from breakout sessions provided in Appendix E.

7a Lakes and Rivers Division

The Lakes and Rivers Division (LRD) identified 8 potential project idea themes and at least 9 potential locations to evaluate among the Louisville, Huntington, and Pittsburgh Districts during breakout sessions. The three districts have a number of prior SRP projects as well as current proposals that have focused on individual segments of rivers. The group identified a visioning meeting for the Ohio River as a significant opportunity to share current SRP project ideas and develop a systemic approach to management of the Ohio River with potentially significant benefits for environmental resources. Other project themes explored by LRD included implementation of flows to support mussel species, modification of flood control reservoir operations and impacts on fisheries and macroinvertebrates, influence of reservoir operations on water quality parameters downstream, creation of island habitats, development of monitoring partnerships to assess response to SRP e-flow actions, pool level management in reservoirs to promote aquatic vegetation while meeting other local objectives, and management options and opportunities to build resilience under different climate change scenarios.

7b Southwest Division

Little Rock District identified the Arkansas River and Fourche LaFave River as two locations for potential future SRP projects due to the presence of several species of conservation concern. Post-workshop, the district plans to reach out to district staff and partners to identify the priority opportunities and assess the range of environmental actions that could be implemented for various environmental resources.

7c Northwest Division

Northwest Division (NWD) identified a number of environmental opportunities including improvements to fish passage, water temperature management, in-stream habitat, and e-flows for target species. Potential changes to management are complicated by existing constraints, authorities, ESA, tribal authority, and other rules and regulations. Additional discussion is needed within the districts as well as with partners to identify and refine potential project themes and locations.

7d South Atlantic Division

South Atlantic Division (SAD) identified two potential projects in Mobile District. The first project idea is located near the Old Tombigbee River and the Tennessee-Tombigbee Waterway. Changes in flow as a result of the project have impacted critical habitat for mussels and large tracts of bottomland hardwood forests. The district is looking at ways to modify flows to improve conditions for mussels, some of which are federally listed, and reduce flood impacts to bottomland hardwood forest resources near the project. The team identified a workshop between USACE and local agencies as the first step toward identifying an implementable project.

The second project identified is located at Woodruff Lock and Dam to improve fish movement upstream to Lake Seminole, located at the confluence of the Flint and Chattahoochee Rivers. Currently, Alabama Shad (state listed) and other small schooling species are unable to move upstream of Woodruff dam to spawn. There is anecdotal evidence that shad can pass over the spillway in some circumstances. The proposed project would look into and evaluate the use of attractant flows to allow fish species to move through the lock to upstream habitats.

7e Mississippi Valley Division

Two districts from Mississippi Valley Division (MVD) were present at the workshop and discussed potential future project efforts. MVS discussed several ongoing projects in the early stages of implementation with potential refinements to evaluation. The main project idea centered on current Lake Sturgeon work in St. Louis District. MVS recently modified gate settings to promote flows that could support Lake Sturgeon spawning immediately downstream of Mel Price Locks and Dam in Pool 26 of the Upper Mississippi River (UMR). Initial efforts were successful. The team hopes to make refinements to the model that is used to help inform initial gate settings, and to work towards expanding implementation to other pools on the UMR. MVS plans to evaluate potential of other St. Louis District locks and dams, and then expand that to Rock Island and St. Paul District. An interagency meeting with resource agencies from Missouri, Illinois, Iowa, Minnesota, and Wisconsin would be needed to begin discussions for a potential expansion to suitable pools.

Recently, MVS has started to evaluate water level management outside of environmental pool management periods to better support other wildlife groups. In 2022, MVS piloted an effort to modify L&D gates for brief periods of time to prolong mudflat suitability for migratory shorebirds. The effort must be closely coordinated to avoid impacts to other water level

management projects (i.e., lake sturgeon spawning, environmental pool management, etc.). More complete evaluations of inundation frequency, duration, and timing are needed along with monitoring of invertebrate and shorebird response to management changes.

Environmental pool management has been implemented in the St. Louis District for several decades but has not been attempted or implemented as frequently in Rock Island and St. Paul Districts. The group identified a pilot project in either district as a possible SRP project as a way to help work through implementation challenges and provide an opportunity to evaluate environmental benefits and tradeoffs.

The team also discussed meeting with agency partners to discuss Environmental Pool Management approaches for the future and potentially including more intentional variability into drawdown planning after having several successful long duration drawdowns greater than 90 days from 2016-2018. This idea would be addressed through annual coordination meetings with partners rather than be developed into a SRP proposal idea.

Vicksburg District identified three potential SRP projects during the breakout session.

