Environmental Flows Recommendations
2nd Workshop Summary

Kansas River, 2020 (USACE photo)

Kansas River Sustainable Rivers Program
May 2024

The Nature Conservancy
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US Army Corps of Engineers ®
Kansas City District

Coauthored by The Nature Conservancy and U.S. Army Corps of Engineers, Kansas City District planning, environmental, and water management staff.

Review performed by Heidi Mehl, The Nature Conservancy, Marvin Boyer, U.S. Army Corps of Engineers, Kansas City District, Rheannon Hart, U.S. Army Corps of Engineers, Little Rock District, and John Hickey, U.S. Army Corps of Engineers, Institute of Water Resources.

Suggested Citation: The Nature Conservancy and U.S. Army Corps of Engineers. 2024. Environmental Flows Recommendations 2nd Workshop Summary, Kansas River Sustainable Rivers Program, May 2024.

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Acknowledgments

This project was made possible with funding from the Sustainable Rivers Program, The Nature Conservancy, and time and effort contributed by numerous agencies and individuals throughout the project. The development of the information was based on collaborative efforts and inputs from regional and state scientists and stakeholders that were critical to this effort.

The shared purpose of the project was to convene key personnel and partners to provide strong scientific and stakeholder support for the Sustainable River Program's commitment to improving ecological flows and reservoir health in the Kansas River system. Stakeholders and partners provided the input, expertise, and hypotheses on current and historical conditions as well as issues and needs.

A core team, represented by the project partners, led the science and technical integration effort. This group spent extensive time developing a plan for coordination and communication of science-based planning across stakeholder groups and identifying and targeting technical assistance as needed. The Nature Conservancy, Kansas, and the U.S. Army Corps of Engineers, Kansas City District, initiated the project as well as provided input, guidance, and feedback throughout the initial phase (literature review and summary).

The information was developed in collaboration with researchers for the Environmental Flow Requirements for the Kansas River (Baker et al. 2022):

- Background Literature Review and Summary by Debra Baker, Assistant Director and Informatics Specialist, Central Plains Center for BioAssessment, Kansas Biological Survey & Center for Ecological Research;
- Donald Huggins, Senior Scientist, Director, Central Plains Center for BioAssessment, Kansas Biological Survey & Center for Ecological Research;
- Steve Cringan, Kansas Department of Health and Environment;
- Robert Angelo, U.S. Environmental Protection Agency;
- The Nature Conservancy;
- U.S. Army Corps of Engineers, Kansas City District

Each was integral to discussions during the environmental flows workshop and development of environmental flow proposals presented.

We are grateful to everyone who has participated and for their interest and contribution to improving the health of the Kansas River. The extensive contributions and collaboration efforts from the various agencies and individuals are integral to the effort now and for future coordination and implementation efforts.

Disclaimer: The development of environmental flow plans is based on best available science and will be carefully balanced with the needs and requirements of stakeholders, to benefit the Kansas River ecosystem while improving or not adversely affecting the system. Environmental flow plans are developed within the constraints of authorized purposes of the reservoirs, water rights, and other human use requirements, and in collaboration with stakeholders.

1.0 Sustainable Rivers Program

Figure 1. Kansas River, 2021 (USACE photo)

The Nature Conservancy (TNC) and U.S. Army Corps of Engineers (USACE) have partnered to form the Sustainable Rivers Program (SRP) to examine opportunities to optimize reservoir releases and river flows to benefit river ecology while maintaining the federal mandates of the reservoir systems within the United States. The mission of the SRP is to improve the health and life of rivers by changing water infrastructure operations to restore and protect ecosystems, while maintaining or enhancing other project benefits. The founding objective of SRP is implementation of environmental flows (e-flows), which are defined as the quantity, timing, and quality of water flows required to sustain ecosystems. Here, e-flows are considered management decisions that manipulate water and land-water interactions to achieve ecological environmental goals. SRP efforts complement other reservoir-centric water resource projects by demonstrating that a strategic and science-based approach can be used at USACE projects to maintain or enhance benefits provided to the nation. As of 2023, SRP involved work on more than 90 USACE reservoirs in 45 river systems influencing 12,183 river miles. SRP is now the largest scale and most comprehensive program for implementing e-flows at USACE reservoirs.

In 2017, the USACE Kansas City District and TNC Kansas added the Kansas River (Figure 1) to the SRP. An initial workshop, with Kansas River stakeholders (reservoir managers, businesses, drinking water suppliers, recreation enthusiasts, etc.) and regional biology and hydrology experts, was held to help guide the process of identifying e-flows. Subsequently, a literature review and data mining exercises were undertaken to identify flow-dependent fish, mussels, and other species in the Kansas River, examine changes in these species over time, and propose the likely causes of these changes (Baker et al. 2022). USACE used this information to better understand reservoir operation impacts and examine possibilities for reservoir management modifications within the range of authorized reservoir releases that would create flows beneficial to the Kansas River ecosystem. The draft literature review was completed in July of 2020 providing the groundwork for informed development of flow-related hypotheses for the e-flows workshop involving expert stakeholders.

The draft literature review was revised from late 2020 through 2022 to include information on expansion of the geographic scope to include Kanopolis, Wilson, Harlan County, and Waconda Reservoirs and the extended reaches to those reservoirs. Reaches added include the Smoky Hill River downstream of Kanopolis, the Saline River downstream of Wilson Reservoir, the Solomon River downstream of Waconda Reservoir, the Big Blue River downstream of Tuttle Creek Reservoir, and the Republican River downstream of Harlan County and Milford Reservoirs. Additional information related to sediment and turbidity was also added including conceptual models for sediment sensitive and sediment tolerant fish species developed by Hernandez-Abrams et al. (2021). The report was final in May 2022 (Baker et al. 2022). It summarizes the natural and current range of variation in low flow, high flow, and flood pulses, duration and frequency of each, and the rate of change from one condition to the other. Background data in the literature review included ecology and biology flow needs, as well as hydrologic conditions before and after construction of dams and impoundment.

Using input from stakeholders and data obtained related to hydrology and information from the ecological assessment, the first e-flows workshop was held in September 2020. The goal of the workshop was to

develop Kansas River e-flow recommendations that could result in benefits to fish, wildlife, and the ecosystem while avoiding conflicts with current human uses. Participants included multi-disciplinary experts and representatives from federal government, state government, academics, non-governmental organizations (NGOs), private industry, and utilities. During this meeting experts crafted e-flow prescriptions for one reach of the mainstem Kansas River below USACE dams (defined as Reach 2 and consists of the Kansas River - Big Blue River Confluence to Willard, Kansas, (below Milford and Tuttle Reservoirs)).

Following the completion of the workshop summary for the first e-flows workshop (TNC and USACE 2021), a second e-flows workshop was held to review the existing e-flow hypotheses and determine if any revisions were needed. The workshop also included a discussion on ideas for e-flow hypotheses for the extended reaches and if there are opportunities to enhance benefits via pool-level or flow manipulations related to specific habitats, target species, or riverine processes. Participants were asked if there were ideas related to oxbow restoration on the Kansas River or the extended reaches or in-lake restoration. Development of an implementation and monitoring strategy to support the e-flows hypothesis in addition to needs related to outreach and coordination were discussed as well. This document summarizes the results of that meeting.

2.0 Workshop Goals and Agenda

The purpose of the second e-flows workshop was to:

- Review environmental flow hypotheses developed for the Kansas River during the first e-flows workshop and determine if these are appropriate or if any changes are needed.
    - The existing environmental flow hypotheses consider a range of species, communities, and ecological processes (fish, birds, other aquatic species, riparian and floodplain systems, nutrient cycling, habitat processes, energy input).
- Discuss ideas for environmental flow hypotheses for extended reaches (i.e., Smoky Hill, Saline, Solomon, Republican). Determine if there were opportunities to enhance benefits via pool-level or flow manipulations related to the selected habitats, target species, or riverine processes.
- Groups were to think about the location, timing, magnitude, duration, and rate of change of flow for the Environmental Flow Components.
- Discuss new ideas such as oxbow restoration and in-lake restoration.
- Provide thoughts on next steps for an implementation and monitoring strategy and outreach and coordination.

The full workshop agenda and list of participants are included in Appendix A and Appendix B, respectively.

The workshop began with welcome and introductions, review of the SRP process, and discussion of desired workshop outcomes. Next was an overview of revisions to the literature review which included:

- Expansion of the geographic scope to include:
    - Kanopolis Reservoir and the Smoky Hill River downstream
    - Wilson Reservoir and the Saline River downstream
    - Waconda Reservoir and the Solomon River downstream
    - Big Blue River downstream of Tuttle Creek Reservoir
    - Republican River downstream of Harlan County Reservoir

- Identifying and quantifying ecological resources, basin characteristics, river morphology, and the information to establish the period of record flow benefits.
- Sediment and turbidity and the effects to fish.

3.0 USACE Updates

3.1 Water Control Manual Updates

During the e-flows workshop, the USACE staff provided an update regarding recent appropriations received by the USACE Kansas City District to update the reservoir Water Control Manuals (WCMs) in the Kansas River Basin. The reservoirs scheduled for updates include Milford, Tuttle Creek, Perry, Clinton, Wilson, Kanopolis, and Harlan County Reservoirs. Updates are also being conducted on three reservoirs in the Osage River Basin (i.e., Pomona, Hillsdale, Melvern). The WCM updates will be done in groups with Milford, Tuttle Creek, Perry, and Clinton Reservoirs currently (2023) starting. All WCM updates are scheduled for completion in September 2027 (see Appendix A).

The updates will include:

- Flood Risk Management:
    - Modeling and analysis to account for changes in land use, population, river systems
    - Changes to phased releases from the reservoirs
- National Environmental Policy Act:
    - Public Outreach Communication and Participation
    - Environmental Conditions
- Drought Contingency (New):
    - Identify when drought conditions begin
    - Incorporate rules that will then conserve water
    - Identify when to return to normal operating rules
    - Create a coordination and communication plan to provide guidance during implementation
    - Include a public information program

The WCM updates could offer opportunities for consideration of SRP e-flows and coordination meetings for the WCM updates will include informational briefings on SRP needs.

The WCM update during the e-flows workshop included a summary of reservoir management in the Kansas River Basin and Water Level Management Plans (see Appendix A).

Workshop participants provided questions and comments related to the WCM updates. Question and comments, as well as USACE responses include:

- Climate change – Will climate change be a consideration in the planning for the WCM updates? The USACE will look at climate change implications as part of the WCM update process.
- Pool level management – How would we incorporate SRP into pool level management? The SRP leads submitted a proposal to consider pool level management at several reservoirs in the basin. This was accepted and started in 2023.

3.2 Tuttle Creek Reservoir Water Injection Dredging Demonstration

The USACE is currently working on the Tuttle Creek Reservoir Water Injection Dredging (WID) Demonstration. The project is in the early planning phases and is funded with a combination of federal and non-federal funds through the Kansas Water Office (KWO). The purpose of the demonstration is to test the effectiveness of WID technology (Figure 2) at a range of downstream discharges, pool elevations, and in-reservoir locations for potential long-term implementation. The demonstration includes phases of planning for pre-WID, during WID, and post-WID. The USACE and KWO are working to develop a monitoring and adaptive management plan to include the steps required to evaluate WID effectiveness, environmental affects (beneficial and adverse), and human considerations. The period of active WID is expected to occur during 3 timeframes (i.e., spring, summer, fall) in 2024.

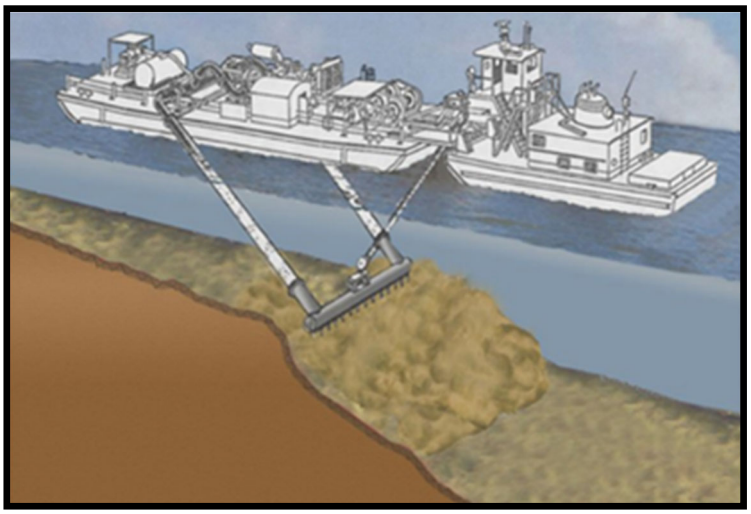

Figure 2. Water Injection Dredge

Workshop participants provided comments and questions related to the WID demonstration at Tuttle Creek Reservoir. Question and comments, as well as USACE responses include:

- Technical experts from the SRP process should be included in the discussions related to WID.
- Concerns related to passing contaminated sediment downstream and ensuring that an adequate baseline should be established.
- The USACE clarified that the planning team for the WID demonstration is including monitoring downstream of Tuttle Creek Reservoir of water quality analytes, bed contaminants, sediment gradations, and macroinvertebrates.
- Are there any considerations for decommissioning the reservoir in the future? The reservoir would still have remaining flood control storage and operate for this purpose.
- Do you have a cost estimate of the dredging process? Early estimates show that WID would be more cost effective then other methods. The demonstration will determine if WID is more cost effective than other forms of sediment management (e.g., traditional dredging).
- Are there any synergies with passing of sediment and e-flows? Could we design a pulse release and couple the release of sediment with it? Through the monitoring plan development, we are considering the metrics that could be measured to determine if passing sediment would benefit environmental resources (e.g., fish food sources such as macroinvertebrates).
- If there was a way to pass most of the sediment inflows that would be a benefit. The WID will likely only move fines as it will work close to the dam and will not likely pass the heavier materials and likely not have the ability to match inflows.
- The monitoring of the WID would provide valuable information on passing materials downstream and the fate of the sediment including sorting of the sediment through the system. This information can then be paired with discharges needed to move sediments downstream.

3.3 Smoky Hill River Ecosystem Restoration Project

The USACE is currently (2023) working with the City of Salina, Kansas, on a feasibility study and environmental assessment under the Continuing Authorities Program (CAP) for the Smoky Hill River in Salina, Kansas (Figure 3). The project is ecosystem focused and includes restoration of aquatic habitat functions and features within and near the old channel that were lost as a result of the flood risk management project. Restoration measures include reconnection of the old channel, improvements to base flow, aquatic connectivity and habitat functions, wetland and riparian habitats, and whole system functions. The project includes work in two reaches with step pools, glide, pool, riffle, and run habitat, and wetland shelves with improved connectivity and a more natural condition. The project is expected to move to a larger general investigation because of the potential cost for restoration under the recommended plan that exceeds the limit of a CAP project.

Figure 3. Location of Smoky Hill River Ecosystem Restoration Project in Salina, Kansas

4.0 Summary of Key Findings from the Literature Review

A summary of the key findings of the literature review was provided during the workshop (Baker et al. 2022). These consisted of observations by Sanders et al. (1993) and were also cited in the literature review. Key findings include:

- The Kansas River is becoming less turbid.
- Regulated flows have caused spatial and temporal changes in stream flow and the nature of the stream bed.
- Indigenous fish were tolerant of great fluctuations in discharge, shifting sand substrate, high turbidity. Shovelnose sturgeon, chub species (*Platygobio* and *Macrhybopsis*), plains minnow, western silvery minnow, and river carpsucker are especially adapted to these conditions due to their tactile and chemical sensory systems.
- Large, sight-feeding piscivores were rare or absent, and gars and catfish were the main predators.
- Turbid river species were more prevalent until mid-20th century, and then were replaced by planktivores and visual predators.
- With reservoirs, the river substrate stabilized and enhanced benthos production, which increased plankton abundance, therefore Centrarchids (except green and orange-spotted sunfish) increased and buffalo, drum, flathead catfish, and walleye extended their ranges.

