

Green River Basin Sustainable Rivers Program Workshop

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1.0 Project Purpose

The Sustainable Rivers Program (SRP) is a partnership between the Nature Conservancy (TNC) and the U.S. Army Corps of Engineers (USACE) that is focused on identifying and implementing opportunities for changes to operations at USACE infrastructure (locks and dams, dry dams, reservoirs, etc.) to create environmental benefits, in addition to serving the infrastructure's authorized purposes. The purpose of the Green River Basin Sustainable Rivers Program (GRB SRP) Workshop was to engage stakeholders in the GRB to re-open lines of communication, discuss the existing condition of the rivers and watersheds in the basin, identify potential opportunities for environmental benefit, and discuss possibilities for future SRP projects within the basin.

The first ever SRP project was completed on Green River Reservoir in 2002. Once the adjustments that resulted from the re-operation of Green River Reservoir were approved for implementation and incorporation into future reservoir operations, periodic engagement and discussion occurred among stakeholders over the following years. Due to the biodiversity and known stakeholder interest in the Green River Basin (GRB), SRP efforts in fiscal year (FY) 23 were targeted at re-engaging stakeholders, determining the current state of the basin 20 years after the initial SRP effort, and seeking environmental opportunities in the basin with a basin-wide management perspective, as well as identifying areas where SRP could apply and aid in determining the best opportunities present for the ecosystems within the basin.

A proposal for a GRB stakeholder workshop was submitted to the SRP for consideration in October of 2022, and was approved for funding in November of 2022. The initial proposal for the workshop highlighted the significance of the GRB and the need to engage stakeholders to identify environmental opportunities present within the GRB. The proposal documentation for the GRB SRP Workshop is included with this report as Appendix A.

2.0 Background

The Green River Watershed, encompassing approximately 9,230 square miles, is located in west-central Kentucky and extends into north-central Tennessee. The headwaters of the Green River originate in Lincoln and Casey Counties, Kentucky (KY) in the Mississippian Plateau where it then flows in a northwesterly direction for 330 miles through the Western Coal Field region to its confluence with the Ohio River near Henderson, KY (USACE, not dated). As the largest of the twelve river watersheds in Kentucky, six sub-basins are contained within the Green River watershed - the Barren River, Upper Green, Middle Green, Rough River, Pond Creek and Lower Green watersheds. The GRB has a long history of human use and is one of the most ecologically diverse river systems in the United States. The GRB contains four USACE Louisville District (LRL) Reservoirs: Green River Lake, Barren River Lake, Nolin River Lake, and Rough River Lake. These multi-purpose reservoirs on the main stem and tributaries to the Green River support flood risk management, water supply, water quality, and recreation. The use of each reservoir is guided by project-specific water control manuals (WCMS) to ensure project compliance with congressionally approved operating purposes.

Remaining unglaciated during the most recent Ice Ages, the GRB provided an environment where species could persist and diversify. Therefore, the Green River is one of the most ecologically significant aquatic systems in the United States, and the most biologically diverse branch of the greater Ohio River Basin. The Green River contains more than 150 species of fish, more than 70 species of freshwater mussels (70% of total mussel species in KY), and at least 10 endemic aquatic species. The State of Kentucky has designated the Green River as an Outstanding Resource Water. At least 20 federally threatened & endangered (T&E) mussel species have been documented in the basin, with the Kentucky Department of Fish and Wildlife Resources (KDFWR) recognizing that the river is the last refugia for some mussel species that were once common in the Ohio Valley but are “tenuously holding onto their presence on Earth in the Green” (McClellan, not dated).

Karstic landscapes influence the nature of the Green River throughout its journey to the Ohio River. Many springs feed the river and the cool, clean water provides microhabitats for wildlife and give the river its pellucid color. Approximately 110 miles downstream of Green River Reservoir, the Green River flows into the cave systems of Mammoth Cave National Park (MACA). This stretch of river, from the reservoir dam through MACA, holds the greatest aquatic diversity in the whole watershed (KDFWR 2023). MACA has one of the most biodiverse subterranean habitats in the world with approximately 40 cave-adapted organisms, including the endemic Kentucky cave shrimp whose range exists only within the National Park boundary. Inside MACA, nearly 200 species of benthic macroinvertebrates have been found. With six miles of the Nolin River and 25 miles of the Green River flowing through the National Park, both directly impact the delicate aquatic ecological communities present in the cave systems below. Mammoth Cave and other caves in the region depend on flow from the GRB to anchor the food web that supports the rare subterranean ecosystems found there (NPS 2023a).

Part of the Green River’s high ecosystem quality come not only from the clean, fresh water provided by springs, but from the limited development in the upper reaches of the river and its tributaries. Used primarily for agriculture and timber, rather than industrial purposes, the relatively undeveloped landscape within the basin has meant that the waters of the GRB avoided many point sources of pollution that plagued other river systems of the Ohio River drainage. Nevertheless, water quality impacts associated with agricultural inputs, sedimentation, and inadequate land use planning have impacted the region over the past 150 years and continue to pose ongoing threats to the basin (USACE 2011). Furthermore, the karst topography in the region can allow pollutants to travel further, and with less traceability, than traditional runoff (NPS 2023b).

The rise of commercial river commerce following the impoundment of several rivers of the basin in the mid-1800s resulted in major ecological changes to the Green River and many of its tributaries. The subsequent decline of the logging economy and steamboat trade in the late 1800’s was followed by a rise of a coal-based economy in the 1900’s which catalyzed the modernization of Green River lock and dam (L&D) #1 and #2 and the clearing of the lower 1/3 of the Green River for modern barge traffic. It was decades of in-stream development and wholesale changes the hydrology and flow regimes of the major streams of the basin which ultimately precipitated and/or accelerated the decline of many of the species now known to be imperiled there (Crocker 1976).

The middle of the 20th century saw not only alterations to the lower stretch of the Green River, but also the creation of flood risk management reservoirs on the upper sections of the GRB. USACE LRL currently operates four federal reservoir projects (Green River Dam, Nolin River Dam, Barren River Dam, and Rough River Dam) in the GRB system. These reservoirs, providing needed flood security to downstream residents, were praised by many in the region, but also criticized by some looking at the environmental effects of the water control structures built on the river over the previous 100 years. These environmental concerns only heightened in the late 20th century as the importance of the GRB for preserving unique, endemic, and T&E species was understood (Crocker 1976).

In recent decades, scientists, conservation organizations, and governments have recognized the importance of the Green River ecosystem and the need to preserve and, where possible, restore it. In the 1990s, these groups came together for that common, unified purpose. A collaboration between USACE, TNC, and other stakeholders saw the completion of the first Sustainable Rivers Program (SRP) project in the GRB in 2002. This SRP project reestablished more natural water flow and hydrology in the Green River below Green River Lake Dam which helped to prevent unnatural backflows into Mammoth Cave from water releases at the upstream dam. A need was eventually identified for the removal of L&Ds in the basin to restore natural flow to the section of the Green River flowing through MACA. In 2014, Congress recommended that the Green River L&D #'s 3, 4, 5, 6 and Barren River L&D #1 be deauthorized. Subsequent dam removal efforts both completed (Green River #6 in 2017, Barren River #1 in 2022) and ongoing (Green River #5) have moved towards reestablishing the original hydrological regimes and lotic ecology of the GRB system. This is expected to have both short- and long-term benefits on fish and mussel populations as well as recreation activities within the watershed.

The history of the Green River Watershed over the last two centuries is one of river management for commerce and flood reduction. In the last four decades there has been a refocus on the importance of the ecological health and hydrology of the unique environment, ecosystems, and species found only in the GRB. Many stakeholders from state and federal government agencies and non-governmental organizations such as TNC have devoted resources to restore and protect this vital resource. The SRP has demonstrated how successful cooperation between these stakeholders can affect change, generate ideas, and spur future action to improve ecological function in the GRB. Recent and current work, such as L&D removals and the establishment of SRP working groups, offer ideas and solutions for potential future actions to further benefit and protect the natural heritage of the GRB. Helen Bartter Crocker noted in her 1976 book *The Green River of Kentucky*, which documents the history of the watershed and its people,

“[The] assistant secretary of agriculture, wisely advised valley leaders that "no single Government agency - Federal, State or Local - possesses all the facilities to do the job in its entirety." Especially prophetic was his conclusion that "the missing link is an adequate facility to coordinate these skills, authorities, and interests in developing a single integrated plan.””

Our hope is that the SRP, and its partnerships, can be that missing link.

3.0 Scope

The workshop scope included a description of the work to be completed for the project, as well as an estimated schedule for deliverables. This work included the formation of the GRB SRP Workgroup by USACE LRL; the planning and execution of a workshop to identify ecosystem problems, opportunities, data gaps, and research needs; and a summary report of the workshop to detail the findings, recommendations, priorities, and potential future SRP project opportunities. The workshop was to include water managers, reservoir project staff, natural resource agencies, scientific experts, academia representatives, and other relevant stakeholders in the basin. A goal was also set to identify a new ecological baseline for the basin. This report serves as the workshop summary report detailing the potential ecosystem projects, resources, and information that can be used to improve the health and sustainability of the GRB aquatic ecosystems in future efforts. The project scope for the workshop has been included with this report as Appendix B.

4.0 Planning Process

The following section explains the planning process for the development and execution of the GRB SRP Workshop.

4.1 Collaboration Efforts

The development of the workshop occurred primarily over a period of nine months and involved a substantial amount of collaboration from both an internal USACE project delivery team (PDT; Table 1) and an external stakeholder group called the GRB SRP Workgroup (hereafter, Workgroup; Table 2).

4.1.1 Project Delivery Team (PDT)

Table 1. USACE Project Delivery Team (Alphabetical)

PDT Member	Roles & Responsibilities	Organization
Abbey Miglio	H&H Engineer-in-Training / Project Manager	USACE - LRL
Abby Korfhage	Public Affairs Specialist Assistance with visual information as needed, including development of save the date fliers, and an introduction video clip.	USACE - LRL
Annie Howard	Environmental Resources Section Chief	USACE - LRL
Chris Boggs	Operations Manager, Green River Area	USACE - LRL
Jaime Candelario	Geographer / GIS Create the GIS GRB SRP web application tool and produce GRB area maps for breakout sessions	USACE - LRL

Jenny Stromberg	Planner / Project Manager	USACE - LRL
John Hickey	SRP Support / Hydraulic Engineer	USACE - IWR
Kristin Berger	Water Quality Biologist	USACE - LRL
Lane Richter	SRP Support / Wildlife Biologist	USACE - MVP
Lauren Alexander	H&H Modeling Section Chief	USACE - LRL
Marissa Conn Minister	H&H Engineer-in-Training	USACE - LRL
Melanie Babin	H&H Engineer-in-Training	USACE - LRL
Michael Borchers	Hydrology and Hydraulics Branch Chief	USACE - LRL
Michelle Mattson	SRP Support / Ecologist	USACE - IWR
Nathan Moulder	Plan Formulation Section Chief	USACE - LRL
Weston Young	H&H Engineer-in-Training	USACE - LRL
Zac Wolf	Water Quality Team Leader / Limnologist	USACE - LRL

4.1.2 Green River Basin Sustainable Rivers Program Workgroup

Table 2. GRB SRP Workgroup Team (Alphabetical)

Workgroup Member	Roles & Responsibilities	Organization
Abbey Miglio	H&H Engineer-in-Training / Project Manager	USACE - LRL
Chris Boggs	Operations Manager, Green River Area	USACE - LRL
Jenny Stromberg	Planner / Project Manager	USACE - LRL
Michaela Lambert	Nonpoint Source & Basin Team Supervisor	Kentucky Division of Water
Richie Kessler	Environmental Science Lead Professor	Campbellsville University
Rob Bullard	Director of Freshwater Programs	The Nature Conservancy – TN Chapter (Nashville)

4.1.3 Project Meetings and Site Visits

The PDT project meetings occurred on a monthly basis in person at the LRL Office, while Workgroup meetings occurred more frequently, typically on a bi-weekly basis in a virtual format

(Webex) to accommodate participants located throughout Kentucky and Tennessee. Both PDT and Workgroup meetings were about an hour in length and covered team updates since the previous meeting. This time also provided an opportunity for the group to come to consensus on agenda and workshop logistical decisions, and collaboratively track and troubleshoot any risks or issues presented. Additional discussions occurring outside of the recurring meetings were typically conducted through e-mail or by phone.

The Workgroup completed a site visit to MACA to gain a better understanding of existing facility conditions at the MACA training center and to perform a trial run of the workshop and field trip on June 23, 2023. The knowledge gained through the site visit allowed for greater clarity in communication with participants prior to the workshop and created a better understanding of the remaining outstanding items.

4.2 Outreach Efforts

In an effort to engage with the intended audience for this workshop, a variety of approaches and strategies were implemented. Initial discussions occurred internally within the PDT to develop a list of potential stakeholders to invite to the workshop. Additionally, research occurred into the original 2002 GRB SRP's meeting notes, as well as other Green River and Ohio River area projects to gain knowledge on prior efforts in the basin and the participants involved to help build the list of stakeholders to be contacted in engagement efforts. After the stakeholder list was initially crafted and vetted for appropriate participants by the PDT, the workgroup and vertical teams reviewed for broader input. The PDT also reached out to high priority stakeholders for their review and input. Stakeholders who provided input on the development of the invitees to the workshop included the following:

- Campbellsville University
- Kentucky Division of Water (KY-DOW)
- Office of Kentucky Nature Preserves (OKNP)
- The Nature Conservancy (TNC)
- U.S. Fish and Wildlife Service (USFWS)

Once a final list of invitees was developed, a mass email was sent out inviting participants to the workshop. Another method of invitation included in-person, verbal invites during field work or by phone if stakeholders were identified on an ad hoc basis. The overall response from stakeholders was very positive and optimistic, with many looking forward to participating in the workshop. Several stakeholders even forwarded the invitation on to more people who would benefit from attending. Overall, invitations were given to over 100 stakeholders who would have the most knowledge on the problems and opportunities within the GRB.

4.3 Content Coordination and Logistics

Content coordination and logistical planning required collaboration between several areas of expertise, including the following:

- USACE administration, resource management, office of counsel, national SRP members, and various vertical team members within LRL and the Great Lakes and Ohio River Division (LRD) to complete the conference approval process
- The National Park Service (NPS) to coordinate the facility rental and field trip site visit logistics
- Concessionaires and outfitters for overnight accommodations and field trip mission critical equipment

4.4 Planning Documentation

Key project documentation, including the project management plan (PMP), PDT and Workgroup meeting notes, working files, resources, planning documentation, presentation material, and final report for the workshop planning and GRB SRP efforts is stored internally at USACE.

5.0 Workshop Summary

The GRB SRP Workshop was a three-day event that included presentations from various individuals, a pair of site visits to areas within the GRB, as well as a series of breakout sessions that were used to facilitate communication about existing conditions and potential opportunities present within the basin. The workshop was held at the Mammoth Cave National Park Training Center from August 29th to the 31st, 2023.

5.1 Workshop Attendance

A total of 60 individuals attended the workshop. Representatives were present from the following agencies and affiliations:

- Campbellsville University
- Crawford Hydrology Lab – Western Kentucky University (WKU)
- Kentucky Department of Fish and Wildlife Resources (KDFWR)
- Kentucky Division of Water (KY-DOW)
- Kentucky Rural Water Association (KRWA)
- National Park Service - Mammoth Cave National Park (MACA)
- Office of Kentucky Nature Preserves (OKNP)
- The Nature Conservancy (TNC)
- USACE – Institute for Water Resources (IWR)
- USACE Louisville District (LRL)
- USACE Nashville District (LRN)
- USACE St. Paul District (MVP)
- U.S. Fish and Wildlife Service (USFWS)
- Western Kentucky University (WKU)

Invitations were disseminated to a wide range of representatives from additional agencies, groups, and stakeholders in the region. Figure 1 below depicts the group of workshop attendees from the first day of the workshop.



Figure 1. Workshop Attendees on August 29th, 2023 (USACE Photo)

A complete list of workshop attendees is included with this report as Appendix C.

5.2 Workshop Agenda

The workshop agenda was developed by the PDT during the planning process; however, slight adjustments were made during the workshop to the planned agenda. Therefore, the agenda contained in Appendix E shows what occurred during the workshop, not the agenda that was disseminated to participants. Notes were taken by designated notetakers throughout the workshop to capture significant discussion and points for consideration, which can be found in Appendix D of this report.

The first day of the workshop (August 29, 2023) included presentations on the significance of the GRB, an overview of the SRP, the history of the GRB including discussion on the changes made in the initial re-operation of Green River Reservoir in 2002 (the first ever SRP project in the program), the dam removals on the Green and Barren Rivers, the existing conditions of the fauna of the region in terms of mussels and fish, the ongoing ecological monitoring efforts pre and post dam removals, and temperature control capabilities of the reservoir control towers of Nolin, Barren, and Green River Reservoirs. Rough River Reservoir was not considered in this discussion due to its limited selective withdrawal capabilities. A breakout session was held on the first day that was focused on establishing existing conditions within the basin. More information will be provided on the specific breakout sessions in section 5.3 of this document.

The second day of the workshop (August 30, 2023) included continued conversations about SRP capabilities and opportunities with presentations on examples of SRP success stories, including separate presentations on the ongoing SRP projects at Cape Fear River in USACE Wilmington District and at Melvin Price L&D in St. Paul District. A breakout session was held to brainstorm opportunities to utilize SRP within the GRB. The site visits took place concurrently on the second day of the workshop. The intention of the site visits was to provide context for the workshop and allow participants to gain familiarity with the landscape and watershed conditions, as well as to spark thoughts on applications for SRP within the basin. One group participated in a canoe trip from Dennison Ferry to Green River Ferry in MACA. Biologists helped provide context to the float as well as helped identify river flora and fauna (Figure 2).



Figure 2. Workshop participants before the canoe float (USACE Photo)

Another group went on a guided hike led by Dr. Richie Kessler of Campbellsville University and Brice Leech of the National Park Service (MACA) that included portions of the Turnhole Bend Trail, Echo River Trail, and Mammoth Cave itself to better understand the geography of the karstic landscape in the area and the significance of the interconnectedness of the water in the cave system and the river system above ground (Figure 3).



Figure 3. Workshop participants on the guided hike (USACE Photo)

The final day of the workshop (August 31, 2023) included a recap from the site visits, discussion from the previous days, a breakout session focused on doing a deep dive on the potential opportunities identified the previous day, and a discussion on the future of the GRB. After the workshop concluded, LRL USACE personnel continued the conversation with the Green, Nolin, Barren, and Rough River Reservoir project staff to get feedback from them on the conversations that were had during the workshop. The discussion included a debriefing of the workshop, a review of the SRP opportunities that were generated, and conversation about what these potential SRP project ideas and opportunities might look like or require from USACE Operations staff. Operations staff was supportive of the outcomes and assisted in generating potential future SRP project proposals for the collection of baseline data in the basin and a series of environmental flow (e-flow) workshops at Barren, Nolin, and Rough River Reservoirs, sequentially. A separate effort to quantify the benefits from the original Green River Reservoir SRP from 2002 was discussed during this conversation as well.

5.3 Breakout Sessions

A total of three breakout sessions were held throughout the workshop to help facilitate discussion and the sharing of information across agencies and experience. Workshop participants were separated into 8 breakout session groups.

Notes were taken for the whole group discussion at the end of each breakout session by the lead facilitators, Kristin Berger (USACE-LRL) and Zac Wolf (USACE-LRL). These notes capture additional details on each of the thoughts and ideas discussed at the end of each breakout session. The notes are included with this report as Appendix F. Each group was led by a USACE facilitator who was responsible for taking notes and guiding the direction of the conversation. Each individual group's breakout session notes taken by the facilitator can be found in Appendix G. Additionally, each facilitator was provided a breakout session facilitator guide that included the goal of each breakout session, general instructions for the facilitator, and discussion prompts for reference as needed. A copy of this breakout session facilitator guide has been included with this report as Appendix H.

5.3.1 Breakout Session 1: Existing Conditions

The first breakout session focused on determining and evaluating existing conditions in the basin with its objective being to identify strengths and weaknesses within the GRB in its current condition. A set of maps of the GRB were provided to each group to help tie information provided by the group to specific geographic locations in the basin and to help provide context during later breakout sessions. A blank set of the maps can be found in Appendix I of this report. A species information sheet was also developed to aid in the collection of habitat and flow information for organisms throughout the workshop, should participants have the information on hand (Figure 4). These worksheets were available during each breakout session. Blank and filled copies of the worksheets used during the workshop are included in Appendix J.



Figure 4. Kentucky Cave Shrimp breakout group during a breakout session (USACE Photo)

During the group dialogue, concerns with increased development, the discontinuation of the Conservation Reserve Enhancement Program (CREP) under the U.S. Department of Agriculture (USDA), and gravel mining impacts to water quality in the rivers and stream systems in the basin were discussed as notable issues. The loss of land available for riparian vegetation establishment and conservation raised concerns among the group for maintaining healthy water quality as these

areas begin to be converted back into farmland with the loss of CREP. With respect to biodiversity, the Upper Green subbasin was identified as having significant available fauna data while the Lower Green subbasin was noted as an area that could benefit from further study. The Lower Green has more agricultural activity and channelized streams than that of the Upper Green, and as such, has become an understudied area with unknown stream conditions and aquatic fauna counts. Another item that was raised as an area for further investigation was the stream gage network in the basin. It was recommended that a stream gage gap analysis be completed to ensure necessary parameters (flow, temperature, water quality data, etc.) for vital locations are being captured so that they can be utilized for optimization of the basin.

5.3.2 Breakout Session 2: Opportunities and Capabilities

The second breakout session was focused on identifying opportunities present in the basin for SRP projects and the possible capabilities of SRP to create environmental benefits. The objective of the second breakout session was to brainstorm potential opportunities for improving conditions in the basin, or to solve the problems identified in the first breakout session. These conversations focused on USACE capabilities, the abilities of partnering agencies, and possibilities for cooperation within the basin. This session utilized both the maps and the species information sheet from the first breakout session to continue building upon previously discussed ideas. In addition to these resources, a list of potential SRP opportunities (based on previous submittals to the program) was available for reference to give groups additional context for the types of projects SRP can support. This list of SRP Opportunities can be found in Appendix K of this report. In addition, a handout of the reservoir control tower designs and selective withdrawal capabilities was available for reference as well so participants could discuss the refinement of any temperature operations from the reservoirs where applicable. This control tower handout can be found in Appendix L of this report.

Several opportunities for studies were identified by individual groups during the group discussion. One idea for a study that was identified was an analysis of downstream floodplain connectivity and general downstream impacts from reservoir releases, such as the impact to temperature and flow regimes. This could include portions of a stream gage gap analysis and analyzing temperature needs for the basin by looking at pre-dam conditions. Understanding baseline data for how USACE reservoirs impact downstream conditions, such as how often releases activate floodplains, which water sources govern in the river at various locations, and how releases impact temperature, could lead to operational adjustments that create environmental benefits. Additional ideas for studies included an inventory of bank erosion areas, an inventory of mussel habitat, studies on fish host relationships and flow needs, a critical habitat inventory for the region, a benthic trawling survey to assess migration limitations (with Green River L&D #1), and a study to evaluate impacts from the original Green River SRP project were also brought up as potential SRP projects that could be catalysts for future work in the GRB.

In addition to studies, other needs were identified for educating and building a relationship with the public to build support for potential projects within the basin. These needs included those listed below:

- discussion on the CLEAR30 program to help limit potential water quality degradation associated with the discontinuation of the CREP program
- additional low head dam removals and study of these removals to inform other dam removal efforts in the region
- restoration activities on tributaries and connecting streams
- reconsidering how USACE Regulatory issues permits, and investigating how land use is impacting the watershed
- potential formulation of a centralized database for environmental issues and concerns that could facilitate partnerships, allow stakeholders access to pertinent information, and that USACE could utilize to inform future work in the basin

It was also noted that KDFWR has done work to establish aquatic species hotspots in the basin that could be a resource for future studies.