The first project idea focused on improving water level management in Catahoula Lake to improve environmental conditions within the lake. Catahoula Lake is a Ramsar-designated wetland known for its importance to migratory waterbirds, nursery habitat for fish species, and habitat for a range of amphibians, reptiles, and aquatic plants. The area is cooperatively managed by the state of Louisiana Department of Wildlife and Fisheries and USACE. A potential proposal would evaluate deviation at Jonesville Lock and Dam to raise or lower the lake levels to improve environmental benefits.

The Pearl River found along the border of Louisiana and Mississippi is one of the most diverse river systems in North America. Three locks and dams were constructed along with an approximately 20-mile navigation canal along with 3 sills (low water dams) between 1935-1956. By 1995, all three locks and dams were placed in caretaker status due to decreases in river traffic. Due to the ecological importance of this river system, the district thought it could be valuable to meet with partners to identify potential environmental opportunities and needs that could overlap with SRP environmental action themes.

The Red River flows through the states of Texas, Oklahoma, Arkansas, and Louisiana. The river basin supports a wide range of aquatic and terrestrial species. Five locks and dams along the J. Bennett Johnston Waterway are managed to provide a navigable channel approximately 236 miles from Shreveport, Louisiana, to the Mississippi River. The locks and dams are USACE owned and managed. State and federal lands managed by partner resource agencies can be found along the Red River and its tributaries. Coordination with resource agencies and district personnel would be needed to evaluate potential for environmental opportunities and needs on the managed portion of the Red River.

Appendix A: Agenda

Sustainable Rivers Program – National Locks and Dams Workshop
Water Level Management for Environmental Benefits
May 24th – May 26th

Agenda with Times to Be Determined by Discussion

Tuesday, May 24th		
Morning Session (0800-1200)	Discussion on Meeting Agenda/Expectations Goals of the Meeting: 5. Increase knowledge of water level management capabilities with Corps infrastructure 6. Identify more sustainable ways to manage river infrastructure to maximize benefits for people and the environment 7. Discuss successful and potential water level management opportunities 8. Further water level management implementation with Corps infrastructure Objectives: 4. Identify operational opportunities and restrictions 5. Identify specific implementable locations for water level management 6. Identify information/data gathering tasks to home districts within implementable locations	Dave Busse
	Introductions: Name, office, involvement with SRP, & what you hope to get from the meeting	All
	Intro to Sustainable Rivers Program Examples of Successful Implementation at L&Ds	Russell Errett; Ashley Hatchell; Michael Borchers
1200 – 1330	Lunch	
Afternoon Session (1330 – 1600)	Ohio River SRP Project Mel Price L&D Lake Sturgeon Spawning Geographical Overview of Divisions and Infrastructure	Jennie Brancho Russell Errett & Ryan Swearingin Claire Kreitzman

	SRP Project of Analysis of EPM Potential at UMR L&Ds Water Control L&D operations overview by District • AOR Overview of L&D Ops and efforts related to EPM	Russell Errett Each Office
Wednesday, May 25th		
Morning Session (0800 – 1200)	Tuesday Recap/Summary	Joan Stemler/All
	Panel Discussion for successful EPM/SRP implementation Panel: TNC (Gretchen Pfeiffer) MVS (Joan Stemler) SAW (Ashley Hatchell)	Facilitator: Brian Johnson
	Breakout Sessions (grouped by Division) Top idea so far going into Lunch Break	Facilitators: Dave Busse & Gretchen Pfeiffer Each Group
1200 - 1330	Lunch	
Afternoon Session (1330- 1600)	continue Breakout Sessions (grouped by Division) Breakout Session Reporting	Facilitators: Dave Busse & Gretchen Pfeiffer All
Thursday, May 26th		
Morning Session (0800-1200)	Wednesday Recap/Summary Ranking of Implementable Locations Applying for Sustainable Rivers Program Funds Path Forward/Where Do We Go from Here? - Identify potential future locations/District-specific meetings - Additional information/data needed	Joan Stemler/All Brian Johnson Facilitators: Joan Stemler, Brian Johnson, & Dave Busse

Appendix B: Additional discussion about EPM implementation or WLM on the UMR

- Gretchen Pfeiffer, Large River Specialist, The Nature Conservancy
    - Water Level Management (WLM) on the UMR – Restoring Variability to System
        - Restoring variability to the system refers to water level management on the Upper Mississippi River. That leads into the purpose of drawdowns, which is to allow revegetation in mudflats and wetlands by reducing the water level.