The literature review includes measures to benefit fish in the Kansas River Basin that could be considered under SRP (Baker et al. 2022).

- A more heterogeneous flow regime would be beneficial.

    - To reintroduce heterogeneity to the Kansas River, modification of dam releases in consideration of these flow needs must incorporate:
        - Frequency – How often flows increase and decrease (variability of flows). Frequency in flows increases water and terrestrial connectivity and shifts instream habitat availability.
        - Duration – The temporal range of flow events. While large flood peaks must be attenuated, both high and low flow periods should follow normal time periods.
        - Extent – The magnitude of flow increases and decreases. Again, while flood peaks need to be attenuated, both extreme high and low flow periods should not be extended beyond normal patterns.
        - Temporal shifts – Current flow regimes remain closely correlated with natural flow regimes. The historic changes in river flows were linked to climate and precipitation patterns within the basin and shifts in seasonal flow patterns should be minimized.
- Variation in flows may enhance spawning success.
- Lower river discharge during the fall, following the critical spawning window, would benefit fish species.
    - During the time that fry need refugia, reservoir discharges are maintaining flows at a higher level than naturally occurred, reducing river complexity.

Measures to benefit mussel recovery in the Kansas River Basin (Cringan et al. 2020) that could be considered under SRP include:

- Changes in the seasonal operation of existing flood control dams – gradual attenuation of high reservoir release rates.
    - Streamflow in the Kansas River is dominated at times by releases from reservoirs, and the rapid attenuation of these releases can strand mussels on exposed sand and gravel bars.
    - Stranding often results in lethal heat stress and heavy predation, and severe or repeated stranding events can jeopardize entire mussel communities.
    - To minimize stranding-related mortality, reservoir releases should be attenuated over at least a one to two-week period, particularly during the summer and early fall when daytime air temperatures commonly exceed 90° Fahrenheit (32° Celsius).
    - This precaution is especially important when streamflow falls below the level needed to inundate most sand and gravel bars. In the Kansas River, this level corresponds to about 5,000 cubic feet per second (cfs).

5.0 First E-Flows Workshop Flow-Ecology Relationships

During the first e-flows workshop participants created flow prescriptions for fish, mussels, riparian and floodplain systems, and sandbar nesting birds that would provide benefits to the Kansas River ecosystem. The outcome of the workshop was a unified flow prescriptions for fish, mussels, riparian and floodplain systems, and sandbar nesting birds.

When unifying the flow prescriptions the participants came to the following agreements:

- Variability in the system is desired. Opportunistically varying the flow regime (wet, average, dry years) would more closely resemble the natural annual variation that occurred from annual differences in runoff amounts. The intent of operational adjustments, while designed for a particular group or species, are to benefit the entire ecosystem rather that a specific species group or species.
- For birds/riparian and floodplain systems flow recommendations would be done every other year as the need for variability when these occur is desired.
- Fish that are short lived with narrow spawning windows have the highest conflicts with other flow recommendations. The timing for these species is important.
- For mussels it is important to elongate a flow recession, a 1-2-week attenuation of pulses is desired.
- There is some compatibility between flows in the spring for blue sucker spawning and flows that move sediments. The flows developed for the blue sucker and sediment movement could be combined.
- The higher peaks developed in the birds/riparian and floodplain group could be modified to include a slower recession.
- Focus e-flows related to spawning on the first pulse in May for fish spawning.
- Monitoring plans should account for lag time for ecological and hydrogeomorphic responses and be long-term to identify trends.

Figure 4. Unified E-Flow Prescriptions General Agreements

The life stages and habitat needs of fish, mussels, riparian and floodplain systems, and sandbar nesting birds were considered in crafting ecological operational windows during the prescription unification process. The species selected are those that would allow measurement of a response to flow prescriptions (i.e., species that have low population numbers may not be a good candidate to measure response). The characteristics (i.e., season, events per season, magnitude, duration, duration of peak) of each flow component by water year are detailed in Appendix F of the first e-flows workshop summary (TNC and USACE 2021).

Figure 5 is an example summary of ecological considerations and environmental flow targets that emerged from the first e-flows workshop. This flow prescription is specific to the Kansas River mainstem influenced by Milford and Tuttle Creek Reservoir operation. Figure 5 is a culmination of ideas for fish, mussels, riparian and floodplain systems, and sandbar nesting birds. The rest of this report will summarize the process to general flow recommendations, specific flow prescriptions from individual groups, as well as the unified flow recommendations for multiple stretches of the river.

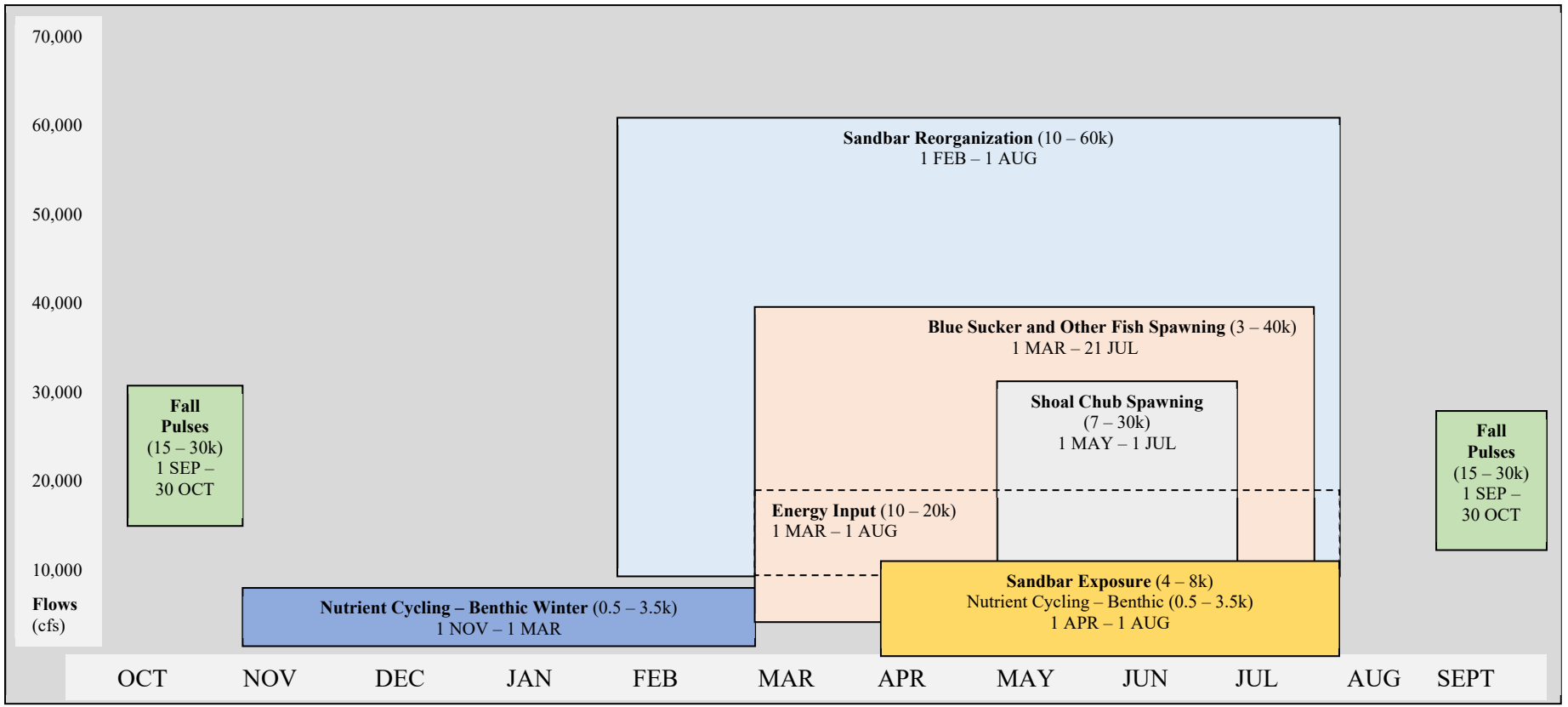

Figure 5. Kansas River SRP Unified Flow Prescriptions with Ecological Explanations for Reach 2 (Kansas River - Big Blue River Confluence to Willard, Kansas, (below Milford and Tuttle Reservoirs)
Wet/Average/Dry Combined

Table 1 lists the prescriptions developed for all water year types during the first e-flows workshop with the dates and flow columns listing the full range of the water prescriptions.

Table 1. Unified flow prescriptions developed during the first environmental-flows workshop for the Kansas River.

Flow Prescriptions	Dates	Flow (cfs)	Details, Purpose, and Benefits
Shoal Chub Spawning	1 MAY – 1 JUL	7 – 30k	• Cue spawning for shoal chub • Benefits to other species • Surrogate candidate to measure response
Blue Sucker and Other Fish Spawning	20 MAR – 21 JUL	3 – 40k	• Umbrella species • Creation of spawning habitat (clean cobbles) • Spawning cue • Attenuate flows needed to maintain recruitment habitat • Promotes habitat/channel complexity • Heterogeneous flow regime • Enhancement of spawning success
Habitat Creation	1 MAR – 1 APR	20 – 40k	• Higher flows to create scouring • Fish spawning and rearing habitat • Mussel habitat
Energy Input	20 MAR – 1 AUG	10 – 20k	• Series of pulses to discourage recruitment of perennial vegetation on bird nesting habitat • Pulls in allochthonous material and nutrients • Late season pulse (July) also provides short-term rearing habitat for young-of-year fish
Fall Pulses	1 SEP – 30 OCT	15 – 30k	• Increase production of waterfowl habitat • Inundate oxbows and backwaters
Mussel Flow Needs	5 MAR – 23 APR	4 – 11k	• High flows followed by a slow tapering decline • Reduces stranding and mortality
Sandbar Exposure	1 APR – 1 AUG	4 – 8k	• Habitat for turtle and bird nesting • Reduces chance of bird nest failure

Flow Prescriptions	Dates	Flow (cfs)	Details, Purpose, and Benefits
Sandbar Reorganization	1 FEB – 1 AUG	10 – 60k	• Reorganization of materials to create and maintain habitat • Removal of woody vegetation
Nutrient Cycling - Benthic	1 APR – 01 AUG	0.5 – 3.5k	• Mimics natural rises for the purpose of nutrient cycling and benthic success
Nutrient Cycling – Benthic Winter	1 NOV – 1 MAR	0.5 – 3.5k	• Mimics natural rises for the purpose of nutrient cycling and benthic success

6.0 Workshop Discussion

Participants were asked for input on the existing e-flow recommendations and if there are needs for any changes. Generally, participants did not voice any need for changes and agree with the current set of e-flow recommendations.

Participants offered new questions, comments, and ideas for consideration related to e-flow recommendations:

- The needs of the ecological resources in the Kansas River are not solely dependent on improvements to the magnitude of flows but also related to variation in flows and in habitat availability.
- The variables related to needs of the ecological resources are linked together. Looking at improving one single variable will not likely lead to overall improvements.
- The Kansas River historically had populations of spiny and softshell turtles. There has been substantial research done on these two species. They are not listed as federal or state threatened or endangered and they are listed as stable in Kansas but surrounding states list them as species of concern. During nesting periods there could be some e-flows needs that if improved might enhance survival of young turtles. Don Huggins, Senior Scientist, Director, Central Plains Center for BioAssessment, Kansas Biological Survey & Center for Ecological Research, can provide the data if needed for consideration under the SRP. Any information that supports the benefits of e-flows and specific needs would be welcome and could be used in implementation planning.
- Streams west of the Kansas River mainstem often experience low flow conditions. This is often the main stressor on species in the reaches downstream of the reservoirs (e.g., Kanopolis, Wilson, Waconda, Harlan County).
- Many of the fish species evaluated for the Kansas River mainstem may not occur on the extended river reaches and the environmental proposals may not be applicable. One approach could be to perform a test, then monitor, and using adaptive management, make changes to prescriptions if needed.
- The reach on the Smoky Hill River below Kanopolis Reservoir may have similar needs to those on the Kansas River mainstem. Other reaches, though, may have different flow needs and should be investigated further before hypothesizing what is needed. The work completed for the extended reaches needs to be expanded further using more specific fish species data. More research in these reaches was recommended in the future as funding and opportunity becomes available.

- The information could be compiled for the extended reaches (e.g., spawning windows) using the original data used for the Kansas River mainstem. This would offer some efficiencies in the development of the information needed to develop environmental flows.
- The group discussed the need to further discuss the monitoring plan for the Kansas River SRP e-flows. A plan will be developed for this including identification of metrics for targets and entities that could help support this effort.
- Monitoring efforts should try to include opportunities for multiple types of data collection during the same timeframes (e.g., fish data, water quality data, flows, turbidity measurements, habitat variables, macroinvertebrates).
- The U.S. Geological Survey (USGS) has continuous data collection at several locations and several new monitors were recently installed. The USACE is also currently funding monitoring for the WID project and that data could be useful for SRP implementation and monitoring efforts as well.
- Dr. Keith Gido, Kansas State University, commented that there are methods related to fish that can fairly rapidly track responses to flows (e.g., larval fish rings).
- The group agreed that the priority for next steps should be to develop the monitoring plan and determine how to monitor the effects of the e-flows.
- The group was encouraged to strive for implementation of at least one of the e-flows as soon as possible. Working for perfection can cause delays in performing actions and learning and adapting as needed.
- Potential location for oxbow restoration might be on the Kansas River mainstem just upstream of Wamego, Kansas. The SRP team has requested funding to conduct several workshops and a baseline assessment for potential reconnection of this oxbow with the Kansas River. Silver Lake Oxbow, adjacent to the Kansas River mainstem, is also disconnected and is becoming silted in with little deep-water habitat. There are also other oxbows that could be reconnected if the opportunity arose. The USACE is meeting with the Lakeview Association to discuss opportunities for habitat improvement at the Lakeview Hunting Association oxbow in the next several months SRP could look at the flows that would be needed to support reconnection and functionality of a restored oxbow.

7.0 Next Steps in the SRP Process

Depending on funding and workload availability of partners, the team plans to pursue the following next steps:

- Initiate discussions to implement prescribed flow pulses for ecological benefits to native aquatics and birds that fall within USACE current operational flexibility.
- Work with USACE to incorporate SRP considerations into the WCM process.
- Using information from the WID demonstration look for opportunities/synergies to couple discharges of sediment with downstream benefits.
- Coordinate with operations/water managers and stakeholders to develop an implementation and monitoring plan.

- TNC and the USACE will update stakeholders as implementation and monitoring plans are developed.

8.0 Literature Cited

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TNC and USACE. 2021 Environmental Flows Recommendations Workshop Summary. Kansas River Sustainable River Program. December 2021.