5.3.3 Breakout Session 3: Deep Dive into GRB Opportunities

The third breakout session was centered on more fully developing ideas that had been suggested during the opportunities and capabilities breakout session. The objective of this breakout session was to discuss any newly thought of opportunities that might have been missed in session 2, then focus on priority opportunities and the details of how to achieve them. This was to include discussion of the benefits, risks, pros and cons, and the data and studies needed before, during, and after implementation. This breakout session utilized the maps, species information sheets, control tower handouts, and SRP capabilities sheets that had been used in prior sessions as resources for the groups (Figure 5). No additional materials were supplied during this session.



Figure 5. Zac Wolf (USACE) facilitating the third breakout session (USACE Photo)

A list of potential project ideas that would benefit the basin and its stakeholders was generated from the deep dive breakout session. These ideas included:

- the creation of a central repository to house all relevant Green River data and points of contact for various agencies
- evaluating the bank erosion conditions present in the basin to determine if further restoration is needed near the Munfordville, Green River L&D #4, and Barren River L&D #1 sites
- collecting baseline data to determine pre-impoundment conditions, the conditions needed for the organisms in the impacted environment, and the reaches of influence downstream of each reservoir
- conducting a series of e-flow workshops for the reservoirs in the basin
- the completion of a stream gage gap analysis to ensure the gages in the region are collecting data that is useful to the stakeholders in the basin
- further discussion on ways to account for the loss of the CREP program

6.0 Workshop Outcomes

One of the goals of hosting this workshop was to create a list of potential projects that would benefit the ecosystem in the GRB, including those that could be addressed with SRP as well as any additional opportunities that exist for environmental benefit. Another anticipated outcome was the re-establishment of stakeholder connections within the basin across local, state, and federal levels. A geographic information system (GIS) comment tool was also developed to help house any input or data collected from workshop participants that could be referenced during future efforts.

6.1 GIS Comment Tool

For the purpose of collecting pertinent data for the existing conditions of the GRB, a GIS Comment tool was developed that allowed users to input geolocated points to indicate high priority conservation areas; habitat and area improvements (problems and opportunities); routine and non-routine monitoring locations; areas protected for conservation; amenities, structures, and facilities; and any other data, thoughts or concerns that might be relevant in considering opportunities present within the basin. Users can select a category, designate a location relevant to their data entry point, and provide a description of the concern, opportunity, data gap, or other relevant information that will then be stored in the tool. Figure 6 below depicts the user interface of the GIS comment tool.

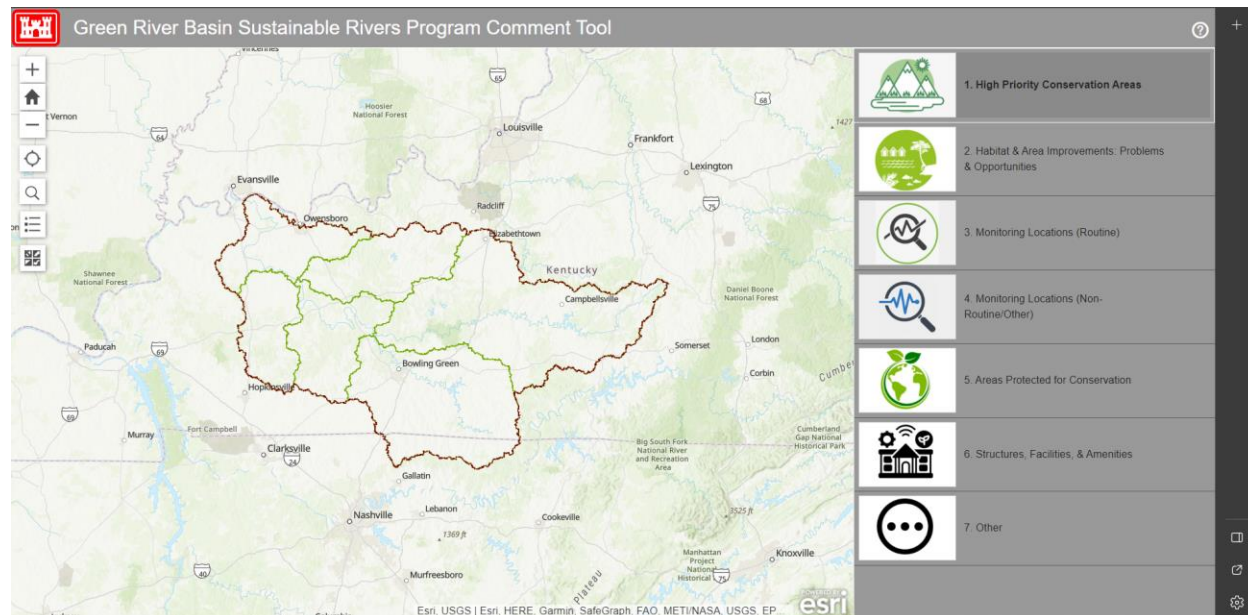


Figure 6. Image of the GIS comment tool user interface (USACE Photo)

The link was sent out in the welcome packet for the workshop to registrants, as well as after the workshop to allow for continued data aggregation so participants could share any information they had about specific areas in the GRB.

The comments collected in this map tool are to be used as a record to help delineate areas for environmental opportunities within the basin, identify any gaps in research and data collection, and to help focus the attention of any future SRP projects. The group of stakeholders has agreed to continue to add to the comment tool in the time following the workshop. The link to the GRB SRP GIS Comment tool has been included in this report for reference below.

Green River Basin SRP GIS Comment Tool Link:

<https://lrl.maps.arcgis.com/apps/CrowdsourcingReporter/index.html?appid=436cb202fe50464798854d836e2bb11d>

All of the comments placed into the tool have been aggregated into a table and have been included as Appendix M with this report.

6.2 Potential Ecosystem Projects

A list of potential projects for environmental benefit was formulated during the breakout sessions of the GRB SRP Workshop. These project ideas have been summarized in each respective breakout session description. A list of the broad ideas generated can be found below for reference as well. Notes on more of the specifics of each of these ideas can be found in Appendices F & G.

A. Baseline data collection

- a. Determine the lengths of the reaches downstream that project operations influence (temperature & flow impacts)
- b. Determine established reference conditions for each watershed

- c. Determine the pre-impoundment conditions
 - d. Determine the priority areas for targeting operational changes
 - e. Determine flow needs of various organisms (fish, mussels, etc.)
 - f. Establish the downstream floodplain connection
 - g. Inventory critical habitat
- B. E-flow prescriptions for the remaining reservoirs (Barren, Nolin, and Rough River)
 - C. Stream Gage gap analysis for the basin
 - D. Opportunities to curb impacts from the loss of the CREP program
 - E. Controlled releases for recreational safety
 - F. Evaluation of the prior Green River SRP project impacts
 - G. Centralized GRB environmental database or repository
 - H. Identify areas experiencing bank erosion and opportunities for restoration (Munfordville, Green L&D #4, Barren L&D #1)
 - a. Inventory areas of notable bank erosion
 - I. Develop a scope for benthic trawling surveys on the lower Green to assess migration limitations of river fauna
 - J. Explore potential for conservation lockages on Green River L&D #1
 - K. Explore potential for low head dam removals across the basin
 - L. Utilize education and outreach efforts that could result in securing conservation easements
 - M. Evaluate how USACE regulatory issues permits for impacts and take a more holistic approach for each basin

This comprehensive list is not in priority order. Though the list was developed during the workshop, participants did not prioritize the list in the allotted workshop time. Additional group engagements such as continued workgroup meetings are required to create a list of prioritized project opportunities in the basin. Due to the short turnaround to submit FY24 SRP proposals (2 weeks after the conclusion of the workshop), the project opportunities that were discussed with the operations staff after the conclusion of the workshop were selected as taking priority as FY24 proposals, as the operations staff were supportive of the proposals discussed with them at the close of the workshop. These included a proposal for baseline data collection with a subsequent series of e-flow workshops for Barren River, Nolin River, and Rough River Reservoirs sequentially, as well as an evaluation of the prior 2002 Green River SRP project's impacts on the basin. It was determined that multiple meetings with stakeholders in FY24 to continue engagement would be the most effective way to maintain consistent effort on prioritizing the remaining ideas for future SRP submittals as well as for determining partnership opportunities to start work on some of the listed efforts that may not be funded by SRP.

6.3 Potential Resources

Several resources were identified at the GRB SRP Workshop that would be beneficial to use to inform future environmental efforts in the basin. One of the most significant resources is a re-engaged stakeholder group that is poised for partnerships and can interact to share information and hold discussion on the best methods for improving the basin. In addition to engaged stakeholders, the following list of potential resources has been identified for future GRB efforts.

- Historic mussel surveys
- KDFWR mussel monitoring sites
- KDFWR mussel re-introduction sites
- KDFWR fish sampling data
- KDFWR habitat assessments
- KDFWR fish community monitoring within the Green River Bioreserve (2000-2005)
- KDFWR Kentucky State Wildlife Action Plan (2023)
- OKNP studies and data sets
- KY-DOW priority watershed designations
- Data from the USACE reservoir projects (Green, Barren, Nolin, & Rough River Reservoirs)
- USACE water quality data

Additional resources likely exist within the complete stakeholder group that are not captured in this list. The stakeholder group consists of both those that were able to attend the workshop and those who were not.

7.0 Lessons Learned

The August 2023 GRB SRP Workshop was the first of its kind in LRL. As such, a series of lessons learned has been developed to aid in the planning and coordination of any future SRP workshops. These lessons learned are as follows:

- Start the conference approval process early so there is enough time to host the workshop, prioritize any ideas, and formulate any SRP proposals by the request for proposal (RFP) due date.
 - Engage with SRP program and division point of contacts early for vertical awareness, support, and guidance on the conference approval process.
 - Anticipate a minimum of four months for conference approval process completion, which needs to be completed prior to advertising for a conference.
- Provide the group a set of organization charts for each agency that covers who each person is, who covers what areas, and the person's general responsibilities as a part of the welcome packet to help get attendees acquainted with other workshop participants in advance of the meeting.
- The GRB SRP Workshop utilized pre-determined, intentionally split groups for the breakout sessions to ensure a balanced knowledge and experience level across the groups. While this was effective, it was noted that more mixing of group participants might stimulate additional conversation throughout the breakout session discussions.
- Verbal feedback received from participants found the breakout sessions format to be positive, although several felt the hour limited discussions and a longer amount of time set aside would have been beneficial.
- A designated point person should be selected from each agency to ensure clear communication of responsibilities for any ideas or outcomes. This would allow for POCs

to be in place for any management needs moving forward and could help in the designation of future workgroups.

- Set regular post-workshop engagements to keep momentum on these efforts and conversations moving (monthly workgroup discussions or annual re-engagement meetings to discuss any progress over the last year).
- Set a pre-workshop discussion with registrants a few weeks prior the workshop to discuss the intent of the workshop and allow participants time to collect any pertinent data that might be helpful and be better prepared for the discussions that were going to be had during the workshop.
- Advertising and outreach challenges were due to several factors but culminated in one common result: limited knowledge of which stakeholders needed to be invited, based on the specific goals of this workshop. Newer USACE team members, who have not had the opportunities to network with stakeholders and establish connections as much as previous USACE members had during the first GRB SRP initiative in the 1990s, had limited knowledge. Retirements and staff turnover created network gaps and lost knowledge. Maintaining a log of who attended this workshop and continuing to maintain these new working relationships will help to strengthen this for future outreach efforts.
- The GIS comment tool app to collect GRB-wide data was distributed prior to the workshop to allow participants to brainstorm and input data leading up to the workshop, however the tool was found to be largely under-utilized. One possible reason was the over-inundation of workshop-related information provided to participants, and the GIS tool being lost in the mass amount of information. Setting aside an hour and inviting participants to attend a virtual pre-workshop meeting to share the workshop goals and a live demo of the GIS comment tool would likely increase the usage going forward.

These items may aid in future SRP workshop formulation and execution. Though the GRB SRP Workshop was considered largely a success, these were observations made by the PDT and workshop attendees that could smooth out the planning process and the workshop flow in future efforts.

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Appendix A – Project Proposal

Proposal Spreadsheet*

Priority	Site	Task Name ¹	Type of Structure ²	Type of Task ³ (percentage)	Description, Connections to Task Categories, and Expected Products or Outcomes ⁴	Federal Cost ⁵ (\$k)	Additional funding and source(s), if Federal funds are available	Months of Effort	Target Start Month
1	Green River Basin	Conduct workshop on environmental opportunities for the Green River Basin	general	Outreach (60), Innovation (30), Science (10)	<p>Conduct a three-day technical meeting in May 2023 with representatives from stakeholders such as TNC, USFWS, Campbellsville Univ., state agencies, biologists, ecologists, and other interested parties in the Green River Basin. The meeting's primary purpose will be to gather information on the ecological state of the basin, with the immediate goal of evaluating, maintaining, and maximizing the benefits of the 2002 Green River Lake SRP project.</p> <p>The meeting will include a combination of presentations, discussions, and planned site visits that demonstrate the various changes in the Green River Basin and the diversity of ecological habitats. Recent dam removals have restored connectivity to reaches of the Barren and Green Rivers. We would like to re-evaluate the hydraulic conditions and consider potential environmental flow opportunities present at the existing reservoirs in the Basin (Nolin, Barren, Rough, & Green). This includes identifying existing environmental or ecological concerns and limitations that USACE projects may have to address those concerns. Our district intends to identify existing and ongoing work by stakeholders within the Basin. This data and community feedback will then be used to guide our future projects.</p> <p>The information collected will be used to develop a report documenting the results of this task. This report can then be used to inform a new Basin-wide environmental plan. The plan should build collaboration, address future needs, and consider possible actions to be taken at various reservoirs in the basin.</p>	60		6	Dec

¹ Please include all tasks that are feasible to accomplish this year.

² "Type of Structure" categorizes proposals per the following types: general reservoirs, locks and dams, dry dams, Section 7, and other structures.

³ "Type of Task" categorizes proposals per the following types: outreach, science, technology, implementation, and innovation.

⁴ Special attentions will be given to tasks that are key catalysts for future work. Please describe this potential for individual tasks as appropriate and acknowledge by adding an asterisk to task priority (eg, 1*).

⁵ In 2010-2019, most SRP tasks were in the 20-50k range. While 2020-2022 and hopefully 2023 budgets allow for bigger tasks, SRP does not have a particular size in mind. As a basic guide, please consider tasks up to 150-200k and split bigger efforts into separate tasks.

Proposed Expenditure Schedule**

Priority	Site	Task Name	Type of Structure	Federal Cost (\$k)	Target Start Month	Months of Effort	Cost Check	Expenditures (non-cumulative)	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
1	Green River Basin	Plan and conduct workshop on environmental opportunities for the Green River Basin - Travel required.	general	60	Dec	6	60	Labor			6	3	3	4	4	30				
								Other								10				

*Additional funding was requested to cover additional planning costs. A total of 90K was requested and funded to fulfill the scope requirements for this workshop.

**The expenditure schedule was shifted throughout the year to have a project completion date at the end of September 2023.

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Appendix B – Project Scope

Sustainable Rivers Program

Green River Basin Environmental Opportunities Workshop

Louisville District (LRL)

Scope of Work – FY23 Funding

Project Scope Statement

The Sustainable Rivers Program (SRP) historically examines opportunities to benefit river ecology while maintaining the federal mandates of the United States Corps of Engineers (USACE) facilities through identifying environmental flows (e-flows) or flows that benefit native species and ecological systems. SRP has begun exploring other environmental actions that will produce ecological benefits to river ecology as well for which this Green River Basin (GRB) proposal applies.

The Green River Watershed, encompassing approximately 9,230 square miles, is located in west-central Kentucky and extends into north-central Tennessee. The headwaters of the Green River originate in Lincoln and Casey Counties, Kentucky in the Mississippian Plateau where it then flows in a northwesterly direction for 330 miles through the Western Coal Field region to its confluence with the Ohio River near Henderson, KY. The largest of the twelve river watersheds in Kentucky, six United States Geological Survey (USGS) Hydrologic Unit Code (HUC) 8 sub basins are contained within the HUC 4 Green River watershed (051100) including the Barren River, Upper Green, Middle Green, Rough River, Pond Creek and Lower Green watersheds. The GRB contains four LRL USACE Reservoirs: Green River Lake, Barren River Lake, Nolin River Lake, and Rough River Lake. These multi-purpose reservoirs on the main tributaries to the Green River support flood control, water supply, water quality, and recreation use. Each reservoir is guided by project specific Water Control Manuals (WCMs) to ensure project compliance with congressionally approved operating purposes.

The Green River in and of itself is one of the most ecologically significant aquatic systems in the United States containing more than 150 species of fish, more than 70 species of freshwater mussels, and 43 endemic species. At least nine endangered mussel species have been documented in the basin. Additionally, just 110 miles downstream of Green River Reservoir, the Green River flows and supplies water into the cave systems of Mammoth Cave National Park which in itself has one of the highest biodiverse subterranean habitats in the world with 41 cave-adapted organisms. With six miles of the Nolin River and 25 miles of the Green River flowing through Mammoth Cave National Park, both the tributaries and main stem river of the GRB directly impact the delicate aquatic ecological communities present in in the cave systems below.

The USACE Water Management Section of the LRL operates four federal reservoir projects (Green River Dam, Nolin River Dam, Barren River Dam, and Rough River Dam) as a component of the GRB system. A system of locks and dams originally authorized for navigation purposes were also built for commercial use along the Green and Barren Rivers beginning in the 1840's to early 1900's with replacements made in the early to mid 1900's. However, Green River Lock and Dams Nos. 3, 4, 5, 6 and Barren River Lock and Dam No. 1 were recommended to be congressionally deauthorized in 2014, which later spurred the removal of some of these structures. Recent dam removal efforts both completed (Green River No. 6 in 2017, Barren River No. 1 in 2022) and ongoing (Green River No. 5) have altered the hydrology, hydraulics, and ecology of the GRB system. The removed dams benefit fish and mussel populations as

well as recreation on the rivers. Potential SRP actions could further benefit these areas once the impact from these lock and dam removals has been established and evaluated.

The scope of work includes formation of the Green River Basin Working Group by LRL and the preparation of a workshop to identify ecosystem problems, opportunities, data gaps, and research needs within the watershed. A summary report will document the workshop findings, priorities, recommendations, and potential future district and SRP environmental work. The workshop would be scheduled for late spring or early summer of 2023 so that the summary report and any subsequent FY24 work can be completed in a timely manner.

Project Management

Laura Mattingly – LRL Project Manager

Abbey Just – LRL Project Manager

TBD – LRL & TNC staff as appropriate

Description of Activities and Products

LRL will coordinate and conduct a workshop with water managers, reservoir project staff, natural resources agencies, scientific experts, academia, environmental practitioners, and river authorities in the GRB. The goal of the workshop is to gather stakeholders to identify ecosystem problems and opportunities present within the basin, including those that could be addressed by SRP, and to work towards establishing a new ecological baseline condition for the basin. Preparation and execution of workshop would help to identify existing data sources and data gaps, and compile data to assess problems and opportunities. The expected outcome would be the development of a summary report which would include a prioritized list of potential ecosystem projects, resources, and studies to improve the health and sustainability of GRB aquatic ecosystems. The workshop would be scheduled for the late spring or early summer of FY23, ideally at a centrally located site within the basin. It is expected that USACE engineers and scientists will actively participate in this effort from Engineering, Operations, and Planning Divisions with LRL. Additional disciplines may be added as necessary.

Deliverables:

- a. Workshop Planning: Identify stakeholders, hold pre-workshop coordination calls, secure meeting venue, create meeting agenda, send invitations, prepare read ahead materials and meeting materials
- b. Workshop: 3-day event
- c. Report: Review and discuss all data, verify, eliminate, or add previous discussion regarding water quality trends, impacts to aquatic species, and ecosystem

Project Milestones

15 Apr 2023 Complete research and data gathering for workshop

15 Aug2023 Conduct Green River Basin workshop

15 Sep 2023 Complete report and determine ecosystem priorities – Green River Basin workshop summary report

Project Budget

-- 2023 USACE costs associated with this SOW will be funded through SRP funding
-- Stakeholder work will be funded by each participating organization or will be volunteer efforts.
Anticipated stakeholders include the Nature Conservancy, US Fish & Wildlife Services, Kentucky Department of Fish and Wildlife, National Park Service, KY Waterways Alliance, Campbellsville University, University of Kentucky, University of Louisville, Tennessee Tech, Western KY University, KY NRCS, Green River Lake, Rough River Lake, Nolin River Lake, and Barren River Lake Project Staff, and other interested river authorities.