    - Origin of drawdowns on the Upper Mississippi
        - In the late 1980's there was an extensive drought that appeared to have broad negative impact on aquatic vegetation. This resulted in the creation of a water management task forces comprised of the various resource agencies working on the Upper Mississippi River. Resource agencies began to explore options for recovering aquatic plant communities, and partner resource agencies requested that USACE explore modified dam operations to help promote plant regeneration.

        - Following the creation of the task force, three different locations were picked to have a 90-day drawdown. All of which experienced great growth of vegetation. In 2001 and 2002, L&D 8 had a 1.5 ft drawdown where 250 yards of materials were dredged, and it was found that 2,000 acres had vegetative growth. The drawdown in Pool 8 did require a request to operate outside the normal operating bands and as a result required approval from MVD and close cooperation with navigation industry and recreational users to reduce potential for impacts. Dredging occurred prior to the drawdown to maintain an adequate navigation channel depth. The second year of drawdown was shown to build on the previous year's success by developing more robust adult plants which are more resilient to changes. After the second year of drawdown, aquatic plants had built up enough reserves to start expanding in extent. Overall this led to a conversion of areas from open water to aquatic vegetation classes such as submersed aquatic, deep marsh, and shallow marsh communities. One issue that was identified during out of operation band drawdowns was the impact on mussel mortality.

        - In 2005 and 2006, L&D 5 pool got the same treatment, but the hydrology was not as ideal as the drawdowns in Pool 8 in previous years. The drawdowns were limited to approximately 60 days the first year and several days the second year. Overall, about 7% of the pool was exposed

during the drawdown, or 405 out of 5,514 hectares. Concern over mussel population impacts resulted in the gathering of crucial data by resource agencies to estimate population levels in Pool 5 along with an estimate of how many could be affected by an out of operation band drawdown. In 2006, 190 million mussels were estimated to be in the pool and estimates of drawdown-induced mortality at the pool scale was 1.2%. Some benefits started to appear eventually, but locals were not happy, which resulted in the drawdown being cut short.

- Environmental Pool Management has been an active program in MVS since 1994. The goal is to optimize pool regulation to maximize environmental benefits. The pools need a minimum of 30 days of drawdown to garner results. Close coordination with resource managers in the field is required to provide insight to conditions and suggestions relative to adjustments. Vegetative response varies year to year. L&D water control manual updates are being made to include fish and wildlife enhancement as well as environmental pool management. In 2014, MVS had their first face to face meeting with multiple stakeholders and agencies to discuss current operations and development of Environmental Pool Management Project Delivery Team.

Appendix C: Lessons Learned Session

- Outreach and communication
    - Educate first, then seek change
    - Start outreach early
        - Feedback can help to modify a proposed action to one that has broader support and still meets project objectives
        - The action and the associated assessment can be revisited and modified in the future based on the results
    - Conduct local outreach relevant to your project area
        - Engage with the groups in the area that either could be affected or have an interest in the study area (e.g., agricultural groups, community groups, tourism, conservation groups, etc.)
    - Include all potential stakeholders in outreach and invite them to meetings
    - Invite stakeholders with different interests to meetings as a way to help identify potential concerns and to manage potential conflicts with a proposed action
    - Build trust with stakeholders through regular coordination calls prior and during implementation, annual coordination/public meetings to discuss the results more broadly. Communicate plans and adjustments for the future
- Development of a change culture within the organization
    - Consider a wide range of alternatives and then hone in on reasonable alternatives that balance authorized purposes, ecological needs, and other stakeholder input
        - It is important to look inside as well as outside of operating bands to identify what could be done to improve conditions
        - Consider a smaller change if a modification to water management can't be achieved at the first proposed conditions. A smaller transition from current operations helps the team better understand the flexibility that may be present and begin assessing potential changes
- Organization factors
    - Gradual but continual change as an organization
    - Reach out to influential individuals at the district level and communicate the importance and value of the considered change
    - Connecting with leadership early in the process is essential for gaining local support prior to attempting a project
- Show benefits
    - Consider what stakeholders care about when considering what to assess and how to communicate the results
    - Show economics benefits if it is possible to do so. This is a metric that is important to many stakeholders and can complement the biological metrics assessed as part of a project
    - Work on the story of why what we are doing matters

Appendix D: District L&D management

- How each district manages Lock & Dams
    - St. Paul and Rock Island districts
        - As we look at all options for SRP, each district manages their L&Ds differently. St. Paul manages L&Ds 1-10, which are all managed and operated off hinge points. The Water Control section issues gate instructions to each L&D. Rock Island manages L&Ds 11-22. These dams are managed similarly to St. Paul besides the L&D 14-15, which must match.

