INTEROFFICE MEMORANDUM

TO: ROSEMARY REILLY, US ARMY CORPS OF ENGINEERS

FROM: SU FANOK, THE NATURE CONSERVANCY

SUBJECT: INTERIM PROGRESS REPORT - USACE-TNC COOPERATIVE AGREEMENT FOR THE UPPER OHIO RIVER BASIN

DATE: OCTOBER 30TH, 2020

CC: BECKY STINSON, KEITH FISHER

This memo summarizes work completed by The Nature Conservancy (The Conservancy) for the project entitled, "SRP20 – Stakeholder Workshop and Biological Monitoring to Inform Provisional Ecosystem Flow Recommendations (PEFRs) for Kinzua Dam/Allegheny Reservoir and Youghiogheny River Lake. During the report period between May 20, 2020 and September 30, 2020, The Nature Conservancy advanced the following deliverables:

A. In collaboration with the District, co-host and facilitate a stakeholder workshop to discuss aspects of the ecosystem flow recommendations for Kinzua Dam (TNC, 2017). This will include developing workshop goals, expected outcomes, and agenda; defining core staff roles; inviting attendees; and organizing on-site locational logistics.

B. In collaboration with the District, develop materials for the workshop that may include 1) a summary of ecosystem flows research for the Allegheny River; 2) preliminary assessments of possible effects of the current flow schedule on target species; 3) conceptual ecological models that identify major anthropogenic and natural drivers and stressors to target species; 4) maps showing the extent of ecosystem flows inundation; and 5) model outputs that illustrate hydrologic and biological conditions for the Allegheny River with and without ecosystem flows implementation.

C. In collaboration with the District, survey flow-sensitive target species, including freshwater mussel, submerged aquatic vegetation (SAV), and flood scour vegetation, in a reach of the Allegheny River downstream of the Dam near West Hickory and Tidioute, PA.

D. In collaboration with the District, conduct surveys of flood scour vegetation in reach of the Youghiogheny River downstream of Youghiogheny Dam near Confluence and Ohiopyle, PA. This will include deploying field cameras at four scour sites on the Youghiogheny River and capture time-lapse video of shoreline vegetation every 15 minutes, between May and September 2020; preparing maps of scour areas; syncing images with river hydrograph data; and conducting preliminary analyses of the effects of flow at these sites.

E. Provide summaries of the results of the biological surveys conducted in the Allegheny and Youghiogheny Rivers, and outline an Adaptive Management Plan and Monitoring Plan regarding ecosystem flows at Kinzua Dam, illustrating the connection between dam operations and ecosystem health.

A. In collaboration with the District, co-host and facilitate a stakeholder workshop to discuss aspects of the ecosystem flow recommendations for Kinzua Dam (TNC, 2017). This will include developing workshop goals, expected outcomes, and agenda; defining core staff roles; inviting attendees; and organizing on-site locational logistics.

The workshop was held from 9:00 am to 4:00 pm on Wednesday, September 9th and from 9:00 am to noon on Thursday, September 10th, 2020. Forty-eight participants were invited; forty attended. Participants included federal, regional, and state agency personnel, consultants, and academics. In response to the continued threat of COVID-19, the workshop was held virtually to ensure the safety of participants. Notes taken during the plenary, breakouts, and concluding sessions of the workshop are included in Appendix A.

From the workshop, seven themes emerged:

1. **DO NO HARM**

Practitioners voiced concern about potential unintended impacts occurring to downstream ecosystems by restoring natural flows. Of priority concern was the downstream freshwater mussel community, which harbors four federally endangered mussel species. Mussel surveys conducted between 1998 and present have found large reproducing populations of clubshell and northern riffleshell within several reaches of the Allegheny River mainstem (Anderson, 1998, Crabtree and Smith 2009, Smith and Meyer 2012). It is hypothesized that these mussel beds occurring on the Allegheny may be a result of or at least benefiting from Kinzua's modified flow regime implemented since 1965 and/or the artificially elevated summer baseflows implemented by Kinzua Dam since 2013. Before restoring a more natural flow regime, which recommends lower summer base flows, research, carefully created adaptive flow experimentation, and monitoring are necessary to better understand the ecosystem flow needs of the freshwater community.

2. **THE NATURAL FLOW REGIME**

Flow is a major determinant of river form and habitat – river form and habitat are major determinants of riverine ecosystems. From an evolutionary or biogeographical perspective, patterns of spatial and temporal habitat dynamics influence the relative success and colonization of species. This habitat stage, which is dictated largely by a natural flow regime, creates both subtle and profound differences in the natural histories of species in different segments of their ranges while also influencing ecosystem function (Poff and Allan 1995, Schlosser 1990, Sparks 1992, Stanford et al. 1996). While workshop participants generally supported the implementation of a more natural flow regime that inherently supports the diversity of native species and communities, again, there was concern, that current, altered flows are supporting the recovering of federally endangered mussels. This conversation raised the issue of trades off between species, between riverine functions, and between ecosystem flow recommendations.

Dam operations often narrow flow variability by eliminating high and/or low flows. While this may result in the increase production of a few species, it could be at the expense of other native species and of systemwide species diversity. In some riverine ecosystems, the creation of potential "novel ecosystems" resulting from flow regulation, raises many questions regarding the ability or desire to restore to historic reference conditions. A more thorough understand of the trade-offs between current conditions and anticipated response to flow restoration is necessary. For example, system-wide coupled with local assessments, if not already available, are necessary to establish a current baseline that can be quantitatively compared to ecological responses to future adaptive flow management efforts.

3. CLIMATE CHANGE

Climate change has already resulted in distributional shifts of some species and is projected to result in many more in the coming decades. Non-stationarity in climate, in ecosystems, and in other environmental conditions (temperature, sediment, nutrients) presents another layer of complexity when determining environmental flows. Interventions may increasingly be required to manage adaptively for system resiliency and will need to consider shifting hydro-climatic and ecological conditions (Poff. 217). What is the role of water management or dam releases under this emerging paradigm? Can upstream water storage be managed flexibly to meet downstream ecosystem and human needs? Well-established scientific insights gleaned from studies of species performance across the dynamic range of historic environmental variation can inform such adaptation planning, but reference conditions can no longer be the only benchmark of comparison. New knowledge gained from controlled dam releases and climate modeling will be necessary to manage future uncertainty (Poff, 2017, Poff, 2014).

4. EXPLORE IMPLEMENTATION OF SPRING PULSE FLOWS

Many practitioners voiced support for implementing a more natural flow regime but recommended avoiding changes to the high-risk flows, such as bankfull and summer low flows. Instead, practitioners recommended exploring adaptive management and implementation of less-extreme or lower-risk spring pulse and spring base flows. Determining the current state of spring pulse or baseflows implementation should be evaluated. If necessary, a next step could then explore small ways to experiment with managed spring flows, so that negative consequences are limited, but lessons are learned. It should be noted that high and low flow events often serve as ecological "bottlenecks" that present critical stresses and reset the successional clock" for disturbance driven floodplain species and communities (Poff and Ward 1989). So, while the restoration of high and lows flows may pose greater ecological risk to riverine ecosystems, their removal from the flow regime may be of equal consequence. This affirms the importance of careful experimentation, monitoring, and modeling that evaluates the need and impacts associated with a range of historic and future flows, including high and low flows.

5. ALLEGHENY RESEVOIR

The focus of the workshop was to review the PEFRs developed to guide releases from Kinzua Dam. The PEFRs aim to improve downstream ecosystem and riverine health. However, during the workshop, a representative from the Seneca Nation of Indians, raised concerns regarding the management of the upstream Allegheny Reservoir.

The Allegany Indian Territory is located along the Allegheny River from the Pennsylvania border upriver to Vandalia, New York, and is located entirely within Cattaraugus County. The Territory originally included 30,469 acres of land surrounding the Allegheny, of which some 10,000 acres were inundated by the Kinzua Reservoir when the Army Corps of Engineers built the Kinzua Dam in 1964. The Allegheny Reservoir stretches 27 miles long and 120 feet deep. Concerns regarding reservoir water quality, recreational use, the walleye fishery, and environmental stewardship were raised at the workshop. Future efforts need to better understand the intricacies of how Kinzua Dam releases affect both *downstream river* and *upstream reservoir* health and goals.

6. CONTINUED COLLABORATION

Continued collaboration to define an Adaptive Management and Monitoring Plan that evaluates trade-offs between ecosystem needs, that considers the scale, scope, and timing of monitoring necessary to fill data gaps, and that develops an effective framework for learning from and implementing ecological flows that "do no harm" to downstream ecosystems was strongly recommended. A post-workshop survey asked attendees to share their level of willingness to continue engagement. While participation in the survey was limited, those who did respond, including representatives from the Pennsylvania Fish & Boat Commission, shared a willingness to meet regularly during the coming year to advance the development and implementation of the anticipated Adaptive Management and Monitoring Plan.

7. OPERATIONAL CHALLENGES AND CONSTRAINTS

The recommended bankfull release of 27,000 cfs should be re-evaluated. Downstream impacts, potentially including damage to downstream private properties, must be thoroughly modeled and evaluated with real-time flow data before a bankfull release of the proposed magnitude is considered. Additionally, the functionality of bankfull flows needs further exploration to determine if another flow of lesser value or different duration could help to address functional aspects of the currently unattainable bankfull flow.

Spring pules releases, with a lesser discharge and shorter duration, may provide an opportunity to re-establish a high-flow component to reservoir releases. While reservoirs are typically filling in the spring, storing water to ensure downstream flow targets can be met later in the season, in recent years, wetter springs, have allowed for releases to occur during the spring coincident with spring storm events (pers. comm, 2020). However, sustaining these flows for the recommended 3-day duration of a spring pulse release requires a large volume of water to be released from the reservoir, potentially impacted storage needed to support later season flows and flow targets. In response to the above challenges associated with implementation of both bankfull and spring pulse releases, validation releases and monitoring was suggested.

B. In collaboration with the District, develop materials for the workshop that may include 1) a summary of ecosystem flows research for the Allegheny River; 2) preliminary assessments of possible effects of the current flow schedule on target species; 3) conceptual ecological models that identify major anthropogenic and natural drivers and stressors to target species; 4) maps showing the extent of ecosystem flows inundation; and 5) model outputs that illustrate hydrologic and biological conditions for the Allegheny River with and without ecosystem flows implementation.

Key products, including the materials listed above, were produced for the workshop and can be found in Appendix B.

C. In collaboration with the District, survey flow-sensitive target species, including freshwater mussel, submerged aquatic vegetation (SAV), and flood scour vegetation, in a reach of the Allegheny River downstream of the Dam near West Hickory and Tidioute, PA.

WPC scientists completed the following activities to characterize the current condition of priority targets in the upper Allegheny River downstream of Kinzua Dam – within the West Hickory and Tidioute, Pennsylvania focus areas on the Allegheny River. Specifically, WPC scientists advanced the following activities:

- Conducted surveys for freshwater mussels along 10 transects established across the river within the two project focal areas of West Hickory and Tidioute, PA. Along each transect, WPC aquatic ecologists documented the mussels present and their abundance and recorded habitat variables including substrate characteristics and vegetation cover. A list of mussel species and ecological habitat variables will be included with the final report. Allegheny National Forest biologists collaborated with the WPC diving team to support assessing the mussel population. Mussel surveys occurred on July 8-9 and July 28-30, 2020.
- Conducted surveys for submerged aquatic vegetation (SAV) beds during mussel inventories and at additional site visits to obtain lists of species occurring within specific zones in the river channel (riffles, runs, pools) and species associated with the freshwater mussels. A species list of SAV communities organized by community will be included in the final report. Vegetation surveys occurred July 8, August 5, and August 19-20.
- Conducted plant surveys to map and describe plant communities and rare plant species within floodplain habitats adjacent to the Allegheny river channel. These data will be used to determine potential floodplain communities impacted by the management of Kinzua Dam. Vegetation surveys occurred July 8, August 5, August 19-20, and August 27, 2020.
- Mapped SAV beds, mussel transects and characteristic floodplain communities by drone, flown from the river on August 5 and August 19-20, 2020.

  For further detail, see Appendix C.

D. In collaboration with the District, conduct surveys of flood scour vegetation in reach of the Youghiogheny River downstream of Youghiogheny Dam near Confluence and Ohiopyle, PA. This will include deploying field cameras at four scour sites on the Youghiogheny River and capture time-lapse video of shoreline vegetation every 15 minutes, between May and September 2020; preparing maps of scour areas; syncing images with river hydrograph data; and conducting preliminary analyses of the effects of flow at these sites.

WPC scientists completed the following activities to characterize the current condition of priority targets in the Youghiogheny River, downstream of the Youghiogheny River Dam at Confluence, PA. WPC selected 5 target flood scour sites along the Youghiogheny River including:

- Drake Run – Ohiopyle State Park/State game Lands #271
- Dimple Rock – Ohiopyle State Park Bear Run Nature Reserve
- Double Hydraulic – Ohiopyle State Park
- Ferncliff Peninsula – Ohiopyle State Park
- Meadow Run – Ohiopyle State Park (note: cameras are not currently deployed at this site due to potential tampering by park visitors)

At each of the scour sites, WPC ecologists advanced the following:

- Installed field cameras to capture flood images and sync these images with river hydrograph data to determine the pattern of inundation during the grant period and determine how changes in flow may affect these small and topographically complex sites. These field cameras have been maintained throughout the year, from May – September. In all, there were 20 camera check visits across the four sites, over 9 field days. These checks have been spaced 4-6 weeks apart.
- Developed preliminary maps of floodplain scour zones using combination of aerial imagery, drone imagery (dependent on permission), LiDAR, and field survey. Drone images were obtained June 1, 2020.
- Assessed vegetation condition and composition of zones supporting indicators of different flood-scour zones using plot and transect survey methods.
- Detailed maps and assessments of the *Marshallia* were conducted in conjunction with a USFWS Section 6 grant to the PA Department of Conservation and Natural Resources.

  For further detail, see Appendix C.

E. Provide summaries of the results of the biological surveys conducted in the Allegheny and Youghiogheny Rivers and outline an Adaptive Management Plan and Monitoring Plan regarding ecosystem flows at Kinzua Dam, illustrating the connection between dam operations and ecosystem health.

Final summaries of the biological surveys are currently under development and will be provided in the final report. The Adaptive Management and Monitoring Plan outline is also currently under development and again will be provided as part of the final report.