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Appendix C – Workshop Attendees

Green River Basin (GRB) Sustainable Rivers Program (SRP) Workshop

Mammoth Cave National Park | August 29 - 31, 2023

Green River Basin SRP Contact List

Green River Basin SRP Participants, Partners, & Stakeholders				
No.	First Name	Last Name	Title / Role / Specialty	Affiliation
1	Richie	Kessler	Environmental Science Lead Professor, Natural Science Division	Campbellsville University
2	Lee Anne	Bledsoe	Research Hydrologist, Assistant Director, Crawford Hydrology Lab, Western Kentucky University; Advisory Council Chair, Mammoth Cave Biosphere Region	Crawford Hydrology Lab at Western Kentucky University; Mammoth Cave Biosphere Region
3	Caleb	Miller	Private Lands Biologist	Kentucky Department of Fish & Wildlife Resources (KDFWR)
4	Chris	Mason	Regional Wildlife Biologist, SE Region	Kentucky Department of Fish & Wildlife Resources (KDFWR)
5	Eric	Cummins	Fisheries Biologist, Barren & Green River Lakes	Kentucky Department of Fish & Wildlife Resources (KDFWR)
6	Jeremy	Shifflet	Fisheries Biologist, Nolin & Rough River Lakes	Kentucky Department of Fish & Wildlife Resources (KDFWR)
7	Matt	Thomas	Ichthyologist & Program Coordinator	Kentucky Department of Fish & Wildlife Resources (KDFWR)
8	Monte	McGregor	Aquatic Scientist / Malacologist	Kentucky Department of Fish & Wildlife Resources (KDFWR)
9	Tyler	Reagan	KDFWR/NRCS Area 1 Liaison	Kentucky Department of Fish & Wildlife Resources (KDFWR)
10	Zachary	Coy	Private Lands Biologist	Kentucky Department of Fish & Wildlife Resources (KDFWR)
11	Wayne	Tamminga	Public Lands Biologist IV at Barren & Nolin River WMA's and Marrowbone SFWMA	Kentucky Department of Fish & Wildlife Resources (KDFWR)
12	Colin	Duncan	Green & Tradewater Rivers Basin Coordinator	Kentucky Division of Water (KDOW)
13	Joanna	Ashford	Branch Manager, Watershed Management	Kentucky Division of Water (KDOW)
14	Michaela	Lambert	Nonpoint Source & Basin Team Supervisor, Watershed Management Branch	Kentucky Division of Water (KDOW)
15	Chloe	Brantley	Source Water Specialist	Kentucky Rural Water Association (KRWA)
16	Barclay	Trimble	Park Superintendent, Mammoth Cave National Park	National Park Service - Mammoth Cave National Park
17	Brice	Leech	Cave Resource Management Specialist	National Park Service - Mammoth Cave National Park
18	Rick	Toomey	Cave Resource Management Specialist and Research Coordinator	National Park Service - Mammoth Cave National Park
19	Mike "Stretch"	Compton	Aquatic Zoologist	Office of Kentucky Nature Preserves (OKNP)
20	Tara	Littlefield	Biological Assessment Manager / Senior Botanist	Office of Kentucky Nature Preserves (OKNP)
21	Jim	Howe	Senior Policy Advisor for Freshwater	The Nature Conservancy (TNC)
22	Rob	Bullard	Director of Freshwater Programs	The Nature Conservancy (TNC)
23	Danna	Baxley	Director of Conservation, Kentucky Chapter	The Nature Conservancy (TNC) - Kentucky Chapter
24	Michelle	Mattson	Ecologist/Compensatory Mitigation SME	U.S. Army Corps of Engineers (USACE) - Institute for Water Resources (IWR)
25	Russell	Errett	Senior Technical Specialist	U.S. Army Corps of Engineers (USACE) - Institute for Water Resources (IWR)
26	Abbey	Miglio	EIT, Hydraulic & Hydrologic Engineer	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
27	Adam	Connelly	Water Resources Section Chief	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
28	Annie	Howard	Environmental Resources Section Chief, Civil Works	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
29	Clayton	Mastin	Civil Engineer, Hydraulics & Hydrologic (H&H)	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
30	Jackie	Henn	Geologist	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
31	Jeff	Hawkins	Biologist, Civil Works	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
32	Jenny	Stromberg	Planner / Project Manager, Civil Works	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
33	John	Bock	Deputy District Engineer, Louisville District	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
34	Kate	Brandner	Dam Safety Section Chief	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
35	Kristin	Berger	Water Quality, Biologist	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
36	Marissa	Conn Minister	Engineer, Hydraulics & Hydrologic (H&H)	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
37	Nate	Moulder	Plan Formulation Section Chief, Civil Works	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
38	Steele	McFadden	Biologist, Civil Works	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
39	Weston	Young	EIT, Hydraulic & Hydrologic Engineer	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
40	Zac	Wolf	Limnologist, Water Quality Team Lead	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
41	Melanie	Babin	EIT, Hydraulic & Hydrologic Engineer	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
42	Michael	Borchers	H&H Branch Chief	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ
43	Dylan	Zinsmeister	Visual Information Specialist	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ - Office of the CIO/G6
44	Mike	Turner	Retired, former Civil Works Environmental Resources Section Chief	U.S. Army Corps of Engineers (USACE) - Louisville District (LRL) HQ (Retired)
45	Alan	Ramey	Manager, Barren River Lake	U.S. Army Corps of Engineers (USACE) - LRL - GRA - Barren River Lake

46	Dan	Taylor	Lead Ranger, Barren River Lake	U.S. Army Corps of Engineers (USACE) - LRL - GRA - Barren River Lake
47	Adam	Warren	Lead Ranger, Rough River Lake	U.S. Army Corps of Engineers (USACE) - LRL - GRA - Rough River Lake
48	Jon	Fillingham	Project Manager, Rough River Lake	U.S. Army Corps of Engineers (USACE) - LRL - GRA - Rough River Lake
49	Chris	Boggs	Operations Manager, Green River Area (GRA)	U.S. Army Corps of Engineers (USACE) - LRL - Green River Area (GRA)
50	Larry	Lemmon	Natural Resources Lead Ranger, Green River Lake	U.S. Army Corps of Engineers (USACE) - LRL - Green River Lake
51	Lori	Brewster	Supervisory Natural Resources Project Manager	U.S. Army Corps of Engineers (USACE) - LRL - Green River Lake
52	Deryck	Rodgers	Manager, Nolin River Lake	U.S. Army Corps of Engineers (USACE) - LRL - Nolin River Lake
53	Libby	Watt	Lead Ranger, Nolin River Lake	U.S. Army Corps of Engineers (USACE) - LRL - Nolin River Lake
54	Kelley	Philbin	Civil Engineer	U.S. Army Corps of Engineers (USACE) - Nashville District (LRN)
55	Ryan	Wigner	Civil Engineer	U.S. Army Corps of Engineers (USACE) - Nashville District (LRN)
56	Lane	Richter	Wildlife Biologist	U.S. Army Corps of Engineers (USACE) - St. Paul District (MVP)
57	Taylor	Fagin	U.S. Fish & Wildlife Biologist	U.S. Fish & Wildlife Service (USFWS)
58	Lee	Andrews	Field Supervisor, Kentucky Field Office	U.S. Fish & Wildlife Service (USFWS) - KY Field Office
59	Ouida	Meier	Professor, Biology	Western Kentucky University & Upper Green River Biological Preserve
60	Albert	Meier	Professor, Biology	Western Kentucky University (WKU)

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Appendix D – Workshop Agenda

GRB SRP - PRESENTERS

Green River Basin Sustainable Rivers Program Workshop
August 29 – 31, 2023 | Mammoth Cave National Park

Day 1: History to Present Day Green River Basin		
Tuesday, August 29, 2023 Location: Meet at the Training Center in Mammoth Cave National Park		
10:00 AM – 5:30 PM CT	Time	Topics & Presenters
Welcome & Introductions & Ice Breaker Moderator/Facilitator: Jenny Stromberg (through Ice Breaker), then Richie Kessler	10:00AM	<ul style="list-style-type: none"> Michael Borchers, USACE (welcome, why are we here?) (20 minutes) NPS MACA (facilities talk) (10 minutes) Ice breaker (Jenny) (20 minutes) Richie Kessler, Campbellsville Univ. (goals of the meeting, teaser video, significance of GRB) (20 minutes)
Presentation 1: Sustainable Rivers Program Overview Moderator: Richie Kessler	11:10AM	SRP Overview (high-level programmatic overview) <ul style="list-style-type: none"> Jim Howe, TNC (20 min)
Presentation 2: History of the Green River Basin Moderator: Richie Kessler	11:30AM	<u>Past Projects:</u> GRL SRP & Reoperations Dual presentation <ul style="list-style-type: none"> Richie Kessler, Campbellsville U. (20 min) Adam Connelly, USACE (20 min) Dam Removals <ul style="list-style-type: none"> Lee Andrews, USFWS (20 min)
<i>Lunch Break</i>	<i>12:30PM</i>	
Presentation 3: Present Day State of the Green River Basin Moderator: Richie Kessler	1:30PM	Current / Existing Conditions: <ul style="list-style-type: none"> Mussels – Monte McGregor (30 min) Fish – Matt Thomas (30 min) Long-term Ecological Monitoring Post-Dam Removal – Mike Compton (30 min)
<i>10-minute Break (Announce format of breakout session before breaking so people can get into groups as they come back from break)</i>		
Breakout Session 1: Existing Conditions	3:10PM	Facilitator (Zac Wolf) (Note: by end of session, should have a master list of problems identified to be used for the Day 2 recap)
Presentation 4: USACE Capabilities, Success Stories Moderator: Richie Kessler	4:10PM	SRP Projects & Success Stories <ul style="list-style-type: none"> Temperature control – Melanie Babin, USACE (20 min)
Closing Statements	4:50PM - 5:00PM	Facilitator (Richie Kessler)

Day 2: Green River Basin - Field Trip		
Wednesday, August 30, 2023 Location: Meet at the <u>Training Center</u> in Mammoth Cave National Park		
8:00 AM – APPROX. 5:00 PM CT*	Time	Presenters
Presentation 4 continued: USACE Capabilities, Success Stories Moderator: Richie Kessler	8:00AM	<ul style="list-style-type: none"> High level overview of capabilities/examples/success stories - Michelle Mattson, USACE (30 min) Cape Fear SRP - Michael Borchers, USACE (20 min) Sturgeon Spawning - Russell Errett, USACE (20 min)
Recap of Day 1 & Overview of Day 2	8:50AM	Facilitator (Zac Wolf) Use master list of problems from breakout 1, and 1 pager about opportunities for recap
Breakout Session 2: Opportunities & Capabilities	9:00AM	Facilitator (Zac Wolf)
<i>Early Lunch (pack your own or eat within the park)</i>	<i>10:00AM</i>	Facilitator (Jenny Stromberg) – give logistics of field trips right before breaking for lunch
Field Trips: Guided Paddle on the Green River* or Guided Hike in Mammoth Cave National Park*	11:00AM – 5:00PM*	<i>*Note - due to the nature of the field trips, we cannot guarantee a specific return time</i>
Group Social Dinner! (Optional) Reservations at El Mazatlán Bar & Grill	6:30PM	El Mazatlán Bar & Grill 105 Gardner Ln., Cave City, KY 42127

Day 3: The Future of the Green River Basin		
Thursday, August 31, 2023 Location: Meet at the <u>Enclosed Shelter</u> in Mammoth Cave National Park		
8:00 AM – 11:30 AM CT	Time	Presenters
Opening Statements & Group Discussion about Field Trip & Recap of problems and opportunities from Days 1 & 2	8:00AM	Facilitator (Richie Kessler)
Breakout Session 3: Deep Dive into GRB Opportunities	9:00AM	Facilitator (Zac Wolf)
<i>15-minute Break – 10:00 AM</i>		
Presentation 5: The Future of the Green River Basin (Visionary)	10:15AM	Michael Borchers, USACE
Wrap-up: Closing Statements, Next Steps, & Q/A	11:00AM – 11:30AM	Facilitator (Richie Kessler)
End of Workshop for Non-USACE Attendees		
Lunch (Corps Only)	11:30-12:30	Either get boxed lunches brought in, and work through lunch, or allow an hour for people to get food/eat then start discussions after
USACE Internal Discussions (Corps Only)	12:30-2:30	

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Appendix E – Complete Workshop Notes

Green River Basin SRP Workshop Notes (M. Conn)

Day 1: History to Present Day Green River Basin (August 29, 2023)

Welcome & Introduction

- Two main goals from this meeting:
 - Networking, develop new relationships
 - Think holistically about basins, entire system thinking
- Important Ideas: Conservation Community
- The GR is a dynamic, biodiverse, ecologically rich, habitat diversity, good water quality (not as much urban development), and old river system
- Challenges with agriculture run off into GR
- Objectives: promote sense of community, various areas of expertise, information exchange via breakout sessions, better partnership view for future

Presentation 1: Sustainable Rivers Program Overview

- Changing current operations, maintaining current environmental aspects
- TNC: Science based organization, Global organization
- Infrastructure built prior to ecosystem understanding – working to improve operations
- Opportunities for collaboration and partnerships to improve environmental aspects via operations
- Freshwater species are in decline due to dam and riverine infrastructure – improve/enhance operations to mimic environmental flows, environmental pool management, conservation locking, dry dams
- SRP 3 step process: Advance, Implement, incorporate
 - Advance: engage partners, experts and review current conditions and what can be improved in the environment and ecosystem
 - Implement: once the improvements are developed you test and monitor the changes
 - Incorporate: Incorporate the changes into the operations of the rivers/dams/infrastructure
- Developing metrics to determine the impacts that SRP is having

QUESTIONS & DISCUSSION

- How was the 17,500 RM identified?
 - Want to try to accelerate growth, 1/3 of total USACE miles
- Are there limitations for qualifications for infrastructure?
 - Any type of corps infrastructure,
- Does it have to be corps infrastructure?
 - Possibly... could be a new avenue

- Is TVA on board with this program?
 - Encouraging discussions with TVA, open to idea that collaboration can occur on projects
 - Also having conversations with Bureau of Reclamation about working on similar SRP projects

Presentation 2: History of the Green River Basin

- Hydrological alteration – main issues on the past GR project
- Knew how to address – threatened species, ecological issues, water quality
- Creating a new process for TNC working with the corps on projects – Get it done program
- Recognize the constraints and be upfront and open about the constraints – Mentality shift to what can be done with the constraints/operations changes because infrastructure is not being removed
- Open communication for ideas and possibilities for environmental improvements based on existing conditions and pre-dam conditions
- How to get the most out of the project? (Ecological needs, diversity needs)
- Partnership between TNC and USACE – had a previous USACE engineer hired with TNC who had contacts at USACE to have open communication between the organization to achieve goals on the GR
- What are the E-flow requirements? How to find the sweet spot between natural flows and altered flow from human nature? -Still being developed because seasons change, climate changes
- Partnerships!!! – local communities, legislation, organizations, tribes
- Top down and bottom-up organization style for project momentum

Re-operations of GR

- E-flow have been in place for 22 years
- There are multiple considerations for operations/running the dams and reservoirs
 - Ex. Weather, Swift water Rescue Training Requests
- GR tower unique multi-level temperature release levels
- Raised winter pool (operational change) helped use multi-levels to maintain more environmentally friendly temperatures
- Extended fall draw down time from October to November – De-stratified by November so temperature not as impactful
- Enhanced mussel reproduction, recreation

Questions

- Could other control tower be revamped to be like GR tower?
 - It would be expensive, other creative ideas
- What is the life span of the projects?
 - Thought they would have a 50-year lifespan

- Lots of maintenance
- Unknown, open-ended

Update on Lock and Dam Removals

- Relationships!!!
- Monumental efforts to get the dams built to facilitate navigation – built with rudimentary technology
- GRLD6
 - Failed in November 2016
 - Dangerous to public safety
 - Fish passage, aeration
- GRLD5
 - Newest of the locks and dams on the GR
 - Directed by congress to remove L&D
 - Still have safety concerns for the public with partially removed dam
- BRLD1
 - Dam started to sluff, active state of failure
 - Directed by congress to remove L&D
 - Opens up habitat and river miles
- 1960s: L&D facilities became obsolete due to interstate/road infrastructure
- Educate public on what to expect on from dam removals

Presentation 3: Present Day State of the Green River Basin

- Mussels provide filtration for the river
- Mussels have a symbiotic connection with host fish – infrastructure that blocks fish passages impacts mussel as well
- Lower percentage of mussel decline so has chances to improve
- Wanted to establish monitoring program (Monte)
 - Establish conservation areas and monitoring sites
 - Sampling mussels
- Seeing an increase in the mussel population over time
- Seeing more of an even community of mussel species, every community is a little different – Shows a resiliency of the river
- Goal to work with other agencies to bring species back to the GR
- Seeing transition of pool fauna/flora to riffle fauna/flora

Questions

- Can re-operations of the GR dam to increase in mussel population?
 - Cant specifically be linked to the dam reoperation
 - Is probably linked to all changes, operations, temperature, dam removal
- Do invasive carp threaten mussel species?
 - All invasive species threaten endangered species

Diversity, Distribution and Conservation Status of Fishes in the GRB

- Have illustration of hot spots for GR fish and mussels locations – rich areas of species
- Highest priority areas map - Fishes
- Carp (invasive) impacts the native fish in the GRB
- Preservation and maintenance of fish population in upper GRB
- Data collection and analysis of fish population in lower GRB

Questions

- In reference to the bioserve, please define the designation?
 - TNC designation
- When is the natural flooding most important for the ecosystem?
 - Most important for developing habitat/spawning areas in the spring

Green River Observations and Happenings

- Conservation is a team sport
- Big picture – land use change (agriculture, urbanization)
- When in the field the systems are very unstable – impacting animal establishment
- Dams are a barrier for migration of fish and invertebrates which leads to genetic isolation
- GRLD5&6 monitoring before/after removal
 - What is the measurable difference when the dam is removed?
 - Have been monitoring and writing a report for baseline conditions for dam removals
 - Using free flowing zone as a comparison for the areas where the dams are removed
 - Dam is removed and river banks are exposed - Vegetation migration and growth helps stabilize the banks
- It was noted that there was diversity but not abundance of the species so there is potential to improve the abundance of species

Presentation 4: USACE Capabilities, Success Stories

- How to operate the reservoir to improve the basin – Cape Fear River
- Develop e-flow prescription – help to improve the reservoir operation
- Implementing changes and tracking/monitoring development
- Communication and Coordination – Partnerships!!

Selective Withdraw – Temperature Stratification

Questions

- Why is GR temperature water sampled weekly rather than every to?
 - Because of previous SRP project
- Is it better for the environment to be hotter or colder for the tailwaters?
 - Match outflow temperature to inflow temperature in the lake

- Are all the tower and lakes original?
 - Yes, the tower designs are the original structure and have only done repairs
- Are there engineers at LRL who could create/design a change to improve temperature control for the towers?
 - Yes possibly, retrofit a temperature tower
- Dissolved oxygen issues?
 - Normally re-aerated within the stilling basin of the dam
 - Our measurements show there is enough dissolved oxygen in the rivers

Closing Statements

- N/A

Day 2: Green River Basin – Field Trip

Presentation 4 (Continued): USACE Capabilities, Success Stories

- Coordinate with partners – be prepared for the right environmental conditions
- SRP will fund telling your story

Questions

- Can you talk a bit about how the SRP proposals process work?
 - Recording on webinar about submitting the proposal
 - Paragraphs per task, review proposals, rank proposals, make recommendations to send to HQ
 - Will work with you on the scope of work
- Is that process/funding only for the Corps or can it be for other organizations?
 - It is only through the Corps via operations
 - Can set up IPAs or contractors
 - Partners bring funding to the table as well
- Do the projects range as soft projects (brainstorming) and more hands on (monitoring)?
 - Yes, it is the entire range

Melvin Price L&D Lake Sturgeon Spawning

- Water managers/engineers' partnership with biologists/ecologists
- Look at big picture of the river – Reservoirs affect the rest of the flow/river downstream to confluences

Questions

- What was the changes to hydropower plant on the reservoir?
 - Needed more generation, benefits both sides

Recap of Day 1 & Overview of Day 2

- N/A

Day 3: The Future of the Green River Basin

Opening Statements & Recap of Workshop Highlights

- Always improving – Hopefully a theme from this workshop
- Let's make our projects work for the river
 - Recognize the easy fixes first
 - Don't overlook challenges
- Let's monitor, monitor, monitor
 - Intentional monitoring – making the connection to other projects
 - Demonstrate our success
- Share the story with the community and public
 - Engagement
 - Communicate with each other
- Central repository for data
- Formalize reoperation – living management document

Presentation: The Future of the Green River Basin (Visionary)

- Very informative – learning partners, agencies, knowledge
- Inspiring meeting to attend and replicate in Nashville – potential in room
- Passionate energy – come out of meeting with actions
- Come out with focused ideas – don't try to take on too much
- Look at entire basing rather than just one piece of infrastructure
- Use all tools not just SRP
- Corps need the help from the biologists and ecologists – make environmental improvements
- Corps = engineers and operators
- Consensus to bridge scientific knowledge with operations, Collaboration!!
- Need a POC for the communications between all organizations

Wrap-up: Closing Statements, Next Steps, & Q/A

- **List of everyone from the group – email and positions**
- **Make presentations available**
- **Data in the notes – Send out report**
- **Another meeting with action items – more focused working groups**
- **List of opportunities broken out by categories – follow up meetings**
 - **Working groups**
 - **Proposals should come out of working groups**
 - **Need to be very focused**
 - **Need to be Actionable!**

- **Annual meeting for GRB**
 - **Maybe winter because august is difficult for biologists**
- **Corps needs to communicate, communicate, communicate**
- **Use GIS tool**
 - **For combining data**
 - **For upcoming proposals**

Day 3: Operations Discussion

- Ops liked the meeting
- Operations didn't feel too scared about the new ideas
- They were supportive/open to changes and new ideas within operations
- Engineering recommendations communicated to division
- Collaborative – open communication
- Most of changes are variable depending on the environmental aspects – not as set as everyday
 - Need feedback from ops
 - Ideas from ops
- Quantify changes reoperation of GRB?
- Fish stocking
 - Stock more hearty trout for temperature variation
 - Eliminate trout stocking?
 - Only stock rainbow trout from December to march
 - Public outreach for changes
 - Maybe only stock trout when there is no importance for higher temperature – mussel reproduction
- Need good PR
- More data collection – lakes are willing to collect more data for temp and dissolved oxygen (weekly rather than biweekly)
- E-flows workshop for Barren reservoir
 - Rain event pulses to help reduce storage and needed discharge from barren after rain events
 - Work on timing surrounding weather events
 - Quick response/pulse after events – delay actual event pulse by a day if no one is flooding DS
- Solid justification for operation changes for public exposure
 - Tell public ahead of time
 - Share reasons for changes
- Next year SRP proposal on Nolin river for pulses
 - Can do pulses on weekends to determine initial conditions
- Pulses on rough river?
 - Lots of farmland and channelized streams
 - Species in rough river
 - Has been understudied
- Rough river removing mill dam thoughts?

- Open wicket and it would let the river return to its normal stage but the mill would remain
- Private land owner – public outcry
- Lots of sediment buildup
- Talk to owners about unplugging mill – would benefit reservoir releases
- Address what would happen with all the sediment buildup – samples for metals
- Reservoir pools
 - Draw downs – re-established vegetation
 - Shoreline erosion – ops is doing some work
 - Sedimentation
 - Urban development impacts sedimentation
 - Agriculture
 - Residential, Elizabethtown
 - Inflow into the lake is a bigger issue that could be worked with
 - Chris Haring has done erosion control plans at Nolin Lake
 - Deep drawdowns for sedimentation
 - Invasive species on shoreline erosion
 - Asian carp issues/worries
 - Discharge from battery plants (Bowling green, Elizabethtown)
- Drawdown at Nolin
 - Eyes on hydraulic conditions – site assessment
 - Slow down drawdowns
 - Help banks and mussel habitats
 - Series of pulses?
 - Sedimentation in system and no floodplain connections
 - Potential limitation is the water the lakes are releasing into the Ohio river during the drawdowns
- Land acquisition (bat fund), FELO, IRT, or conservation easements that could be implemented to benefit the whole system
 - Drive locations for locations that would benefit the lakes
 - Possibly reconnect floodplain to the river – FELO?
- With battery plants coming in more people will be buy land and building near rivers
 - Need to be educated about rivers and pulses
 - They will build right on the river
 - Hit max releases every year so that people see/know they shouldn't build there
- Who is going to be responsible for the next step? One person for each agency?
 - Corps, F&W, forever green, local sponsor, TCN
 - Maybe not the government – people can be reluctant to work with government
 - There is a grant that could be used to fund a position
 - KY DOW play the major role of basin coordination – roles and responsibilities
 - Colin and Michaela Lambert – some outlook
- Report Draft ready in a month – end of September
- Touch point with people at the end of September
- What should be prioritized
 - E-flow workshop for individual lakes)
 - (1) Barren

- (2) Nolin – second to wait for response on removing trout or removing GRLD5, important for pulses
 - (3) Rough
 - (4) Green
 - At end pull people together and make sure e-flows from each reservoir will work together as a system
 - As part of the workshop how will we know the changes are beneficial?
 - Need before/after collecting data/monitoring with contractors or universities
 - Evaluate if others have already collected baseline data
- SRP is looking for bigger projects
 - Want to do all e-flow workshops but in future years
- Where do labor sources come from?
 - Internal labor?
 - Need to resource labor, triage work, prioritize work
 - SRP can provide ops funding
- Jake Allgeier temperature analysis for Rough River within GRB
 - Evaluate new temperature GC for Nolin
- Nolin/Barren capacity to support SRP project for FY24?
 - Yes
- More opened e-flows workshop
 - As we are designing next step keep communication lines open
 - E-flows – identify initial tests for pulses, monitoring before/during/after, comparison river for flows, have biologists and ecologists help come up with the flow study
- Barren historical aerial information
- GIS/Mapping land that includes who owns, public or private, type or land/geology, where the inundation lines are/flooding is
- Operation heads will want to know: structure impacts – cost, maintenance, labor?