Appendix A: Agenda and Presentation

Kansas River SRP
Environmental Flows Workshop

October 28, 2022

Webex Meeting

https://usace1.webex.com/usace1/j.php?MTID=m2d10c47bea7337f32cf283382cd25e58

(If you are unable to access the meeting by directly selecting the link above
copy and paste the link directly into your browser)

844-800-2712

Meeting Number: 2762 130 2107

Meeting Password: PJaqmP7w*93

AGENDA

October 28, 2022

9:00 Welcome and Introductions – U.S. Army Corps of Engineers and The Nature Conservancy

9:05 Review of SRP Process – Laura Totten, U.S. Army Corps of Engineers; Heidi Mehl, The Nature Conservancy

9:10 Meeting Outcomes – Laura Totten, U.S. Army Corps of Engineers; Heidi Mehl, The Nature Conservancy

- Review of environmental flow hypotheses developed for the Kansas River during the 1st E-Flows Workshop and determine if these are appropriate or if any changes are needed.
  - The existing environmental flow hypotheses consider a range of species, communities, and ecological processes (fish, birds, other aquatic species, riparian and floodplain systems, nutrient cycling, habitat processes, energy input).
- Discuss ideas for environmental flow hypotheses for extended reaches (i.e., Smoky Hill, Saline, Solomon, Republican). Are there opportunities to enhance benefits via pool-level or flow manipulations related to the selected habitats, target species, or riverine processes.
- Groups should think about the location, timing, magnitude, duration, and rate of change of flow for the Environmental Flow Components.
- Discuss new ideas – Oxbow Restoration, In-Lake Restoration
- Provide thoughts on next steps – Implementation and Monitoring Strategy, Outreach and Coordination

9:20 Science Report Revisions – Laura Totten, U.S. Army Corps of Engineers

- Expansion of the geographic scope to include Kanopolis, Wilson, Harlan County, and Waconda Reservoirs and the extended reaches to these reservoirs.
- Reaches added include:

    - Smoky Hill River downstream of Kanopolis Reservoir
    - Saline River downstream of Wilson Reservoir
    - Solomon River downstream of Waconda Reservoir
    - Big Blue River downstream of Tuttle Creek Reservoir
    - Republican River downstream of Harlan County Reservoir
- Literature expanded to:
    - Identify and quantify ecological resources, basin characteristics, river morphology, and the information to establish period of record flow benefits
- Sediment and Turbidity and Effects to Fish

9:45 Water Control Manual Updates – Laura Totten and Paul Simon, U.S. Army Corps of Engineers

10:00 Tuttle Creek Reservoir Water Injection Dredging Demonstration – Laura Totten, U.S. Army Corps of Engineers

10:15 Smoky Hill River Ecosystem Restoration – Salina, Kansas – Seth Lerman, U.S. Army Corps of Engineers

10:20 Recap of Science Report Findings and Recommendations

10:30 1st E-Flow Workshop and Current E-Flow Proposals, E-Flow Proposals for Extended Reaches, New Ideas (Oxbow Restoration and In-Lake Restoration)

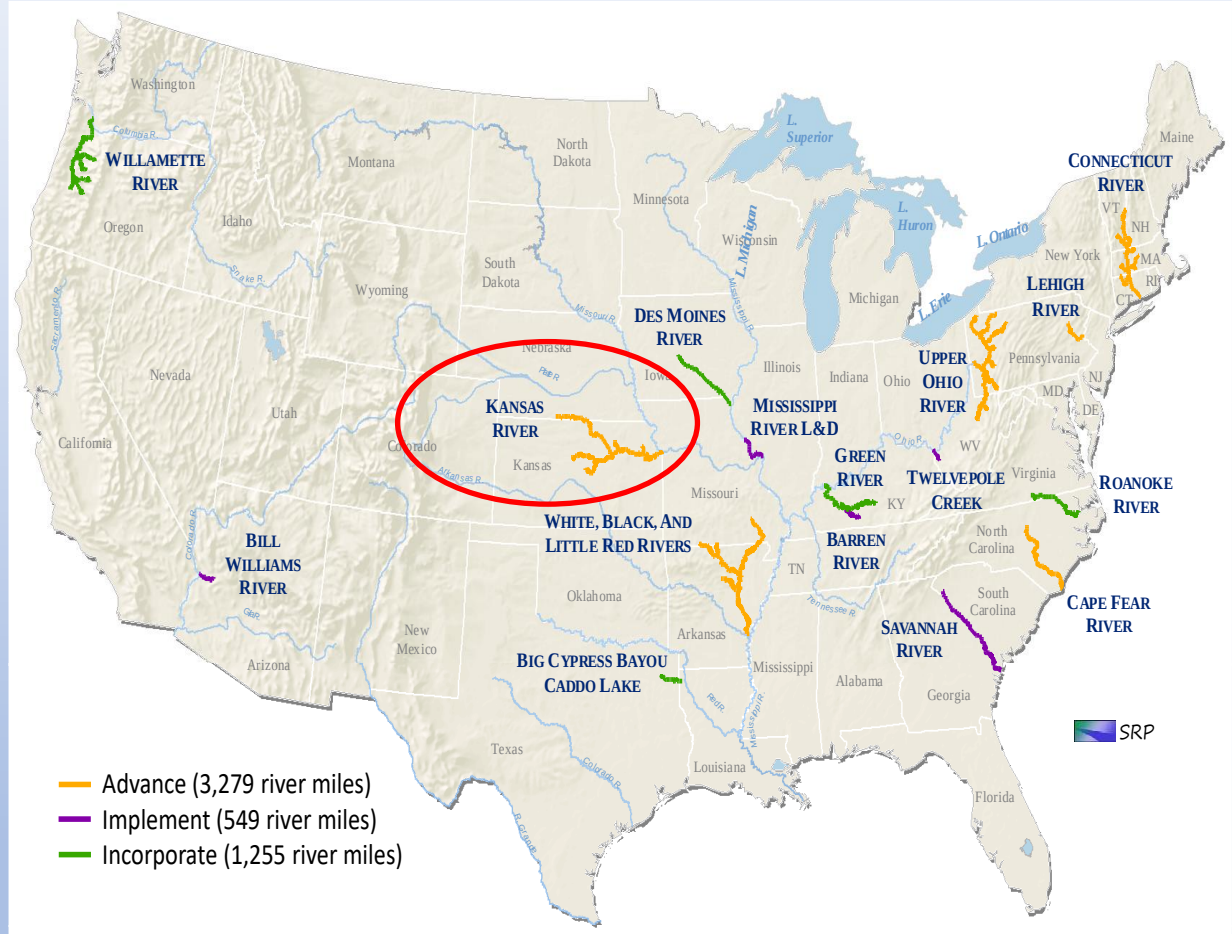
11:50 Next Steps

12:00 Adjourn

Kansas River Sustainable Rivers Project

2nd E-Flows Workshop
October 28, 2022

Heidi Mehl, The Nature Conservancy
Laura Totten, US Army Corps of Engineers



Kansas River Sustainable Rivers Project

Agenda

- Welcome and Introductions
- Review of SRP Process
- Meeting Outcomes
- Science Report Revisions
- Water Control Manual Updates and Reservoir Operations
- Tuttle Creek Reservoir Water Injection Dredging Demonstration
- Smoky Hill River Ecosystem Restoration Project
- Recap of Science Report Findings and Recommendations
- 1st E-Flows Workshop and Current E-Flow Proposals
- Discuss E-Flow Proposals for Extended Reaches
- New Ideas – Oxbow Restoration and In-Lake Restoration
- Next Steps

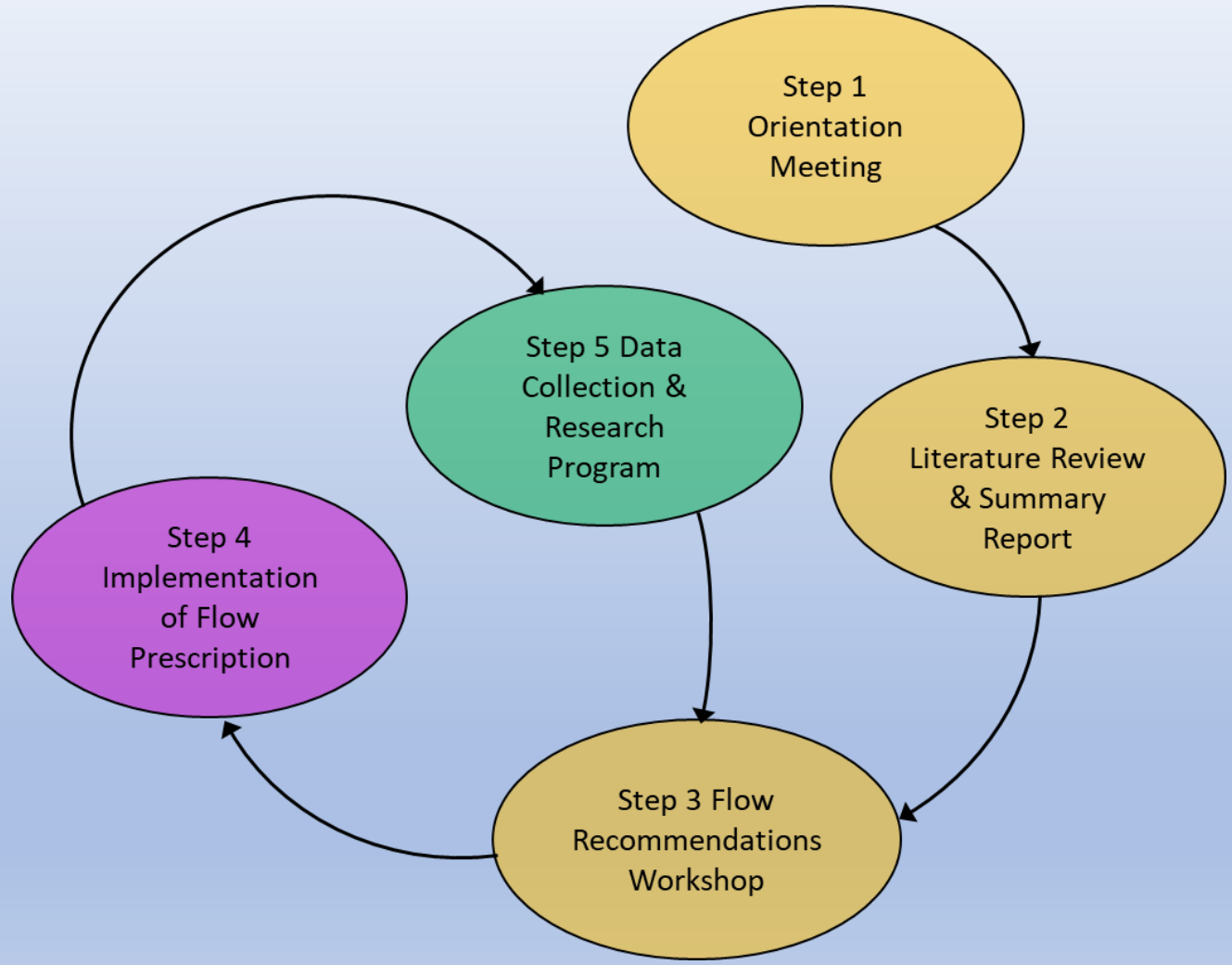
Sustainable Rivers Program

(Advance – Implement – Incorporate)

The SRP process for environmental flows has three phases: "advance, implement, and incorporate".

- **<u>Advancing</u> e-flows involves engaging stakeholders in a science-based process to define the flow needs of riverine ecosystems.**
- **<u>Implementation</u> involves testing the effectiveness and feasibility of the defined flows.**
- **<u>Incorporation</u> involves including environmental flow strategies in reservoir operations policy such as water control manuals.**

Environmental flows were the founding objective of SRP and remain the key focus. In recent years, the Program began exploring other reservoir-oriented actions with potential to produce environmental benefits.



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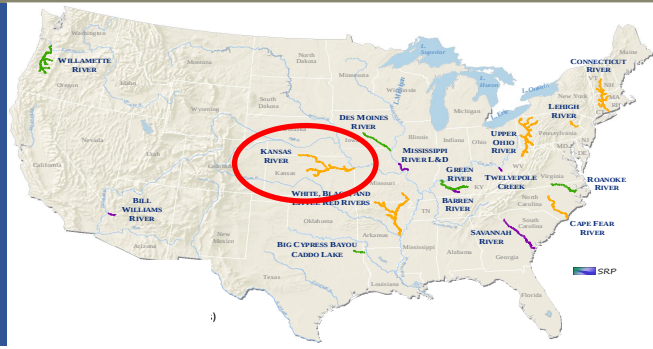
TNC in Kansas



Meeting Outcomes

- Review of environmental flow hypotheses developed for the Kansas River during the 1st E-Flows Workshop and determine if these are appropriate or if any changes are needed.
  - The existing environmental flow hypotheses consider a range of species, communities, and ecological processes (fish, birds, other aquatic species, riparian and floodplain systems, nutrient cycling, habitat processes, energy input).
- Discuss ideas for environmental flow hypotheses for extended reaches (i.e., Smoky Hill, Saline, Solomon, Republican). Are there opportunities to enhance benefits via pool-level or flow manipulations related to the selected habitats, target species, or riverine processes.
- Groups should think about the location, timing, magnitude, duration, and rate of change of flow for the Environmental Flow Components.
- Discuss new ideas – Oxbow Restoration, In-Lake Restoration
- Provide thoughts on next steps – Implementation and Monitoring Strategy, Outreach and Coordination

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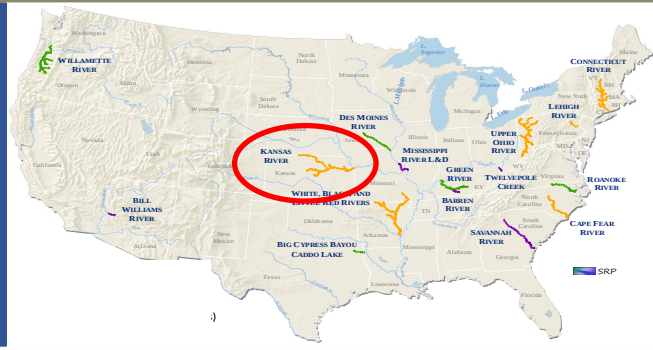

Science Report – Revisions

- Expansion of the geographic scope to include Kanopolis, Wilson, Harlan County, and Waconda Reservoirs and the extended reaches to these reservoirs.
- Reaches added include:
  - Smoky Hill River downstream of Kanopolis Reservoir
  - Saline River downstream of Wilson Reservoir
  - Solomon River downstream of Waconda Reservoir
  - Big Blue River downstream of Tuttle Creek Reservoir
  - Republican River downstream of Harlan County Reservoir
- Literature expanded to:
  - Identify and quantify ecological resources, basin characteristics, river morphology, and the information to establish period of record flow benefits
- Sediment and Turbidity and Effects to Fish