Appendix A. September 2020 Workshop Notes

AMMP Workshop for Kinzua Dam and the Upper Allegheny River
September 9th and 10th, 2020

1. Plenary Discussion: Scientific Input for Implementing Ecosystem Flows (E-flows) Recommendations

Flow Component 1: Restore bankfull flood frequency and Magnitude (Mar & Apr)

- The fundamental question is still whether globally significant populations of endangered species (e.g., Northern Riffleshell, Clubshell, Rayed Bean) exist because of current Kinzua operations or in spite of current operations and this question still remains unanswered. Examining these three species under various current and provisional flow scenarios – in both the river and in the lab – will likely be critical towards understanding macro/micro flow needs for these species and towards USACE operations “doing no harm” to existing mussel communities.
- Temperature: discharges are lower than the warm water regime recommended by the state of PA. Effect of Temperature only extend down to Conowingo creek (A1). Therefore, impacts on the water temperature on West Hickory reaches are insignificant.
- from Matthew Baker: It seems rationale from the perspective of the dam, but I am unsure about how it would interact with downstream channel forms...
- from Steve Faulkner - USGS LSC: What is the rationale for expecting significant ecological change from one 7-day event every 5 yrs?
    - This is one of those validation questions we have. All our recommendations come from a natural flow regime. Not necessarily driven by a geomorphic paradigm. We are unsure how these flows will effect things and how changing it from 5 to 10 years would make a difference.
- from Jim Grazio: Please don't assume that our silence is tacit approval of any proposal. You are asking huge ecological questions that are not likely to have simple answers
- Change from 1 event every 2 to 5 years vs. 1 event every 5 to 10 years.
    - It would be difficult to implement because it would be causing flooding to release bankfull. Durations were shorten- a 7 day duration event is not natural. Volumes were reduced because the amounts were just not feasible.
    - We didn’t foresee an opportunity to do more frequent flooding. A flow above bankfull causes flooding (in human areas) and we simply cannot do that. A Natural flood is much faster, 3-5day event. But keeping it at 7 days keeps it controlled and maintained, not as high but longer because the peak is cut off and released later. A huge flooding event would really only occur 1 in 50 years so releasing it makes since for what is physically possible out of the dam. - Charles Kottler
- from Joe Duris, USGS PAWSC: How close is this to natural flow regimes? Has there been an evaluation of events being stored by the dam (or inflows being conveyed directly downstream) and what those events might look like under unregulated conditions? See Slide 12 from presentation
- from Emily Elliott: Is the water quality (nutrients or toxins from HABs) of water released from Kinzua an important consideration for downstream biota?
- from Matthew Baker: It seems like the basis for recommending particular flow levels is based on the idea that it one approximates those flows, then it will simulate 'natural' conditions in the downstream channel(s). I am not sure that assumption holds since the ecological signal received downstream may be different now that the dam has been operating for half a century or more. If you are trying to generate bankful flows or connectivity, Im not sure you'll get that.

And based on what Charlie is saying, it seems high flows may be longer than what you might want anyway...

- from Bob Anderson: How does this recommendation compare with what climate change models suggest is going to happen over the next several decades during this period of the year?
- from Joe Duris, USGS PAWSC: So if the e-flow recommendation is a rare flow event, should the goal of implementation be to more closely replicate natural events vs just shooting for bankful? What does 5 years of the record look like? Rather than just saying 2 to 5 years to hit bankful, maybe the goal should be to replicate what natural conditions should be.
  - That is the goal but the dam limits our ability to reach some of those goals.
- Talking a lot about discharge but what about velocity? Is velocity important to aquatic species and how did that come into the considerations of the eflow recommendations. Does bankful go above that sheer stress tolerance level for mussels.
  - Velocity is very important. But was not a consideration when developing the recommendations. Sheer stress would be important for mussels- can handle a large range in velocity.

Flow Component 2: Restore high flow pulses during spring (March – April)

- Filling the dam during this time and so it is difficult to release a pulse
- from Jeff Chaplin, USGS PA WSC: How does duration of the prescribed flows factor in to the releases? It seems prescribed flows are similar in magnitude but shorter in duration compared to natural flows.
  - We did look at the natural flows to come up with the prescribed flows.
- USACE is already implementing this one but it is difficult during March when they are filling reservoir. Duration will always be tied into the event. 3 days can be challenging. As an operator, USACE wants to know, does it need to be 15000 and for 3 days. Can we do 14000 for 2 days or is that not worth doing? A range of flows/ band of tolerance that we are still able to meet ecological needs

Flow component 3: Restore magnitude and Timing (seasonality) of spring baseflow (March, Apr, May)

- March implemented flows are less. While filling reservoir, need to reduce discharge from dam.
- Greg Zimmerman: locals believe the dam is holding the baseflow higher and the mussels habitat has increased.

Flow Component 4: Restore magnitude and Timing (seasonality) of summer baseflow (June, July, aug, sept)

- Implementation is higher than eflow recommendation due to operational constraints due to min flow requirements
- from Matthew Baker: What is the reason for filling the pond using the "guide curve" at a particular time? Suggest fill pool at different schedule-fill later and incrementally over early summer so not as much summer discharge. USACE is trying to keep space for flood control but there seemed to be a number of zones below the 'red line' that are possible.

Flow Component 5: Maintain late fall & winter flows that are as high or higher than early fall flows

General Comments:

- Downstream channel forms interactions-flow recommendations

- mimic natural flows for species (Andy Turner)
- A more natural flow regime would be better. Distributions might change but the closer that you get to natural flow.
- Bob Anderson, there are some important and rare species. Changing the flow regime to benefit the more common species at the expensive of the rare species is a bad idea. i.e. natural flows is better for everything. That thinking may result in losing some species.
- Steve Faulker, No one flow regime will make everyone happy. So is there a process needed for evaluating tradeoffs among species, people, end users, USACE regulatory requirements?
- from Nevin Welte: With global climate change, management of the reservoir may allow species to persist (e.g., Northern Riffleshell, Clubshell, Rayed Bean) in a global context vs. anywhere else in their current or historical range. There will probably have to be some weight given to some species vs others although status quo seems to be a good place to be at the moment.
- from Andy Turner: This is a complicated ecosystem with lots of moving parts. Mimicking natural flows has to benefit the species that historically thrived in this system. I love the eflow recommendations. Are there any actual data showing mussels to be less abundant before 1970? Understand the difficulty of teasing out other confounding factors...water quality.
    - There's anecdotal info but nothing susbstantial in terms of historic datasets
    - Other than Ortmann data (likely constrained by access), we do not have quantitative mussel data pre-Kinzua.
    - We have noticed increases in some species at some sites over time (e.g., Hunter Station).
    - from Steve Faulkner - USGS LSC: In the absence of empirical data, anecdotal/ stakeholder information/ traditional knowledge approaches can be valuable.
    - from Bob Anderson: Sally Dennis' dissertation 1970 data
- from Greg Zimmerman: This system is lucky that Conewango brings in a lot of natural sediment, temperature and flow pulses to the system. I would say don't mess with low flow minimum flows first, then adding larger pulses may alter some habitats but could be good for natural substrate processess and sediment transport.

AMMP Workshop for Kinzua Dam and the Upper Allegheny River
September 9th and 10th, 2020

Floodplain, Geomorphology, Herp Group

<u>2. Validating Ecosystem Flow Recommendations</u>

Questions and Discussion

- Mussels: Understanding how flows impact the mussel beds and other species. Is there enough and the right kind of sediment supporting the growth of mussel beds? Test velocity impacts on beds – Do mussels get moved at bankfull?
- Avoid extreme events during spawning period
- Flows linked to sediment deposition. More scour and movement but bankfull will increase or maintain beds . Ice scour is complicated, how is it different from what it has been? And if it is different, how does it impact species that have adapted to current flow regimes?
- Are species diversity and abundance maintained at Summer high and bankfull?
- Floodplain ephermal pools are a concern with summer high flows. Does the recommended high flow regime during the summer change amphibian populations breeding in floodplain ephemeral pools?
- Plants – late winter and early spring monitored through growing season "Spring Pulse?" Does the recommended low flow regime change the extent and composition of submerged and emergent aquatic vegetation? Do high flows, even outside the growing season, also influence SAV?
- Water quality implications; Interested in understanding water quality in summer baseflows

•**MAGNITUDE**: 30000
•**DURATION:** does the change from 3 to 7 days change the distribution of mussel beds
•**FREQUENCY:** 2-5 years in recommendation April

BANKFULL RESTORATION

- Two possible outcomes, depending on duration of event, could have depositional event or could scour away …is this beneficial to mussel lifecycle or no? (mussel entrainment)
- Can test changing duration vs health of mussel beds
- Also, how are SAV influenced by these high flows?
- Cutting down bankfull from 7 day to a three day – reduce possible scour
- Should steer to Floodplain deposition, away from mussel bed health
- Decreasing the duration to 3 days, what about timing? Timing and implications for that?
- Ice scour, can it be replicated by a flow prescription? Prob not, its something we just lose. What that larger flow might be and when, timing with other organisms – during spring, could wash herps from vernal pools.
- Would winter pulse be preferable? Or have other unforeseen consequences…
- If there is a geomorphic purpose, it can happen any time of year, spring pulse is more for biological services
- When is a key spring period for mussels? Put that release in a period where it might have the "most effect" Thinking about the mussels, we want to avoid spawning time – check with mussel group

- WH never hits bankfull, if does it will be in spite of ACE efforts, max at Kinzua 20-25000. They would never pulse more than 30,000 – could happen from uncontrolled portion of drainage
- What flow inundates flood plain but does not cause damage – jumps bank at 48, but not flood until 60+
- Could happen but due to contributing tribs
- If you could raise it twice a day, know transport time, could perform sampling

Experiment 1:
- Increase in flow until we have sediment transport, **slept down in 4 hour** increments on top of a wet condition to push flows that might be catastrophic into the sweet spot that pushes sediment **without flooding human settlements.**
- 15 of April
- Sample flow conditions, discharge, and velocity before after and during.
- Deposition areas - are there opportunities to track deposition.
- Look at a controlled area between Dam and WH that is inundated before the **Q50000**.
- Sediment deposition and destabilization in mussel beds and SAV, measure target areas before and after.
- Monitoring site should be "easily flooded" and well described, Look at critical stress on the mussel bed – mussels as particles, same for SAV – set target areas to monitor

Experiment 2:
- Are release form the dam sensitive to alga releases? Alga bloom nearly every year, summer/fall low releases temperatures greater than 20C What do we do to decrease water temperature target area – downstream.
- Pulse release out of Kinzua , elevate from low flow 5000- 15000 csf
- 15 July
- Pulse release to monitor changes to improve water quality – temperature and DO
- Play with sages and flow levels, duration of peak
- One time pulse or multi-year – unclear what this should be. Need hyper spectral imagery for SAV – more investigation needed
- Figuring out a monitoring schedule is always a challenge, but what I have seen for herp and mussel species is usually like 3-5 year intervals – Ephraim
- Do thought homework – does this apply to more than SAV? Geomorphic changes?
- Some way to do bathymetry, bank erosion, sediment deposition in floodplain, meander, how bed is changing.
- Set fixed and rotating sites, come back at intervals that make sense for
- Jeff USGS: can do cross sections as well as broader scale GM change by flyovers, use local measurements to verify flyover

DAY 2: Monitoring

Discussion & Questions
- For validation - might want to discuss the two ideas for the allegheny - to see if they might be applicable to our study area - 1. low-cost temperature sensors. 2. field cameras 3. animal inventory (herps, algae) of floodplain wetlands.
- Also sediment deposition sensors on floodplains...

- Regarding herps in floodplains, early flooding is important to fill the pools, it is the later floods in the summer that could pose problems for newly metamorphosed amphibians that are about to disperse – Chris Urban
- Understand flows on animal assemblages in the short term and the long term
- Expanding the continuum of monitoring a few to focus on in an expansive list, what is currently happening and what can we build on
- Adequately address necessary spatial/temploral scales?
- Does the monitoring Plan leverage existing monitoring efforts that could be adapted for this effort?
- In times of limited capacity and funding can we identify the Top Priority needs
  - Validation monitoring
  - Floodplains, SAV, Herps
  - Drone flights and structure for motion to create bathymetry data – degrades below 3/4ft but its very good for shallow stream channels
- Are there places were floodplains are inundated but no confident in bathometry?
- Monitoring focuses on physical short term – High bank full conditions, sediment depths after single, double, and triple high flow pulses. Put in transducers in a vernal pool – water depth, temp, DO
- from John Young: Good sampling designs will be important to capture spatial/temporal variability. Go back every 3 – 5 years to see if there are changes for long term
- Ephraim – look at sites at different flows recruitment, flows, sediment- we can choose sites and islands area great because we have a little bit better access and have been more protected from development. Would like a follow up conversation on site selection

Thermal

- With thermal measurements you can get depth measurements and then you can see how fast and how deep water is this will tell you more about the physical characteristics
- Temp/DO change at various discharges/seasons. Magnitude and duration. – Joe Duris

Sediment

- Sediment tiles, bank pins (bank erosion)   - short term for deposition
- Recruitment – survey areas with very little sediment or grassy/shrubby
- Turbitity monitors
- Suspended sediment
- from Harry Stone: sediment depths after single, double, and triple high flow pulses.
- from Brad Maurer: HEC RAS has sediment transport modeling capabilities. I don't have experience using it, but might be worth considering with sediment deposition on the floodplains/islands

Inundation

- Flood plain inundation – Joe Duris
- Drone flights for erosion with bank pins, because erosion happens in places other than where the bank pins are to. Drones help to see change in the bank and the channel.
- Islands see inundation on 54000 full inundation on 10800 – this significantly impacts our floodplain communities.
- Drone would create terrain models of the channels and thermal imagery shows us where water is – drone is not for field monitoring.
- Flooding in pools in early spring – short term

Vegetation

- SAV - determine threshold for damage and changes in colonization. Herps - how to monitor floodplain - high flow timing is critical. Macro-invertebrates - illustrate quick response. YoY fish - recruitment (from Susquehanna) depends on flows in April and May - Kate Zidar
- Hyporheic Exchange, Scour potential- Joe Duris Floodplain validation flows - to mimic "reset", encourage recruitment, evaluate veg response – Kate Zidar
- from John Young Floodplain vegetation extent, structure, and species composition before/after. Floodplain substrate size and distribution before/after
- Germination on bare bars given years with single, double, and triple high flow pulses.