    - St. Louis District
        - For L&D 24, 25, and Mel Price, Water Control uses the flows passed from Rock Island in order to produce a daily 7-day forecast as well as a 28-day forecast every Wednesday. As far as instructions, St Louis issues pool instructions to L&Ds, but not specific gate instructions. L&D 24 and 25 manually do gate changes, while Mel Price operates their gates electronically. Kaskaskia Nav L&D isn't instructed as regularly, the pool elevation is monitored daily.

    - Vicksburg District has L&Ds with and without hinge points
        - In Vicksburg, the L&Ds associated have a mixture of being with and without hinge points.

    - Louisville District
        - In Louisville District, lock personnel maintain a fixed pool at the dam and base gate changes on daily forecasts and hinge point stages and are performed primarily by operations personnel. Forecasting is done through a combination of observing upstream conditions, assumptions on how pools will be held, and implementation of CWMS models that are calibrated frequently. The hope is that the CWMS model will eventually allow lock personnel to see what gate settings they need to set, making communication between Water Control and the project more seamless. During dredging season, sonar equipment is utilized to observe local mussel populations and minimize unnecessary interference that dredging may cause to mussels.

    - Nashville District
        - The district operates two reservoirs in tandem near Cairo, four large storage reservoirs and a wedge storage, which is the Kentucky and Barkley Dam. They calculate volume storage based on slope in the river. Nashville additionally has four L&Ds that are all in good working condition. Water Control is staffed year-round, running CWMS models daily and issuing instructions for every project. The scheduling of hydropower at hydropower projects is done by working in tandem with Tennessee Valley Authority (TVA) and issuing a maximum output and hourly schedule based off the balancing between the hydropower needs of TVA, local trout hatchery interests, and marketing total weekly capacity.

Changes to any L&D gate are made on site. Flow from hydropower units will be from 60-90%. A 10-yr plan to consolidate down to one control center that operates all 9 of LRN projects is underway.

- Huntington District
  - Huntington District L&Ds are hinge-point operated as well. It has four major watersheds. It operates with the use of CWMS models to develop forecasts and provide pool instructions for lock operators.

- Portland District
  - Portland District of NWD has 13 reservoirs that provide a combination of hydropower, e-flows, and navigation assistance to the lower portion of William River Basin. The system empties out and refills during the winter and requires frequent forecasting to successfully manage the basin. Forecasts also dictate the potential of fish passage issues, temperature issues, and achieving target flows. The forecasts provide insight into how much water is going into and out of the system. The system is being reevaluated based on a "biological opinion". That opinion is looking at deauthorizing hydropower to better meet e-flows. Several locks are not used anymore and are in caretaker status.

- Walla Walla District
  - There are transitions to shallow draft navigation downstream that end at Lewiston, Idaho. Regional Water Management coordinates with Canada.

- Omaha District
  - The Missouri River Basin has 6 mainstem dams that have FRM, hydropower, and navigation downstream of Sioux City. Also, the basin has issues with lack of sediment downstream, lack of habitat features, and flow regime or timing. A new study is in the works for flood risk management.

- Kansas City District
  - The Kansas River has 4 reservoirs that provide water supply and navigational flow support to the Missouri Basin.

Appendix E: Notes from breakout group discussions

Lakes and Rivers Division

LRD Ohio River Visioning Meeting

- Meeting to discuss our SRP projects or ideas across the three districts. Louisville, Huntington, and Pittsburgh.
- All districts bring the SRP projects/philosophy ideas to meeting. Purpose will be to envision how we will build an SRP vision for whole of Ohio. To be held this fall.
- Green River canoe trip where Dam is removed – parallel field trip.

Mussel species in Allegheny and OH

- Starting with the FY21 SRP project conducted by LRP.
- Implementing flow manipulation or pool changes from FY21 study.
- Low priority as separate SRP project because this is ongoing in FY22 SRP.

Hydropower Dam - Center Hill / Caney Fork River Trout Evaluation

- Originally flood control project, then hydropower added later.
- Lower flow with seepage cut off, wetted perimeter downstream of the dam is smaller/ invertebrates. Need to study benthic invertebrates and how they are affected by the quickly changing water temps/ depths.
- 30 miles downstream to Cumberland River.
- Bottom water cools creek for trout fishing. Stocked stream. Continuous minimum flow.
- Quantify benefits? Cheaper electricity means lower flow, quantify benefits of fishery. What are benefits and costs for creek ecology and hydropower? Economic analysis?
- Try to identify how SRP can help, especially with first steps.