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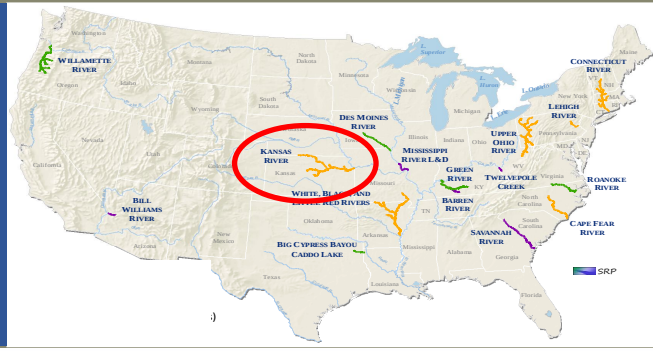
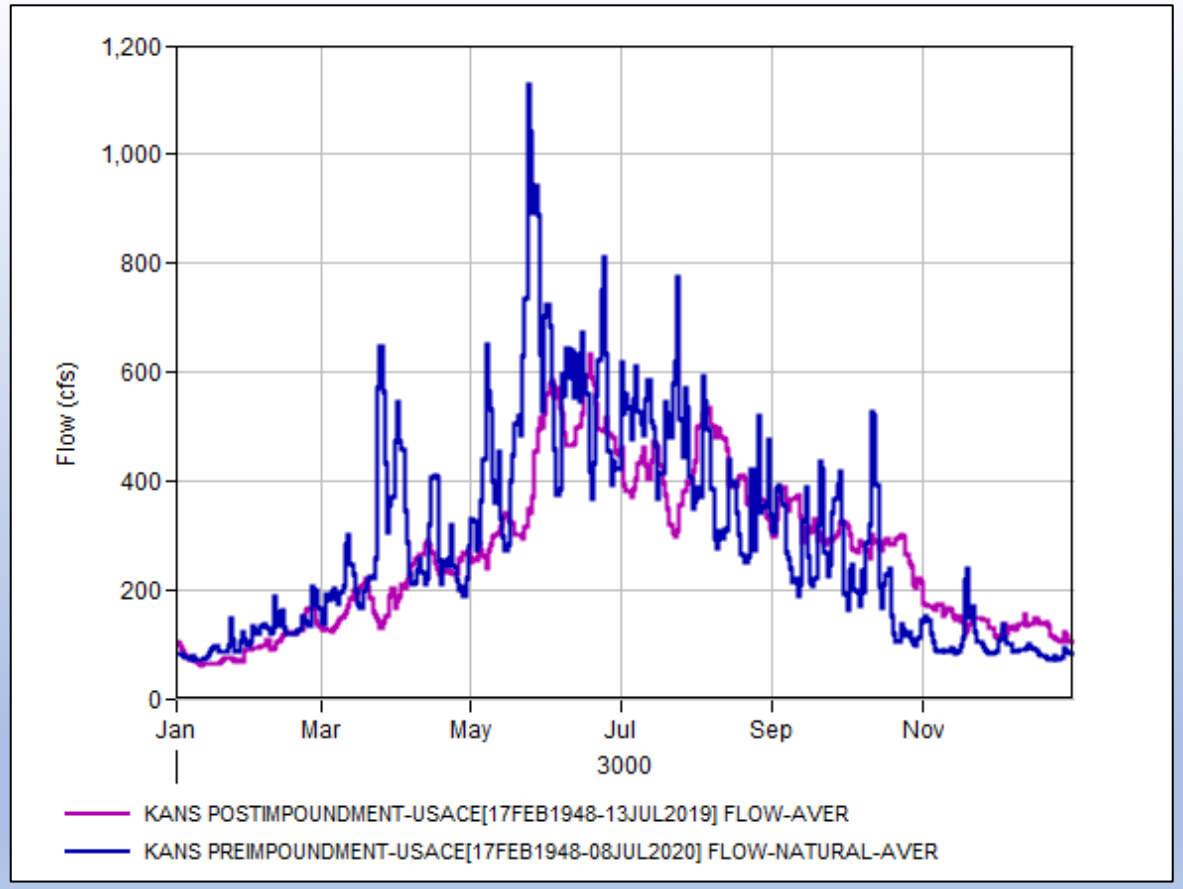
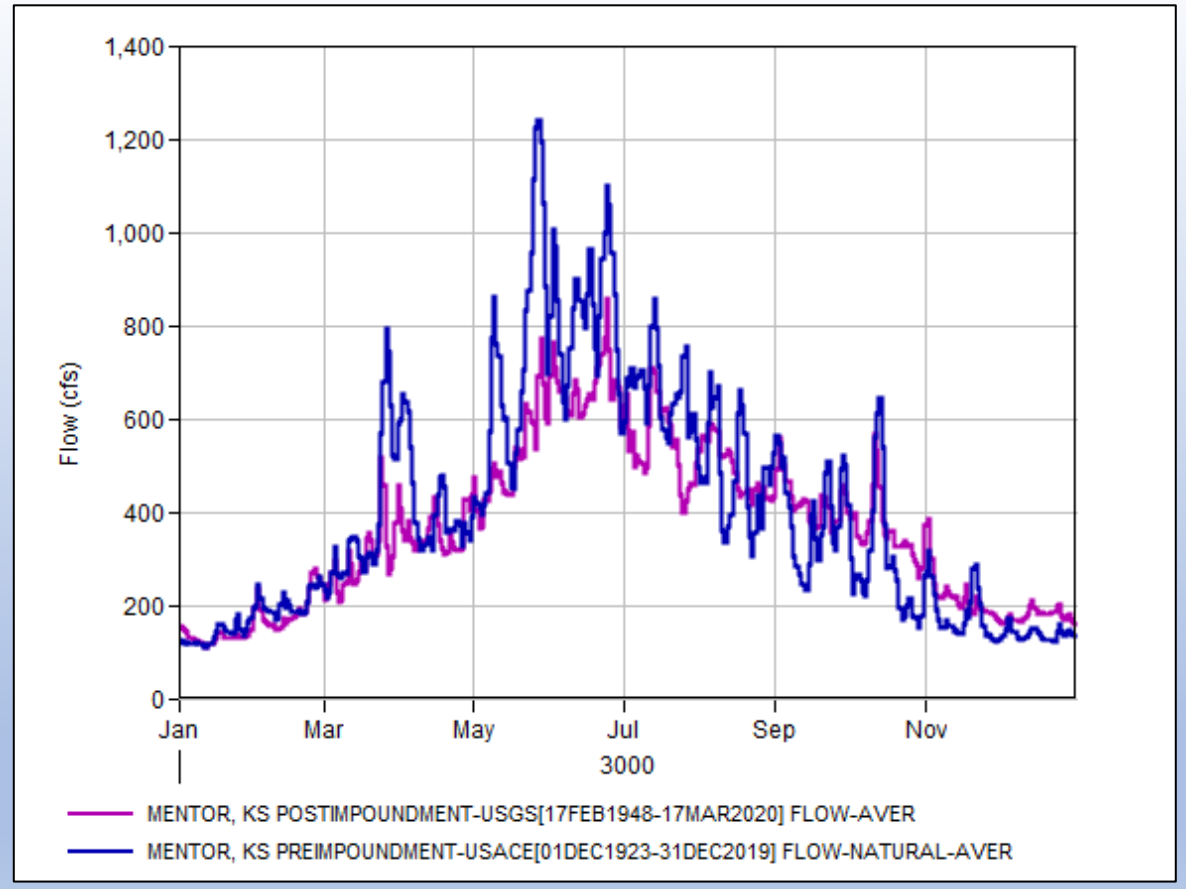


Assessment of Pre- and Post Impoundment Flows of Extended Reaches



Smoky Hill River Flows at Kanopolis Reservoir
Pre- and Post Impoundment



Smoky Hill River Flows at Mentor, KS
Pre- and Post Impoundment

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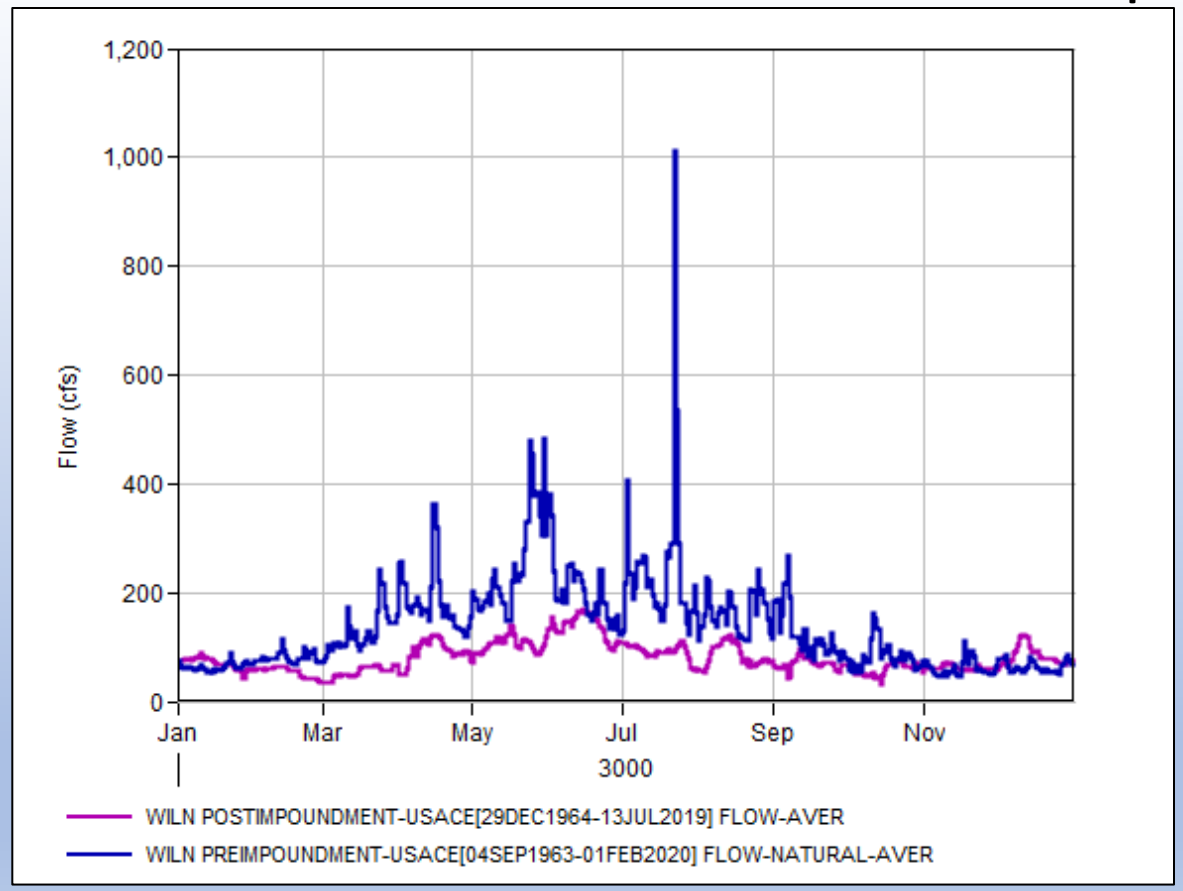
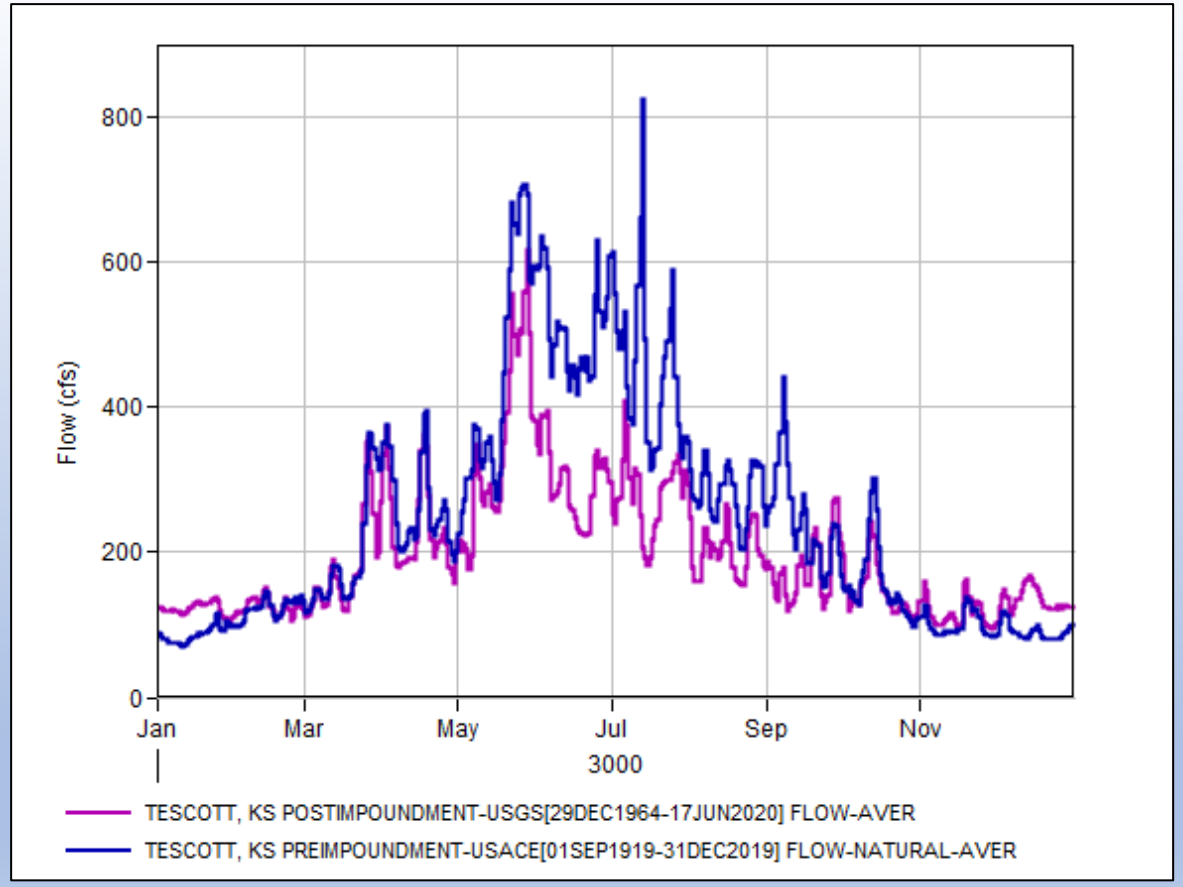
Assessment of Pre- and Post Impoundment Flows of Extended Reaches