Herps, Inverts, and Biota

- With natural river systems, it is important to have high river flows in the early spring - this flooding will fill up the pools. Rain should maintain some level of stability in the pools throughout the breeding, egg laying, and tadpole growth periods. So we want to avoid or minimize flooding in the summer, also because turtles have nested in the floodplains, and we don't want their nests to be ruined... It's tough to protect everything, but again, I think we want to try to mimic natural river systems as much as possible. The issue here is that the management of Kinzua for the last 50 years has likley formed a specific herp community in this floodplain system. Should we be changing it??? – Joe Duris
- Need good before/after surveys of biota to look at effects. There will be winners and losers (always are) depending on timing and magnitude of flows in relation to life history characteristics of individual species
- Measurement of invertebrates (invertebrate community index) appropriate time post high flow pulses. This will help understand reestablishing vegetation versus impacts on "fish food". Ephraim wants to see the same thing for vernal pools
- Chris Urban – Long term sampling stations in pools short term a measurement of reproductive health. A egg count then later how many metaphasis Early and late season surveys.
- from Chris Urban: herps - longer term: inventory/assessment at specific floodplain pools (set up sampling stations, survey every 3-5 years), some measure of reproductive success - counting amphibian egg masses, then looking at end of season metamorphs
- Spatial Scales – Look at a few sets of islands to do a lot of measurements in a smaller/diverse area Island that inundates at a lower flow island. Vernal pools are at different elevations along the island. Herp modeling needs to be done in a number of pools in the island.

Data sources

- Baseline information on mussels from USGS in the 90s and that could be helpful – substrate information Fish commission has good baseline fish data 122 miles some follow up studies covers reach A and sheer stress
- from Chris Urban: long-term datasets or decent baseline data for fish - PA Fish & Boat Commission data on fish; Mussels - USGS, WPC and other efforts, both quantitative and qualitiative data; PA Amphibian and Reptile Survey (PARS) - collaborative effort with PFBC and Mid-Atlantic Center for Herpetology and Conservation (MACHAC)-this is a herp atlas project more focused on herp inventory/distribution
- Baseline information on mussels from USGS in the 90s and that could be helpful – substratist information Fish commission has good baseline fish data 122 miles some follow up studies covers reach A and sheer stress

- Riparian vegetation: https://onlinelibrary.wiley.com/doi/epdf/10.1111/1467-8306.00286
- Hyporheic exchange and mussels study:
    - https://onlinelibrary.wiley.com/doi/full/10.1002/eco.1581
- Mussel habitat relationships:
    - https://bioone.org/journals/northeastern-naturalist/volume-17/issue-4/045.017.0403/Freshwater-Mussel-Bivalvia--Unionidae-Distributions-and-Habitat-Relationships-in/10.1656/045.017.0403.short
- Riparian vegetation:
    - https://onlinelibrary.wiley.com/doi/epdf/10.1111/1467-8306.00286

AMMP Workshop for Kinzua Dam and the Upper Allegheny River
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Mussel and Host Fish Group

2. Validating Ecosystem Flow Recommendations

Component 1: Bankfull

- Channel forming flows. Look at loss of mussel habitat. There might also be new habitat to be developed but it will take time for that new habitat to be developed. Where is the point of equilibrium between habitat loss and creation.
- Bankful flows may be key to getting to another equilibrium.
- Monitoring biological end points are going to take time to see a change.
- Long term process needs to be kept in mind.
- Experience on the Delaware could be appropriate for comparing to Allegheny
- Do high flows decouple the host fish and trying to figure out how often they come back? Do they push fish off a certain area. More bankfull events are more beneficial to fish communities.
- Change in mussel populations is going to take decades to see but you could look at embeddedness on a shorter term scale.
- Monitoring mussel reproduction and distribution. Take that and see if the distributions change with the flow increase. Substrate maintenance, fish response, don't really want it to change but want to add these events anyways.
- Channel forming flows to maintain diverse habitat, can look at riffle-run pool combination, loss of mussel habitat, creation of new mussel habitat,

Component 4: Summer Baseflow

- Summer flows are 50% higher than natural flows. Vegetation is not growing in the riparian zone because of those flows. Likely causing stress to species during summer. Different flows during June through September depending on high, average, or low flows
- H1: water levels and velocity are likely higher causing stress to species during summer
- Mussel beds can take decades to form and so in low flows, the beds can be dewatered. Artificially high summer flow is increasing the suitable mussel habitat. Need to look at past data and how species responded to have a baseline for making informed decisions.

- Alternatively, elevated flows have led to fewer fish due to less shallow water habitat- i.e. decline in darters due to lack of shallow water has resulted in los sof low predation habitat.. Low flow can be a concern for spawning fish. Different fish have different requirements.
- Most stressful time for species. Dam changed the peaks and valleys. Given the ecological value of the system now, is going back towards natural conditions really the direction we want to go? Need to determine what areas are going to be exposed at low flows (modeling exercise). Where are riffles that would be exposed during a dry, hot part of the year?

- Other impact to lower low flows-

  - recreational uses- public outcry if flow gest to low, especially with user groups such as kayaking and canoeing.
  - Lots of funding comes from recreation.
- Water quality issues to reducing flow. Low flow would reduce dilution benefits associated with increased flows from the dam
- H2: Return to the historical low flow for some period of time, i.e. half of the summer, August and September.

General
- Before and After design would be best.
- Mitigation of climate change
  - Opportunity to maintain the system in face of changes that could otherwise devastate it
  - More forward looking analysis of what's being considered using climate change models
- What would higher flows do to the ecological resources downstream?
- Studying predictability of flows to increase the success of restoration efforts
- Importance of groundwater

<u>3. Monitoring Effectiveness of E-flow Implementation</u>

Component 1: Bankfull
- Ecological Purpose: Channel maintenance and floodplain recruitment
- Response: Change in distribution of fine sediment
- Monitor: Pebble counts before and after. Is it sandy or cobble, do we have new deposition in other areas

- Response: Increase in large woody debris with positive ecological response, i.e. good for fishes
- Monitor: monitor woody debris in channel, Annual survey for larger fishes. Literature shows that woody debris is good for the small fishes, which ultimately help larger fishes. FBC has an annual survey for larger fishes

- Response: connectivity between main channel and backwaters, larger weight in sport fish
- Monitor: productivity of larger sport fish (larger weights). Increase weight of fish/ growth rate- back calculated from scale samples. Help to tell which year they were recruited and you could connect the two between pulse flow. Quantify how many acres of water has been reconnected as result of bankfull flows, how much habitat was created

- Ecological Purpose: Geomorphic processes
- Monitor:
  - Monitor mussels bed before and after bankful flows- monitor abundance and density at locations susceptible to scour. Scour might be marginally and limitedly helpful to mussels that occur above Conewango... There's no new sediment being added to the stretch between Kinzua and Warren. Other effects further downstream.
  - Measure density or abundance
  - Bathymetry updated after a bankfull event to see if depths and distribution have changed (mussel bed distribution, pool-riffle

distribution, soft substrate), side-scan sonar good enough to tell differences in substrate types? Can survey differentiate sand/gravel/etc.

General Comments:

- Andy Turner – we have a reasonable frequency of bankfull discharges. No evidence of higher frequency would improve ecology. USACE considered 25k CFS. Have hit 20k CFS maybe 5 times in the last 50 years. There may be more opportunity to achieve that in the future. If we could achieve 20kcfs more times in the future, should we do that? Is there value? What do we monitor if we can?
- Reach below Kinzua is most regulated and would change the most with bankfull flows. Monitoring focus should be placed more closely to the dam
- Greg Zimmerman: suggest focusing on the high flows because the changing the low flows will affect the mussels too much. Would make the marginal plant and animal communities as well as nutrient transport more natural, as well as creating diversity of habitats such as islands but of course there is a danger to existing fauna and the Allegheny River substrate is so large, it takes a lot of flow to make changes and a long time to see if change is good or bad.
- from Jamie Detweiler: Change in bankfull seems like it would have the largest impact on habitat. Both by creating (by providing access) and destroying (erosion and sedimentation)

Component 2: Spring Pulse

- Ecological Purpose: spawning, channel maintenance, floodplain recruitment
- Response:
    - Spring pulses affect temperature, which are spawning triggers for mussels. Unfortunately, not all mussels spawn at the same time and thus there would have to be some "winners" and "losers" in the mussel realm if artificial pulses.
    - Fishes are a similar story in that some species require high flows for successful spawning, but others require more stable conditions and lower water levels. Spring pulses can be one component triggering fish movements - Temperature, photoperiod, etc. may also be important.
    - Geomorphic sculpting flows would be earlier in the spring
- Monitor:
    - look at the gills or fins of fish to determine what mussels have attached to see which mussels are occurring. Would need to do this multiple times to determine
    - Look at the gills or fins of fish to get a sense of if reproduction is occurring.
    - Midsummer monitoring of the young of the year abundance – would take a pretty targeted monitoring system.
    - Could measure glochidia drift below mussel beds. Put out drift nets below the beds to measure glochidia drifting from the beds.
        - from Jim Grazio: how would we know if glochidia parasitism is improving, declining, or unaffected as a result of changes?
    - Non lethally assess mussel reproduction: use a syringe to sample sperm and egg development from Daniel Spooner Lock Haven University:.
- No good way of monitoring fish movement on a large river like the

Allegheny. from Ben Lorson

- Fish spawning: Are size3 classes moving up? Are certain fish missing from the assemblage? A lot of extra effort but monitor the weight and size. Fish and Boat does game fish. Ongoing fish monitoring within the river – should be able to see differences in the cohorts of fish within the river. Spring pulses, if not correctly timed, can cause loss of a fish year. Timing is also temperature dependent
- Tag fish to see growth changes.

General Comments:

- from Daniel Spooner Lock Haven University: The temporal scale is likely really important for mussel assessment. Fluctuation in mussel populations likely operate at a much larger temporal scale. We might detect year to year variation in fish, but not be able detect a discernible change in mussel populations until many many yeas (decades)
- delayed spaying of fish- may lose a year class if not timed correctly timing= winners/ losers depending on the species you're looking for... Temperature is the important variable. What you want to avoid is having a spring pulse two weeks after they spawn.
- Laboratory Testing?
    - from Steve Faulkner - USGS LSC: Yes, absolutely need a baseline prior to new regime. Dan F. alluded to this earlier with the BACI (before-after) design. Power of the design to detect change is another important aspect and dependent on natural variation. Some fish species need long-term (5+ years) data to detect a change, signal-noise ratio concept.
- There are historical sites on the river for small mouth bass and walleye (young of the year abundance). Have been doing this since the 80s. Stable conditions seem to be more beneficial for fisheries and high reproduction rates. Small mouth bass – dryer conditions seem to produce higher young of the year numbers.
- Also related to flow regime with less high peaks and low valleys in the flow. Not just with high/pulse events in spring, not just flow, also temperature, daylight, and they spawn in a timeframe- could spawn early or late. Need to think of seasonal cues to determine WHEN would release pulses. Best option would be to coordinate with fish and boat commission on the day of the pulse.
- It's going to take a long time to determine the value of these changes. Really important to create a solid monitoring plan to prove scientifically that we're improving and not hurting the environment.
- Jim Grazio: What is our specific species goal? Are we managing for a specific species? Rose: no, it is general ecological function. Goal is to maintain good habitat and improve some of the degraded habitat.
- Upstream habitat is important and consultation to Seneca nation should be included in the processes. Concerned with increased eolevations within the reservoir, walleye hatchery in the spring, blue-green algae issues, increased outflows. Take into account the upstream free-flowing portion of the Allegheny to assist with decision-making. Mussels and data collected in upstream free flowing sections could serve as a baseline.

Component 3: Spring Baseflows

- Monitor: tag/ recapture on a young cohort. With control ahead of time. Growth curve
- Silo Studies?
- Temperature large component- can slow or speed up spawning
- Would take a long time for mussel indicator
- Velocity for how far and where mussels settle
- Tag studies for analysis

Component 4: Summer Baseflow

- We are already implementing this and doing what we can.
- Response: May be currently losing habitat for small benthic and fishes by not having a low flow in the summer.
- Better for mussels- would see population growth in drought years.
- What we losing for fishes by not having low flow in summer- would need modeling: benthic fishes- are they hosts for mussels?
- Worse for small fish if water is only in main channel, but good for mussel Monitor: genetic analysis, microsatellite analysis

Conclusions, Gaps, and General comments

- from Heather Galbraith: I would specify "recruitment" (of biota) as an indicator of success
- Bob: Test the ability of reservoir releases to achieve a goal. Large variation would be detrimental to species that are adapted to more stable conditions. Flow and Temperature. Especially with climate changes. High flow events are becoming more frequent and reservoir is getting warmer. Can we model and then use the reservoir releases to dampen the effect of climate changes.
- Mitigation of climate change: Opportunity to maintain the system in face of changes that could otherwise devastate it. More forward looking at analysis of what's being considered using climate change models
- from Jamie Detweiler: I'd be interested in studying if the predictability of flows to increase the success of restoration efforts.
- Doug: Higher summer flows would do for downstream-rec is big part of funding
- from Steve Faulkner - USGS LSC: Not sure where this goes, but I think we should explicitly recognize the need for explicit analysis of difficult trade-offs that can lead to more resilient and sustainable conservation decisions. This is related to the recreational user/stakeholder comment that the dam manager mentioned
- from Heather Galbraith: What is the importance of groundwater input to the system?
- from Steve Faulkner - USGS LSC: E-flow regimes will be difficult to sustain if other users/stakeholders feel that they conflict with their ability to use the river and that they had no stake in process
- Validation flows is difficult. But the discussion of monitoring allowed us to explore ideas where there was gaps in knowledge.
- from shane titus: Water Reallocation Study needs to be done for the Kinzua Reservoir

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September 9th and 10th, 2020

Conclusion Discussion

Initial Thoughts

- Joe Duris -The value of continuous velocity at the USGS gages and what we might be able to do with that additional piece of information during dam releases.
- Nevin Welte - I was curious to see if you guys could give us a few examples of previous efforts (like Green River) where some of these monitoring situations and discussions have already taken place. It might help prevent us reinventing the wheel for the Allegheny. Also curious to see the lessons-learned.
- Greg Zimmerman - Thinking from a mussel / fish and overall water quality / perspective we should avoid changing the existing low flow condition, and instead focus on peak flows in spring / fall that could reconnect flood plain and natural river morphological processes similar to other events that may occasionally happen during high water events.
- Eric Chapman - How important Kinzua is to keeping those federally listed mussels wet all year long?
- Tony Honick - This is essentially a restoration project, but what are the restoration goals? Are we approaching it from a species standpoint? Regardless, there will be winners and losers which complicates things.
- Frank Borsuk - As noted, it may take decades to assess the success of the response of freshwater mussels so as Nevin noted we should use the lessons learned from other projects e.g. Green River; Elowa River etc.