Green River Basin SRP Workshop Notes (W. Young)

Day 1: History to Present Day Green River Basin (August 29, 2023)

Welcome & Introduction

- Introduction
- Michael Borchers:
 - First SRP program was on the Green River; most people who worked on that project have retired or moved elsewhere
 - Two goals for this workshop:
 - building relationships with people in the basin
 - learning about what we can do
 - Start thinking about holistic basin management: not just one dam, not just one area
- Significance of Green River Basin: Richie Kessler
 - Green River: one of the most biodiverse rivers in North America
 - Top 4 nationally in mussel and fish diversity
 - Dynamic system, old system, biodiverse system that deserves conservation attention
 - Meeting the needs of communities (water supply, flood control, recreation) creates a lot of demands on conservation groups
 - TNC Green River Bioreserve Conservation Plan: 1998 report (Internal to TNC) written by Ron Cicerello in cooperation with KY Nature Preserves, details significance of the Green River Basin (did not find this report in a quick web search, but found two related documents:
 - <https://www.hec.usace.army.mil/sustainableivers/publications/docs/Green%20-%20Economic%20impact%20analysis.pdf>
 - <https://eec.ky.gov/Environmental-Protection/Water/Reports/Reports/NPS9919-GreenRiverBMP.pdf>
 - River formed 10-15 million years ago, has not been subject to glaciation
 - Relatively good water quality in the Green River due to a lack of large-scale development
 - “To whom much has been given, much is required”
 - TNC designated the Green as a B1 site: highest ranking for biodiversity for their sites
 - Most “biologically rich” system in the Upper Ohio basin
 - Conservation has no finish line because humanity keeps moving the finish line

Presentation 1: Sustainable River Program Overview

Jim Howe - Senior Policy Advisor TNC

- We know that we can get more environmental benefits from infrastructure while preserving the original authorized project benefits
- TNC: changing how the world meets its needs for food, energy, and water
- SRP importance:
Lots of US infrastructure was built before we knew what impacts it would have on the ecosystem. SRP is looking at how to modernize the infrastructure to generate more environmental benefits
- Positive and optimistic approach: Get people together with the information we need and we can start thinking differently about how we manage our natural resources
- Dams provide numerous real societal benefits but have their drawbacks: they change the structure of habitats, prevent fish passage and flow into wetlands, and have contributed to terrestrial species decline
- Dam-altered flow: higher baseflow, same volume. Altered duration, timing, and frequency.
- Original SRP: slight alterations in flow at GRL to extend recreation season, maintain flood control, and enhance fish and mussel populations
- Original SRP used as a leverage point to extend this type of project to other USACE projects
- About 25% of USACE downstream miles covered by an SRP project currently
- Step 1: Advance
- Step 2: Implement – test effectiveness, document any tradeoffs
- Step 3: Incorporate into the official regulation of USACE infrastructure
- Takes several years to get to incorporation (which has happened for 1,255 river miles)

QUESTIONS AND DISCUSSION

- Q (Nate Moulder): basis for identifying goal of 17,500 miles?
- A: 1/3 of USACE DS river miles
- Q (KDOW): Are there any minimum qualifications for a river to be an SRP river?
A: Open to any river which has USACE infrastructure; local USACE district needs to express interest
- Q (Kelley Philbin, LRN): does it need to be Corps infrastructure?
- A (Michelle Matson): SRP has been limited to Corps-operated infrastructure in the past but there's a chance that it could be new territory to have a project which is owned and operated by a local sponsor
- Q: Has there been any engagement with Tennessee Valley Authority?
- A: TNC has had encouraging preliminary discussions with TVA. It's a big leap to ask them to consider these projects but they seem open to the idea
- SRP has also had some conversations with the Bureau of Reclamation
- Subtle, small changes can make a big difference in the health of a system

Presentation 2: History of the Green River Basin

Green River Lake SRP Project - Richie Kessler

- Green River Section 1135: Handy Riparian Habitat Restoration
- Owner of land was a nongovernmental organization (TNC)
- 800ft+ of streambank restoration project with TNC as land owner and cost share partner
- (This was before SRP)
- Elephant in the room was the issue of hydrological manipulation
- During the first SRP project, TNC knew the obvious issues but working with the Corps was daunting
- Bottom-up and top-down efforts happening at the same time made the original GRL SRP a success
- Local district and TNC expressing interest, legislators (McConnell) and HQ-level USACE officials were interested as well
- A new process had to be created for the partnership between USACE and TNC
- PCA: project cooperative agreements
- General Flowers “Get it done” program: if a partner or stakeholder comes to USACE with an environmental concern worth looking at, then maybe it could be looked at even without an official program. TNC received a modified PCA that met its needs to get the Section 1135 project done.
- Russell Creek: 3:1 slopes, toe protection, bendway weirs, some planted vegetation and natural vegetation, native tree planting 2001-2002 (area where high flows were hitting a bend in the river and causing scour)
- Delayed drawdown in the Green River is technically still in the experimental phase and hasn’t been codified in the WCM, but the re-operation regulation plan continues to be used through present day
- Bob Beale: chief hydrologist from USACE at the time
- TNC Freshwater initiative had about 80 years of data that showed pre-regulation and post-regulation flow conditions, program at the time identified index of hydrological alteration showing degree of change. Follow-up for data source.
- Goal was never to go back to pre-dam conditions, but to something better given the current conditions
- USACE (Bob Beale) was onboard with the science and the idea of reimagining how things could be managed under their current structure
- There was a need for more equity being given to the needs of the downstream ecosystem when compared to the other needs like flood control
- Bob became a contractor for TNC at retirement from USACE, Bill Byron who had worked under him took his position at USACE
- TNC did a temperature assessment for the Green River Lake SRP as well
- Flow regimes: deciding how to change regulation (where to draw the line between natural flow regime and current regulation schedule) involves considering changing hydrology, changing climate, and considering downstream community needs (which may be different than when the project was constructed and regulation was established).

- Green River Lake temperature guide curve originally incorporated cold water for a downstream trout fishery, but once that fishery went away, the guide curve had remained the same. During the SRP this guide curve was reexamined and the unnecessary provisions for cold water were eliminated (?)

USACE Reoperations in Green River Lake SRP - Adam Connelly

- USACE started targeting e-flows 7-8 years ago
- Pilot project: e-flows have been in place at GRL for 22 years
- The four reservoirs in GRB control about 30% of the GRB drainage area
- Modeling determined that winter pool could be raised 4 feet, which allowed more water to be released during the spring fill when flow would ordinarily be naturally higher. A warmer temperature target for March and April was set and achieved by flow through selective bypasses during spring fill
- GRL can go about 2.5 ft above summer pool before main gates have to be opened, which allows for more time and a slower rate of drawdown after floods, which allows selective bypasses to be used more often.
- GRL stratifies through late October/early November
Extending summer pool through the beginning of November delays drawdown until the lake is unstratified when bypass and main gates have the same temp. This allows for more natural temperature releases (through bypasses) all the way through the end of the summer pool period.
- Results: increased reproduction of freshwater mussels directly attributable to changes, documented by monitoring (This link may be worth looking into... it cites several sources of monitoring data pre- and post- Green River Lake re-operation during the original SRP project. <https://pubs.usgs.gov/of/2010/1065/pdf/of20101065.pdf>)
- Delayed fall drawdown benefits recreation in the reservoir and benefits downstream canoes and kayaks.

QUESTIONS AND DISCUSSION

- Q: Would it be difficult to revamp a control tower to enable selective withdrawal?
- A: not impossible, but difficult and expensive
- Q: Lifespan of a dam?
- A: as long as we can possibly make it last

Green River Dam Removals - Lee Andrews – KY Field Office Supervisor – US Fish and Wildlife Service

- Dam removals and river restoration are a huge milestone of the agency's work over the past several years
- GRLD6 failed in Nov 2016 resulting in loss of pool, flow under and through the dam
- GRLD6 was an old site made of rudimentary materials such as wood and concrete created on-site

- GRLD5 was newest of all of the facilities (completed in 1950s), concrete reinforced with steel and was considered structurally sound.
- BRLD1 was actively failing
- No navigation on any of the structures after 1965 (after highways were built)
- Short term ecological effects of dam removal: sedimentation, bank sloughing that we knew would happen but that the public wasn't aware of and reacted negatively to
- GRLD6 removed in 2017 during relatively high water, FWS returned in 2022 to lower the height of the riffle when water was lower and they were able to remove more of the dam material. The riffle was previously difficult for canoes/kayaks to get through and remains that way but only during low water.
- CREP program – took lots of cropland out of production, cost lots of money without much permanent benefit, no longer in effect

Presentation 3: Present Day State of the Green River Basin

Mussels - Monte McGregor – KY FWS

- Mussels are currently being hatched at Morehead Fish Hatchery downstream of Cave Run and at Wolf Creek National Fish Hatchery (where docks growing mussels have been placed inside Lake Cumberland)
- Mussels depend on fish for a host to reproduce, but KY FWS can now produce mussels without a fish host
- KY, TN, AL, GA have lots of mussels
- 300 species in North America, 900 worldwide
- 73 species of mussels in the Green, placing it among the most diverse river systems in North America
- Mussels are impacted by pollution, dams, exotic species, habitat loss due to development, overharvest, and more
- 54% of mussel species in KY are in “greatest conservation need” (not necessarily populations in bad shape, just in need of special attention)
- Robust populations of the endangered fanshell exist in the Green River
- Dr. Layzer at Tennessee Tech did mussel surveys in 2001 in MCNP – 27 species found
- Timing is critical in mussel conservation
- Rayed Bean mussel species restored from Pennsylvania into the Green in 2020
- Mussel work is needed in Rough, Mud, Pond tributaries
- Protecting even a single riffle can be important for re-establishing mussel habitat
- Potential for 93% of original fauna to be reestablished in the Green
- Only 68 species of original fauna could be put in the Green, but getting all 68 would be a remarkable achievement
- Dewatered areas after dam removals: transition occurs as mussel habitats develop in run-of-river riffles instead of on banks in pool conditions

QUESTIONS AND DISCUSSION

- Q (Zac): Can we link re-operations of GRL with change in mussel habitat?

- A: Hard to draw causation, but mussel species recruitment is growing and species are doing well. GRL regulation changes likely contributed to this change. Further extending their growing season by delaying drawdown would help mussels further (mussel reproduction occurs in late fall, delaying drawdown keeps temps warm and pool levels low while mussels are reproducing. Unsure if I heard this correctly, may need to verify.)
- Q: Are invasive carp a threat to mussels?
- A: Not really, greater concern is zebra mussels.

Fish Fauna - Matt Thomas

- 170 species of fish in the Green, including 157 native species and 13 introduced
- High level of endemic darters in Green River basin because of their benthic nature and limited dispersal potential making them more prone to isolation
- There are so many species in the Green because of these factors:
 - Large size of watershed = more species present
 - Multiple physiographic regions
 - Geological history: Eastern Highlands glacial refugium, large period of isolation has resulted in high biodiversity
- Upper basin fish are more adapted to high gradients than lower basin fish
- Shawnee Hills cavefish: lives on surface in spring, lives near cave entrances
- Two species of exclusively subterranean fish
- 22% of species of fish in GRB are imperiled (meaning they have a conservation status designation)
- More fish surveys are needed in Lower Green where there has been less survey effort, low number of species identified in this region may be due to sampling bias.
- American eel adults migrate to Bermuda/Bahamas, spawn in Gulf Coast, swim back to Lower Green (and other areas in the Upper Ohio basin)
- Some species are specifically harmed by sedimentation due to large scale agricultural development
- There is strong knowledge of where species are located in the Upper Green and which areas are of most critical interest, less knowledge about the Lower Green
- Follow up on COA's map full resolution
- Upper Green: impoundment impacts
- Lower Green: coal mining and agriculture impacts
- Black Carp is primarily benthic and is a threat to native mollusks/mussels
 - Observed in Lower Ohio River, Tennessee River, and Cumberland River
- Not reported yet in Green, but likely only a matter of time until it appears in the Lower Green (again, sampling bias may exist)
- Green River Dam to mouth of Nolin River: bioreserve

QUESTIONS AND DISCUSSION

- Q: WKU Green River Preserve vs. TNC Green River Bioreserve?
A: they are separate things
- Q: When are wetlands most valuable to fish and mussels?
- A: generally in the spring when natural flooding would occur. In Lower Green where there is lower gradient, fish use floodplain habitats for spawning and as nurseries.
- MCNP challenge: Connecting analyses of cave flow reversals back to dam operations

Long-Term Ecological Monitoring Post-Dam Removal - Michael Compton – KY Nature Preserves

- KY Nature Preserves has a land management branch that preserves rare species or unique features, also provides information to the state on rare species.
- Office of Nature Preserves oversees “Wild rivers”
- Some species need multiple years of stable habitat to become established
- Green River Basin in general appears “unstable”
- Gravel mining law in KY: gravel on surface during low water can be legally mined out, but whether people do it legally is another story
- Gravel mining causes shifting substrates and eroding banks
- 1,100 dams in KY, 213 dams in GRB
- Dams cause habitat fragmentation and genetic isolation, species become more susceptible to the local environment, less resilient to changes than they would be if they were members of a larger interconnected habitat.

Day 2: Green River Basin – Field Trip

- Did not take notes on these presentations

Day 3: The Future of the Green River Basin

Opening Statements & Recap of Workshop Highlights

Richie Kessler - Critical points:

- Make our projects work for the river
- Monitor!
- Centralized database of interagency information
- At some point, reoperation needs to be formalized as a living management document that’s subject to input from the public and stakeholders from around the river
- Things discussed on the cave tour:
 - Cave flow reversal introducing nutrients into the cave
 - How land use, CREP program, etc. impacts flows into the sinkhole plain and water quality inside the cave

Operations Discussion

- Any re-operation (pulses, e-flows) at Nolin that might incidentally benefit the water intakes or recreation would be a positive thing from a public relations perspective
- Melanie: potentially could send a pulse just a day or two after rainfall if no control points are flooding to have a somewhat natural flow during a time when it's still raining or has recently been raining
- Marinas shouldn't be impacted at Barren, Rough, Nolin by small pool fluctuations
- Need to have solid reasons why we're doing pulses: they would need to have a solid environmental impact that's defensible, not just a recreation impact
 - Abbey: SRP's sole purpose is environmental benefit, but if it happens to benefit recreation then that's a bonus
- Old mill dam downstream of Rough: if a wicket were opened, the dam could stay but would no longer hold back a pool. Operations says public backlash would be tremendously negative if the dam were removed.
- In-reservoir issues: shoreline erosion, sedimentation, invasive species on the shoreline
- Adam: sedimentation issues would be a whole watershed management concern
- Industrial wastewater from the battery plants making its way into the Nolin River could cause problems for the project
- Nolin Lake: You can see the sediment load traveling through the reservoir from aerial imagery (some from residential development, some from agriculture, some from Elizabethtown)
- Most bang for the buck would be to address sedimentation in upstream inflows into Nolin rather than sedimentation caused by shoreline erosion within the reservoir
- Chris Haring at ERDC has done some work at Nolin regarding sedimentation (WATS funding): plan was to develop an erosion control plan that could be applied to any flood control reservoir; plans may be on the shelf ready to deploy for Nolin, Barren, or Rough
- GRB has fewer sedimentation issues than projects in the Midwest because of different soil types
- Modifying drawdown at Nolin could be experimented with immediately and might have benefits for public safety, preventing erosion, and helping mussels that may be harmed by extremely high flows.
- A drawdown with flashier flow conditions would be more natural than a constant high flow
- Bank sloughing occurs downstream due to rapid drawdown after banks are saturated from continuous high flows, then water levels drop off several feet quickly as gates are shut at the end of drawdown at a fairly quick rate
- Non-SRP: may be worth investigating rate of rise in Nolin fall drawdown. MCNP ranger reported that Nolin's high-flow fall drawdown combined with low flow on the Green created hazardous waves at the confluence of the Nolin and Green which caused some canoes to tip over. This has only been observed since L&D's were removed downstream.
- Waylon will want to know how increased gate changes might affect maintenance needs and life cycle cost

United States Army Corps of Engineers
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Green River Basin Sustainable Rivers Program Workshop
2023

Appendix F – Whole Group Breakout Session Notes

Breakout Session 1 Whole Group Discussion – Identify Problems in the Watershed

Group 1:

- CREP going away
 - o A lot of the land that was riparian is now converting back to farmland
- Increased development, especially in areas where development isn't allowed
- No POCs (TNC has no Green River Basin person)
 - o Increased biologist communications to USACE

Group 2

- Upper green seems stable for fish populations
 - o Lower green needs more surveys!
- Reintroduction of diamond darter in upstream areas
- NPS ag pollution is a major problem
- Wetland disconnection in lower green
 - o Ops could be impacting, but not sure
- Could navigation dams in lower green be operated for fish passage??
 - o What about invasive fish passage though?
- Should we be thinking about invasive species barriers on lower dams? Could we do an SRP project?
- The biologists in the room don't understand how we operate our reservoirs – how can we get that message out there?

Group 3

- Loss of land previously allocated to CREP program
- Challenge with creating a vision going forward
- Challenge with public perception – healing that, and public awareness about benefits of projects

Group 4

- Inventory losses from CREP program
- Pinpointed strong vs weak mussel hab areas
- General pollution areas
- Lack of education
 - o Economic
 - o Hydrology, etc
- Alternative to dams for water supply – fragmentation from dams is issue

Group 5

- CREP follow up
- Funding sources seem limited
- Need a stream gage gap analysis

Group 6

- Recent improvements in rec opportunities
- CREP program – 100K acres sunsetting
 - o Mitigation???
- 3 large battery plants in the basin being built
- Development associated with growing nearby towns
 - o BG, Owensboro, etc.
- Water quantity concerns
- Missing representatives from USDA and USGS

Group 7

- Gravel mining in upper watershed
 - o Affecting water quality
- Modifications to outlet structures
 - o With aging infrastructure, and rehab being likely in near future, how can we be considering modifications
- How do we deal with infrastructure providing services
- Erosion issues, especially with CREP
 - o Buying easements?

Group 8

- Discussed weaker mussel groups – snuffbox
 - o Historically seen on mainstem of green, but not anymore
- KY Creekshell
 - o Disconnected populations having separate genomes
 - o Reconnecting those populations
- Update towers to do more temperature controls to meet a more natural
- Discharge more safely for recreation and reduce erosion, reduce species blowout from high releases
- Barren river opportunities:
 - o Alter flows and temps to benefit species

Breakout Session 2 Notes – Identify Opportunities

Groups 1 & 5

- Large study to determine downstream floodplain connection
- Bank erosion issues inventory

Group 2

- KDFWR has done hotspots work already
 - o Partner with them for an SRP project, possibly revisit monitoring sites assessed for the original SRP at Green
- Need better understanding of temps/flow and downstream impacts
 - o More gages, don't have to be USGS gages
- Develop a SOW for benthic trawling surveys on the lower Green to assess migration limitations
 - o Especially because we have flexibility at the lower green lock and dam projects since they have low number of lockages
- Below Barren is heavily impacted by the dam (primarily too cold?)
 - o Studies needed to assess impacts/solutions

Group 3

- Temperature capabilities
 - o Identify needs of 1 (or many) target species and target those temperatures, or try to identify pre-dam temperatures to use as a target?
 - o Build/calibrate models to predict effects of releases downstream
 - o Maybe need more gages to complete this assessment?

Group 4

- Education/outreach to targeted areas that would result in conservation easements to increase riparian buffer around the green
 - o Targeted areas would be those that need more protection (may be a hotspot or good habitat) or areas that have low % of buffers
- Critical habitat inventory, and species inventories
- Mussel flow needs – explore for areas in need
- Explore lessons learned from the 1st SRP project and evaluate what effects (benefits) the 1st project had on downstream mussel/fish populations

Group 6

- Address land use alteration
 - o Identify low-hanging fruit in the basin, especially since loss of CREP
 - Promote CLEAR30 program in the basin
- Schedule releases at Nolin to ameliorate the threat posed by LD6 (recreation during low flow)
 - o Is there water available? Would temperatures be adequate?

Group 7

- Centralized database of environmental issues/concerns
- Barren River has lots of potential for improvement, but more studies are needed!
- Removal of White Mills dam above Nolin and bank stabilization
- Drake's creek gravel mining, other land use is impacting the watershed
- Study effects of the dam removal, and relay this information to other places around the region/country to inform others who may be considering dam removal

Group 8

- Barren data collection – establish baseline
- Centralized database
- Partnerships to enhance data collection
- Tribs/connecting stream restoration which would improve the mainstem
- Reconsider how USACE issues regulatory permits for impacts – think more holistically in the basin, rather than 1 by 1 approval for projects, since lots of small impacts throughout can have major impacts when you add them up

Breakout Session 3 Notes – Opportunities Deep Dive

- Central repository – all green river information
 - o Need to have another meeting to assign people to organize this database, group should meet annually to keep momentum
 - o Get an outline of what's available, who we should talk to, who's doing what?
 - o GIS referenced?
 - o This would help all agencies be more informed, and researchers can also use this data to plan studies/analyze gaps
 - o Would like to have an organization chart for all of these organizations so that you know who to call
 - What are the COE's capabilities/limitations for different ideas so people know who to call/what's possible/how the corps can help?
 - Make better use of interagency agreements
 - Ready source of funds to respond to problems
 - Who is best suited for responding
 - o Place to catalog our needs
 - Data needs
 - Project needs
 - o Identify all partners and what they bring to the table – expertise, services available
 - o Status of funding for each year
 - Based on that funding, which needs can be met assuming we have the right expertise/service people to provide it
 - o Include reports, studies, data needs,
 - o Finding strongholds of various species so that we can target those areas with conservation (maybe near the Clear30)
 - Have a GIS layer that shows where things are thriving/need help
 - o USACE has different restoration project authorities – landowners who want to do that kind of work need to know about these projects
 - Maybe need another meeting to inform everyone about these capabilities
 - Have a list of contacts in case a landowner who is interested is encountered
 - o What about NatureServe?
 - SRP will not fund development of a database/repository
 - o Tara mentioned KNP Heritage Program, but this doesn't seem like a good long-term solution
 - Great for some things, but seems insufficient for everything we will want
 - o More holistic approach would be appropriate
 - Massive undertaking
- Munfordville, LD4, Barren LD1: There is bank erosion, new conditions because of dam removals
 - o Take a closer look at these areas to determine if more restoration is needed
 - o Can we improve canoe access?
- Priority areas for operations mods?
 - o With LD6 being removed, Nolin may have more influence than it previously had
 - Do we need mods to the temperature guide curve? Do we need operation mods?