Saline River Flows at Wilson Reservoir
Pre- and Post Impoundment



Saline River Flows at Tescott, KS
Pre- and Post Impoundment

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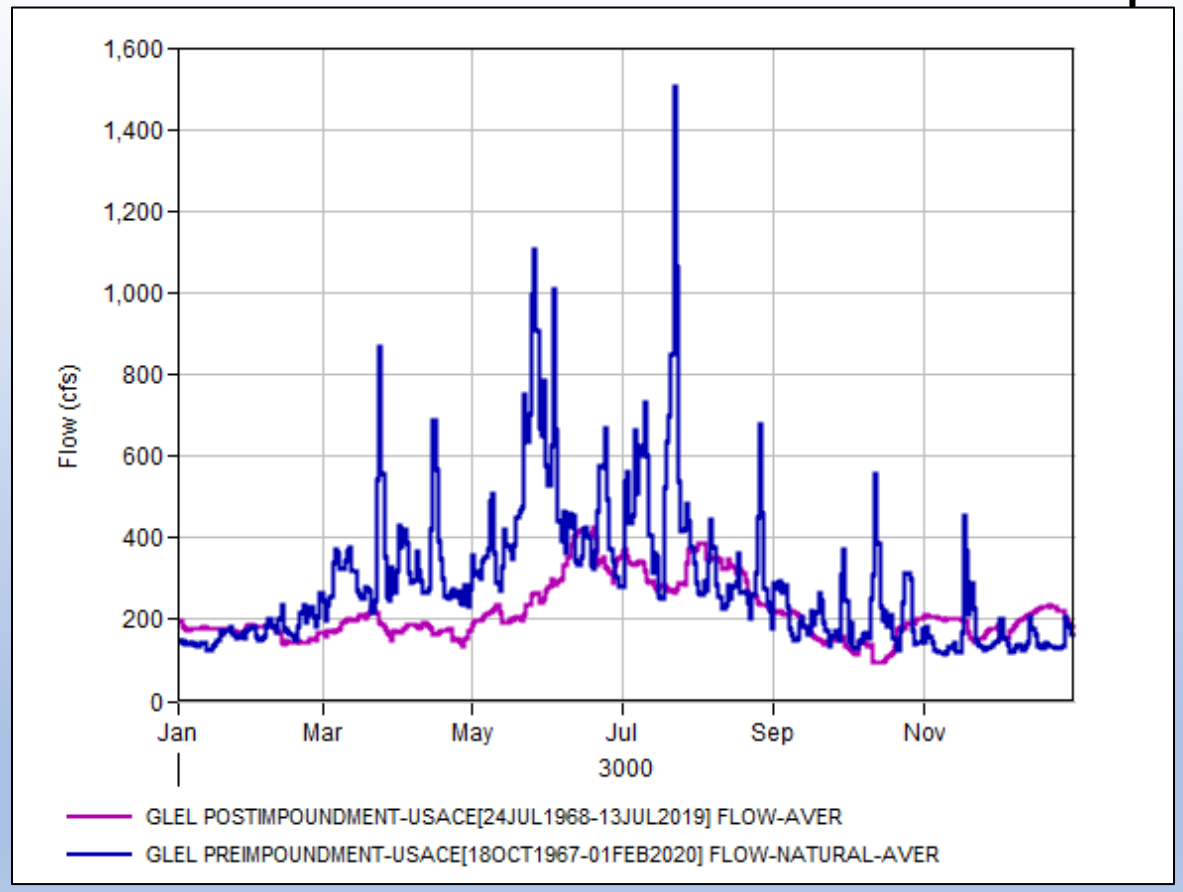
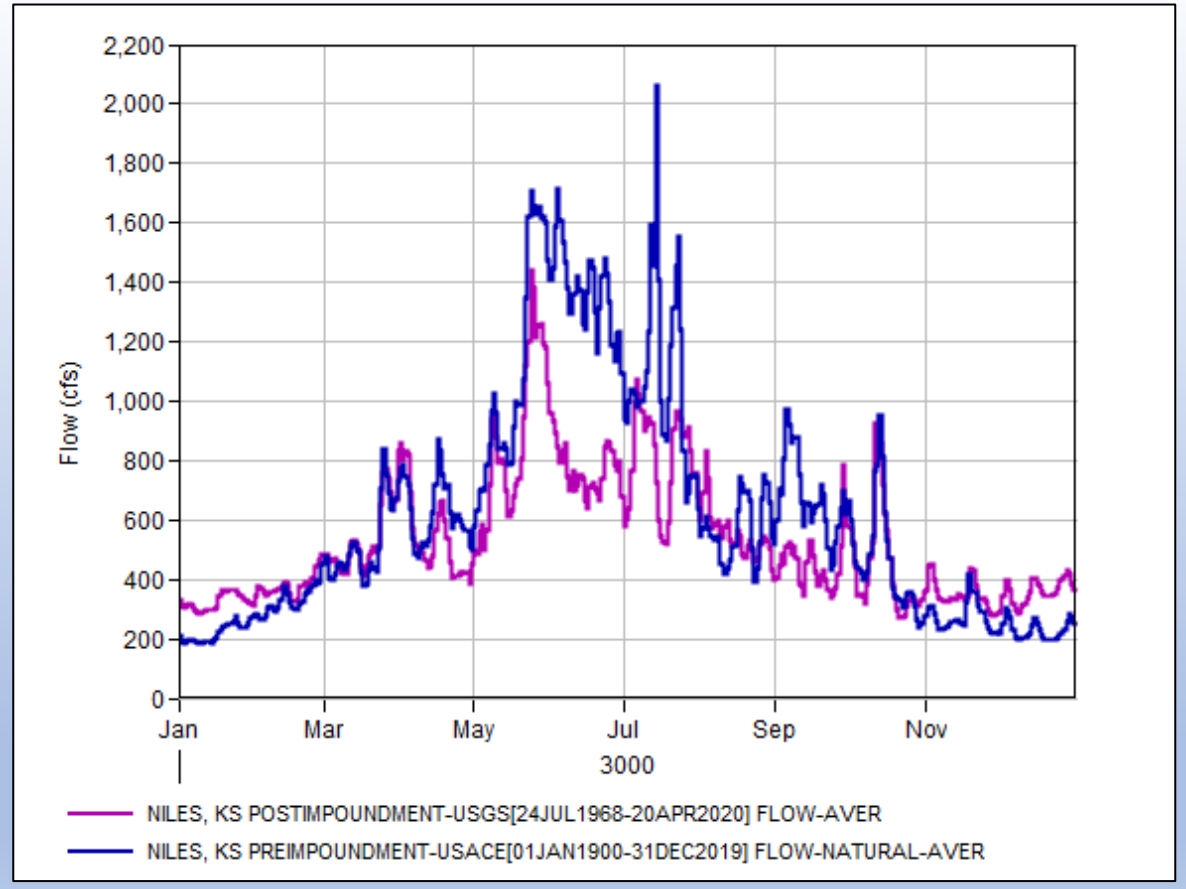
Assessment of Pre- and Post Impoundment Flows of Extended Reaches



Solomon River Flows at Waconda Reservoir
Pre- and Post Impoundment



Solomon River Flows at Niles, KS
Pre- and Post Impoundment

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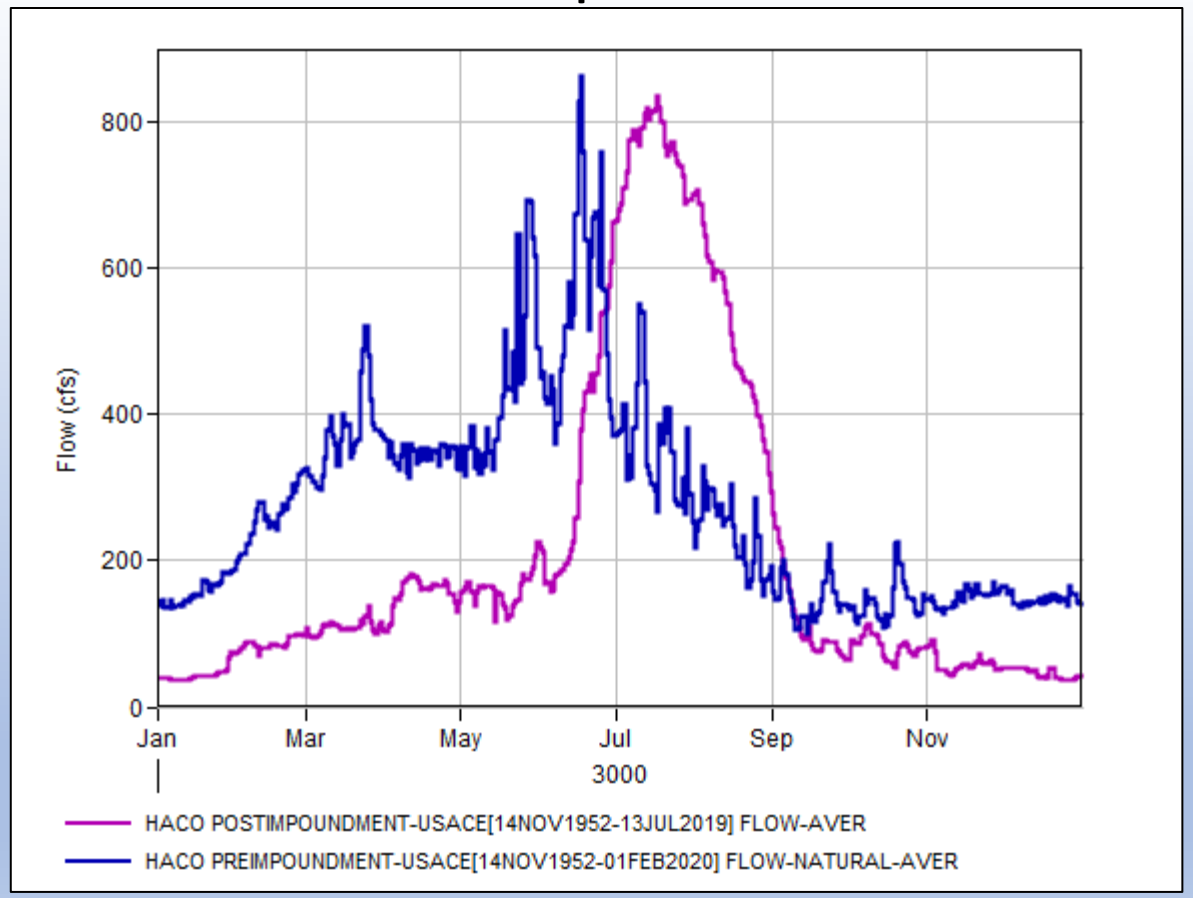
Assessment of Pre- and Post Impoundment Flows of Extended Reaches



Republican River Flows at Harlan Reservoir
Pre- and Post Impoundment

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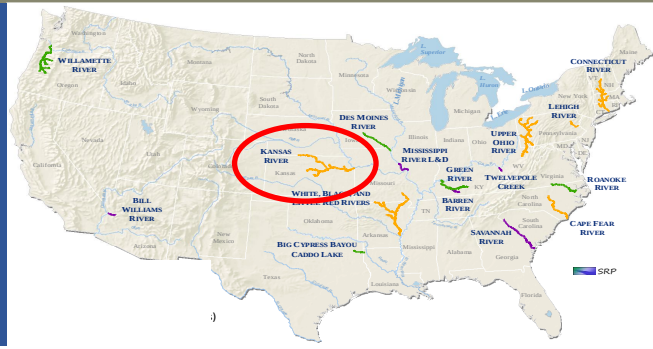
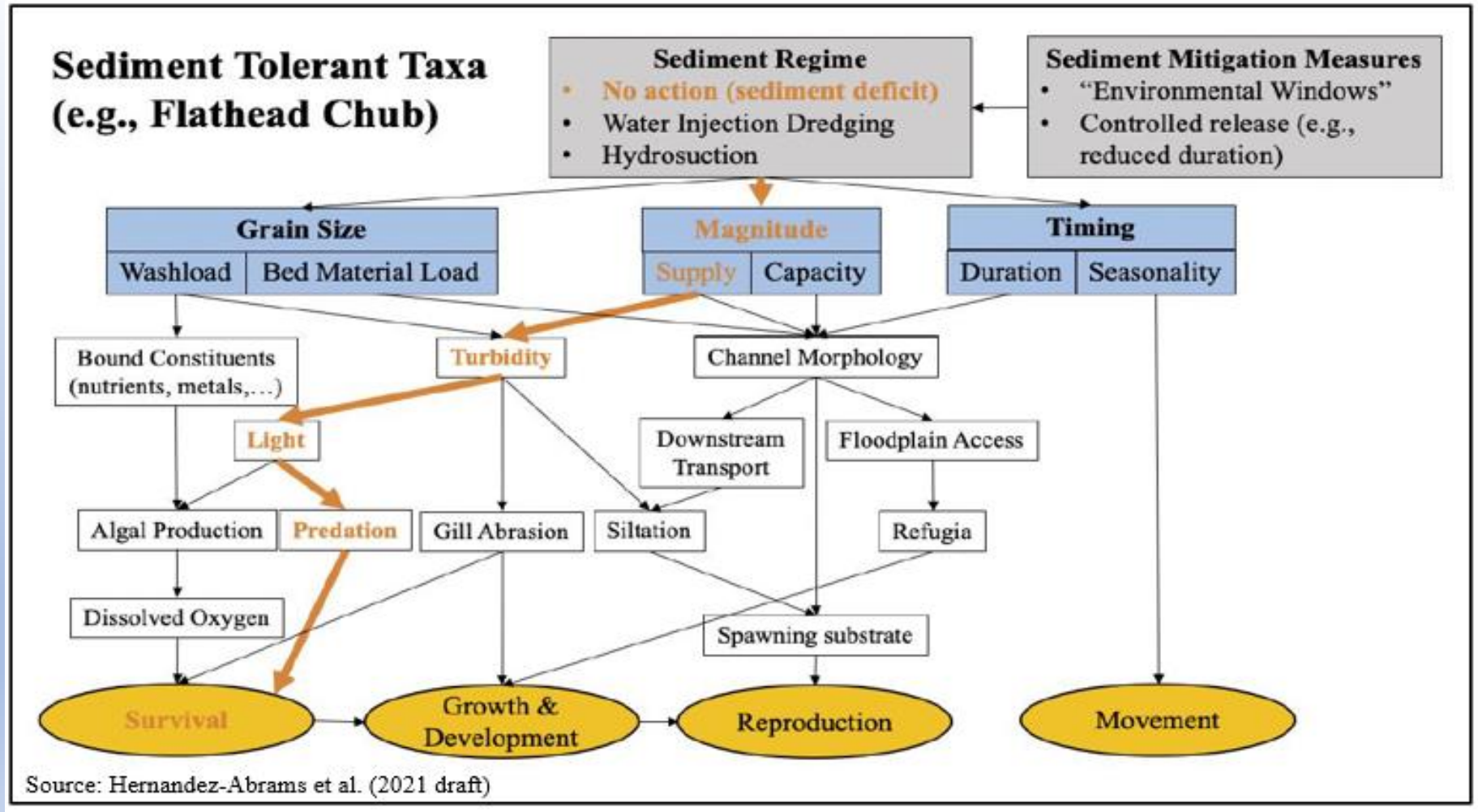


Sediment and Turbidity and Effects to Fish



Source: Hernandez-Abrams et al. (2021 draft)

Sediment Tolerant Fish
These species could increase from increases in turbidity

Hernandez-Abrams Conceptual Models

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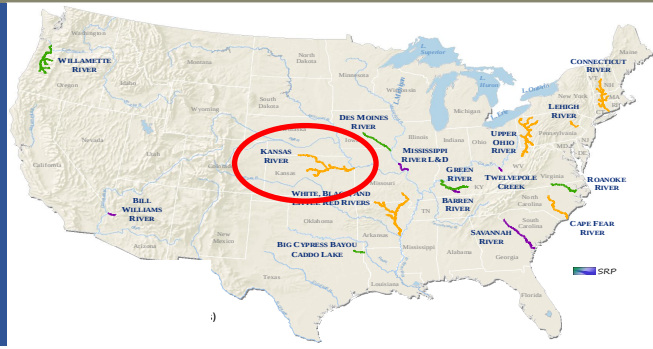
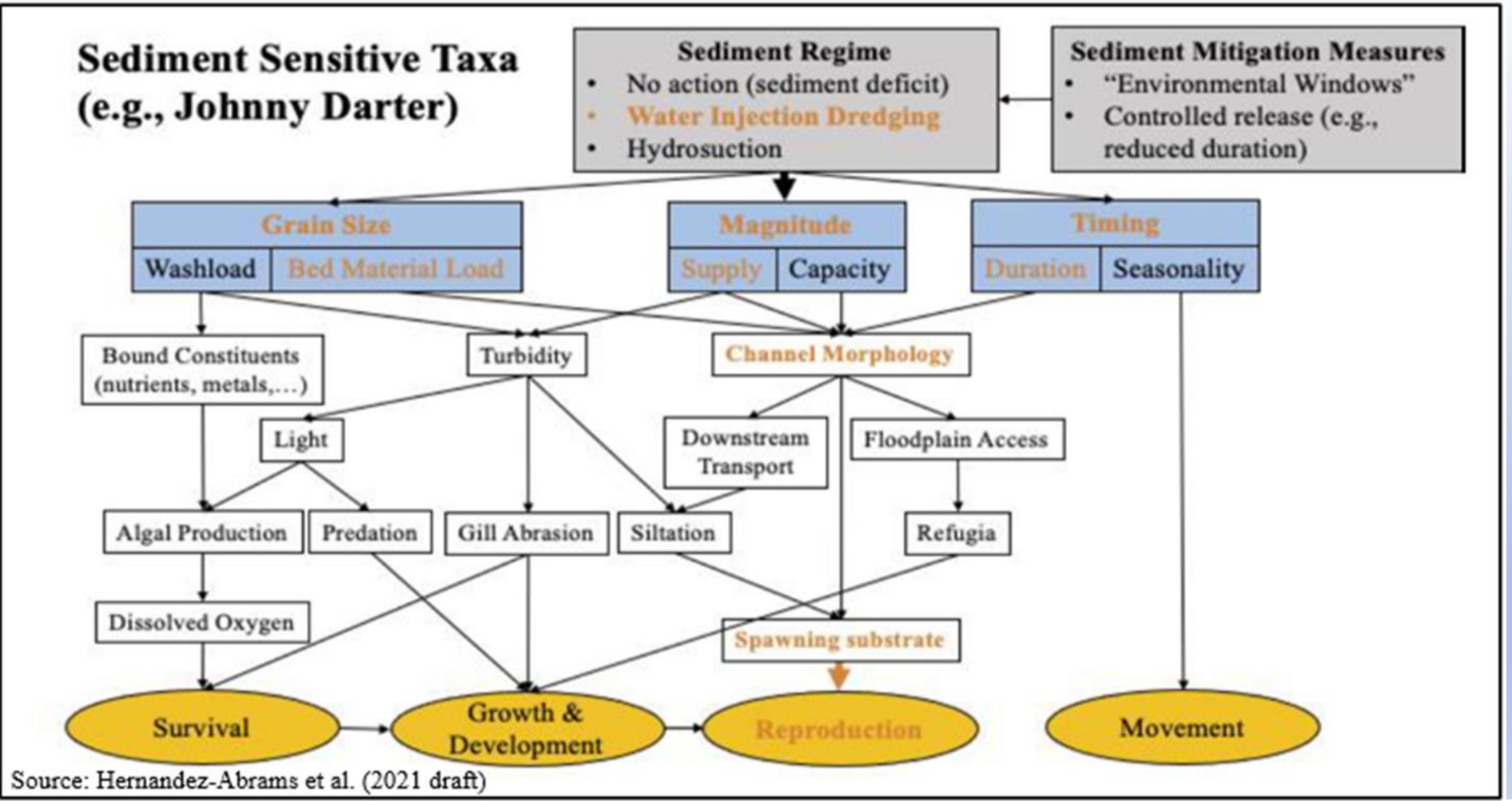