Floodplain report out

- 8 Validation flow ideas but not done through RPT with magnitude, duration, timing. Hybrid approach
- Sediment movement – impacts SAV, substrate, etc. spring near bankfull validation of steps to 5000csf a day and collect samples to see what type and concentration of sediment is moving. Step up and down.
- Floodplain validation flows – use remote sensing lidar (depressions) and gages to measure fluctuation of water in the vernal pools. Short term and long-term monitoring for physical and biological
- This is the beginning of a conversation so much more here to say and this is a process.

Mussels Report out

- Use existing data and learn from other areas
- Session 2 Summary- priority gaps small fish habitat, higher summer base gaps
- How reservoir and eflows implementation ride the waves of climate change
- Predictability of flows to increase the success of restoration

Conclusions:

- In general, the group gained a better understanding of operational constructions, but still needs to know who is on the landscape
- Mussels likely benefiting from high baseflow operations at the dam
- DO NO HARM – looking at multi-species and beyond the A2/A5 reaches
- Silence is not approval

- Avoid changing flow conditions and focus on peak flows – emulate natural peaks
- Bigger picture than emulating natural flows
- Learn more from others – improve communication
- Natural vs. managed – climate change and future changes the picture. A continuing conversation

Next Steps:
- Draft a working adaptive management plan that is a living breathing document
- Explore opportunities to advance partnerships
- Expanding geographies in the Upper Ohio

Appendix B. September 2020 Workshop Materials

Orientation to Document

- Slides are meant to be scrolled through using “Single Page” view.
- Bookmarks direct you to key document sections.
- Hyperlinks *(provided at the bottom of select pages)* provide access to additional documentation and detail.

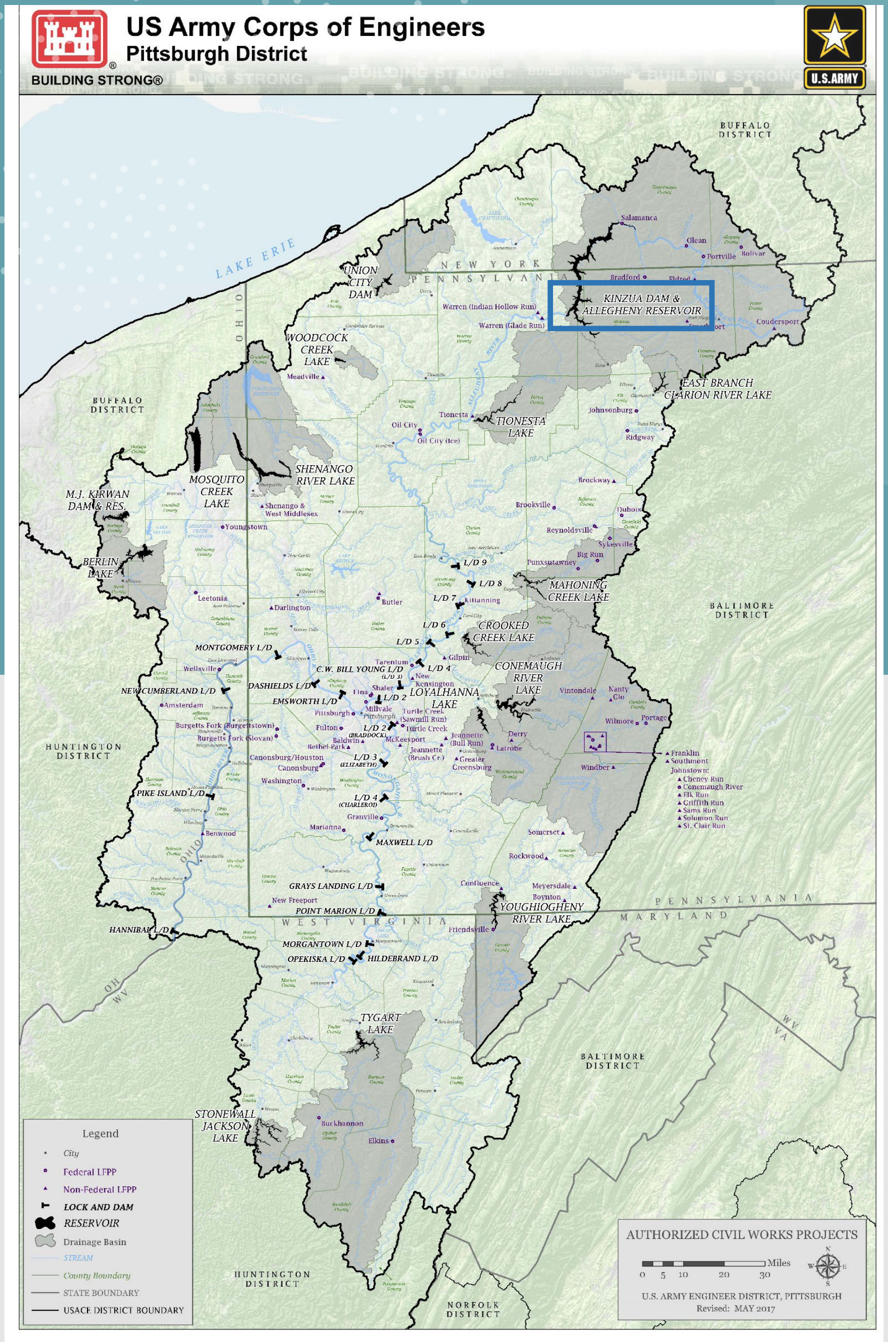
Orientation to

The Allegheny River Adaptive Management and Monitoring Workshop

September 9th and 10th, 2020

Workshop Executive Summary

Completed in 1965, the Allegheny Reservoir, located in the headwaters of the Allegheny River, is the largest reservoir in the Upper Ohio Basin. With headwaters emanating from the Allegheny National Forest, three reaches totaling 86.6 miles of the 325-mile Allegheny River are designated nationally as Wild and Scenic and harbor some of the highest freshwater biodiversity of any basin in Pennsylvania (DePhilip and Moberg, 2013). Through the Sustainable Rivers Program, the Nature Conservancy (TNC) and the United States Army Corps of Engineers (USACE) Pittsburgh District have evaluated how the operation of Kinzua Dam has changed the natural flow regime while hypothesizing the potential impacts of altered flows to downstream flow-sensitive ecosystems. The September 2020 Workshop will engage agencies and technical experts in a discussion framing an Adaptive Management and Monitoring Plan for Kinzua Dam Releases and the Upper Allegheny River.



For more about the Sustainable Rivers Program, see website here

Workshop Agenda

Goals

Develop Partner-Supported Adaptive Management and Monitoring Plan

Collect scientific input on Ecosystem Flow Recommendations

Create a Space for Shared Learning and Collaboration

Call-In Information

1. Log into the webinar space (preferably using internet explorer): https://usace.webex.com/meet/PittsburghDistrict
2. Sign in using your FULL NAME and AFFILIATION
3. Click the Phone Button and choose the 'Call Me' option if available

If you have trouble logging onto the webinar, call: (877)336-1831; Access Code: 1048650; Security Code: 1234

The full agenda is here

Adaptive Management and Monitoring Planning Workshop
for Kinzua Dam and the Upper Allegheny River

September 9th and 10th, 2020

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AGENDA

September 9th, 2020

9:00 Welcome & Workshop Overview
Andrea Carson (USACE), Rose Reilly (USACE), and Su Fanok (TNC)

9:15 Sustainable Rivers Program Overview
John Hickey (USACE, HEC), Gretchen Benjamin (TNC)

9:30 Allegheny Reservoir and Kinzua Dam Operation Overview
Charley Kottler (USACE)

9:45 Provisional Ecosystem Flow Recommendations for Kinzua Dam
Su Fanok (TNC)

10:00 **Break**

10:15 Introduction to Working Sessions 1-3
Andrea Carson (USACE)

10:20 Regime Prescription Tool Overview
John Hickey (USACE, HEC)

10:35 Conceptual Ecological Model Examples
Mary Walsh and Ephraim Zimmerman (Heritage)

10:50 Break

10:55 Session 1: Plenary Discussion – Scientific Input for Implementing Ecosystem Flows (E-Flows) Recommendations
Rose Reilly, Andrea Carson, and Charley Kottler (USACE), John Hickey (USACE, HEC)

11:55 **Lunch**

12:45 Introduction to Work Sessions 2 & 3
Andrea Carson (USACE), Su Fanok (TNC)

1:00 Session 2: Breakout Groups – Validating E-Flow Recommendations
Rose Reilly (USACE), Su Fanok (TNC)

2:00 **Break**

2:15 Session 3: Breakout Groups - Monitoring Effectiveness of E-Flow Implementation
Rose Reilly (USACE), Su Fanok (TNC)

3:00 **Break**

3:05 Flex Time: Continuation of Sessions

3:45 Wrap Up – Overview of Next Day
Andrea Carson (USACE)

September 10th, 2020

9:00 Welcome Back – Overview of the Day
Andrea Carson (USACE)

9:10 Breakout Groups (continued) – Final Discussions & Summarize Outcomes

10:00 **Break**

10:15 Report Outs and Q&A (~20 minutes each)

11:00 Pulling It All Together: Session Summaries and Connections to Adaptive Management & Monitoring Plan
John Hickey (USACE), Gretchen Benjamin (TNC)

11:45 Concluding Remarks
Andrea Carson (USACE), Rose Reilly (USACE), Su Fanok (TNC)

Workshop Attendees

Break-Out Group
Floodplains, Herptiles, Geomorphology

- Matt Baker (University of MD Baltimore County)
- Emily Elliot (University of Pittsburgh)
- Kate Zidar (University of Pittsburgh)
- Rick Spear (PA Dep. of Environmental Protection)
- Robert Novak (USFWS)
- Melinda Chapman (U.S. Geologic Survey)
- Mark Roland (USGS)
- Harry Stone (Ohio River Valley Sanitation Comm)
- Nate Welker (Allegheny National Forest)
- Heather Smiles (PFBC)
- Chris Tracey (PA Natural Heritage Program (PNHP))
- Ephraim Zimmerman (PNHP)
- Charles Kottler (USACE)
- Amy Jensen (USACE)
- John Chopp (USACE)
- Gretchen Benjamin (The Nature Conservancy(TNC))
- Brad Maurer (TNC)
- Emily Doerner (TNC)
- Su Fanok (TNC)

Break-Out Group
Freshwater Mussels, Host, and Other Fish

- Robert Anderson (U.S. Fish & Wildlife Service (USFWS))
- Andy Turner (Clarion University)
- Frank Borsuck (Env Prot Agency (EPA))
- Lou Reynolds (EPA)
- Dan Fitzgerald (USGS)
- Brian Ensign (PA Fish & Boat Commission (PFBC))
- Doug Fischer (PFBC)
- Jamie Detweiler (PA DEP)
- Greg Zimmerman (Enviroscience)
- Heather Galbraith (PFBC)
- Nevin Welte (PFBC)
- Mary Walsh (PNHP)
- Eric Chapman (Western PA Conservancy)
- John Hickey (USACE, HEC)
- Rose Reilly (USACE)
- Mindy Grupe (USACE)
- Nick Lazzaro (USACE)
- Tony Honick (USACE)
- Eric Merriam (USACE)
- Doug Helman (USACE)
- Gabrielle Georgetson (USACE)

Overview of Ecologically Sustainable Water Management in the Allegheny River

(2013-2019)

A Six Step Framework

Ecologically Sustainable Water Management

A Six Step Framework

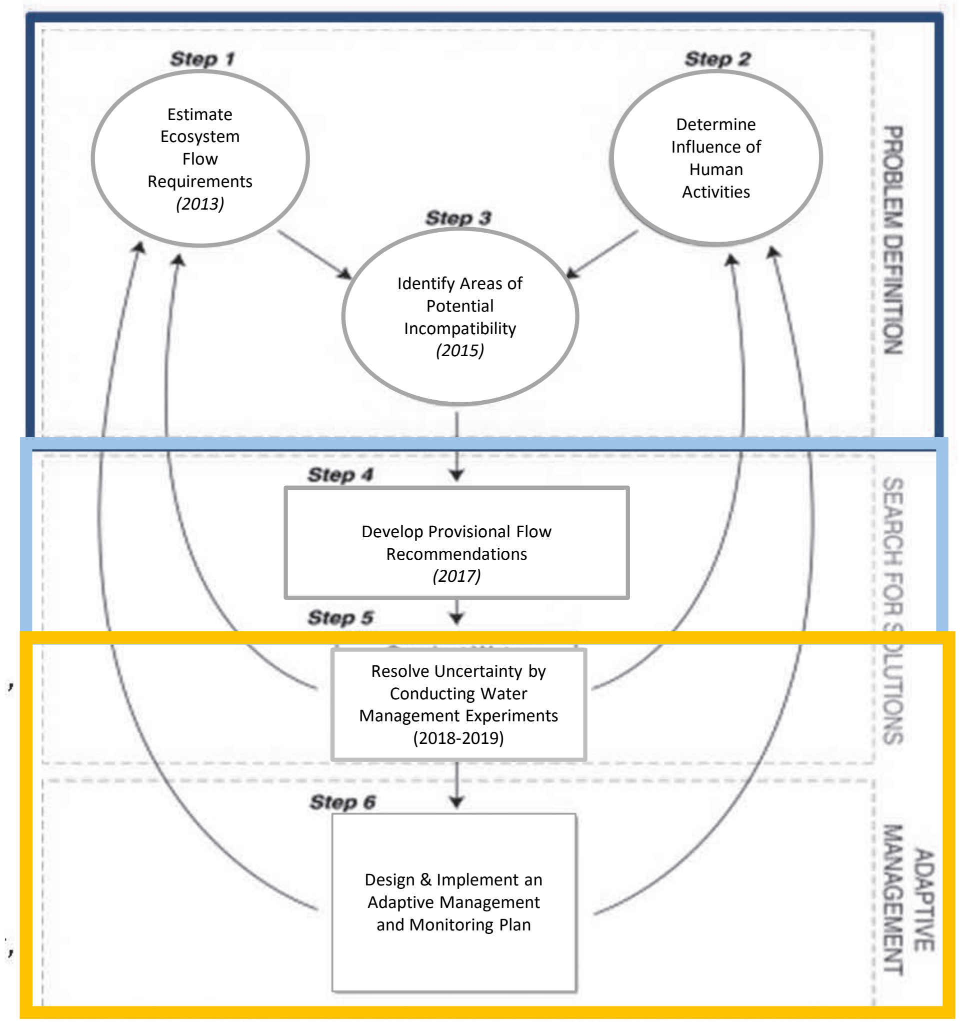
Step 1. Estimate Ecosystem Flow Requirements (2013): Initial efforts identified flow-sensitive taxa and their flow needs per season and reach.