- Barren – since BLD1 was removed, we have more opportunities for modification/improvements to that stretch
- Controlled releases/pulses for recreation safety?
 - Pulses on weekends for paddlers, and more ecological/base flows during the week?
- Use changes on green river lake dam to focus our thinking on Nolin and Barren – can we use the previous SRP results/reoperation plan to assess the Nolin and Barren systems?
 - Perform e-flow workshops at Barren, Nolin separately?
 - SRP will fund e-flow workshops
 - Location
 - Facilitators
 - IWR has a group of folks who can possibly help with facilitators, conflict resolution, etc.
 - Before biologists can tell us how to re-operate, we need to establish reference conditions for all the watersheds
 - What are pre-impoundment conditions for flow and temperature?
 - This would be part of the e-flows workshop!
 - Need a model to determine baselines
 - Are there other similar studies we can use to figure out how to do this?
 - Can we use the models from the green to do the same analysis on the barren/nolin?
 - What species do we use as the biological parameters determiners?
- Gap analysis for gages/gage needs
 - Working example: would like to add temperature gage to Greensburg to assess influence
- CREP issue
 - CREP is gone
 - May be another opportunity that comes along and we need to be ready for that possibility so we can act quickly
 - Had a pre-CREP database that identified 1135 opportunities (high bank erosion sites) so they had ideas for where to use CREP money
 - Could use flyover data to show loss of buffers since CREP ended, and identify landowners who are still buffering
 - RCCPs through USDA – proposals accepted, may be some kind of match
 - TNC RRE (riparian restoration)
 - Sourcewater protection – 10% going to sourcewater protection for drinking water
 - Public intakes
 - Areas delineated where water quality is a priority
 - Must be drinking water focused
 - Limited to farms who will talk to NRCS, are open to these types of projects

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Appendix G – Individual Group Breakout Session Notes

Group 1: Breakout Session Notes

Breakout Session 1: Existing Conditions

1. CREP
 - 15-year agreement: Riparian buffer and sinkhole cover in upland
 - Many farmers are exiting agreements
 - Thermal protection are exiting agreements
 - Clear 30: lower pay, longer contract
2. Green Algae – large mats in UP GR Cladophora
3. Native Grasslands in the Uplands
 - NRCS Equip Pollinator Habitat
4. Increased Development/Bad Zoning
 - Warren county is bad (encroachment)
 - Poor enforcement of 404 + regulations
5. Point of contact for environmental issues, public outreach
6. 1135 is needed again (Mumfordsville)
7. WATS – could provide a plan for stream restoration after a week; DOTS (dredging), WRAPS
8. Continue removing LD5 to encourage rare species due to exposed rock, free flowing water, and clean water
9. Invasive plants – “flushing” flows are needed (pulses)
 - Floodplain easements – buyouts to benefit FRM and natural pulses
 - Allen – manager of Barren
 - Need more Water Quality (temperature) data
 - FW – spring is a difficult time to schedule, summer is better
 - SAP – university contract (WKU)
 - More information for land owners about benefits
 - Nolin trout fishery – should look into removal only access to fish is near dam
 - Western Direct/Student Conservation Association
 - More awareness of Drakes Creek could be related to pool rise
 - How have operations impacted stream banks
 - Russel Creek – major erosion
 - Sediment – how have dams and bank erosion effected sedimentation? What is base sediment load?
 - Green River Lake – annual plantings; pool raise affecting tributary sediment
 - Wetlands – reservoirs and private land (NRCS)
 - Look into inundation for flood plain connection
 - Western GIS program
 - Study/evaluate flood plain downstream of Reservoir (temp data)
 - Pulses to mix water downstream of dams for algae disruption

Green River Depository

- Meeting of experts to list resource – use reports to find researchers (WKU subterranean and surface); categories, capabilities, and organizational charts
- Make accessible and visual
- Metadata assessment
- Regular meeting (annual)

Banks (not mainstream)

- Tributaries in Mumfordsville (1135?)
- Silver Jackets FRM
- NCCS/USDA
- Land use (more general); OKNP (formal monitoring)
- KYFW – fish sampling (summer and winter)
- Need to educate “new” people how to protect the Green River
- OKNP outreach program?
- Floodplain boundaries downstream
- USACE – look into flood easements downstream of reservoir (SRP), find local partners

Barren River

- New conditions after removal (bank erosion)
- Check dam near intake
- Old dam site restoration
- Canoe access
- OKNP and USFW informal monitoring

GRLD #4

- SRP analysis of passage opportunities (habitat)
- Boat ramp effects
- Need USDA/NRCS, USGS, and University Professors

Group 2: Breakout Session Notes

Breakout Session 1: Existing Conditions

- Matt Thomas has known hotspots for biodiversity on the Green River
- Removal of Dams is a huge improvement
- The upper Green seems relatively stable for fish populations. The lower Green needs much more survey work
- We should attempt to maintain fish populations as much as possible
- There is potential to re-introduce the Diamond Darter
- Non-point source ag pollution is a major issue in the watershed
- Wetland disconnection in the lower Green due to flood control dam operations
- Lower Green lacks basic survey information
- Does the Corps permit gravel mining? Could we limit it?
- Kelley Philbin (USACE) has a wetland study from Nashville district that could be used as a template
- Could the navigation dams on the lower Green be operated for fish passage? There are data gaps on fish migration. A consideration with fish passage should be invasive carp. Sound barriers and surveys.
- How consistent are Green River releases?
- Biologists are unclear about how the dams operate and what operational goals are
- We should include other reservoirs in the watershed in our study and coordinate releases for beneficial impacts to the lower Green
- Cold water below Barren River Dam have impacted fish population – could we reoperate to fix temperature problems?
- Temperature matters most in the spring.

Breakout Session 2: Opportunities and Capabilities

- Coordinate Reservoir releases to replenish wetlands in the lower Green River
- Conservation Opportunity Areas – identified in the State Wildlife Action Plan from KDFWR
- Need for better understanding of temps and flows – more gauges, more monitoring
- Main stem below Barren River has the biggest negative impact to aquatic life due to cold water releases.
- Need for better understanding of species life histories as it relates to flows and temperatures.
- Revisit original SRP monitoring effort with lessons learned.
- Conduct a “State of the Watershed” study for Barren River
- Tennessee Tech, Dr. K has low-cost gauge network. Potential for IPA opportunity.
- Benthic trawl surves in the lower Green. Could incorporate tissue samples to understand if navigation dams are preventing fish migration.
- Navigation dams are so infrequently used there is flexibility in operation

Breakout Session 3: Opportunities Deep Dive

- Aerial imagery study – change over time study. Ask Lane Richter - Digital Globe – 1 page request form for imagery
- We need a reference flow and temperature condition to determine how to reoperate the dams. Need to understand this for all the reservoirs
- Lack of understanding in Lower Green.
- Navigation dams have high potential for operational flexibility
- Need to continue working together
- Could pulse flows after dam removals aid in natural river geomorphological recovery?
Lit review
- Status of the Barren River Watershed. Have a specific Barren River specific workshop.

Group 3: Breakout Session Notes

- Brice Leech – MACA – Cave Resource Management Specialist
- Rick Toomey – MACA – Cave Resource Management Specialist and Research Coordinator
- Danna Baxley – TNC (KY Chapter) – Director of Conservation
- Ryan Wigner – USACE Nashville District
- Tyler Reagan – KY FWS – KDFWR/NRCS liaison for Area 1

Breakout Session 1: Existing Conditions

Major themes identified:

1. Agriculture practices impacting water quality
 2. Continuity and centralization challenges, creating a vision beyond current projects
 3. Public perception and challenges with recreational benefits; more outreach to highlight the benefits of dam removals letting people know about the new areas where a float is possible
- Danna: biggest challenge is that several projects are closing out and there's no long term vision or person pushing a long term vision forward or bringing people together
 - CREP program ending was a loss
 - Money-driven landowners didn't notice benefit
 - Tyler: older landowners saw species return
 - Danna: Paying landowners high money for cost share reshaped their expectations, making future efforts more money
 - Tyler: Economical benefits should have been studied
 - CREP improved water quality but data to quantify is scarce
 - Tyler: depends on who you ask whether/how much benefit there was? Farming steeper slopes may have caused more erosion as farmers looked to farm land they owned not on CREP
 - Danna: TNC did a nutrient loading study for MS river basin
 - Brice and Danna: Biggest challenge is seeing whether we can affect benefits given the constraints with selective withdrawal at Barren, Rough, and Nolin
 - Tyler: bank sloughing concerns around where L&D 6 failed
 - Danna: until L&D 5 is gone, whole system remains unstable
 - Rochester Dam = L&D 3
 - Danna: agriculture edge-of-field practices, nutrient loading, loss of CREP, land which is now being plowed under

Breakout Session 2: Opportunities and Capabilities

Most important opportunities identified:

1. Pre-dam temperature regime – what's the closest we can get to that?
2. Building and calibrating models that predict temperature in the basin
3. Improving USGS gage infrastructure to improve model accuracy
4. Learning exchange between scientists and engineers

- Rick: potential to push back drawdown at Nolin until after turnover
- Brice: more natural flow regime downstream of Nolin (Nolin different from Green River Lake since there's only 7 miles to the confluence)
- Announce to people for safety that high flows are happening at the confluence (more canoe traffic)
- When L&Ds were in, high outflows from Nolin would cause backwater at Green River Ferry, but not anymore probably
- Brice: standing waves in Green at confluence downstream of Nolin during high outflows (only since dams have been removed)
- Danna: some answers ecologically are known, some we need more data to know what to do
- Danna: 2-state SRP to gather knowledge on what temperatures are needed
- Rick: biology of individual species, knowledge of temperature and Dissolved Oxygen
- Ryan: Add temperature and Dissolved Oxygen to the RAS model, gain a better understanding of how temperature decisions affect the basin/ get more USGS temperature gages
- Rick: finding pre-dam temperature regime would be an easier starting target than identifying individual species needs (we know that it was good for native species)
- Ryan: naturals models
- Danna: better modeling to predict output temperature based on gate selection need the basic pieces of the puzzle
- Rick: potentially a delayed drawdown would be helpful downstream of Nolin, especially once L&D 5 is gone, downstream of Nolin could become a very good stretch of river
- Brice emailing sinkhole plain maps
- Rick: under different release patterns, how does flow reversal happen inside the cave

Breakout Session 3: Opportunities Deep Dive

- Danna: university partner would be good for database creation; everyone seem very interested in e-flows but need more data; contract university to research pre-dam temperature regime
- Brice: unrealistic to get pre-dam regime, but we need something else that the public can see and approve
- Danna: apply for funding for new stream gages
- Brice: MACA does 2-years of monitoring, 5-year break, SRP could potentially do something similar
- Danna: An MOU to formalize interagency goals might make goals more likely to succeed
- Danna: Applied workshop (more technical) to have scientists and engineers (water management) learn from each other
- GRB overall master plan (strategic plan, theories of change, intermediate results, stepwise process to end result)

- Central idea: process of reoperating the other three dams; more extensive monitoring to more conclusively demonstrate the impacts of reoperation; ask university for monitoring to help establish correlation
- Benefit: more natural flow regime
- How to achieve:
 - Planning document, Memorandum of Understanding (MOU)
 - University research of pre-dam conditions, database
 - Public communication
 - Streamgages
 - Communication between scientists and engineers
 - Literature review to find regional pre-dam information
- Opportunity: person designated as the “SRP person” at USACE
- Joe Meiman: produced a WM plan for MACA and detailed sinkhole plain watershed map (MACA can send this resource if we need it)
- Add temperature to Greensburg USGS gage, compare to existing Russell Greek gage to find out magnitude of temperature influence from releases

Group 4: Breakout Session Notes

Breakout Session 1: Existing Conditions

- March-June; mussels (late summer too)
- Monte's locations on Green (7) – slide
- Diamond darter critical habitat unit – Matt Thomas
- 8 HUC 11 hotspots for species rich areas – slide; Barren and Green
- Sample sites for fish (4) – slide
 - Wetlands most significant in spring due to natural flooding
- Dams within Green River Basin-map (slide-stretch)
- Stretches monitoring report (baseline)
- Package plant issues rough river area
- E-town – oil slick
 - Battery plant going in; KY creekshell habitat (100-acres wetland)
- Nolin = worst subbasin – lost most fauna
 - Interested in watershed planning efforts; see priority watershed (designates resources)
- Recent spill – leaving staining until spring at Jennings's Creek
- Bowling Green – suds in lost river cave
- Lack of education: economic community, water quality, groundwater, sinkhole management
- (cfs) barrier gone now allows for movement (fish can pass for mussels)
- Agricultural farmers – if take land back – CREP program
- Mussels
 - April-June: spawning group; getting on fish
 - Late August-October: spawning group (shallow habitat); hold larvae all winter, growth
 - Release more water earlier and then let be shallow? (~3ft deep)
- Types of sand (84 microns – 2mm) in habitat; well graded mussel beds
- Falls of rough; removal of barrier?
- Less use of Green River 1 and 2; monitor progress; water intake structures
- Alternatives for water districts?
- Prioritize areas for lidar surveys; imagery; with bathymetry (KYDOW)
 - Lidar – map areas and flows (erosion surveys)
 - Overlay former CREP areas with map
- Mussel habitat locations
- Pollution areas (urbanization)
- Alternatives to dams; water intakes (dams)
- Ag. Channelization – Ag practices and funding
- Stream gage gap analysis

Breakout Session 2: Opportunities and Capabilities

- Do profiles – stratification in upstream areas of reservoir (water quality team)
- KYDOW-319; Ag US health-wetland areas (NRCS) – Green River gets most Ag funding
- Utilize lidar coverage for restoration and protection
 - Severe erosion
 - Vegetation health
- Sediment ponds, headwaters – BMP, wetlands
- Raingardens in floodplains (KYDOW) – Green sinks; Morehead; USACE partnership
- Fish habitat partnerships (reservoir) – funding (headwaters) priority watersheds in KYDOW
- Mussel flow needs (temp) – forecasting for a season to see what can be pulled off
- Nolin can supplement green river flows, more concerned with downstream of Nolin River
- Comprehensive watershed plans
 - HUC-14, prioritize, tag team funding with NRCS and USDA
 - Streambanks, riparian zone work, floodplain management
 - Work with private landowners on encroachment issues
- Some WMA adjust to Green in Mullenburg county – shallow water impoundments
- Studies for critical habitat inventory – targeting those and working out from that
 - Channelized, poor water quality, understudied downstream/lower Green
 - Fish surveys, habitat and mussel surveys overlay
- Analysis on mussel data and what we did, can we link it to the re-operations
- Fishery models, scatter plot, drivers – patterns and clusters
- Navigation and coal – L&D 1 and 2
 - Downstream of 2 is a good habitat; bass habitat
 - Conservation lockage ops – someday
- Water quality issues, bacteria sediment and nutrients
- Hardinsburg Lake – FFA Department of Education owned at a camp
 - Algae and runoff; from southern states- 20 years runoff
- Rough County – FFA Leadership camp; lake unusable
- More gages for water quality data (temp and water quality) – filling in gaps on tributaries
- Reef bars; WATS request (shoreline stabilization)
 - Special projects and data needs; ERDC and Nolin – Chris Haring
- Identified areas; dye tracing – streamside riparian work; consider groundwater infiltration
- Filo program KYFWR
 - Conservation easement programs
 - KYDOW funds easements
 - Education, impacts to communities (making them aware), build up competency in own backyard
 - Local ties; watershed champion; targeted efforts
- Watershed level management plan strategically sample tributaries (sources, etc.)

- Prioritize
- Educate/outreach – target funding in right place
- Consulting firm; KYDOW funds these – regional/demonstration; apply for implementation fund
- Programmatic funding; partner/septic sources, sewer lines
- 1. Education and outreach; prioritization – conservation easement plan for riparian work
- 2. Critical habitat studies/inventories
- 3. Mussel flow needs – e-flows workshop for mussels/confirmation or impacts from 202 SRP can be attributed to operational changes *lessons learned*
- 4. For special data needs – ERDC (Chris Harring)
 - Dan Taylor – Barren; data exists at project offices, compile information from project offices

Breakout Session 3: Opportunities Deep Dive

- Combination of flow and temperature; research for flows needed at downstream locations
 - Not releasing main gate water in the fall = significant change
 - If juveniles aren't grown enough by cold water time (-)
- Data from prior to changes – DO (USACE)
- Historically where in the green was the biodiversity (prior to dams); judge where naturally strong areas
 - Clubshell and rabbits foot (upper part of Green up to dam)
- Mussels – some spawn in Fall; need temperatures for fall/spring
 - 2010-2015: older mussels started to die off and new recruits
 - 20-60 year lifespan of mussels
 - 2004-2006: 3-4 dominant species – want balance
- What kind of relationships between fish, mussels, crayfish communities (even distribution?) – critical threshold for species (Monte)
 - Richness index; place values for prioritization area
 - Geographic considerations; groups may be different (number of T & E mussel species ~20; have potential for making it the best) – species that used to be in the river are back
- Measure changes of fauna in river (pool to riverine) from dam removal (connected areas)
- Why are they not declining? Age and structure of fish?
- Fish host species; sand darters/diamond darters (sculpin)
- Matt's fish survey's with Monte's work
- Get critical thresholds for relationships above threshold – some number of strongholds throughout locations
 - Use strongholds to prioritize cons. Project/program efforts
- Why doing poorly and why doing well?
- Data repository, map overlays – ESRI online format – user group (OAS) for sharing
- Modify management of water – SRP funds for layers

- Nolin- more influence now with dam gone *guide curves*; flow modifications from Nolin are helpful – still have trout below (stock) – Wolf Creek hatchery
 - Barren River = more too; look at operations
 - Database development; pair with release needs
1. Nolin releases (temperature and flow) – for fish hosts and mussels
 2. Barren releases (temperature and flow) – for fish hosts and mussels
 3. Database
 - Reports/studies data
 - Indices for relationships (fish, mussels, crayfish) – strongholds for programmatic focuses and release informing (NLCD, water quality)
- Nolin – 20 degree C; summer gate 3, spring gate 1-2 (some level of trout fishery)
 - Below 72 degrees = trout struggle (Browns = warmer water) (Rainbows?)
 - 80% saturation DO – fish
 - 90% saturation DO – mussels
 - Land trust in the green? TNC? Tracking property movement
 - TNC partnerships, easement and land conservation operation; KY National LT?
 - EPAs – where’s my waterway format
 - Establish what pre-impoundment would have looked like for e-flow

Feedback

- Focused ideas – clear about responsibilities for ideas/outcomes
- Ways to keep it moving
 - Small group – what each group has (email)
 - SRP proposals and workgroups
 - POC for management moving forward and collaborating
- Send out to attendees: list of attendees, presentations, and reports
- Meeting – focused on implementation/working groups
- Monthly meetings and working group discussions (actionable)
- Annual meeting for reengagement

Group 5: Breakout Session Notes

Breakout Session 1: Strengths and Weaknesses

1. Headcutting: due to pools in sections influenced by discharges; steep/eroded banks
 2. Gages: Streamgage gap analysis; are there enough?
 3. Drake's Creek: tributaries impacting the area (impacting Barren near Bowling Green)
 4. Weakness: not tracking what is changing; ex. Mussels
 5. Adjust flow at other projects
 6. Recreation opportunities; i.e. temperature control curtains, reservoir benefits-what are they?
- Weakness- hard to sample in areas; collection and sampling and is it accurate?; depends on environmental conditions, time of year, etc.
 - *applicable to both fish and mussels
 - commercial fishing – carp, etc.
 - SRP can fund sampling
 - Funding sources are limited
 - Baseline habitat conditions understanding – lacking at project areas
 - Limited by downstream development, i.e. water releases
 - Floodplains – Barren and Rough
 - Competing Interests
 - Analysis below dams, strength as an opportunity
 - CREP follow-up
 - Lack of point of contact with the public and communication

Theme: Always Improving

Let's:

- Monitor- baseline monitoring stretch, matt, monte; how to get more out of what they are doing. Can it inform a current status or a need?
- Share with the community
- Co Judge relations
- Ventral repository
- What are we losing because of CREP
- GR Bibliography- publications, agency reports, gray literature, studies

Hike: CREP, sinkholes, flow, reoperations

Float: VD6 removal

Group 6: Breakout Session Notes

Breakout Session 1: Existing Conditions

- Ideas
 - Analysis on the effect of ending the CREP Program. Last of these contracts will be ending in 2026.
 - Put greater emphasis on enrolling landowners in the CLER30 Program
 - Include additional agencies in the SRP workshop group not currently in attendance, e.g., NOAA, USDA, and USGS.
- Problems
 - Overall theme: residential and commercial development within the basin pose threats to the character and ecological function of the basin as a whole. For example:
 - Very large manufacturing plants coming on line in several areas of the basin, including the Ford Battery Plant in Glendale which is expected to employ 16,000 people. These plants will result in development around them to support the plant.
 - ATV Parks within the basin, e.g., Blue Hollow and Mammoth Cave
 - Continued growth of many of the larger metropolitan areas within the basin, e.g., Bowling Green, Owensboro, Elizabethtown. This growth will result in greater sprawl, pollution, and increase strain on the surrounding water resources.
 - Additional increases in the need for water resources at the USACE lake project within the basin and other water bodies, e.g., Bowling Green Reauthorization Study, Edmonson County Water Supply.
 - Sedimentation in Nolin River Lake was mentioned as a problem.

Breakout Session 2: Opportunities and Capabilities

- Ideas/Solutions
 - Engage partners and public to foster awareness and conservation in the basin.
 - Invest more effort in the promotion of the CLER30 program. Focus efforts on the HUC8 Biodiversity hotspots highlighted in the Fishes and Mussels presentations.
 - TNC purchase more lands in the basin.
- Problems
 - The remaining riffle at GRLD6 continues to pose hazards to recreation.
 - One solution forwarded in the group would be to coordinate water releases at Nolin River Dam with the paddler's trips. However, this creates problems with using the limited resource, i.e., does the lake have enough extra water to do this. Also, will the temperature profile of the water released at this time cause problems with flora/fauna downstream.

Breakout Session 3: Opportunities Deep Dive

N/A

Group 7: Breakout Session Notes

Group: Michael, Taylor Fagin, Caleb Miller, Jon Fillingham, Ouida Meier

Breakout Session 1: Existing Conditions

- **SRP Project** – Green – truly very special; what are the problems? USACE can make adjustments, help solve but need to know issues in the watershed in order to figure out how to fix.
- Temperature controls – Rough River Dam
- From Nolin Dam to Green
 - Used to be many mussels; no longer
 - Cold temp? Definitely cold
 - Trout are successful
 - Also heard of waves/capsizing in Green from Nolin's fast release
 - Nolin Dam is bottom release (as in Barren) of water
 - Stocked for trout by USFWS, more so since L&D 6
 - ATV/UTV Park – Blue Holler – much exposed solid siltation contribute to sediment, for years not; contributed to low mussel pops and offspring survival
 - Maybe mostly a fish survival problem now
 - Heavy release – push siltation into Green
- Drakes Creek, Warren Co – horrific banks; steep, eroded, bank erosion, cut back; Ag being run all the way to creek
- More gravel mining in Allen Co off of Traminel Fork; also ETVs and to E (see map); Gravel mining regs – check on these! If water down, get in.
- Land use – NEED LAW ENFORCEMENT around gravel mining! Cave City too.

Lower Green River

- Rochester Dam GRLD4; Butler Co. needs pool for water use
- Need water company alignment in some cases
- Nolin, Green River, L&D 5 – given pump by TNC
- Solutions for Edmonson Co Water District
- TVA – holding water for drought – lower Ohio coordination issue
- Congress directs ECWD and TNC – ACOE helping
- Maybe possible to get funding from Congress to solve the water issue for small water companies where this is an obstacle (or wait for plug failure in this case)

Dam Maintenance

- Not currently being designed for fish passage
- Built for navigation and pool maintenance
- Curtains, add-ons, etc possible; expensive
- Could be a solution (water temp) for Nolin entering Green
- Clear fold water supports some spp springs – but not us!