Sediment and Turbidity and Effects to Fish



Source: Hernandez-Abrams et al. (2021 draft)

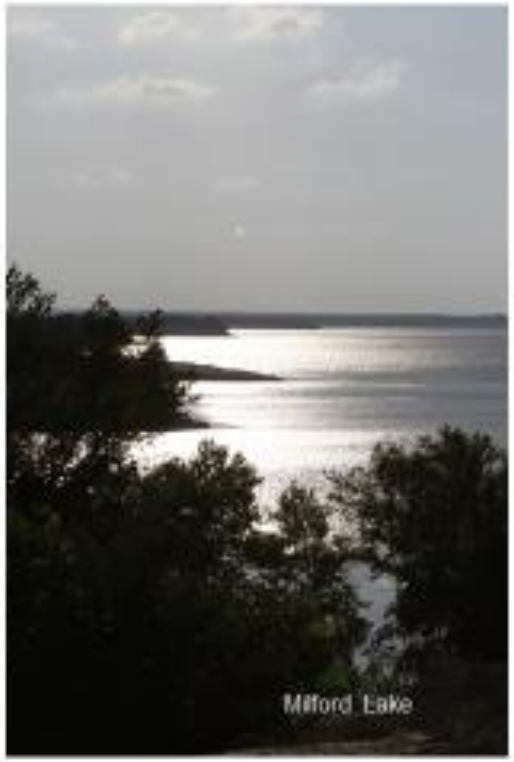
Sediment Sensitive Fish
These species could decline from increases in turbidity

Hernandez-Abrams Conceptual Models

WATER CONTROL MANUAL PROJECTS (10 LAKES)

Project Highlights

1. 10 Project Sites – Kansas River Watershed; Osage River Watershed
2. Total budget - $9.7 mil
3. Anticipated end date FY27



Water Control Manual Updates

Flood Risk Management

- Modeling and analysis to account for changes in land use, population, river systems
- Changes Phased Releases necessary to reflect?

NEPA

- Public Outreach Communication, and Participation
- Environmental Conditions

Drought Contingency (New)

- Identify when drought conditions begin
- Incorporate rules that will then conserve water
- Identify when to return to normal operating rules
- Create a coordination and communication plan to provide guidance during implementation
- Include a public information program

Water Control Manual Updates

Date	Task
Group 1 – Tuttle Creek, Perry, Milford, Clinton Reservoirs	
01 Oct 2022	Initiate Group 1 Work
Sep 2025	Begin to Finalize EA and WCM – Group 1
Group 2 – Pomona, Melvern, Hillsdale Reservoirs	
01 Oct 2023	Initiate Group 2 Work
Mar 2026	Begin to Finalize EA and WCM – Group 2
Group 3 – Wilson and Kanopolis Reservoirs	
Apr 2024	Initiate Group 3 Work
Mar 2026	Begin to Finalize EA and WCM – Group 3
Group 4 – Harlan Reservoirs	
Apr 2024	Initiate Group 4 work
Mar 2026	Begin to Finalize EA and WCM – Group4
Sep 2027	**All work completed**

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Reservoir Management in the Kansas River Basin

- USACE reservoirs operated for specific congressionally authorized purposes and operated according to rules and regulations of specific Water Control Manuals
- Operations include three main categories: multipurpose, flood control and Surcharge
- Critical drinking water supply for more than 600,000 people
- Flows also used for irrigation, municipal wastewater and industrial discharges, and power generation
- USACE works to seasonally fluctuate reservoir elevations to benefit fish and wildlife purposes (when flooding is not occurring)
- Minimum releases maintained for the purpose of sustaining water quality

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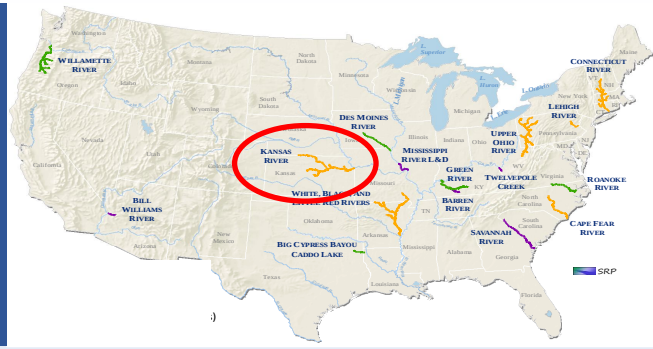

USACE Reservoirs Authorized Purposes

Reservoir	Flood Control	Water Supply	Water Quality	Fish and Wildlife	Recreation	Navigation	Hydropower	Irrigation
Kanopolis	X	X	X	X	X	*	*	*
Wilson	X		X	X	X	*		*
Harlan County	X			X	X			X
Milford	X	X	X	X	X	X		
Tuttle Creek	X	X	X	X	X	X		
Perry	X	X	X	X	X	X		
Clinton	X	X	X	X	X			

* Authorized purpose, not operating purpose

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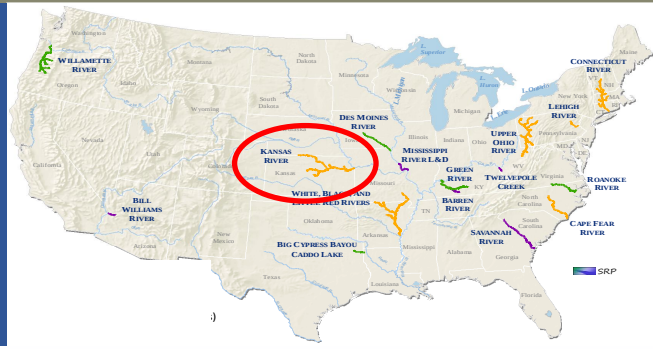
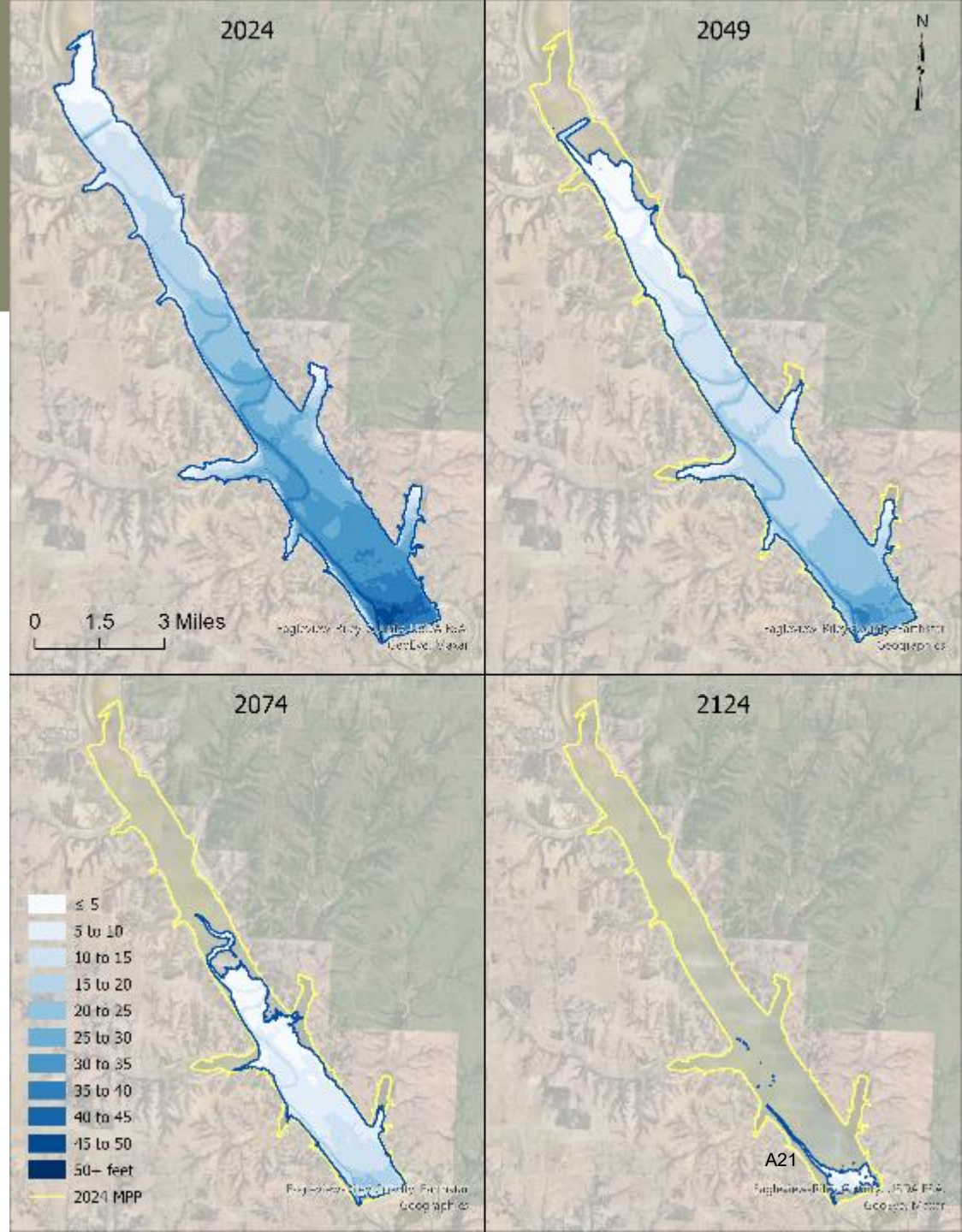


USACE Water Level Management Plans

- Low winter level for ice control and to provide additional buffer storage for large winter and spring inflows
- Slow pool rise in the spring to enhance fish spawn
- Late spring and summer pool maintained close to the multipurpose pool level to enhance recreation and maximize flood control benefits during the wet season
- Late summer/early fall pool may be lowered to enhance shoreline vegetation growth
- Late fall pool is allowed to rise when water is available to inundate the vegetation growth and maximize waterfowl habitat
- Late December pool is lowered to its winter level

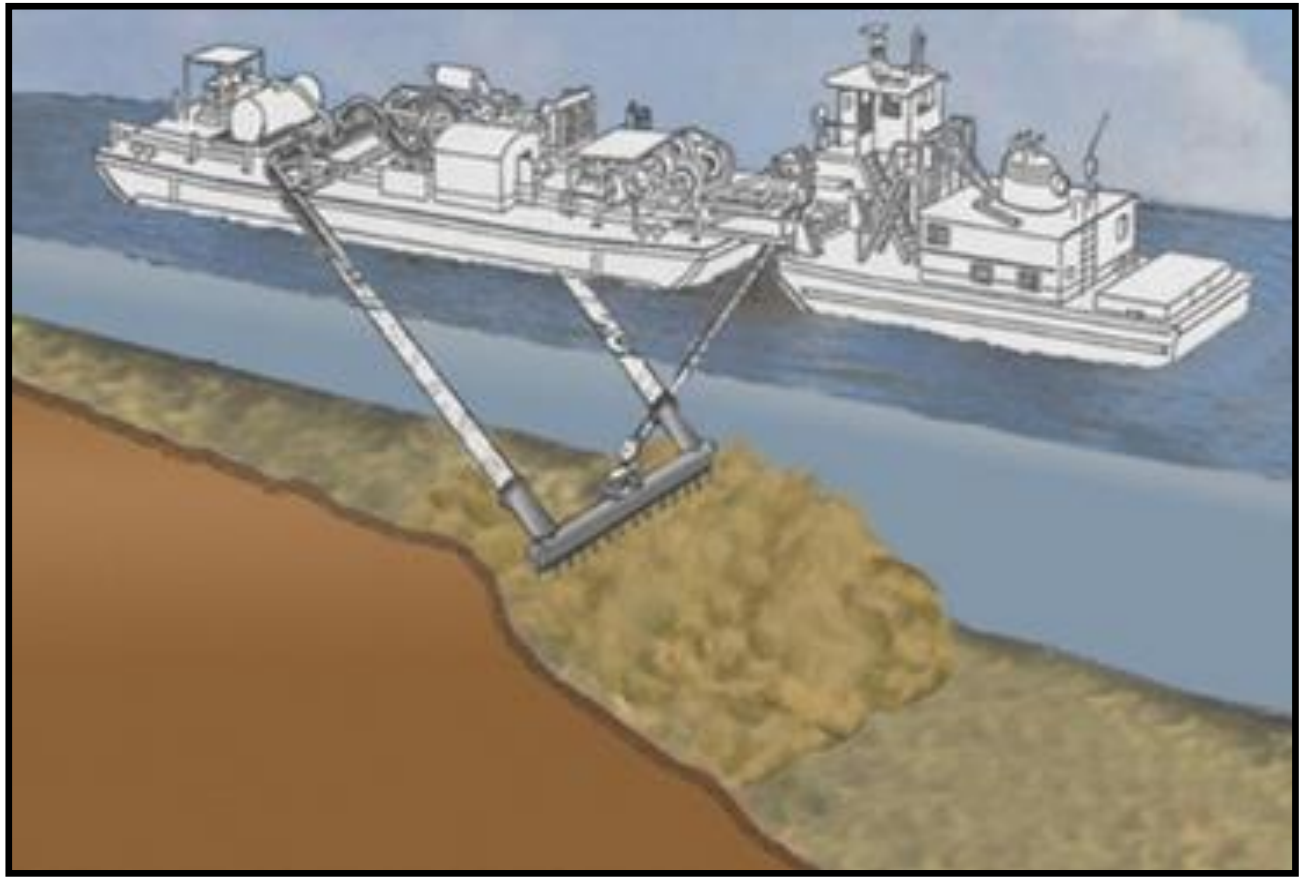
Tuttle Creek Reservoir Water Injection Dredging Demonstration

- Since 1962, 438 million cubic yard of sediment have accumulated, displacing 62,000 acre-feet of storage for flood control and 209,000 acre-feet of storage for navigation, water supply, ecological, and other uses
- Sediment has buried boat ramps, cut off habitat in coves, and led to abandonment of water intakes
- Approximately 5.8 million cubic yards of sediment accumulates in Tuttle per year
- Estimates indicate that by 2049, the multi-purpose pool will be 64% full of sediment and by 2074 only 25% of the original capacity would remain