Step 2. Determine Influence of Human Activities (2015): In order to isolate the effects of Corps reservoir operations on streamflow, we used existing flow and reservoir operations data to define current (*including the impacts of existing operations*) and baseflows (*flows not impacted by reservoir operations)* conditions and compared a suite of flow statistics for the two conditions.

Step 3. Identify Areas of Potential Incompatibility (2015): Using the flow alterations identified in Step 2, we focused on species that are likely to be affected in each season and then identified conservation opportunities related to dam operations.

Step 4. Develop Provisional Ecosystem Flow Recommendations (2017): Building on Steps 1, 2, & 3, Provisional Ecosystem Flow Recommendations for the Allegheny were developed to provide more specific flow recommendations in a form that may be operationalized. The flow recommendations are intended to target the five flow components that would have the greatest ecological benefits.

Step 5 & 6: Resolve Uncertainty by Conducting Water Management Experiments and Design & Implement an Adaptive Management and Monitoring Plan (2020): Water management validation experiments and monitoring are necessary to determine if dam operations are having their intended results, and to adaptively manage ecosystem flows if possible and necessary.



Ecologically Sustainable Water Management Framework

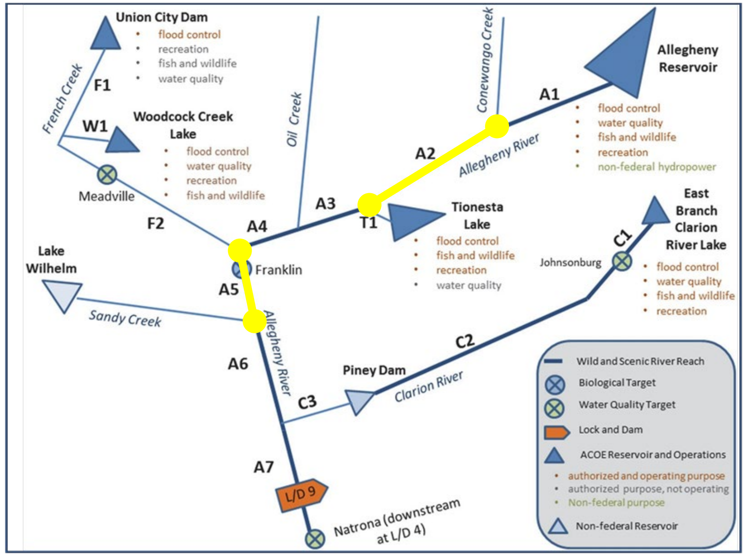
The 2013 Report, "Ecosystem Flow Recommendations for the Upper Ohio River Basin" is <u>*here*</u>
The 2015 Report, "Ecological Flow Study for the Upper Allegheny River" is <u>*here*</u>
The 2017 Report, "Provisional Ecosystem Flow Recommendations" is <u>*here*</u>

Allegheny River Reaches

The Allegheny River was divided into 7 geographically distinct reaches. These reaches account for the variability across the regulated portions of the Upper Allegheny River and were defined based on locations of major confluences, ecological values, flow targets (to meet existing management objectives) and potential influences of both Corps' and non-federal reservoirs. Allegheny Reservoir releases are made to support water quality on the mainstem Allegheny River (at Natrona) and to meet a biological target of 1720 cfs on the mainstem Allegheny River (at Franklin).

Reaches A2 and A5 will be the focus of the workshop.

	Workshop Study Reaches	Potential Hydrologic Influence on Study Reac
A1	Kinzua Dam to Conewango Creek	Influence of Kinzua Dam; authorized purposes include floo control, water quality, fish and wildlife, and recreation. Hydropower is a non-federal purpose
*A2	Conewango Creek to Tionesta Creek Confluence	Influence of Kinzua Dam on downstream of a major tributa flow (Conewango Creek)
A3	Tionesta Creek to Oil Creek Confluence	Influence of Kinzua & Tionesta Dams on the mainstem
A4	Oil Creek to French Creek Confluence	Influence of Kinzua & Tionesta Dams downstream of a maj tributary inflow (Oil Creek)
*A5	French Creek to Sandy Creek Confluence	Influence of Kinzua, Tionesta, Union City and Woodcock or Allegheny



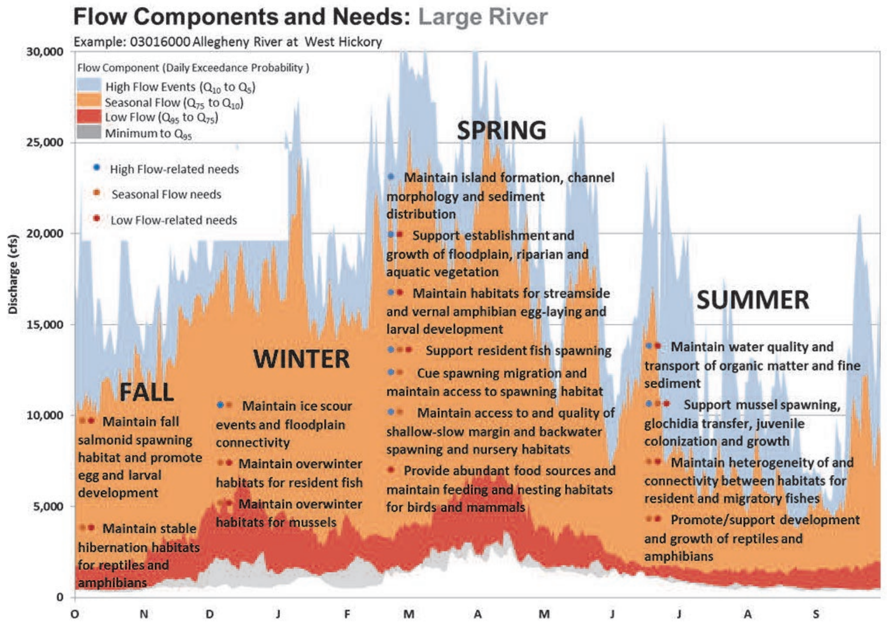
Step 1

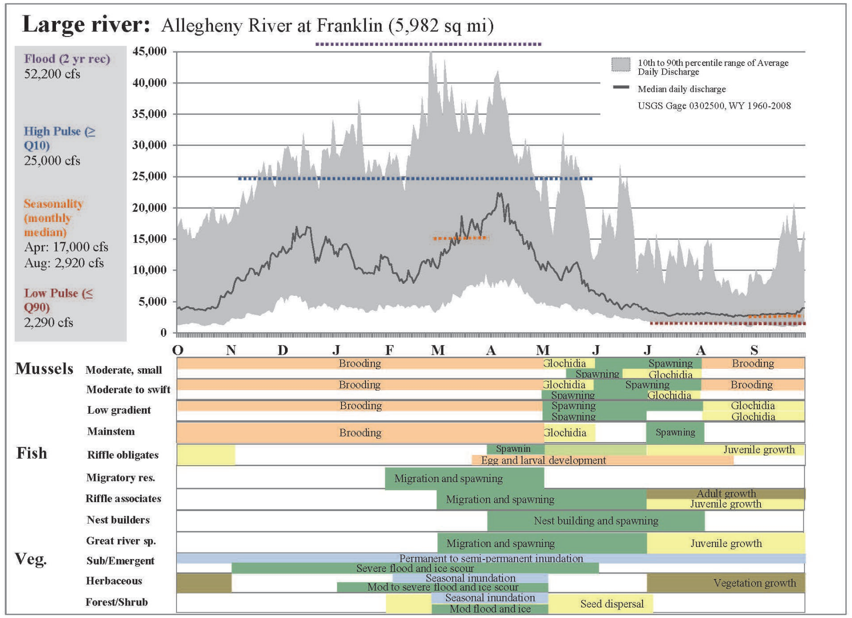
Upper Allegheny River Ecosystem Flow Needs *(2013)*

In Step 1, we identified flow-sensitive taxa and their flow needs per season and reach. We identified the species, natural communities, and physical processes within the Upper Allegheny for 1. Fish; 2. Mussels; 3. Reptiles and Amphibians; 4. Riparian and Floodplain Vegetation Connectivity; and 5. Channel Maintenance Flow.

Through literature review and expert consultation, we also identified the most critical periods and flow conditions for each taxa group and summarized key ecological flow needs for all seasons. This “bottom up” approach confirmed the importance of high, seasonal, and low flows throughout the year and of natural variability among years. The emerging set of recommendations focuses on limiting alteration to a key set of flow statistics that represent high, typical seasonal, and low flows.

Figures note taxa that may occur in the Allegheny, their eco-hydrological relationships, and the timing of life stages (DePhilip and Moberg 2013).





A summary of Flow-Sensitive Taxa Groups for the Allegheny River is *here*

Figure 5.5. Degree of hydrologic alteration to spring flows illustrated using the April median. Please see Table 5.1 for a description of risk categories.

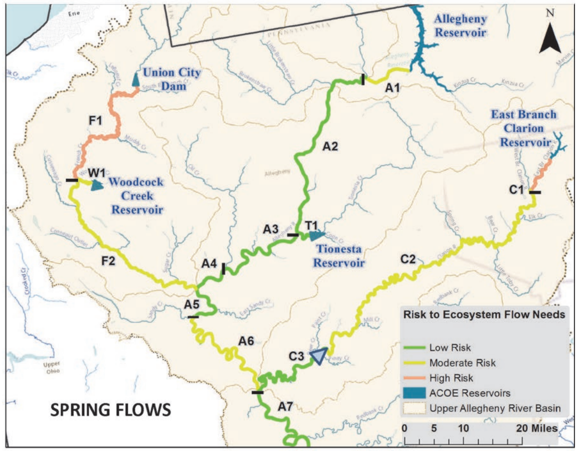


Figure 5.6. Degree of hydrologic alteration to bankfull flood frequency illustrated using the 1 in 2 year high flow event. Please see Table 5.1 for a description of risk categories.

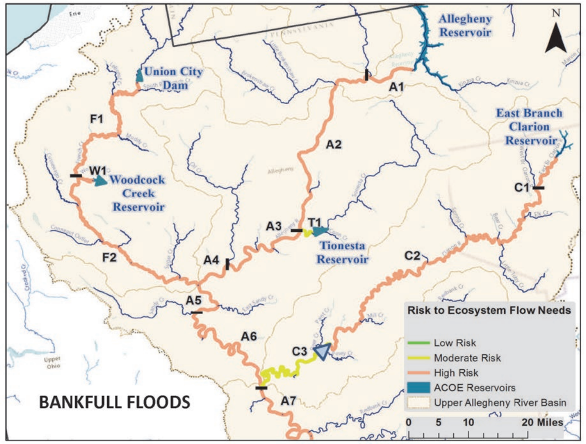


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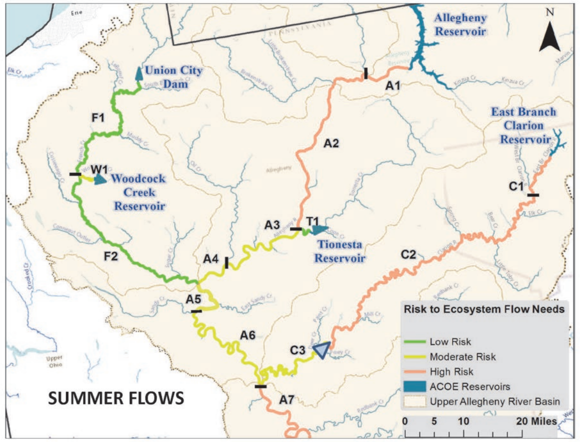
Figure 5.2. Degree of hydrologic alteration to summer flows illustrated by change to the August median. Please see Table 5.1 for a description of risk categories.



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Figures excerpted from 2015 Report, pgs. 90-95

Step 2

Determine Influence of Human Activities

(2015)

In Step 2, we isolated the effects of Corps reservoir operations on streamflow. We used existing flow and reservoir operations data to define current (*including the impacts of existing operations*) and baseflows (*flows not impacted by reservoir operations)* conditions and compared a suite of flow statistics for the two conditions. The figures above and supportive text illustrate the results of this analysis.

- *Spring (Figure 5.5) (March, April, May).* During the spring months, all stream reaches below Allegheny Reservoir are lower than the baseline conditions, with the most significant affects occurring directly below the reservoirs. During these months, the reservoirs are ‘filling’ or storing to meet summer pool elevations. Monthly median flows in March are 23% and 17% below baseline flows at West Hickory and Franklin, respectively.

- *High Flows (Figure 5.6*). All five reservoirs operate to retain high flow pulses and floods. Through modeling, we found that the annual 1- and 3- day high flow events were reduced on reaches below all reservoirs. Bankfull floods were eliminated on all reaches below the reservoirs.

- *Summer (Figure 5.2) (June, July, August, September)*. During the summer months, median flows below Allegheny Reservoir (A1 and A2) are >50% higher than the baseline condition. Monthly median flows in July, August, and September are 33%, 55%, and 96% above baseline flows at West Hickory, respectively, and 28%, 52%, and 89% above baseline at Franklin, respectively.

Figure 5.3. Degree of hydrologic alteration to fall flows illustrated using the October median. Please see Table 5.1 for a description of risk categories.

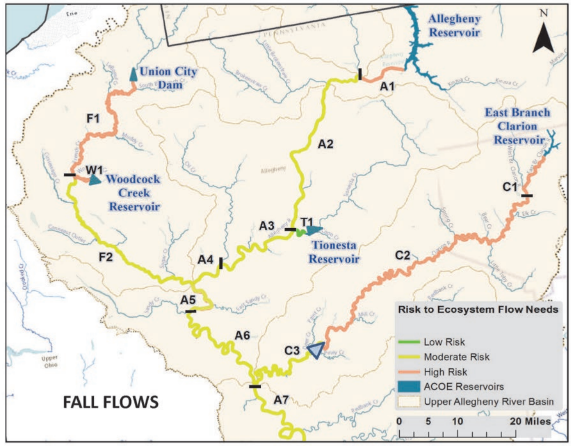


Figure 5.4. Degree of hydrologic alteration to winter flows illustrated using the December median. Please see Table 5.1 for a description of risk categories.