- Bottom/muddy/anoxic

Erosion

- Ways to prolong CREP plantings – gets taken right back out after payments stop (trees/grasses go back to crop)
- Possible to buy permanent easements?
- Riparian buffers encourage

- Survey upper Barren River / or all of Barren after the dam
 - Baseline survey and flow and temperature
 - How does it compare to upper Green?
 - Why is there a lack of mussels?
 - Survey of fish and mussels
 - Data already there and more of a literature review
 - Barren River dam to Green River
- Compare data pro/post dam removal on Barren
- Literature review and baseline assessment
- Survey/monitoring of confluence to L&D 4
 - Green River L&D 1-4
 - Lit Review
 - Figure out what's going on as it may affect the Ohio River
- White Mills – lowhead dam
 - Bisecting 2 populations of KY
 - On Nolin River
 - USFWS would bring money to remove
 - Could be old mill dam/ could be water supply (bonded sculpin passage)
- Hodgenville Dam
 - Water supply issue
- Literature Review right below Green River Dam
 - Re-baseline and new review
 - Learn what the SRP did and the benefits
 - Small changes at Green River Dam = all kinds of benefits

Group 8 – Breakout Session Notes

Breakout Session 1: Existing Conditions

- Snuffbox Mussel
 - Historically found on main stem of the GR
 - Conduct more research to locate the mussels
- Round Hickory Nut Mussel
- KY Creekshell Mussel
 - The creekshell mussel is very species specific for reproduction
 - There is disconnection between the creekshell mussels spots
 - There is research being conducted and species being gathered from separate areas to create diverse genomes (Stretch)
 - Initial findings says it could be beneficial to mix genes from the different locations
 - Clifton Creek and Rough River main stem are not connected
 - Is there a way that the dam could be run to reconnect the rivers to allow fish migration/mussel migration
- Possibly develop/research more ways to get temperature benefit from the reservoir releases in the tailwaters
- It is noted that the habitat below the Nolin dam is scoured
 - Could a more control or regulated discharges/step down the discharge
 - With the dams removed there could be an increase in recreation which is a safety concern for public with large discharges
 - There are horns sounded with the discharge
 - Educate public
 - Pre-release?
- Oil drilling and Fracking could cause issues with the ground water and river
 - It is happening within 200ft of the park
- Round-up is impactful to mussels
- Conservation fund to help purchase conservation areas
- Slower discharge – E-flow prescriptions?
- If it is too cold or high discharges then it can blow out mussels/habitat
- Barren River Opportunities
 - GR dam could be the baseline
 - More control on barren dam
 - Land acquisitions
 - Surge events to reduce floodplain development
 - Springs within the Barren River could be helping with water quality - uncertain

Breakout Session 2: Opportunities and Capabilities

- Barren River has lots of potential
 - Flow/temperature/pulses
 - Pilot study to understand baseline flows and temperatures
 - Some historical data is available and could be used

- Incorporate Monte's Mussel work
 - Monitoring stations for fish and mussels
 - Temperature monitoring
- Connectivity between Barren river and Green River
- Understand habitat, basic water chemistry, mussels, and fish
- Purchase of private property DS of reservoir for greater releases/pulses
 - Issues with flooding DS, safety
- Some mussel data but not complete
- WKU, Campbellsville, UofL partnerships?
- Potential for creeks entering the main stem
 - Creeks are more in need of stream restoration
 - Historically there were mussels in the tributaries
 - Improve main stem by restoring tributaries that enter
 - Buy land to do stream restoration
 - FELO program for degraded stream or system
- Maribow is an unstable system
- Flame chub in the Cumberland
- Educate the public on the habitat degradation/gravel mining
- **L&D 4 – had a section of the initial dam in the river that could be removed (weakness – Breakout session 1)**
- **Below GRLD5 is a hotspot for mussels (strength – Breakout session 1)**
- It would be helpful to know who is drawing/using the water from the river
- It could be beneficial for Bowling Green or other areas to pipe water from Barren Reservoir since sometimes there is more water that needs to be released than can be
- Another consideration is how long it will take the mussels to re-populate in the Barren river
 - We could work with Monte to reintroduce mussel species
- Hellbenders could also be reintroduced into streams
 - There were sections of the barren that used to be populated by hellbenders
 - The areas where there is good hellbender habitat could be mapped on the main stem and creeks
 - Note water quality
- Need to have more access to the Barren river (defined as public access given the private land ownership in KY)
- Possible dam removal at West Fork Drakes Creek – Franklin Dam
- It was noted that there is no electric generation on the dams – could be beneficial?
- GRLD6 sediment
 - Have to pick stabilized habitat areas to reintroduce mussels
 - It would be beneficial to monitor the habitat because US or DS changes could destabilize the system
 - Need to protect the stabilized sections of the system to keep them from degrading in the future

- Conservation fishes could help with the reintroduction of fish species
- Have historical fish data on the Barren river but need some updated data – fish monitoring
- How can the infrastructure benefit the habitat?
 - Could added infrastructure enhance the environmental areas?
- Data Managements
 - Central Location to house data
 - Have more data sharing
- Temperature modifications to the tower to be able to release warmer waters
 - Could modify infrastructure
- Rather than modifying the tower to release warmer water from the top of the reservoir there could be a pump passage installed to transport warmer water from the top of the reservoir to the tailwaters
- Want the temperature releases from the reservoir to correspond to seasonal changes
 - Warm water helps with mussel growth
 - The fauna needs several months of warm water
 - Touchbase with Monte for exact temperature needed for growth and reproduction of mussels
 - CFI in Knoxville are fish specialists (minnows and darters)
- Collect/use data upstream of the reservoirs as a baseline
 - Division of water has come data
- There is a disconnect with the ground water and river systems
- The snuffbox mussel population is in decline from the temperature change
 - The host fish is the log perch which is a hearty fish and not very sensitive to temperature changes
- There is a fixed weir in Bowling Green
 - The weir backs up water for the municipal water supply
 - Possibly partner with Bowling Green utilities
 - Maybe add a passage through the weir for recreation
 - Cost share for the feature
 - Help with fish passage and public access
- Spring flow timing could be improved
- Permitting and how it fits into sustaining rivers
 - Gravel mining operations
 - Dredging
 - The issues comes from allowing many of the permits to pass, passing a couple permits do minimal impact

Breakout Session 3: Opportunities Deep Dive

- On Barren river the host fish don't seem to be the limiting factor for mussel reproduction
- Ecologists and biologists think mussel growth and reproduction is mainly limited by the temperatures released from the reservoirs
- Mussels also need environmental stability

- Are there any changes that could be made to dam discharge to reduce the impacts DS?
- Create a wetland area under barren dam to help warm water flowing DS or do a reach off of the river that would back water up and allow that water to warm prior to flowing DS
- Large stream lack of ground water and floodplain connection
- Add syphons for warm temperature at the top of the reservoir
- Barren is on a sinkhole plain
- There are many springs feeding into the barren river that contribute to the colder temperatures
- A minimum water level is required at Bowling Green because of water supply
 - Connecting cites to reservoirs?
- Incentives to private landowners to maintain mussel habitat
 - Tax incentives
- Wide spread damage on the tributaries right off of the main stems – gravel mining
- Have to consider the sediment the mussels like – sand, gravel, pebbles
 - Not as much sand observed on the Barren River – issue?
 - Could compare DS and US of the reservoir to see if they are similar in sediment
- Overall there is a lot of poor land use
 - Could use GIS layers to analyze
 - No trees up to creek – riparian area
 - More regulation
- More regulation on creek gravel
 - Have one site where landowners could pick up gravel
 - Have a fee that could go into a restoration/conservation fund
- Challenge: balance between humans and nature
- How is the water quality DS of Barren Reservoir?
 - Agricultural impacts
 - Urbanization impacts, battery plants
 - Division of water and KY fish and wildlife have some data
- Ground water data would be beneficial
 - The division of water could have data or the fishery folks
- Lee _____ (Fish and Wildlife) sits on the FELO committee
- The buy in from the public is necessary for these projects
 - Target their interests to get buy in
- KY and US Fish & Wildlife has funds to work with individual landowners to get their buy in and work on conservation
- Recovery of America's Wildlife Act
 - Funding for species
 - Yearly pot of money that needs to be used
- Rather than using the barren river US of the reservoir for natural temperature regime use the middle of the GR (after GR dam and before Nolin) because they are both spring loaded areas
 - There are not many springs on the US section of the Barren river

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Appendix H – Breakout Session Facilitator Guide

Breakout Session 1: Existing Conditions

Tuesday, 8/29

Objectives: *Identify strengths & weaknesses of GRB in its current condition. What's going well, what's not going well & why?*

Instructions for Group Facilitator:

1. Quick introductions within group
2. Explain that you will be the facilitator for the group, taking notes, and reporting out to the rest of the groups at the end of the session.
3. Re-iterate goal of the session: Identify strengths & weaknesses of GRB in its current condition. What's going well, what's not going well & why? These problems can be anywhere in the basin.
4. Initiate group discussion, and
 - a. keep discussion notes on the notecard.
 - b. If needed, use prompts in the section below to keep conversations moving/on track.
 - c. If needed, remind group of the map which can be used to mark specific location conditions, and of the species information sheet.
5. Towards the end of discussion time, have the group condense the conditions/problems identified into top three items which will be shared with the rest of the group.
6. Share your group's items, while trying to not repeat other groups' items.
7. Place group's materials into group folder (maps, notecard, species sheets). Folders will be collected after the breakout session, then redistributed for next breakout session.

Discussion Prompts

- What areas might need improvement in the basin?
- What areas are hotspots for biodiversity in the basin?
- Where are species/populations declining, and why?
- What species are thriving?
- Are there general water quality/habitat/flow regime problems in the basin?
- Are there data gaps that might need to be addressed before we can answer these questions for the whole basin?

Breakout Session 2: Opportunities and Capabilities

Wednesday, 8/30

Objectives: *Brainstorm potential opportunities for improving conditions (i.e., ways we can solve the problems identified). Doesn't have to be USACE specific, but USACE-opportunities should be discussed.*

Instructions for Group Facilitator:

1. Using the notecard, give a recap of the problems that were identified in the previous breakout session.
2. Ask the group if there are any other problems they want to add to the list. If yes, take note of these additions.
3. Re-iterate goal of the session: *Brainstorm potential opportunities for improving conditions (i.e., ways we can solve the problems identified). Remember – these don't have to be USACE specific exclusively, but USACE opportunities should be discussed.*
4. Initiate group discussion, and
 - a. keep discussion notes on the notecard.
 - b. If needed, use prompts in the section below to keep conversations moving/on track.
 - c. If needed, remind group of the tower drawings, opportunities list, and species information sheets, all of which may aid in brainstorming opportunities.
5. Towards the end of discussion time, have the group condense the opportunities they identified into top three items which will be shared with the rest of the group.
6. Share your group's items, while trying to not repeat other groups' items.
7. Place group's materials into group folder (maps, notecards, species sheets, opportunities list, tower drawings). Folders will be collected after the breakout session, then redistributed for next breakout session.

Discussion Prompts

- What are some potential approaches to the problems identified yesterday?
- Can you think of other solutions that were not presented?
- Can you think of potential partnerships and contributions from other groups/entities associated with these opportunities?

Breakout Session 3: Deep Dive into GRB Opportunities

Thursday, 8/31

Objectives: *Discuss newly thought-of opportunities missed in session 2. Focus on priority opportunities and discuss details like how to achieve it, benefits, risks, pros/cons, data/studies needed before/during/after implementation, etc. If time allows, rank opportunities based on priority.*

Instructions for Group Facilitator:

1. Using the notecards from breakout sessions 1 & 2, give a recap of the problems and opportunities that were identified in the previous breakout sessions.
2. Ask the group if there are any other opportunities that they want to add to the list. If yes, take note of these additions.
3. Re-iterate goal of the session: *Focus on priority opportunities and discuss details like how to achieve it, benefits, risks, pros/cons, data/studies needed before/during/after implementation, etc. If time allows, rank opportunities based on priority.*
4. Ask the group to select 2-3 opportunities they want to focus on for this session.
5. Initiate group discussion, and
 - a. Keep discussion notes on the notecard.
 - b. If needed, use prompts in the section below to keep conversations moving/on track.
 - c. If needed, remind group of the tower drawings, opportunities list, and species information sheets, all of which may aid in brainstorming details about opportunities.
6. Towards the end of discussion time, have the group select one top priority opportunity which will be shared with the rest of the group.
7. Zac will get a quick survey of the top priorities for the whole group, then Zac will lead discussion.
8. Place group's materials into group folder (maps, notecards, species sheets, opportunities list, tower drawings). Folders will be collected after the breakout session.

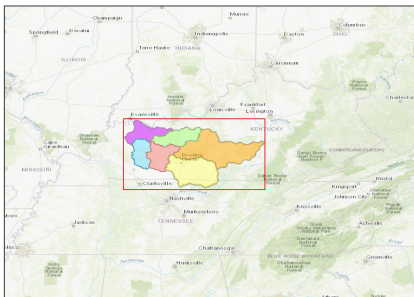
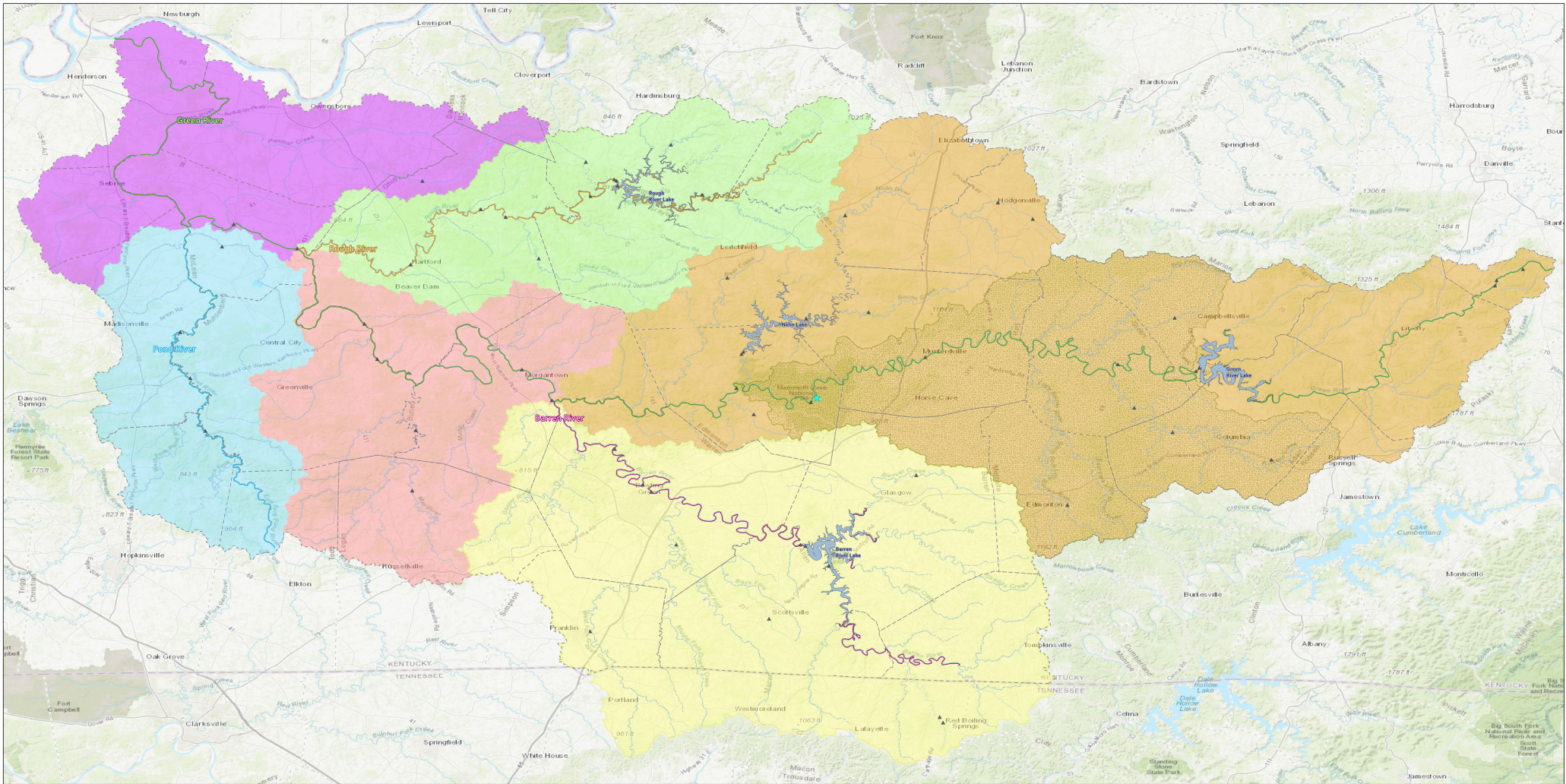
Discussion Prompts

- For each opportunity, discuss:
 - o Which problem(s) will this opportunity solve?
 - o Where would we implement this opportunity?
 - o What does the implementation process look like?
 - o What data/studies would be needed before/during/after implementation?
 - o Are there any risks/downsides to implementing this opportunity?
- Which opportunity is the top priority for the group and why?

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Appendix I – Breakout Session Maps (Figures I1 to I4)



Green River Basin Sustainable Rivers Project (GRB SRP)

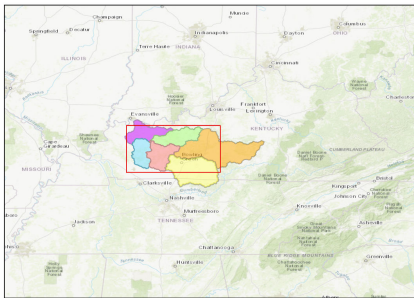
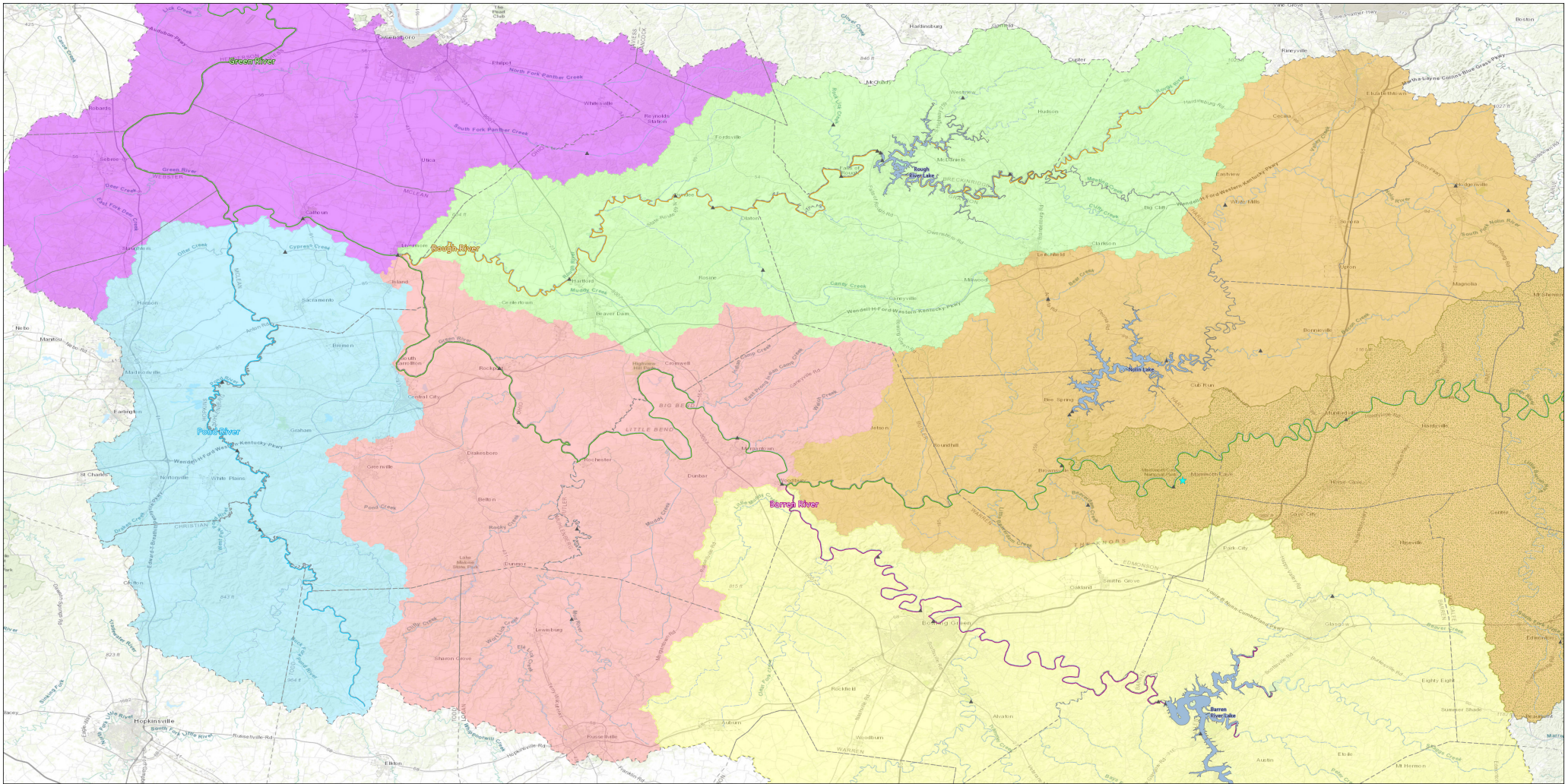


25 Miles

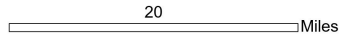


☆ Mammoth Cave	Green River	Mammoth Cave Boundary	Green River Subbasins (SB)	Middle Green River SB
▲ Gages	Pond River	Tributaries	Lower Green River SB	Upper Green River SB
■ USACE Lakes	Rough River	County Outlines	Pond River SB	Barren River SB
■ Green River Bioserve	Barren River		Rough River SB	

Figure II. Green River Watershed with sub watersheds for upper, middle, and lower Green River and Barren, Rough, and Pond River tributaries.

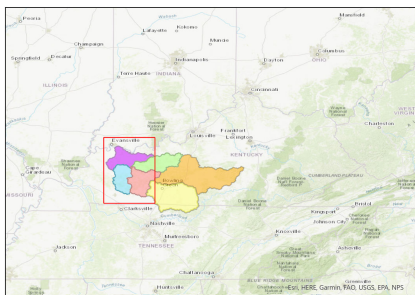
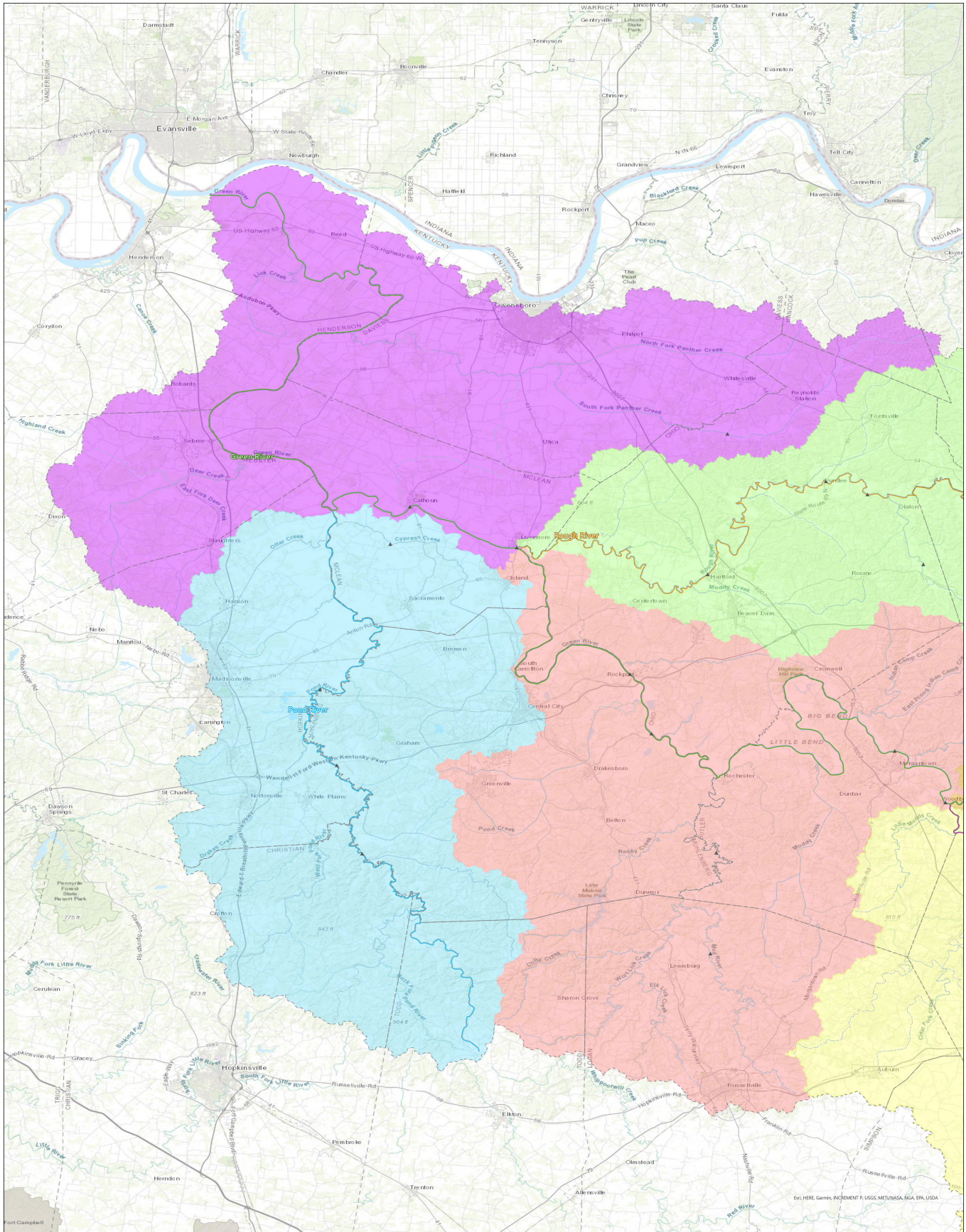


GRB SRP Rough River & Middle Green River Subbasins



★ Mammoth Cave	— Pond River	— Tributaries	— Pond River SB	— Upper Green River SB
▲ Gages	— Rough River	— County Outlines	— Rough River SB	— Middle Green River SB
■ USACE Lakes Green River Bioreserve	— Barren River	— Green River Subbasins (SB)	— Lower Green River SB	

Figure I2. Close up of the Green River Watershed with sub watersheds for upper, middle, and lower Green River and Barren, Rough, and Pond River tributaries.