Tuttle Creek Reservoir
Water Injection Dredging Demonstration

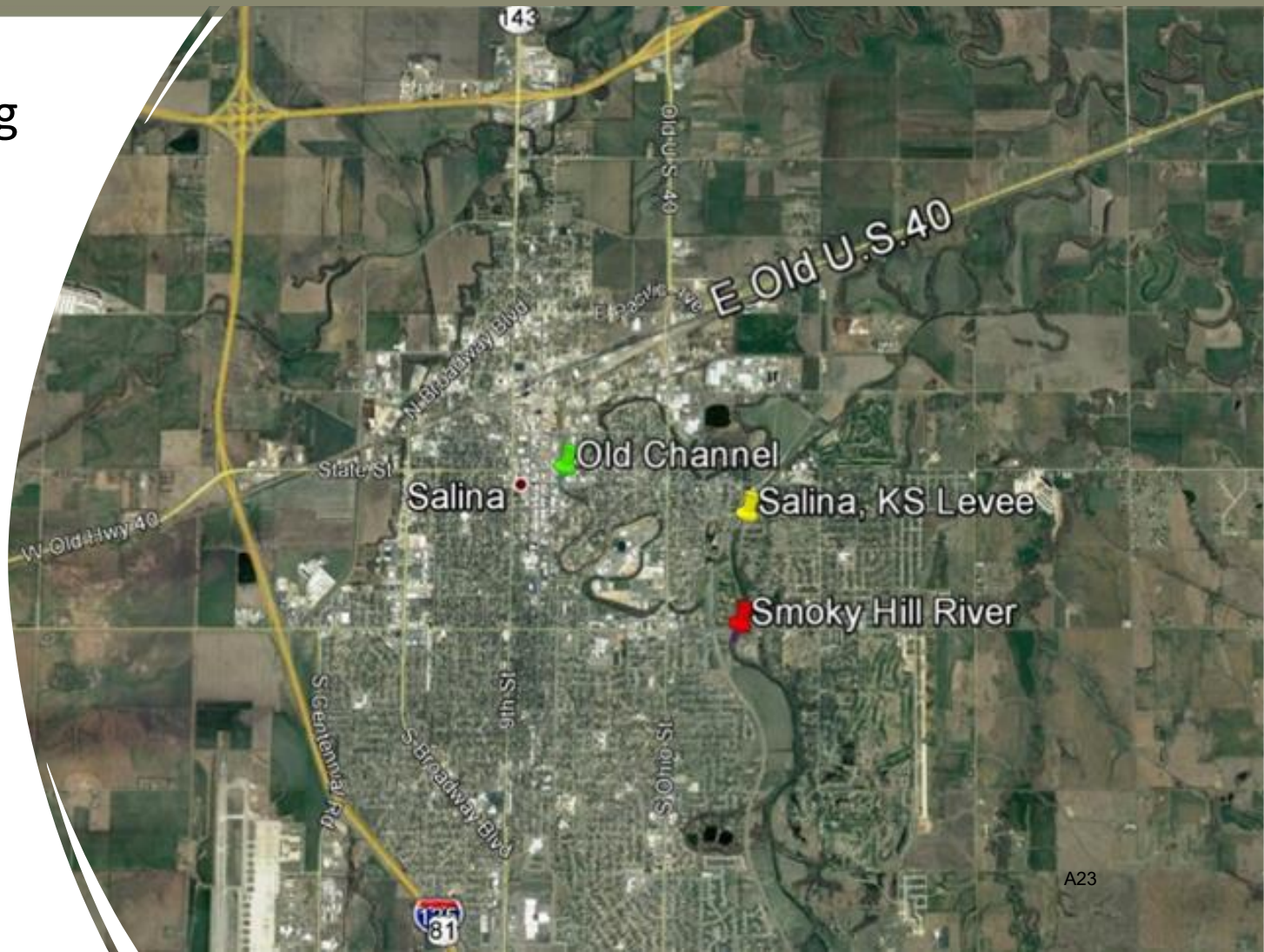
- State and Federal funding to buy a water injection dredge and perform a demonstration at Tuttle Creek Reservoir
- Will test the effectiveness of WID technology at a range of downstream discharges, pool elevations, and in-reservoir locations for potential long-term implementation
- Pre, during, and post-WID demonstration monitoring and evaluation for WID effectiveness, environmental affects (beneficial and adverse), and human considerations



Smoky Hill River Ecosystem Restoration Salina, KS

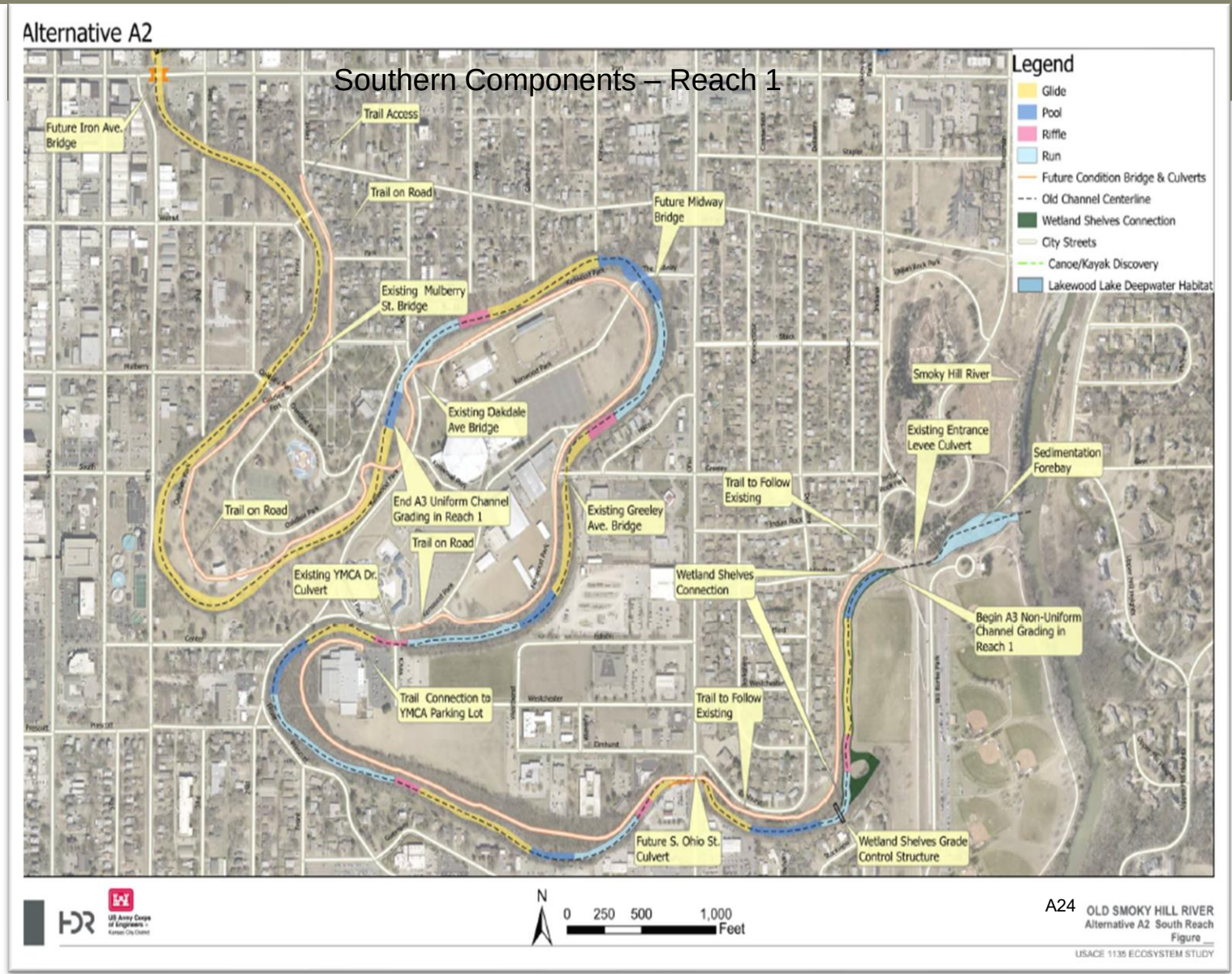
- Feasibility Study with Environmental Assessment under the USACE Continuing Authorities Program
- Restoration of aquatic habitat functions and features within and near the Old Channel that were lost as a result of the Flood Risk Management project:
  - Base Flow
  - Aquatic Connectivity and Habitat Functions
  - Wetland and Riparian Habitats
  - Whole System Functions

Project Sponsor: City of Salina, KS



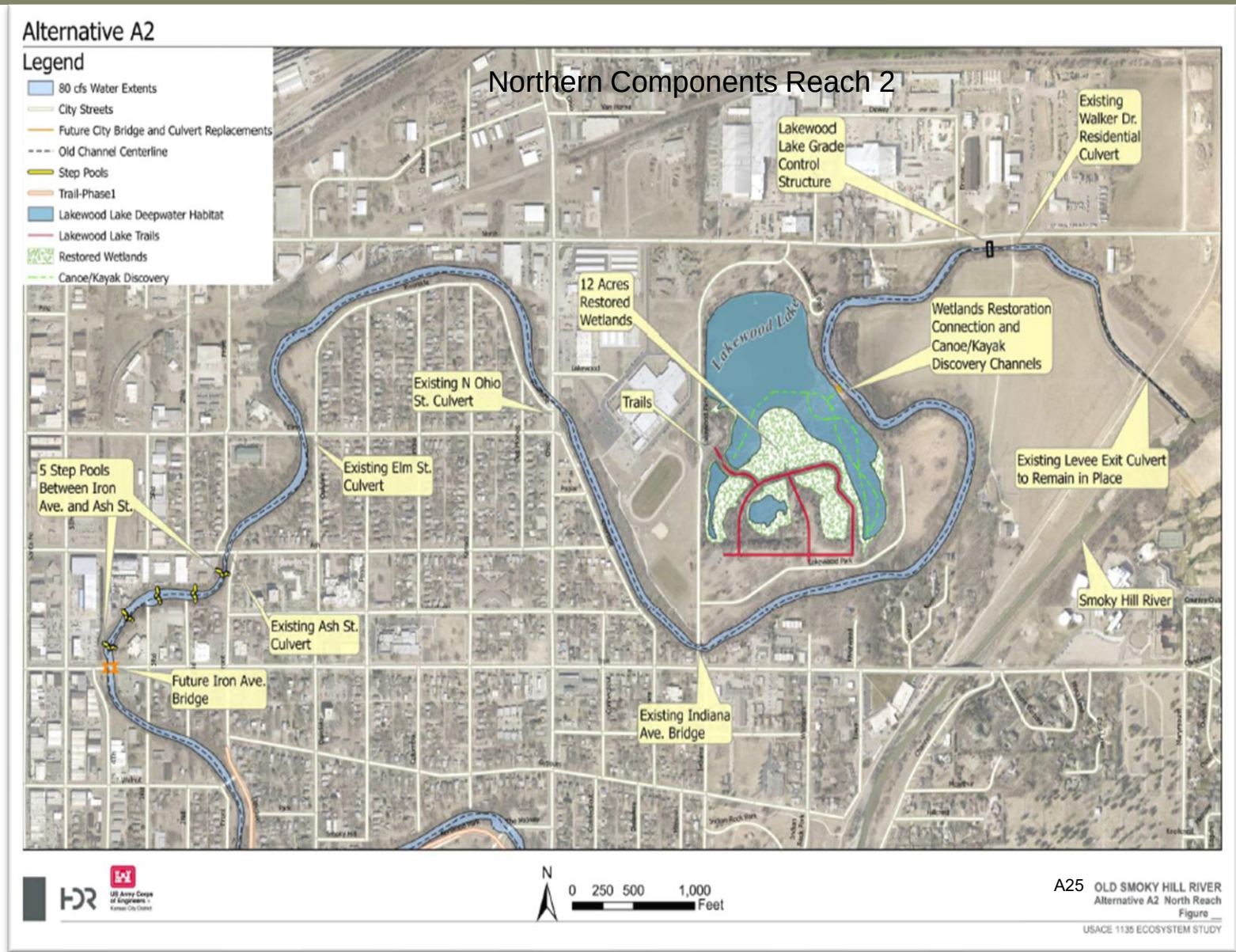
Smoky Hill River Ecosystem Restoration
Salina, KS

- Channel Dredging Reach 1 – Variable Section and Depth Profile (Glide/Pool/Riffle/Run)
  - Sediment Forebay (Inlet Area)
    - Sediment Forebay at the existing levee entrance culvert to remove coarse settleable sediment
  - Old Channel Connected Wetland Shelves
    - Created below the levee entrance culvert
  - Lake Wood Lake –Restored/Created Connected Wetland



Smoky Hill River Ecosystem Restoration
Salina, KS

- Pool Habitat Reach 2
  - Dredge excess sediment - Reach 1, upstream of the Western Star Mill Weir;
  - Pool Habitat in Reach 2 created by a two-foot tall weir
  - Remove and replace Western Star Mill Weir with Five Step Pools
  - Remove sediment filled South Ohio Street Culvert (replacement at City cost) to maintain positive downslope water gradient



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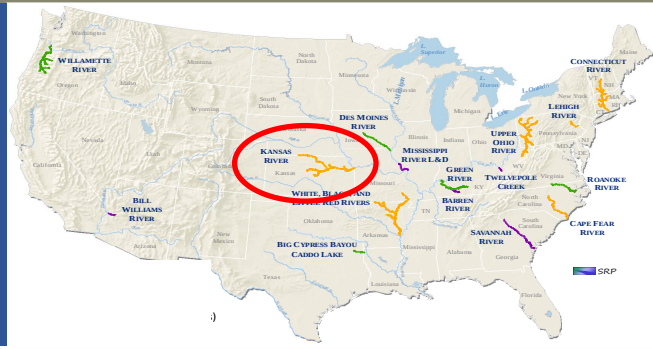

A Sample of the Ecology Section: Fish Flow Needs

- Summary of findings (observations by Sanders et al. (1993) as cited in the science report):
  - The Kansas River is becoming less turbid.
  - Regulated flows have caused spatial and temporal changes in stream flow and the nature of the stream bed.
  - Indigenous fish were tolerant of great fluctuations in discharge, shifting sand substrate, high turbidity. Shovelnose sturgeon, chub species (*Platygobio* and *Macrhybopsis*), plains minnow, western silvery minnow, and river carpsucker are especially adapted to these conditions due to their tactile and chemical sensory systems.
  - Large, sight-feeding piscivores were rare or absent, and gars and catfish were the main predators.
  - Turbid river species were more prevalent until mid-20th century, and then were replaced by planktivores and visual predators.
  - With reservoirs, the river substrate stabilized and enhanced benthos production, which increased plankton abundance, therefore Centrarchids (except green and orange-spotted sunfish) increased and buffalo, drum, flathead catfish, walleye extended their ranges.