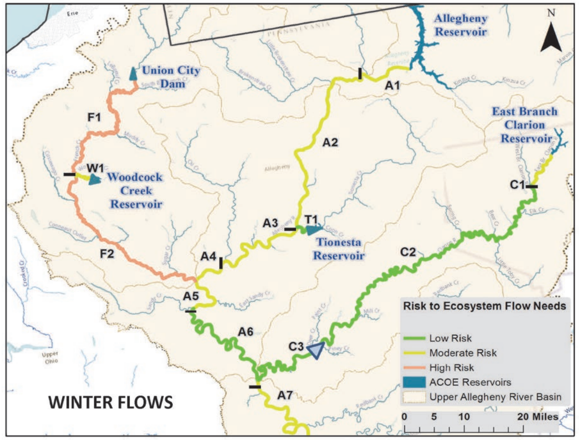
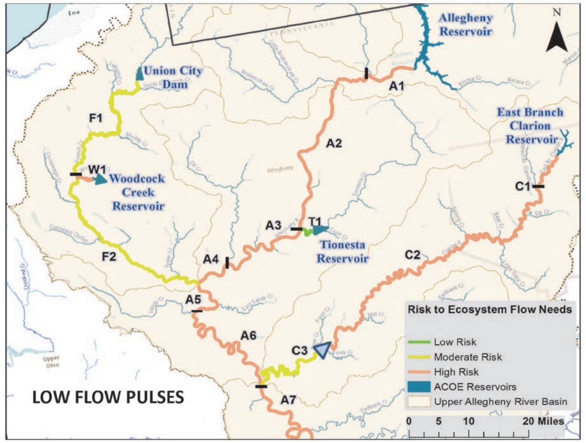


Figure 5.7. Degree of hydrologic alteration to low flow pulse magnitude illustrated using the 7-day low flow event. Please see Table 5.1 for a description of risk categories.



Figures excerpted from 2015 Report, pgs. 90-95

Step 2 *(continued from previous slide)*

Determine Influence of Human Activities *(2015)*

- *Fall (Figure 5.3) (Oct, Nov).* Patterns of alteration are similar to the summer months. Monthly median flows in October are 48% and 56% above baseline flows at West Hickory and Franklin, respectively.

- *Winter (Figure 5.4) (Dec, Jan, Feb).* In general, alteration during the winter months is lower than in the fall and summer. Monthly medians are higher than the baseline due to winter pool drawdown. Monthly median flows in December and January are 35% above baseline flows at West Hickory and 18% and 16% above baseline during December and February at Franklin.

- *Low Flows (Figure 5.7).* As described during the summer season, the magnitude of low flow pulses increased, with increases being highest below Allegheny. The seasonal timing of low flows is also altered by dam operations- under baseline conditions, the majority of low flows happen between July through October. Under current conditions below the Kinzua Dam, low flows happen throughout the year. Many low flows occur in spring, which is usually the highest flow season of the year under unaltered conditions.

Step 3

Identify Areas of Potential Incompatibility *(2015)*

In Step 3, we used the flow alterations identified in Step 2, to identify species that are likely to be affected in each season and then identified conservation opportunities related to dam operations. The following highlights potential operational opportunities to enhance or conserve habitat and river processes on the Allegheny River from reaches A1-A5, specifically by improving conditions that support the following ecosystem needs:

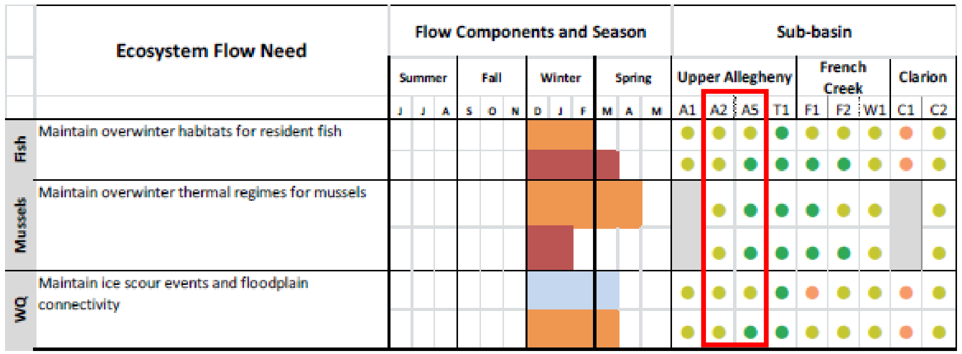
Improve the heterogeneity and conditions for resident and migratory fishes: Reaches A1-A5 include some of the region's most diverse fish populations, most notably hosting more than a dozen species of darters (*Nocomis* and *Etheostoma)*. Several guilds are present, requiring different habitats for rearing and growth including cold-cool water fish (e.g. salmonids and sculpin), riffle obligates (e.g. madtoms, darters and shiners), and larger-bodied, migratory species (e.g. white sucker, redhorse species, walleye and Ohio lamprey). Operational changes during the summer months may influence the diversity and quality of available riffle, glide and pool habitats.

Support habitat conditions for mussel spawning, glochidia transfer and juvenile colonization and growth: The Allegheny River, from reach A2 through A6, hosts one of the region's most diverse mussel populations. Operational guidance for seasonal flow variability and ramping rates (particularly down-ramping rates), may improve mussel habitat conditions on the Allegheny. The reach directly below the Allegheny Reservoir does not currently support viable mussel populations, due to the cold temperatures of summer and fall reservoir releases.

For more information regarding Target Species Eco-Hydrologic Relationships see Slides 20-26

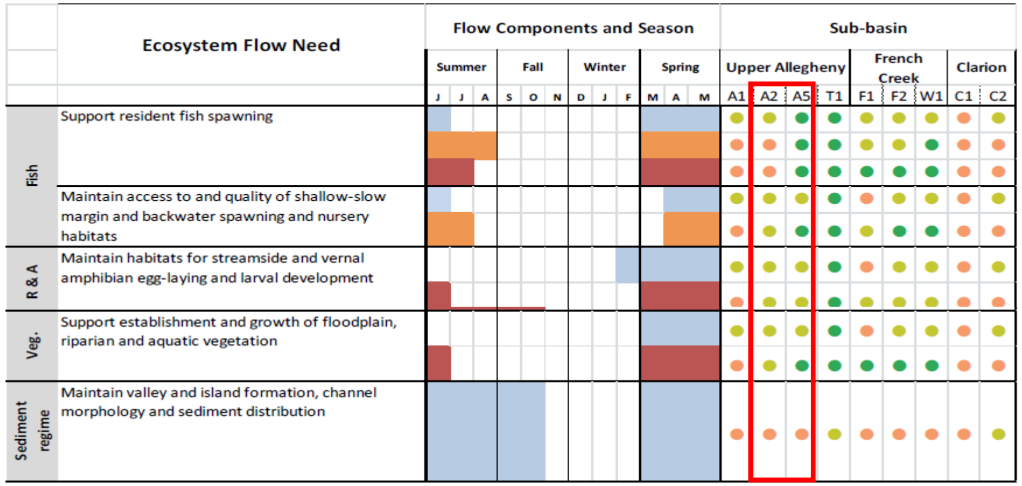
Based on the specific flow alteration for each reach, we summarize the hypothesized ecological effects in each season. Ecosystem flow needs are connected to maintenance of high, seasonal, and low flow components. Gray boxes indicate the ecosystem flow need is not relevant for that reach.

WINTER



- If flows are too low in winter, it could increase risk of freezing and anchor ice, which could affect overwinter conditions, particularly for immobile life stages like salmonid eggs and mussels
- If flows are too high in winter, it could increase bioenergetic costs for fish and mussels
- If high flows are lost during winter/spring while ice is breaking up, it could reduce floodplain scour needed by some floodplain vegetation

SPRING



- Loss of high flows in spring could decreased the extent of or access to shallow-slow habitats used for fish spawning and nursery habitat & could affect downtream larval fish transport.
- Loss of high flows during spring could reduce floodplain connectivity and inundation important for herptiles
- Loss of high (scouring) flows can reduce the extent of floodplain scour vegetation
- Loss of high flow events can reduce seed dispersal and affect channel and island maintenance

The above tables are excepted from the 2015 Report, pgs. 98-100

Step 3 *(continued from previous slide)*

Identify Areas of Potential Incompatibility *(2015)*

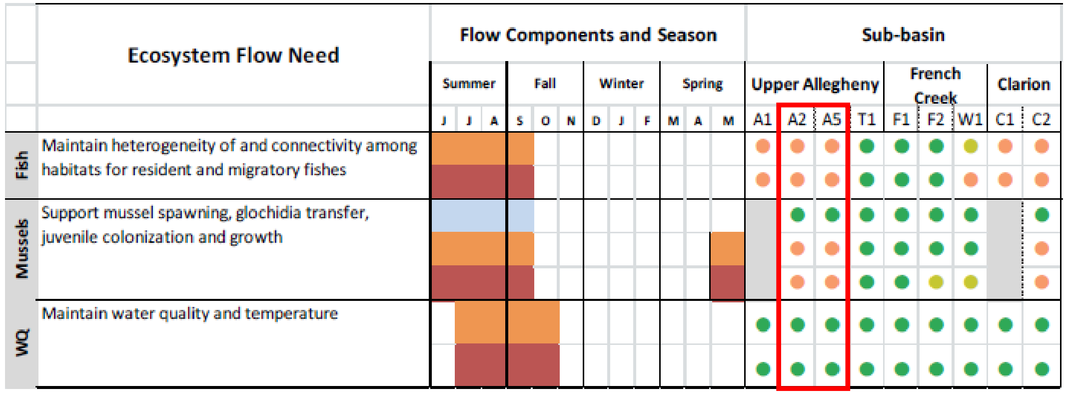
Improve overwinter habitat for hibernating reptiles and amphibians: Reptiles (e.g. Eastern Spiny Softshell) and amphibians begin hibernation during late October and early November. Operational changes that maintain seasonal flows during the fall, winter and spring may provide more stable hibernation habitats.

Improve establishment and growth of aquatic, riparian and floodplain vegetation: The Allegheny supports diverse complexes of submerged and emergent bed, herbaceous communities, and riparian and floodplain forests. Operational changes that support seasonal winter and spring high flows, and bankfull floods may improve seed dispersal, moisture regimes and sediment distribution for vegetation habitat.

Improve river processes including maintenance of channel morphology and sediment distribution: Habitat-forming or bankfull flows and small floods have been eliminated or significantly reduced on all regulated reaches of the Allegheny and Clarion rivers. Operational changes that support restoring these events may improve channel maintenance and sediment distribution.

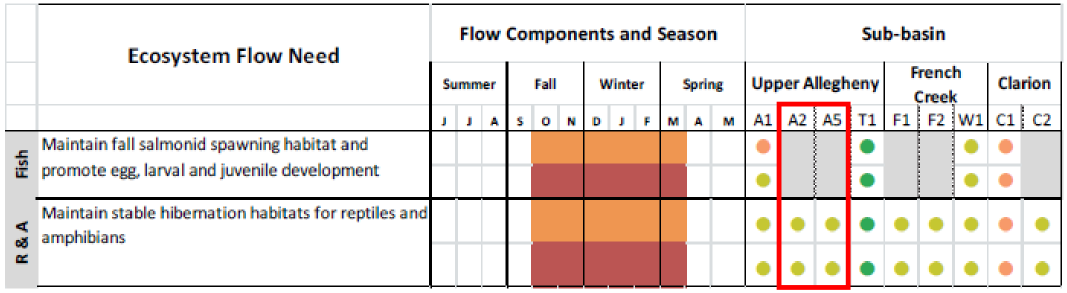
Based on the specific flow alteration for each reach, we summarize the hypothesized ecological effects in each season. Ecosystem flow needs are connected to maintenance of high, seasonal, and low flow components. Gray boxes indicate the ecosystem flow need is not relevant for that reach.

SUMMER



- If seasonal and low flows increase in summer, the distribution of riffle habitat may change or convert to run habitat, affecting riffle fishes
- If seasonal and low flows increase in summer, the depth of side channel, nursery habitats may increase allowing access to predator fish
- If low flows increase and are more stable in summer, mussels may colonize margin habitats that are easily dewatered.

FALL



- If flows are too low, or the rate of change increases in fall, the availability of salmonid spawning habitat could be reduced
- If flows are high in fall then low in winter, it could result in dewatered salmonid redds or habitat unsuitable for egg and larval development
- If flows are high in fall then low in winter, it could also make reptile and amphibian habitat unsuitable for hibernation

For more information regarding Target Species Eco-Hydrologic Relationships see Slides 20-26

The above tables are excepted from the 2015 Report, pgs. 98-100

Step 4

Upper Allegheny River Provisional Ecosystem Flow Recommendations

(2017)

Building on Steps 1, 2, & 3, in Step 4, Provisional Ecosystem Flow Recommendations for the Allegheny were developed to provide more specific flow recommendations in a form that may be operationalized. The flow recommendations are intended to target the five flow components that would have the greatest ecological benefits.

These recommendations are a starting point for discussion about desired future conditions, ecological benefits and feasibility, including operational flexibility, structural limitations and compatibility with other project purposes.

1 **Bankfull and small flood events** –The bankfull discharge was estimated by modeling a range of bankfull release scenarios to determine the acreage of habitat (floodplain, riverine wetlands, etc.) that were inundated while limiting inundation to developed areas.

High flow pulses (less than bankfull) –The baseline magnitude and frequency of pulses were calculated by restricting the period of analysis to the months of interest (March-May), then calculating the Q10 for the period. This step established the magnitude of the high flow pulses in spring under baseline conditions. High pulse frequency recommendations can be presented in two ways: number of pulse events or number of days above the threshold. Since high pulses in spring are often multi-day events caused by spring storms, snowmelt, and rain-on-snow events, the spring high flow pulse recommendation is for a *number of events* in spring of each year. The spring high pulse frequency recommendation is a range based on the number of high flow events that typically occur in a year under baseline conditions. Event duration was defined by calculating the median number of days per event, for all events over the period of record (1962-2013).

3 4 **Monthly baseflows** – Monthly baseflow recommendations were based on analysis of baseline flow conditions to describe the range of long-term variability of selected flow statistics. The recommendations would restore naturally-occurring flow variability that has been affected by current operations. We extracted the monthly Q25 and Q75 values from the baseline condition and used these values to establish the recommended range of daily flows for each month. We recommend that 50% of the daily flows be within the recommended range for each month.

5 **Seasonal transitions – Fall to winter** – Under baseline conditions, flows are typically low in early fall and increase during late fall and into winter as the growing season ends. We calculated the daily flows in October of each year in the baseline condition and compared them with daily flows in November, December, January, and February. Winter flows occasionally fell below October flows naturally, but this occurred infrequently in the baseline condition. Therefore, we recommend that late fall and winter flows should be equal to or exceed the daily flows during October. The actual flow value (in cfs) will change in each year; the goal is to restore the typical seasonal pattern of late fall and winter flows that are higher than early fall flows.