Ohio River Water Quality Partnership for Tributaries/ Ohio River Tributary Influence on WQ - Longitudinal Study

- Stakeholders include ORBA, ORSANCO, MORBA, Water Collaboratory, Water Network.
- How do reservoir operations affect stream DO way downstream? Can we strategically release from certain reservoirs on tributaries at certain times to mitigate HABs?
- Use SRP to set priorities, develop relationships. Model only at high level or leverage existing models.
- Which entity contributes more runoff - Ag or Urban areas? Wabash River is a huge contributor.

- Examine ORB as a whole? System in general. Water quality modeling using simpler models to focus ideas and identify focus areas.
- Water quality groups do tributary work in LRD, leverage WQ work from ORSANCO, USGS, EPA, State-level DEP's, 303d waters, Build WQ network on Ohio and headwaters.

Dredge Material Beneficial Reuse – Maybe not SRP project

- Creating islands from dredge material on Ohio River? Supplementing islands from dredged material to maintain islands that no longer receive deposition naturally.
- Currently on Wabash dredge material used to create material yearly for bird (least Tern) habitat.
- Section 204 on island in Louisville.

Monitoring

- Graduate collaboratives to look at pre-e-flow conditions versus post. I.e., veg surveys, etc.
- Focus on some defined action areas.

Strategic Reservoir Management in Coordination with Maintenance Drawdown

- Old Hickory L&D - For lock work, invasive species control, and habitat benefit.
- Look at timing of a drawdown, during a period of active plant growth?
- Identify next steps.
- General Reservoirs – Maintain higher pool level in spring for fish spawning, in conjunction with F&W.
- Identify how SRP can help support.

Southwest Division

Arkansas River

- Little Rock District
- Endangered species in Arkansas River: Pallid sturgeon, Arkansas shiner, least tern. Plus alligator gar is in Fourche LaFave River, which is a tributary to the Arkansas River.
- What could be done for them via SRP?
- Next step – circle back with District staff and partners, refine issues and opportunities.

Northwest Division

- Columbia River issues are fish passage, water temperature, in-stream habitat. There are many constraints and authorities governing the system, including international water governance, ESA, and tribal authority.
- Pallid sturgeon is a species that could be of interest for SRP.
- Missouri River – there is one lock in a 736-mile section of river that that has limited navigational use.
- Next step – circle back with District & MSC staff and partners, refine issues and opportunities.

South Atlantic Division

Tenn-Tom Waterway and Old River

- The Old River channel has critical habitat for mussels and contains large contiguous tract of bottomland hardwood forest.
- Flow issues from USACE structures have greatly impacted these resources.
- Need for quick action
- SRP workshop with USACE and agencies, initial step.

Woodruff Conservation Lockages in the Apalachicola, Chattahoochee, Flint rivers system

- Alabama shad and other small schooling species are unable to move upstream of Woodruff Dam to spawn.
- A study to see if conservation lockages with attract flow can better move these species upstream. Anecdotal evidence of shad passage through the spillway exists.

Mississippi Valley Division

Pool 26 WLM for Migrating Shorebirds

- This year has been a learning opportunity for MVS to determine viability.
- Early trials showed success.
- Focus on rewetting areas in during spring and fall migrations.
- SRP action – refine actions with Water Control and Ops.
    - Balance this with:
        - sturgeon spawning so eggs are not exposed.
        - start of EPM efforts.
        - fall use of EPM areas by waterfowl.

Pool 26 EPM Regime

- Build on EPM success

- Vegetation changes within 3 MVS pools
- Need to look at EPM regimes (building intentional variability into EPM actions)
- SRP Initial Action – workshop with Federal & state partners

Lake Sturgeon Spawning in UMR

St. Louis and Rock Island District

- Modeling at Mel Price showed gate changes could help create spawning conditions.
- Monitoring helped determine presence, document spawning (and SRP success).
- Look at L&D actions and opportunities upstream of Mel Price L&D 25-19 tailwaters.
- SRP Initial Action – Inter-district and agency meeting with Federal & state natural resource partners.
- Long term SRP action – implement success of Mel Price to other UMR L&D sites.

Environmental Water Level Management in MVR and MVP

St. Louis, Rock Island, St. Paul District

- Data shows that reducing water level fluctuations would increase habitat in several UMR pools.
- What is constraint to implementation of WLM project in upper pools?
- Identify whether there is role for SRP support, perhaps as pilot effort in UMR pool.

Vicksburg District

Ouachita Black System

- Jonesville L&D deviation schedule for raising and lowering downstream lake to improve ecosystem of lake.
- Identified in South Region Operations and Water Management meeting.

Pearl River

- 3 Locks and Dams on the system.
- All in caretaker status.
- L&D 1,2,3.
- Are there environmental opportunities and needs?

Red River L&Ds

- Are there environmental opportunities and needs?