Source: Baker, Huggins, Cringan, Angelo, Mehl, USACE. 2022

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A Sample of the Ecology Section: Fish Flow Needs

- Measures to benefit fish in the Kansas River Basin that could be considered by the Kansas River SRP:
  - **A more heterogeneous flow regime**
    - To reintroduce heterogeneity to the Kansas River, modification of dam releases in consideration of these flow needs must incorporate:
      - Frequency – How often flows increase and decrease (variability of flows). Frequency in flows increases water and terrestrial connectivity and shifts instream habitat availability.
      - Duration – The temporal range of flow events. While large flood peaks must be attenuated, both high and low flow periods should follow normal patterns.
      - Extent – The magnitude of flow increases and decreases. Again while flood peaks need to be attenuated, both extreme high and low flow periods should not be extended beyond normal time periods.
      - Temporal shifts – Current flow regimes remain closely correlated with natural flow regimes. The historic changes in river flows were linked to climate and precipitation patterns within the basin and shifts in seasonal flow patterns should be minimized.
  - **Variation in flows** may enhance spawning success
  - **Lower river discharge during the fall following the critical spawning window** would benefit fish species
    - During the time that fry need refugia reservoir discharges are maintaining flows at a higher level than naturally occurred reducing river complexity

Source: Baker, Huggins, Cringan, Angelo, Mehl, USACE. 2022

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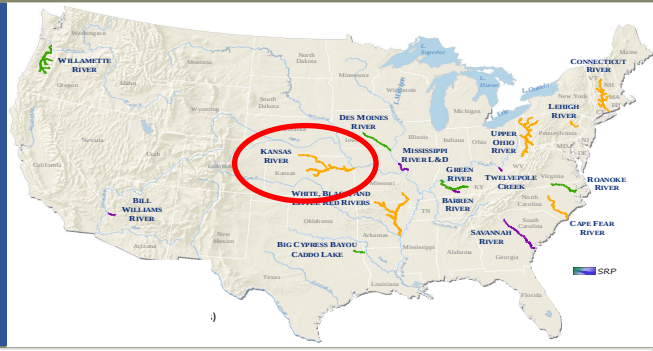
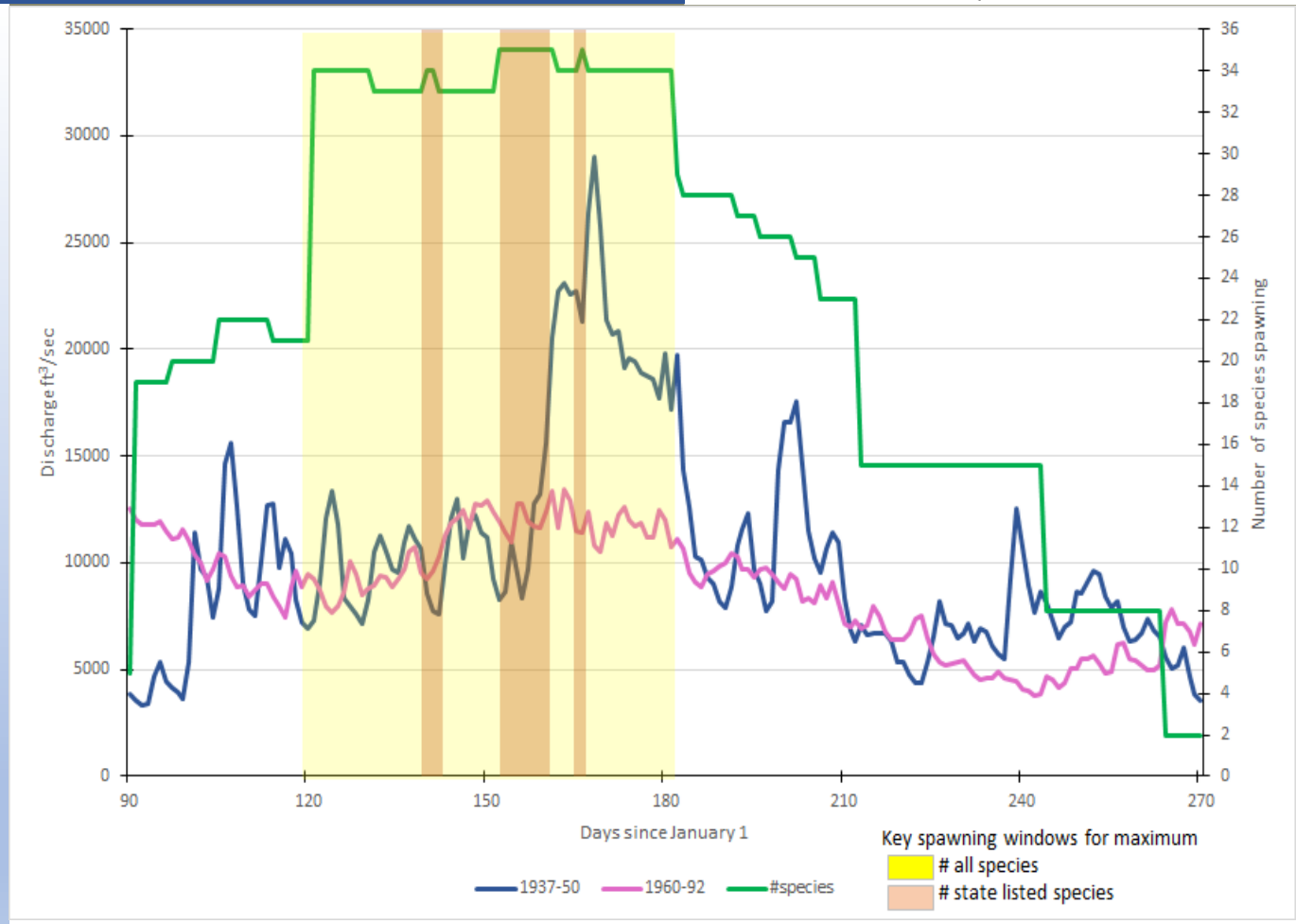


A Sample of the Ecology Section: Fish Flow Needs

- Spawning ranges were compiled for 46 species.
- Critical periods were determined based on those that contain the most overlap among species plus ranges that contain state listed species.
- **May 1 – June 30 has the highest overlap of spawning ranges, with 33-35 of 46 species spawning.** Within this timeframe are 3 peaks.



Source: Baker, Huggins, Cringan, Angelo, Mehl, USACE. 2022

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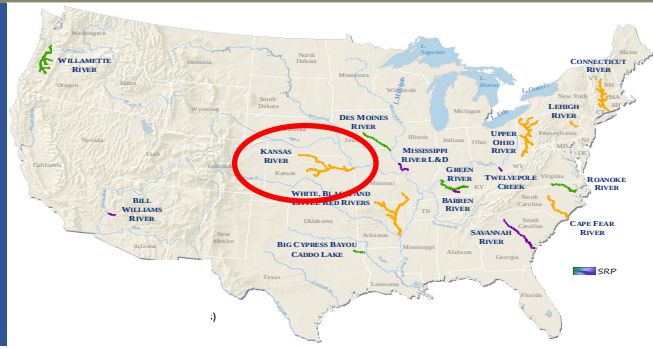

A Sample of the Ecology Section: Freshwater Mussels Needs

- Measures to benefit mussel recovery in the Kansas River Basin that could be considered by the Kansas River SRP:
  - **Changes in the seasonal operation of existing flood control dams – Gradual attenuation of high reservoir release rates.**
    - Streamflow in the Kansas River is dominated at times by releases from reservoirs, and the rapid attenuation of these releases can strand mussels on exposed sand and gravel bars.
    - Stranding often results in lethal heat stress and heavy predation, and severe or repeated stranding events can jeopardize entire mussel communities.
    - To minimize stranding-related mortality, reservoir releases should be attenuated over at least a one to two-week period, particularly during the summer and early fall when daytime air temperatures commonly exceed 90 °F (32°C).
    - This precaution is especially important when streamflow falls below the level needed to inundate most sand and gravel bars. In the Kansas River, this level corresponds to about 5,000 cfs.

Source: Cringan, Angelo, and Baker. 2020

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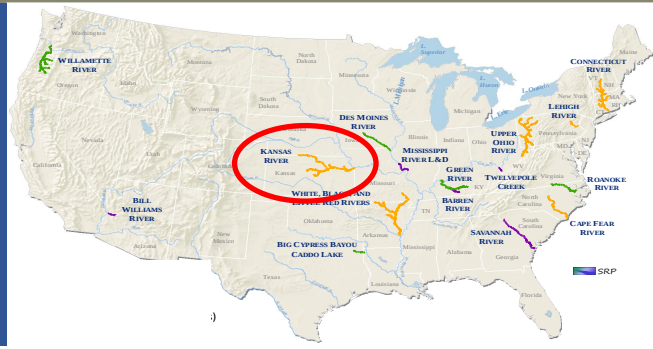

1st E-Flows Workshop
Current E-Flow Proposals

Kansas River SRP

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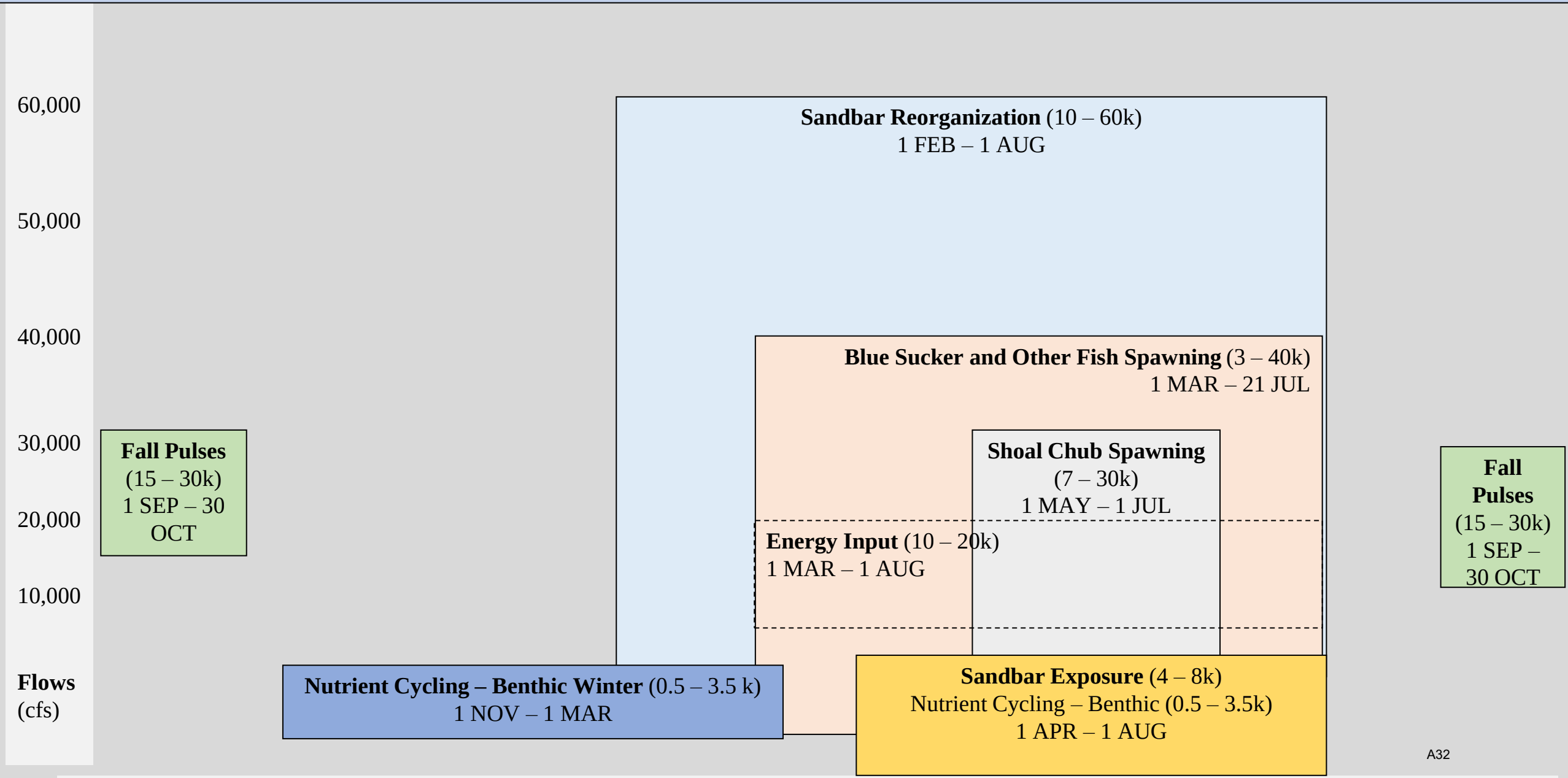
Kansas River SRP Unified Flow Prescriptions for Reach 2
Wet/Average/Dry Combined

- Variability in the system is desired. Opportunistically varying the flow regime (wet, average, dry years) would more closely resemble the natural annual variation that occurred from annual differences in runoff amounts. The intent of operational adjustments, while designed for a particular group or species, are to benefit the entire ecosystem rather that a specific species group or species.
- For birds/riparian and floodplain systems flow recommendations would be done every other year as the need for variability when these occur is desired.
- Fish that are short lived with narrow spawning windows have the highest conflicts with other flow recommendations. The timing for these species is important.
- For mussels it is important to elongate a flow recession. 1-2-week attenuation of pulses is desired.
- There is some compatibility between flows in the spring for blue sucker spawning and flows that move sediments. The flows developed for the blue sucker and sediment movement could be combined.
- The higher peaks developed in the birds/riparian and floodplain group could be modified to include a slower recession.
- Focus on the first pulse in May for fish spawning.
- Monitoring plans should account for lag time for ecological and hydrogeomorphic responses and be long-term to identify trends.

Wet/Average/Dry Combined



Flow Prescriptions	Dates	CFS	Details, Purpose, and Benefits
Shoal Chub Spawning	1 MAY – 1 JUL	7 – 30 K	• Cue spawning for shoal chub • Benefits to other species • Surrogate candidate to measure response
Blue Sucker and Other Fish Spawning	20 MAR – 21 JUL	3 – 40 K	• Umbrella species • Creation of spawning habitat (clean cobbles) • Spawning cue • Attenuate flows needed to maintain recruitment habitat • Promotes habitat/channel complexity • Heterogeneous flow regime • Enhancement of spawning success
Habitat Creation	1 MAR – 1 APR	20 – 40 K	• Higher flows to create scouring • Fish spawning and rearing habitat • Mussel habitat
Energy Input	20 MAR – 1 AUG	10 – 20 K	• Series of pulses to discourage recruitment of perennial vegetation on bird nesting habitat • Pulls in allochthonous material and nutrients • Late season pulse (July) also provides short-term rearing habitat for young-of-year fish
Fall Pulses	1 SEP – 30 OCT	15 – 30 K	• Increase production of waterfowl habitat • Inundate oxbows and backwaters

Flow Prescriptions	Dates	CFS	Details, Purpose, and Benefits
Mussel Flow Needs	5 MAR – 23 APR	4 – 11 K	• High flows followed by a slow tapering decline • Reduces stranding and mortality
Sandbar Exposure	1 APR – 1 AUG	4 – 8 K	• Habitat for turtle and bird nesting • Reduces chance of bird nest failure
Sandbar Reorganization	1 FEB – 1 AUG	10 – 60 K	• Reorganization of materials to create and maintain habitat • Removal of woody vegetation
Nutrient Cycling - Benthic	1 APR – 01 AUG	0.5 – 3.5 K	• Mimics natural rises for the purpose of nutrient cycling and benthic success
Nutrient Cycling – Benthic Winter	1 NOV – 1 MAR	0.5 – 3.5 K	• Mimics natural rises for the purpose of nutrient cycling and benthic success

Kansas River Sustainable Rivers Project

Thank you!

For more information about the Kansas River SRP contact:

Heidi Mehl, The Nature Conservancy
Laura Totten, US Army Corps of Engineers

The Nature Conservancy
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Appendix B: Participant List

Name	Affiliation
Chris Thorton	Ducks Unlimited
Dawn Buehler	Friends of the Kaw
Aaron Deters	Kansas Alliance of Wetlands and Streams
Don Huggins	Kansas Biological Survey
Jeff Conley	Kansas Department of Wildlife, Parks and Tourism
Jordan Hofmeier	Kansas Department of Wildlife, Parks and Tourism
Mark VanScoyoc	Kansas Department of Wildlife, Parks and Tourism
Erin Seybold	Kansas Geological Survey/Kansas University
Sam Zipper	Kansas Geological Survey
Martha Mather	Kansas State University
Keith Gido	Kansas State University
Josh Olson	Kansas Water Office
Richard Rockel	Kansas Water Office
Kirk Tjelmeland	Kansas Water Office
Nate Westrup	Kansas Water Office
Heidi Mehl	The Nature Conservancy
Jim Howe	The Nature Conservancy
John Hickey	U.S. Army Corps of Engineers
Michelle Mattson	U.S. Army Corps of Engineers
Marvin Boyer	U.S. Army Corps of Engineers
Kyle Ruona	U.S. Army Corps of Engineers
Seth Lerman	U.S. Army Corps of Engineers
Ginger Niemann-Harper	U.S. Army Corps of Engineers

Name	Affiliation
Paul Simon	U.S. Army Corps of Engineers
Laura Totten	U.S. Army Corps of Engineers
Seiji Kuwata	U.S. Environmental Protection Agency, Region 7
Brian Kelly	U.S. Geological Survey
Ariele Kramer	U.S. Geological Survey
Thomas Williams	U.S. Geological Survey