GRB SRP Lower Green River & Pond River Subbasins

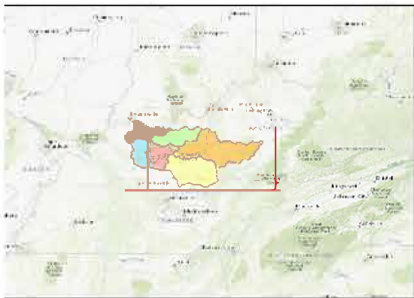
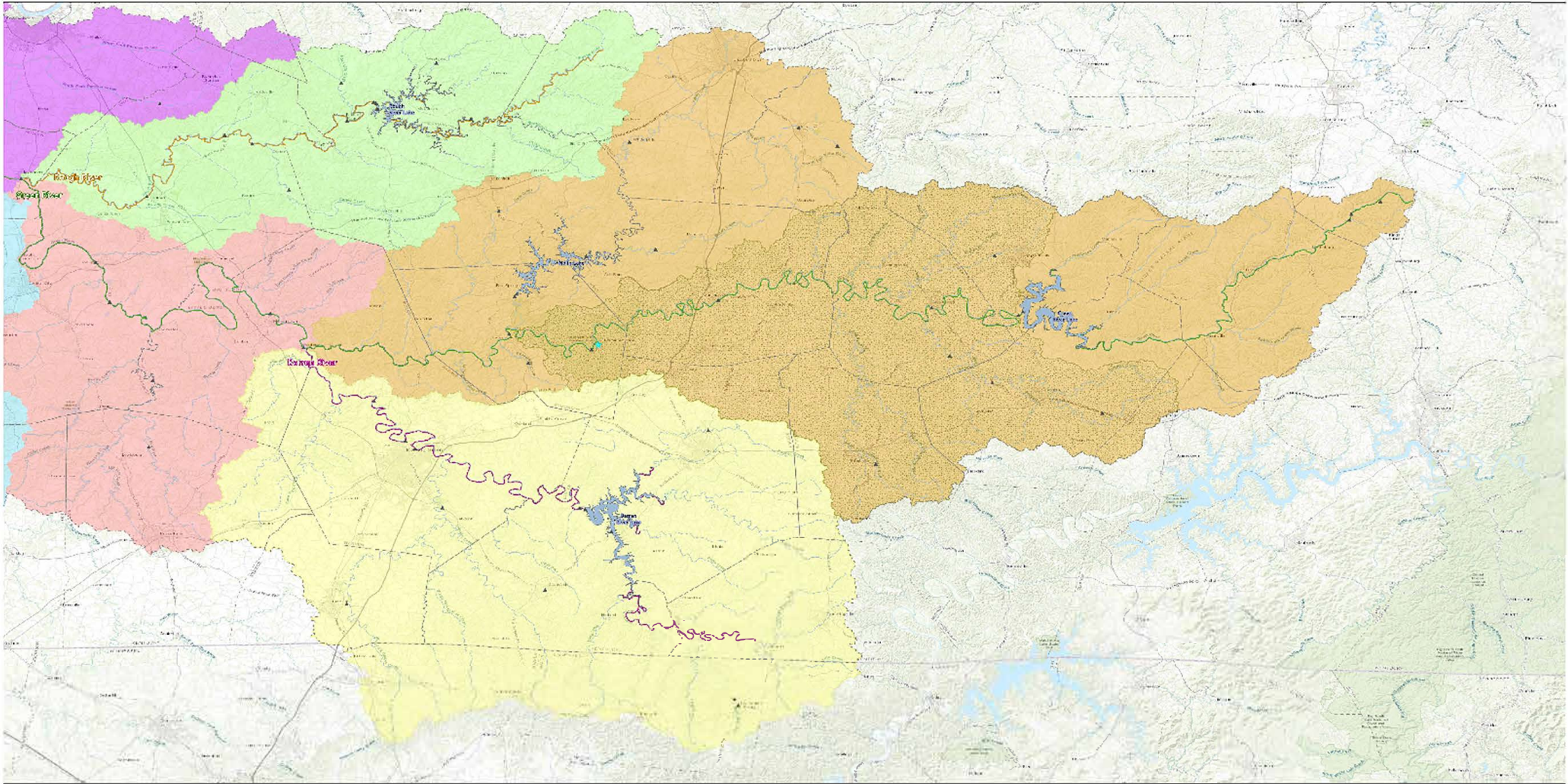

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10 Miles

▲ Gages	County Outlines	Rough River SB
— Green River	Green River Subbasins (SB)	Middle River SB
— Pond River	Lower Green River SB	Upper Green River SB
— Rough River	Green River SB	Green River SB
— Barren River	Pond River SB	Barren River SB
— Tributaries		

Figure I3. Close up of Pond River and the middle and lower Green River sub watersheds.



GRB SRP Upper Green River & Barren River Subbasins



25 Miles



★ Mammoth Cave	Green River	Mammoth Cave Boundary	Green River Subbasins (SB)	Middle Green River SB
▲ Gages	Pond	Tributaries	Lower Green River SB	Upper Green River SB
■ USACE Lakes	Rough River	County Outlines	Pond River SB	Barren River SB
■ Green River Bioreserve	Barren River		Rough River SB	

Figure I4. Close up of the upper Green River, Barren River, and Rough River sub watersheds.

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Appendix J – Species Information Sheet

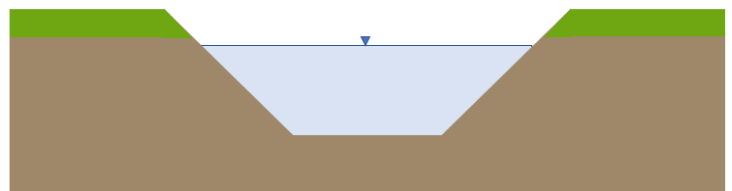
Species or organism:

Designate any known flow needs in the table below.

Timing/Magnitude	Low Flows	High Flows/Pulses	Floods
Winter			
Spring			
Summer			
Fall			

Known Geographic Area:

Habitat Requirements (provide a brief description of habitat needed for the species - indicate locations on the graphic or draw it out if helpful):



NOTE: Graphic may not be applicable to all species - feel free to modify the graphic or to draw your own if you think it would be helpful.

Spawning Habitat Requirements & Conditions (to include water quality requirements if applicable):

Additional notes:

Species or organism: Shoal Chub (Machlybopsis hystoma); this species has declined substantially over past 30 yrs. in the GRB and other Ohio R. tribs in KY

Designate any known flow needs in the table below.

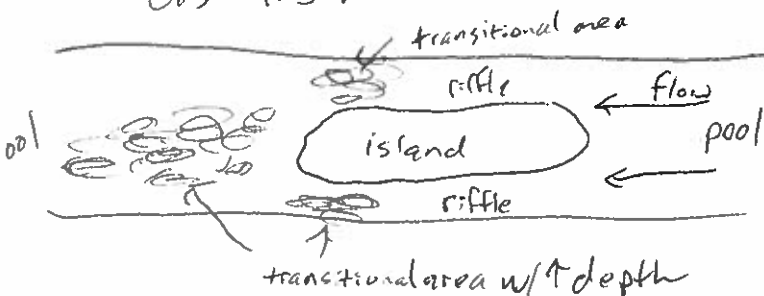
Timing/Magnitude	Low Flows	High Flows/Pulses	Floods
Winter	?	?	?
Spring	?	?	?
Summer	?	?	?
Fall	?	?	?

Presumably would benefit from modification that mimics natural flow ~~variation~~ and temperature variation

Known Geographic Area: Green River mainstem from Greensburg downstream to the Ohio R. confluence.

Habitat Requirements (provide a brief description of habitat needed for the species - indicate locations on the graphic or draw it out if helpful):

Shoals, over mixed sand and gravel substrates w/ minimal silt. Depths from 0.5 - 1.5 m.



NOTE: Graphic may not be applicable to all species - feel free to modify the graphic or to draw your own if you think it would be helpful.

Spawning Habitat Requirements & Conditions (to include water quality requirements if applicable):

Same as described above.

Additional notes: Multiple ^{benthic} species that are part of the native GRB fish community have similar habitat and spawning requirements.

Riffles also support a diverse array of benthic species, including darters & madtoms. Lampreys require riffles to spawn.

Species or organism:

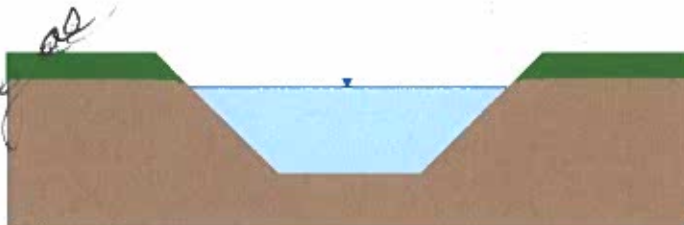
Designate any known flow needs in the table below.

Timing/Magnitude	Low Flows	High Flows/Pulses	Floods
Winter			
Spring			
Summer			
Fall			

Known Geographic Area:

Habitat Requirements (provide a brief description of habitat needed for the species - indicate locations on the graphic or draw it out if helpful):

- Podostemum bed
- Cladophora / Green Algae
(Flushing) blooms below dam.



NOTE: Graphic may not be applicable to all species - feel free to modify the graphic or to draw your own if you think it would be helpful.

Spawning Habitat Requirements & Conditions (to include water quality requirements if applicable):

Temp upstream

Additional notes:

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Appendix K – SRP Opportunities List

Sustainable Rivers Program Opportunities

Note that several of these opportunities and potential solutions would require partnerships to get to implementing an effective approach. Be creative - this list includes examples of types of SRP projects that have been submitted and implemented through the program, but conversations should not be limited to them if there are ideas outside of those listed below.

- Environmental flows (E-flows) – any form of flow prescription that adjusts flows to create some environmental benefit (recruitment of species, generating preferred habitat, etc.)
 - Pulses (to mimic more natural hydrograph or to improve water quality)
 - Controlled floods
 - Low flows
 - Hold flows high (during nesting seasons to keep species from encroaching on the river and getting washed out during flood season)
 - Other
- Conservation locking – performing lockages for the purpose of fish passage
- Environmental pool management – managing reservoir pool levels to benefit the environment; can mimic natural flooding events to stimulate vegetation growth, fish nursery habitat, etc.
- Physical habitat improvements – could be by means of operational management (e.g., releases that modify stream banks) or active ecosystem restoration
- Modifications to infrastructure (e.g., retrofitting better selective withdrawal capabilities on reservoir control towers)
- Dam removals
- Oxbow restoration
- Wetland improvements
- Studies
 - Fish sampling
 - Critical habitat inventory
 - Temperature data collection
 - Other data collection
- Ground truthing for studies
- Implementation of studied opportunities
- Hydrology/water quality modeling
- Invasive species management

Additional Opportunities Beyond SRP

Section 206 of the Water Resources Development Act of 1996, as amended. Aquatic Ecosystem Restoration Projects. Capabilities include low-head dam removal.

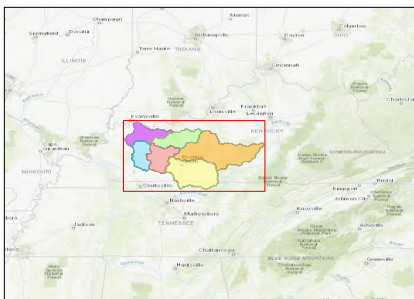
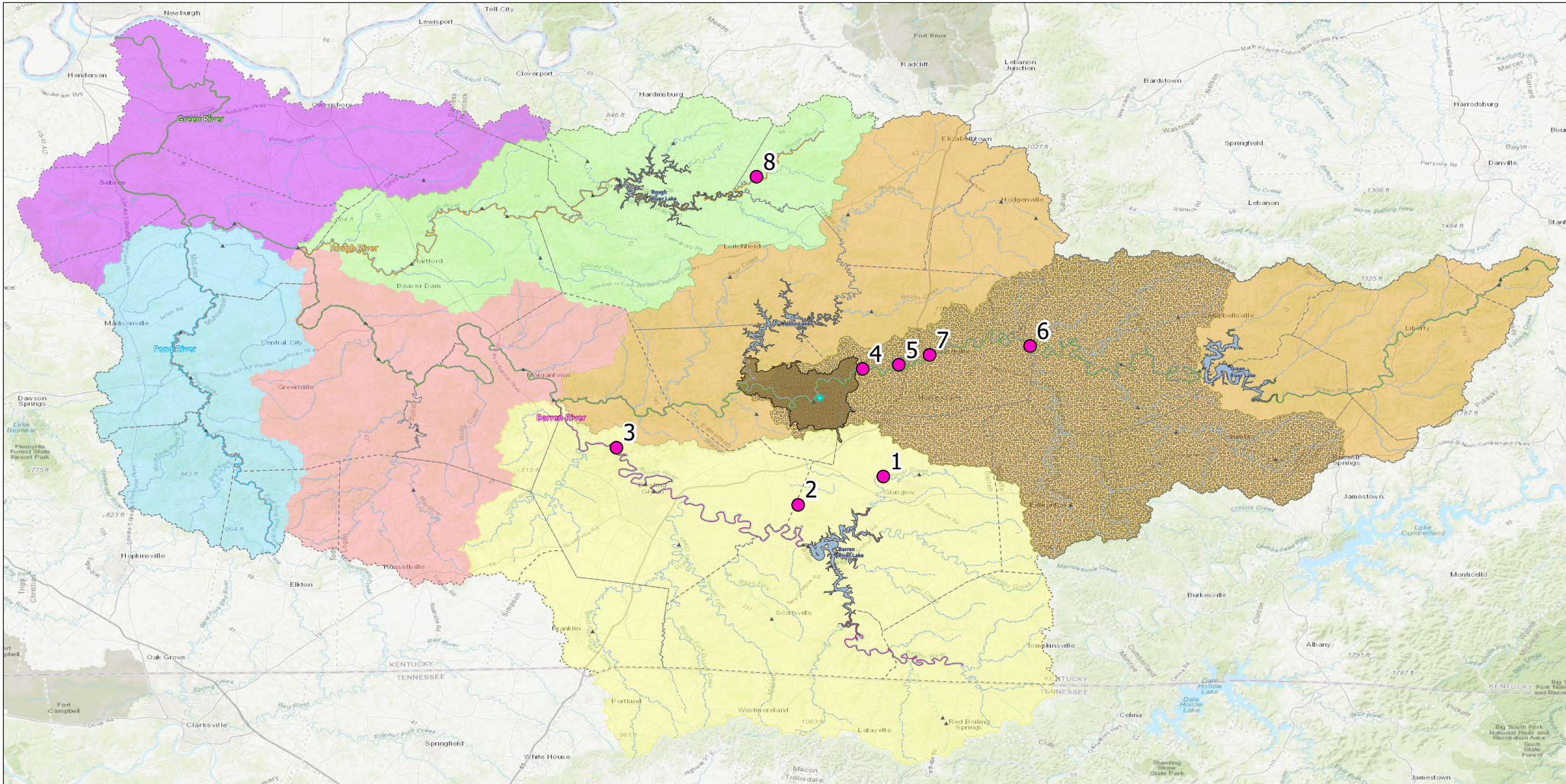
Section 1135 – Environmental Restoration. Project Modifications for Improvements to the Environment.

Planning Assistance to States (PAS) - Ecosystem Restoration and Recreation Master Planning, including Impact Analysis

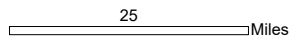
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Appendix L – GIS Comment Tool Results (Figures and Tables L1 to L6)



Green River Basin Sustainable Rivers Program (GRB SRP) High Priority Conservation Areas



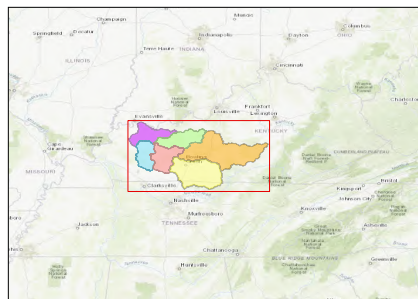
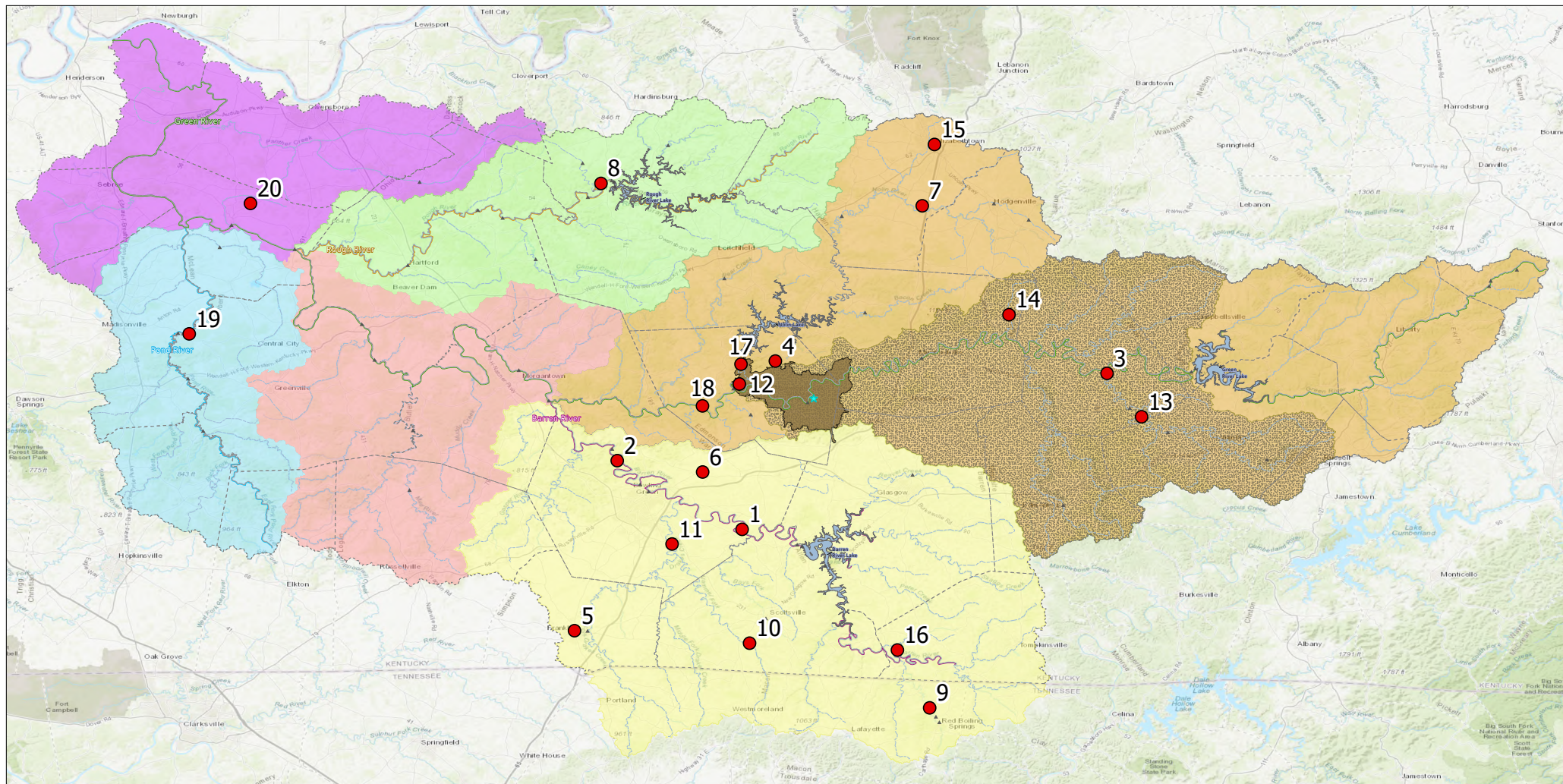
★ Mammoth Cave	Green River	Mammoth Cave Boundary	Green River Subbasins (SB)	Rough River SB	Barren River SB
▲ Gages	Pond River	— Tributaries	Lower Green River SB	Green River SB	High Priority Conservation Areas
■ USACE Green River Bioreserve	Rough River	--- County Outlines	Pond River SB	Upper Green River SB	
	Barren River				

Figure L1. High priority conservation areas as noted by workshop participants.

High Priority Conservation Areas

Table L1. High priority conservation areas as noted by workshop participants.