Provisional flow recommendations for the Allegheny River are presented as Figure 3 in Slide 15 and as Table 2 in Slide 16

Step 4 *(Continued from previous slide)*

Upper Allegheny River Provisional Ecosystem Flow Recommendations

(2017)

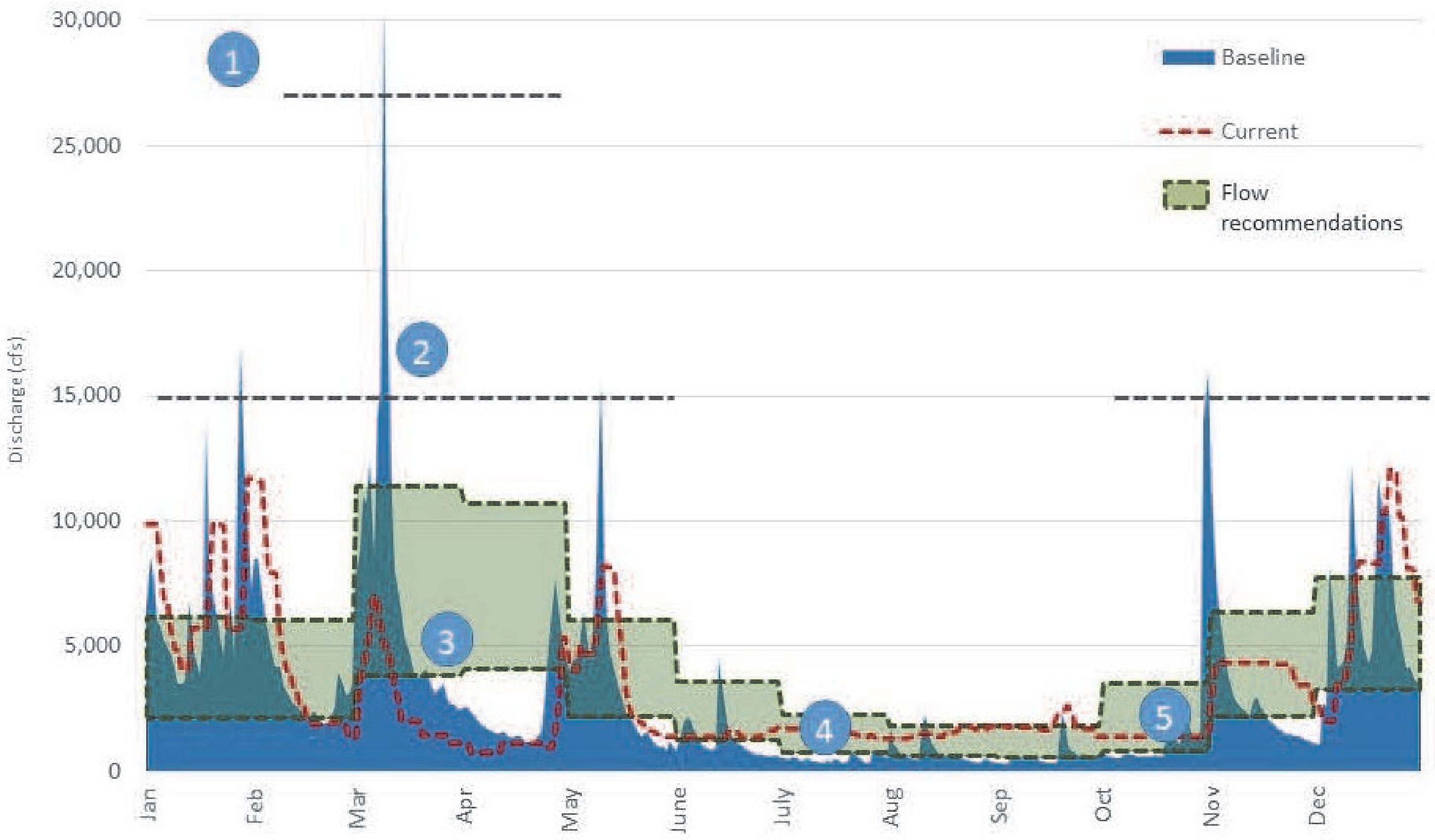


Figure 3. Illustrated provisional recommendations (dashed green lines and shading) for Allegheny River below Kinzua dam including high flow events (1, 2) and seasonal baseflows in spring, summer, fall and winter (3, 4, 5) See Table 2 for detailed recommendations for each of the five flow components.

A full version of Figure 3 is in the [2017 Report](), pg. 4

Step 4 *(Continued from previous slide)*

Upper Allegheny River Provisional Ecosystem Flow Recommendations
(2017)

Provisional Ecosystem Flow Recommendations

Flow Components

1. Bankfull Flow
2. Spring Pulse Flow
3. Spring Baseflow
4. Summer Baseflow
5. Fall/Winter Baseflow

Table 2. Allegheny River provisional flow recommendations.

	SPRING		
1	**Restore bankfull flood frequency and magnitude (Annual, and Mar, Apr)**	**Below Kinzua Dam:** Release a bankfull event approximately every 2-5 years (estimated bankfull below Kinzua Dam: 27,000 cfs), 7-day duration[5]	**At Franklin:** Release a bankfull event approximately every 2-5 years. Discharge should approach 100,000 cfs
2	**Restore high flow pulses during spring (pulse defined as March-April Q_{10}[6])**	**Below Kinzua Dam:** Release 1-3 events each year > 15,000 cfs, 3-day duration, during spring for channel maintenance, habitat availability and seed dispersal	**At Franklin:** 1-3 events each year > 38,000 cfs
3	**Restore magnitude and timing (seasonality) of spring baseflows (March, Apr, May)**	Approximately 50% of daily flows in March, April and May should be within the range defined by the monthly Q_{25} and Q_{75}: **Below Kinzua Dam:** March: 3,200-9,500 cfs Apr: 3,400-8,900 cfs May: 1,800-5,000 cfs	**At Franklin:** March: 9,600-22,300 cfs Apr: 10,200-24,000 cfs May: 4,700–13,200 cfs
	SUMMER		
4	**Restore magnitude and timing (seasonality) of summer baseflows (June, July, Aug, Sept)**	Approximately 50% of daily flows in June, July, Aug and Sept should be within the range defined by the monthly Q_{25} and Q_{75}[7]: **Below Kinzua Dam:** June: 1,030-3,000 cfs; July: 600-1,900 cfs; Aug: 500-1,500 cfs; Sept: 450-1,500 cfs	**At Franklin:** June: 2,300[7]-7,800 cfs; July: 1,500[7]-4,600 cfs; Aug: 1,200[7]-3,800 cfs; Sept: 1,000[7]-6,100 cfs
	FALL/WINTER		
5	**Maintain late fall and winter flows that are as high or higher than early fall flows**	**Below Kinzua (Allegheny River from Franklin to Foxburg):** Late fall and winter flows should be equal to or exceed the daily flows during October. **Below Kinzua Dam:** Oct: 658 -2,900 cfs; Nov: 600-5,300 cfs; Dec: 2,700-6,450 cfs; Jan: 1,758-5,100 cfs	**At Franklin:** Oct: 1,600 -8,000 cfs; Nov: 4,300-14,900 cfs; Dec: 6,900-17,800 cfs; Jan: 5,700-20,000 cfs

[5] When possible, all recommendations for high flow events (bankfull floods and high flow pulses), should be released commensurate with high flow events occurring in the watershed, peaking at the recommended flow and closely following ascending and descending limbs of the hydrograph. This is discussed further in Section IV.
[6] Monthly Q10 (also called the 90 percentile flow) is the flow in cubic feet per second which was equaled or exceeded for 10% of the days during the specified months over the period of record (1962-2013).
[7] The Allegheny River reach near Tidioute and West Hickory supports expanding beds of native mussels. The Corps releases water from Kinzua to meet a target of 1720 cfs at West Hickory (~2,800 cfs at Franklin) for federally listed mussels. See Section IV for more discussion about next steps in understanding habitat hydraulics under low-flow conditions and finalizing low flow recommendations.

A full version of Table 2 is in the 2017 Report, pg. 5; A table converting Table 2 flow values from Kinzua Dam to equivalent flows at the West Hickory gage is found here; and A table relating the above Provisional Flow Recommendations to Ecosystem Needs can be found here

Step 5 & 6

Why Water Management Experiments & Adaptive Management & Monitoring?

Ecosystem flow recommendations are developed based on estimated and observed pre- and post-dam streamflow and the hydrogeomorphic and vegetation conditions that support key aquatic and riparian communities through an iterative process that incorporates input from experts. These recommendations are developed for specific river segments and are composed of multiple, seasonally varying environmental flow components. Each environmental flow component has distinct ecological goals and streamflow targets for achieving those goals.

Flow recommendations are then evaluated by dam operators for feasibility, implemented where possible, and monitored to evaluate their effects on the river ecosystem and dam operations.

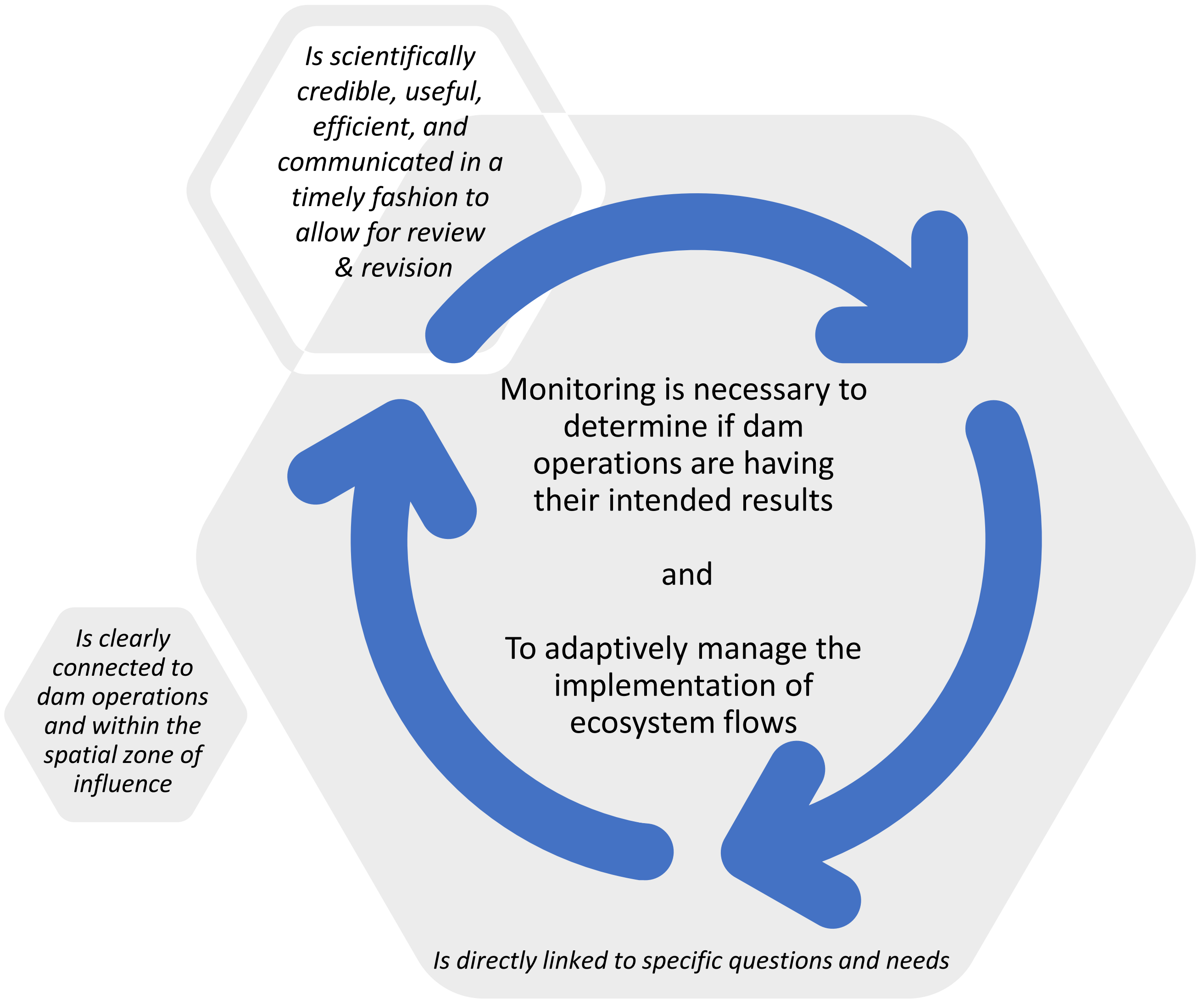
Because initial ecosystem flow recommendations often are made using the best available knowledge of streamflow and ecological relationships, adaptive management and monitoring programs are necessary to determine the success of implemented flows in meeting ecosystem objectives and to refine the goals of the environmental flow recommendations over time (Higgins et al, 2011).

The Adaptive Management & Monitoring Plan should:

1. Define Ecosystem Flow Recommendations
2. Monitor the degree to which the Ecosystem Flow is Implemented
3. Monitor Ecosystem Response and Trends that relate to Implementing Ecosystem Flow Recommendations

The following slides illustrate Examples of Water Management Experiments/Adaptive Management & Monitoring Efforts advanced in the Allegheny during 2018 and 2019.