Entry ID	Name (optional)	Email address (optional)	Comment
1	Breakout Group 4		Priority watershed: Beaver Creek
2	Breakout Group 4		This general area labeled on the map as "more rich, prioritize"
3	Breakout Group 4		Barren River L&D 1 (not exact location). There is a high level of mussel fauna in this area. Pool fauna has been historically located upstream of BRLD1, and riverine fauna has been located downstream. With the dam removed, riverine fauna are expected to move upstream.
4	Breakout Group 4		Clubshell mussels exist at this location
5	Breakout Group 4		Peak mussel habitat in this part of the basin
6	Breakout Group 4		Transitional zone exists in this area where upper basin fauna transitions into lower basin fauna. Tributaries and springs influence the temperature in this area (possibilities for protecting these?)
7	Breakout Group 4		More "lower basin" fauna downstream of here
8	Breakout Group 4		6-8 mussel species in this area



Green River Basin Sustainable Rivers Program (GRB SRP) Habitat and Area Improvements: Problems and Opportunities



25 Miles

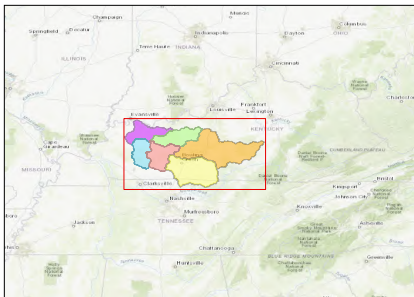
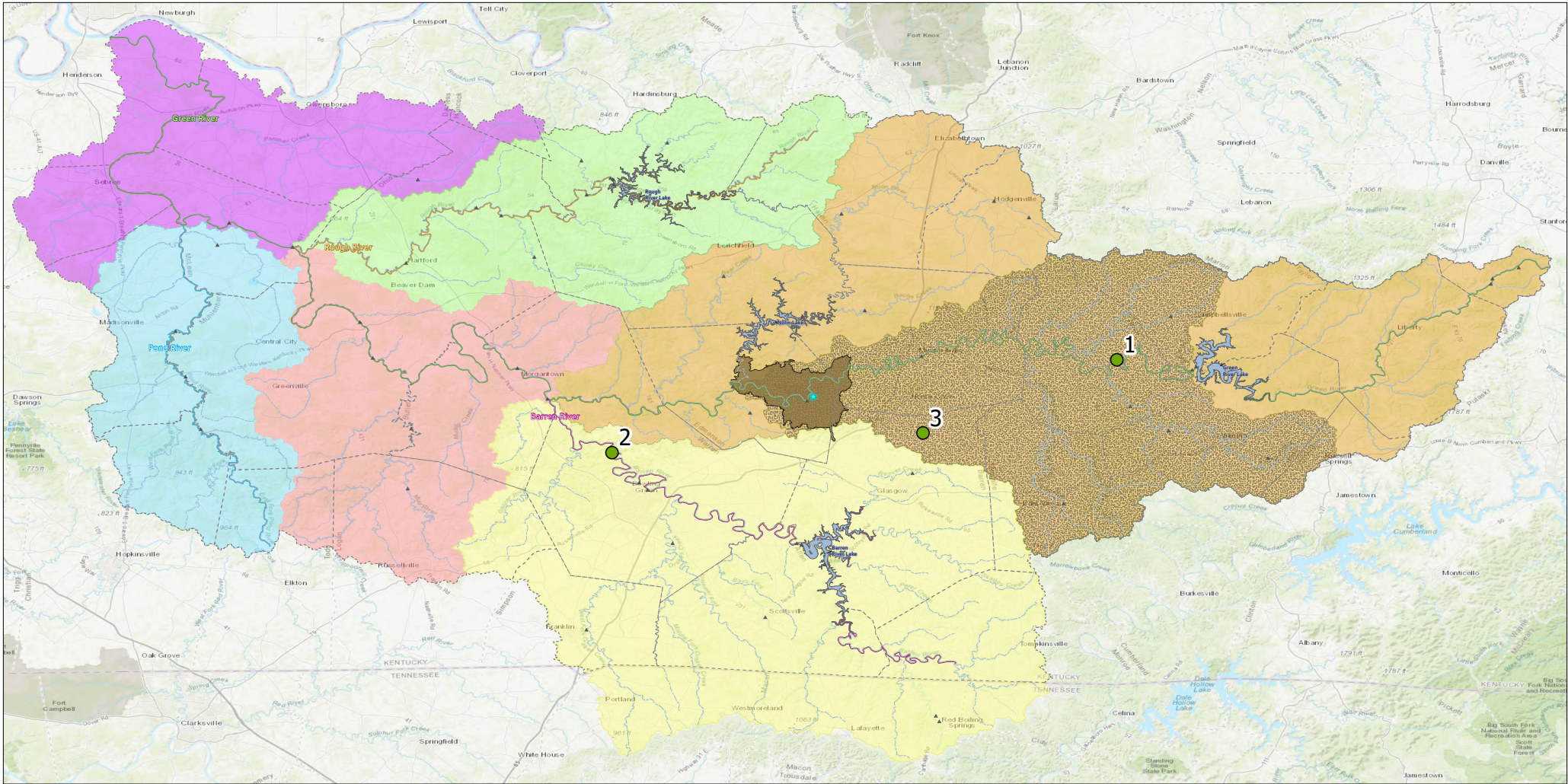


★ Mammoth Cave	Green River	Mammoth Cave Boundary	Green River Subbasins (SB)	Rough River SB	Barren River SB
▲ Gages	Pond River	Tributaries	Lower Green River SB	Middle Green River SB	Habitat & Area Improvements: Problems & Opportunities
■ USACE Lakes Green River Bioreserve	Rough River	County Outlines	Pond River SB	Upper Green River SB	
	Barren River				

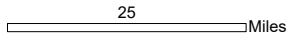
Figure L2. Habitat and area improvements (including both problems and opportunities) as noted by workshop participants.

Table L2. Habitat and area improvements (including both problems and opportunities) as noted by workshop participants.

Entry ID	Name (Optional)	Email address (Optional)	Comment
1	Marissa's Breakout Group		This area is generally devoid of species (downstream of Barren River Lake, upstream of Bowling Green)
2	Marissa's Breakout Group		Opportunities for restoration in this area (downstream of Bowling Green in the Barren River)
3	Jeff's Breakout Group		There is an ATV park in this area (potential water quality/turbidity concerns)
4	Jeff's Breakout Group		There is an ATV park here (Blue Holler Offroad Park) (potential water quality concerns)
5	Jeff's Breakout Group		New factory making supplies for EV batteries under construction in this area (water quality concerns)
6	Jeff's Breakout Group		New EV battery plant in this area (in Kentucky Transpark, water quality concerns)
7	Jeff's Breakout Group		New EV battery plant under construction in this area (BlueOvalSK Battery Park, water quality concerns)
8	Breakout Group		Pool downstream of Rough River Lake tailwater
9	Breakout Group		Gravel mining occurring in this area (USACE, DOW, or OSRW concern?)
10	Breakout Group		Gravel mining occurring in this area (USACE, DOW, or OSRW concern?)
11	Breakout Group		destabilized banks in this area
12	Weston's Breakout Group		Brice, one of the MCNP representatives at the workshop, mentioned that last fall, during Nolin Lake's fall drawdown, there were large waves at the confluence of the Nolin River with the Green River, probably due to high flows on the Nolin combining with relatively low flows on the Green. These waves created a hazard for canoes and kayaks, and Brice had to rescue some canoers who had tipped over in the waves. This situation has only been present since the partial removal of L&D 5, because previously this stretch of the Green River was a pool. It may be worthwhile to monitor for this situation during future fall drawdowns and consider ways that the drawdown might need to be modified (slower rate of gate opening?) to avoid creating waves at the confluence.
13	Breakout Group 4		"Mussel recruitment temps off"
14	Breakout Group 4		Lynn Camp Creek: needs reconnection to Green River Main Stem
15	Breakout Group 4		Several water quality concerns associated with agricultural runoff and urban runoff from Elizabethtown. Oil sheen, potential Superfund opportunity
16	Breakout Group 4		Agricultural runoff issues in this area
17	Breakout Group 4		No mussel habitat currently present in Nolin River from Nolin Lake tailwater to the confluence with the Green
18	Breakout Group 4		Green River upstream of L&D 5 to Mammoth Cave National Park/confluence with Nolin River: There is a large area of mussel fauna here, but there is room for improvement in this area (Nolin Lake releases could potentially be adjusted to help).
19	Breakout Group 4		Pond River watershed: generally polluted
20	Breakout Group 4		Lower Green River watershed: Lots of channelized and/or tiled agricultural fields



Green River Basin Sustainable Rivers Program (GRB SRP) Monitoring Locations

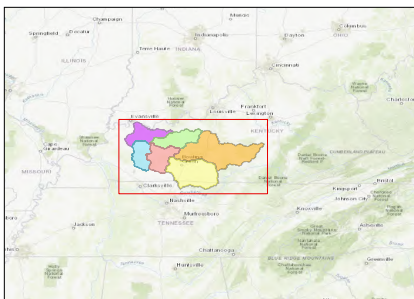
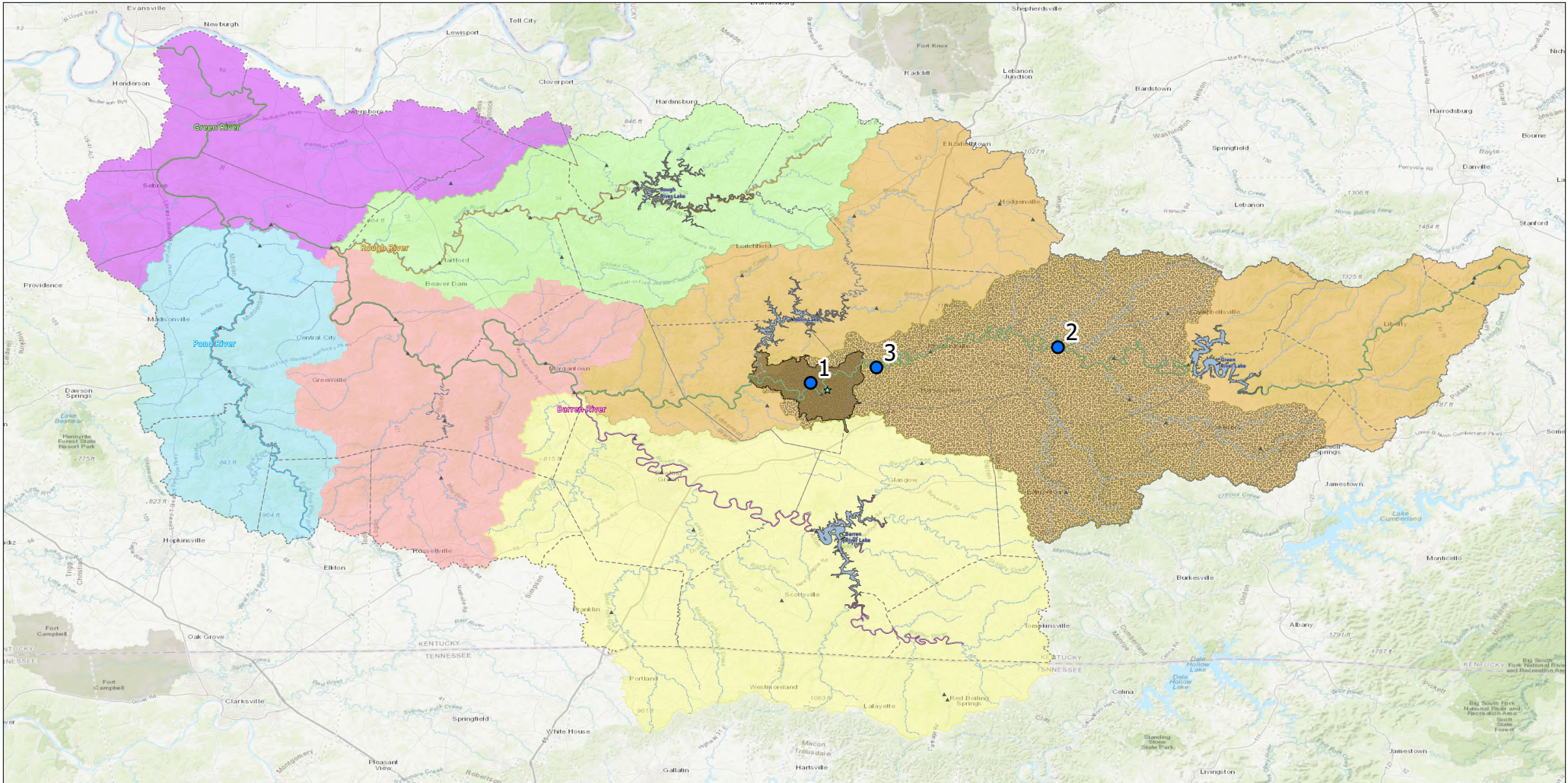


★ Mammoth Cave	Green River	Mammoth Cave Boundary	Green River Subbasins	Rough River SB	Barren River SB
▲ Gages	Pond River	--- Tributaries	Lower Green River SB	Middle Green River SB	Monitoring Locations (Non-Routine/Other)
■ USACE Lakes	Rough River	- - - County Outlines	Green River SB	Upper Green River SB	
■ Green River Bioreserve	Barren River		Pond River SB	Green River SB	

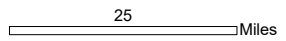
Figure L3. Existing monitoring locations as noted by workshop participants.

Table L3. Existing monitoring locations as noted by workshop participants.

Entry ID	Name (Optional)	Email address (Optional)	Comment	Monitoring_Type
1	Richie Kessler	rkessler@campbellsville.edu	We discussed adding temp to the Gburg gauge to further assist with hitting temp targets (Russell Creek) at various flows. In addition could monitor populations of endangered clubshell and rabbitsfoot mussels which seem to be responding well in this region of the river compared to elsewhere.	Mussels
2	Steele's Breakout Group		This is an area (from Bowling Green to the confluence of the Barren with the Green) where Steele's group mentioned there is a gap in the stream gaging network where more gages (perhaps super gages) would be useful.	Water Quality
3	Breakout Group		Labeled on map as "baseline data"	Other



Green River Basin Sustainable Rivers Program (GRB SRP) Areas Protected for Conservation



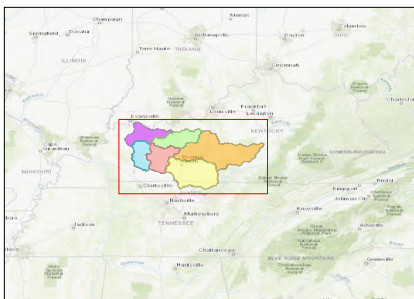
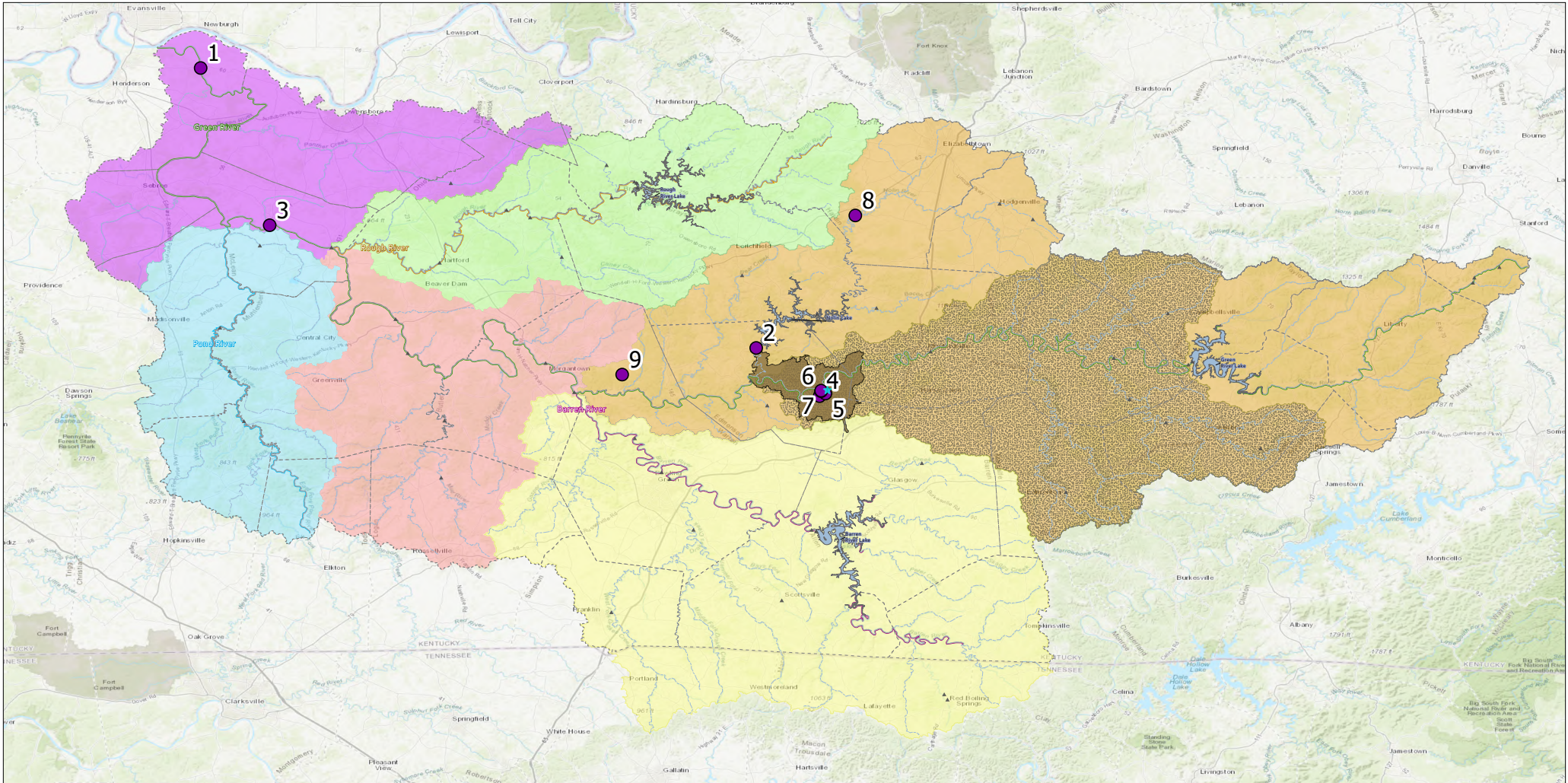
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Figure L4. Existing areas protected for conservation as noted by workshop participants.

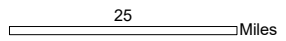
Areas Protected for Conservation

Table L4. Existing areas protected for conservation as noted by workshop participants.

Entry ID	Name (Optional)	Email address (Optional)	Comment
1	Weston Young		Mammoth Cave National Park
2	Weston Young		Green River Bioreserve: downstream of Green River Lake to Mammoth Cave National Park
3	Weston Young		WKU Green River Preserve



Green River Basin Sustainable Rivers Program (GRB SRP) Structures, Facilities, and Amenities

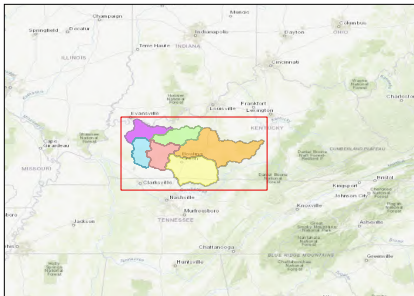
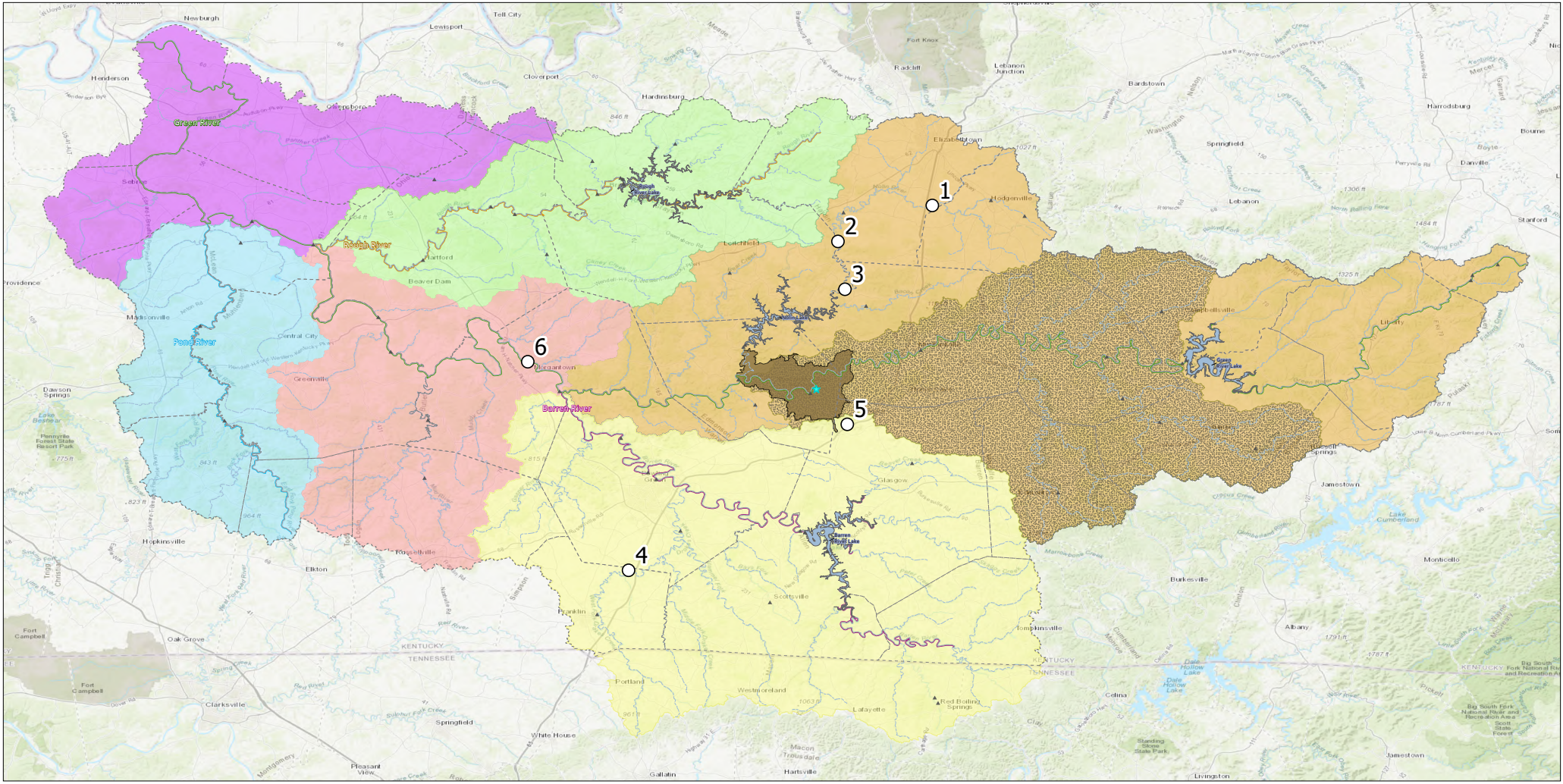


★ Mammoth Cave	Green River	Mammoth Cave	Green River	Rough River SB	Barren River SB
▲ Gages	Pond	Boundary	Green River Subbasins (SB)	Middle Green River SB	Structures, Facilities, & Amenities
■ USACE Green River Bioreserve	Rough River	Tributaries	Lower Green River SB	Upper Green River SB	
	Barren River	County Outlines	Pond River SB		

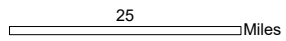
Figure L5. Existing structures, facilities, and amenities as noted by workshop participants.

Table L5. Existing structures, facilities, and amenities as noted by workshop participants.

Entry ID	Name (Optional)	Email address (Optional)	Comment
1	Abbey Miglio	abgjail.m.miglio@usace.army.mil	Green River L&D1
2	Jenny Stromberg	jennifer.stromberg@usace.army.mil	The 11-miles between Nolin Lake Dam tailwater and Brownsville have water levels that can fluctuate and be too low for recreational activities like canoeing/kayaking to occur.
3	Abbey Miglio		Green River L&D 2
4	Chloe Brantley	c.brantley@krwa.org	Source Water Assessment and Protection Plans Delineations Files
5	Chloe Brantley	c.brantley@krwa.org	Wellhead Protection Plan Delineation Files
6	Chloe Brantley	c.brantley@krwa.org	Source Water Protection Viewer- https://kygis.maps.arcgis.com/apps/webappviewer/index.html?id=c2324b998e78433aaf9e6a3d7ad9f86a
7	Chloe Brantley	c.brantley@krwa.org	https://kygis.maps.arcgis.com/apps/webappviewer/index.html?id=c2324b998e78433aaf9e6a3d7ad9f86a
8	Breakout Group		White Mills, KY
9	Breakout Group 4		Gabbard Branch Wildlife Management Area (WMA). KY Fish & Wildlife. https://fw.ky.gov/News/Pages/Kentucky-Fish-and-Wildlife-opens-1,400-acres-for-public-hunting-in-western-Kentucky.aspx



Green River Basin Sustainable Rivers Program (GRB SRP) Other Points of Interest



★ Mammoth Cave	Green River	Mammoth Cave Boundary	Green River Subbasins (SB)	Middle Green River SB
▲ Gages	Pond	--- Tributaries	Lower Green River SB	Upper Green River SB
■ USACE Lakes	Rough River	--- County Outlines	Pond River SB	Barren River SB
■ Green River Bioreserve	Barren River		Rough River SB	Other

Figure L6. Other points of interest as noted by workshop participants.

Table L6. Other points of interest as noted by workshop participants.

Entry ID	Name (Optional)	Email address (Optional)	Comment
1	Breakout Group		Labeled on map as "KC"
2	Breakout Group		Labeled on map as "KC"
3	Breakout Group		Labeled on map as "KC"
4	Breakout Group		The breakout group labeled this general area of the map with various notations: WKU, Murray, WOTS, WRAP, WRDA, Dr. Rich Fisher at ERDC.
5	Weston's Breakout Group		Brice, one of the MCNP representatives, mentioned that this area has a karstic landscape and MCNP has actually found that surface water from this area drains into Mammoth Cave and should be considered part of the Upper Green watershed instead of the Barren River watershed. MCNP has shapefiles of where they have determined the watershed boundaries to be, and they can provide them to us if they are of interest.
6	Breakout Group 4		Labeled as "1965 breach"