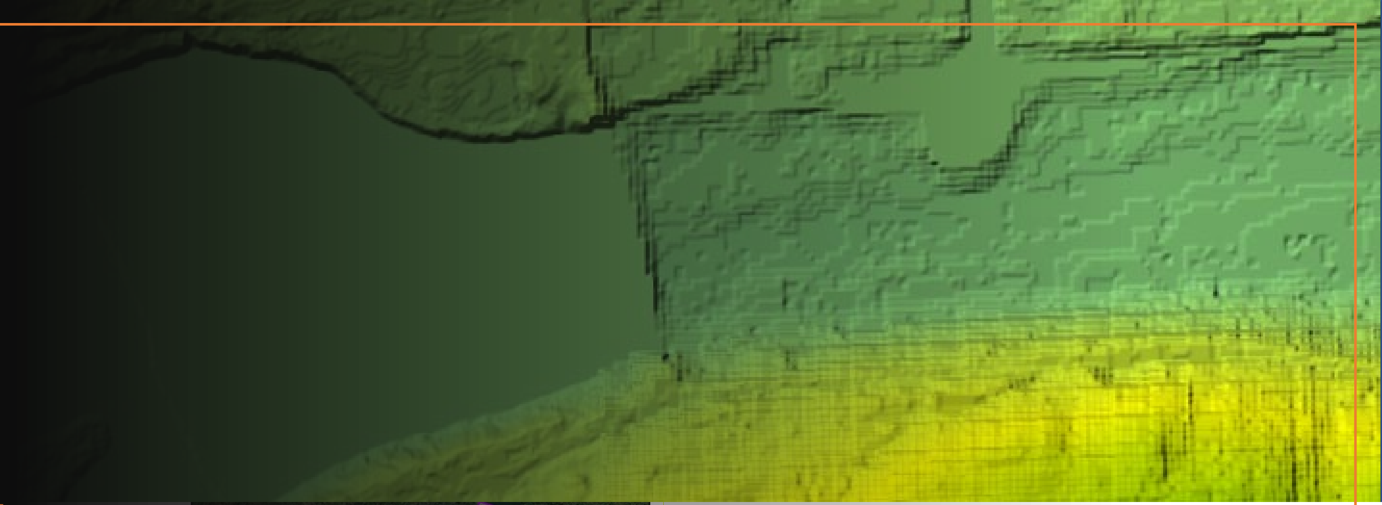
The Adaptive Management and Monitoring Cycle



Key Adaptive Management & Monitoring Publications are here & here

Step 5 & 6 *(continued from previous slide)*

Upper Allegheny Adaptive Management & Monitoring *Example I* *(2018)*



Using the methods defined by Long and Chapman (2008) and during controlled releases advanced by the USACE Pittsburgh District, the river bottom of the Tidioute (*river mile 166-170*) and the West Hickory (*river mile 156-160*) reaches of the Upper Allegheny River were surveyed.

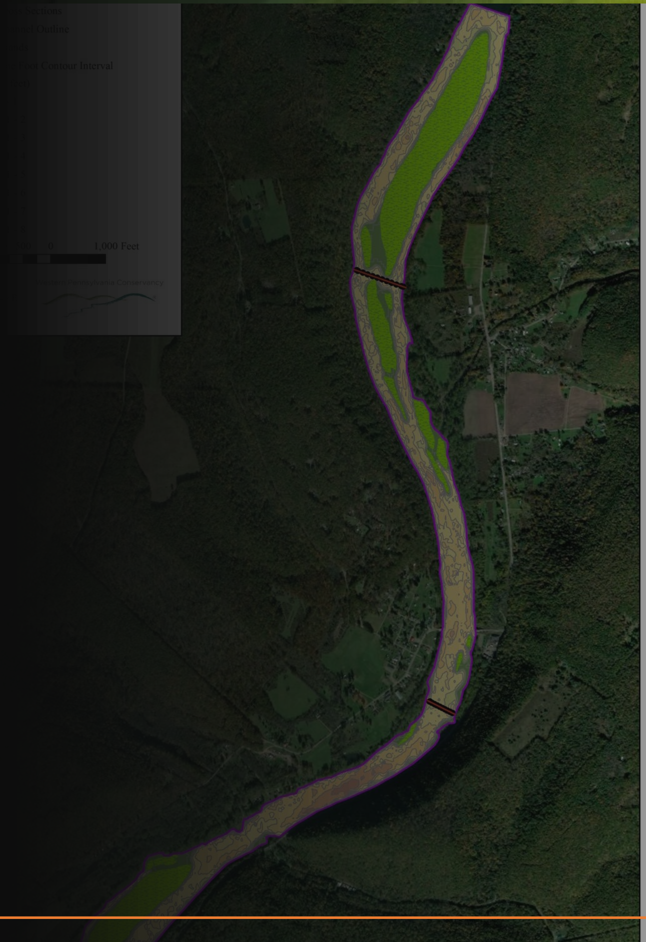
The purpose of the survey was to 1) Gain a better understanding of the riverbed shape and dynamics in areas with healthy mussel populations, and 2) Create a bathymetric data set that could be merged with an existing above water topographic dataset derived from the PAMAP LiDAR 2006-2008 to increase hydraulic modelling accuracy.

The survey was conducted by traversing the study reaches in a grid pattern in a boat equipped with sonar. Nearly 40,000 geo-located depth measurements were collected and recorded over the 8.6 miles of the two reaches.

The first release and bathymetric survey was carried out October 22-25, 2018. During this release, the District adjusted the release at Kinzua Dam to maintained an average flow of 4800 cfs (*flow ranged between 4260 and 5360 cfs*) at West Hickory (during working hours) for four days. The second release and bathymetric survey was carried out on December 12-13, 2018, during which the District maintained an average flow of 7900 cfs (*flows ranged between 7190 and 7600 cfs*) for two days (during working hours).

From this collective survey data, detailed topographic maps of 8.6 miles of the river bottom were developed.

Long and Chapman, 2008 can be viewed here



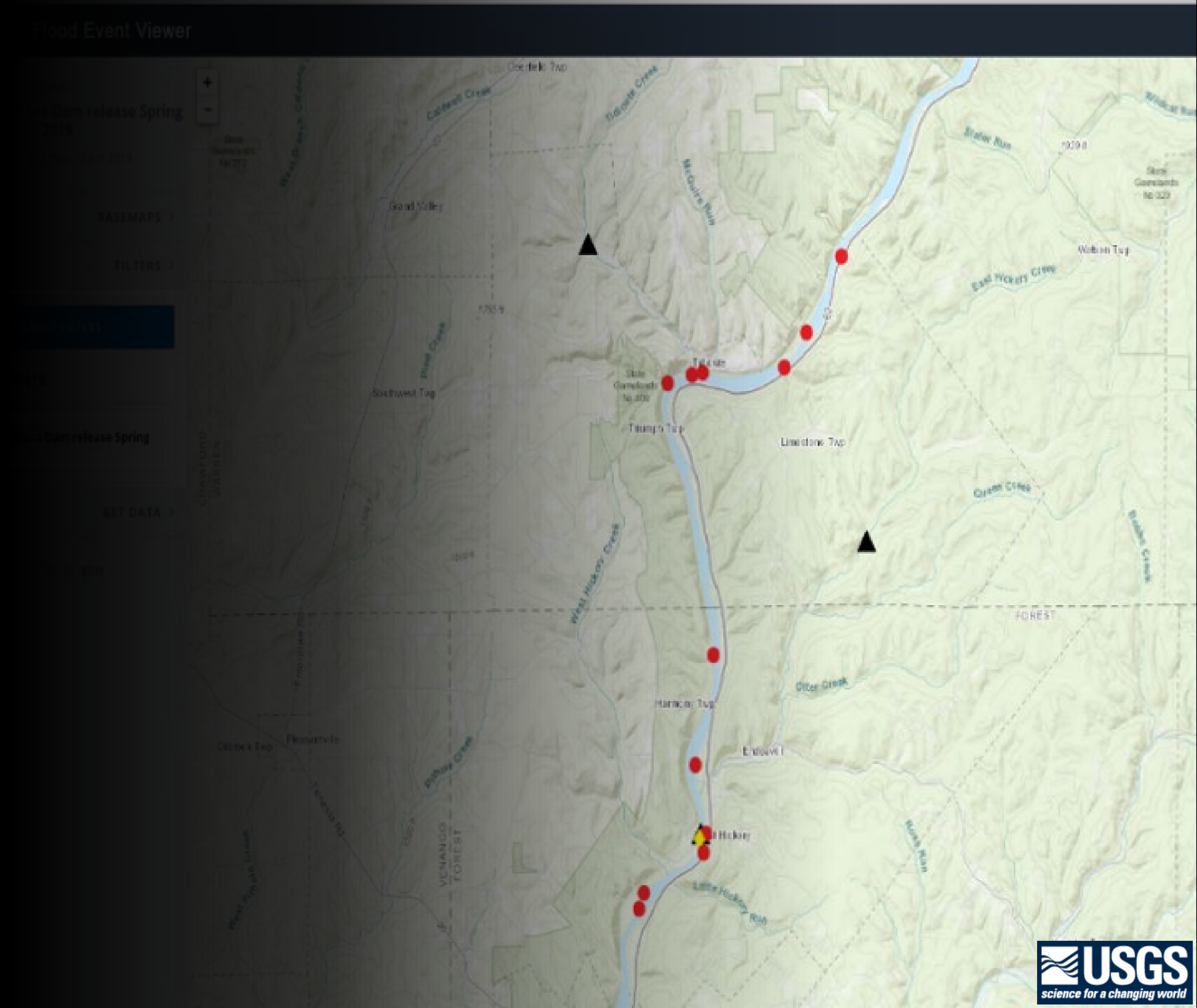
Step 5 & 6 *(Continued from previous slide)*

Upper Allegheny Adaptive Management & Monitoring *Example II (2019)*

During the Spring of 2019, the USGS conducted a survey and monitored water levels from Spring Pulses. Calibrated flows were then used to increase the accuracy of hydrologic models.

The product provided an enhanced understanding of the relationship between Kinzua Dam operations and the extent of a Spring Pulse Release(s) and the associated habitat for downstream species and communities.

The results of the high-water survey are here







Eco-Hydrologic Relationships for Targets

Two Examples – Freshwater Mussels and Floodplains

Freshwater Mussels

With more than 40 extant freshwater mussel species, the upper Ohio basin has the most diverse mussel assemblage of any basin in Pennsylvania (Ortmann 1909, Bogan and Proch 1992, Watters 1995, Smith and Crabtree 2010, Smith and Meyer 2012). Five federally endangered mussel species, Clubshell (*Pleurobema clava*), Northern Riffleshell (*Epioblasma rangiana*), Rayed Bean (*Villosa fabalis*), Snuffbox (*Epioblasma triquetra*), Sheepnose (*Plethobasus cyphyus)* and one threatened species, Rabbitsfoot (*Theliderma cylindrica*), occur in the basin.

The upper Allegheny River watershed is home to 23 mussel species and supports a high density of mussels (>30/ sq. m.) in some areas of the river (e.g. Hunter's Station, Chapman and Rihel 2015-2016). The Upper Allegheny River and tributaries are strongholds for rare mussels including reproducing populations of Clubshell and Northern Riffleshell (Crabtree and Smith 2009; Smith and Crabtree 2010; Smith and Meyer 2012).

Efforts by the Pennsylvania Natural Heritage Program (PNHP) to understand the distribution of rare mussels include studying their habitats and modeling their occurrences. In 2020, Pennsylvania Natural Heritage Program with Watershed Conservation staff surveyed mussel habitats in reaches of the Upper Allegheny River downstream of Kinzua Dam.

Fact Sheets for Flow Sensitive Species Taxa and Guilds are here

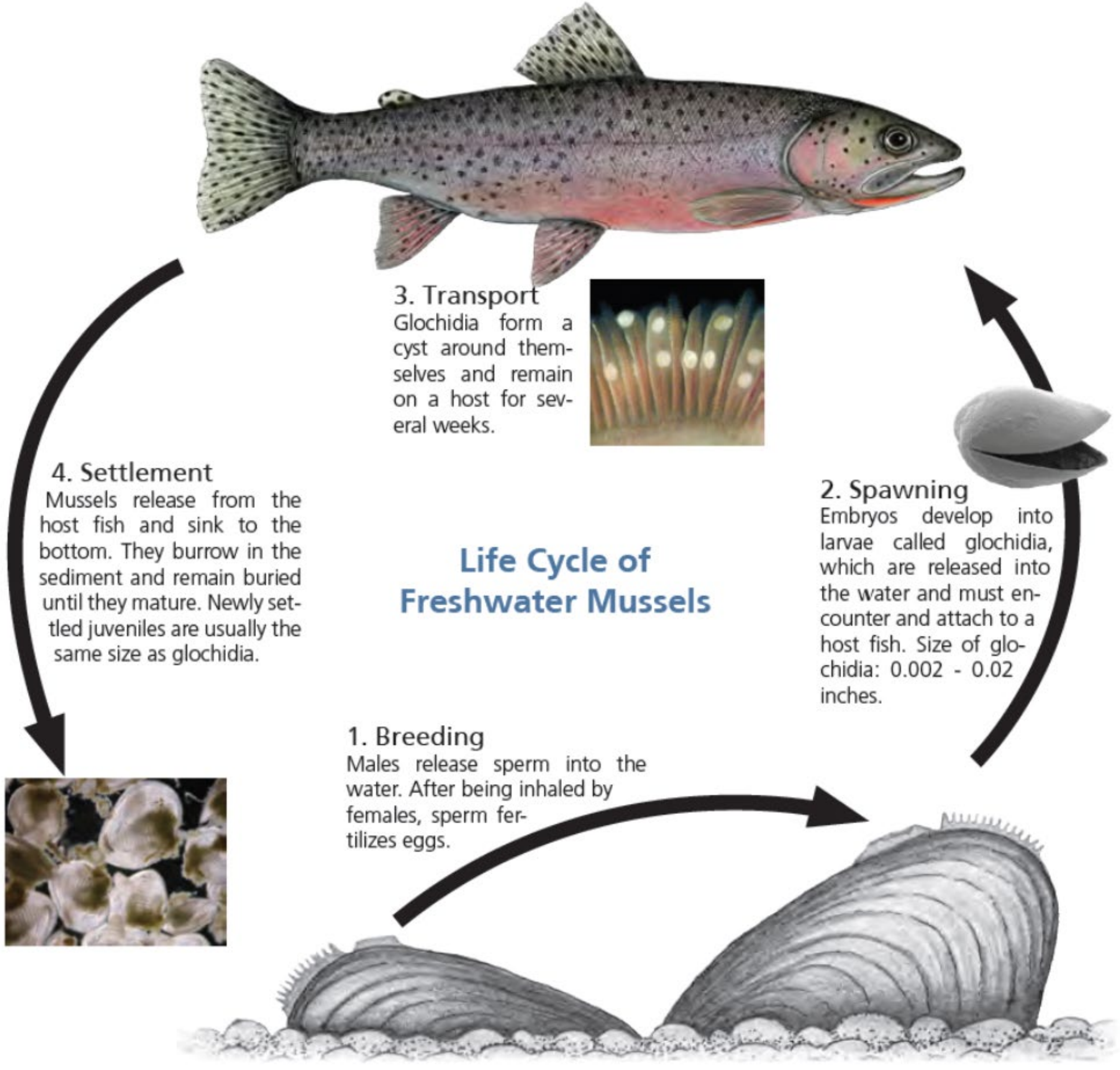
Key Flow-Related Needs for Upper Ohio Basin Mussels

Support mussel spawning, glochidia transfer, and growth

- Because of their limited mobility, mussels are sensitive to extreme high and low flow events and rapid changes in river stage
- Extreme low flows may expose mussels in marginal habitats and increase predation or desiccation
- High or low flow events may inhibit transfer of glochidia to host fish
- Extreme low flows may increase temperature, reduce dissolved oxygen and increase ammonia concentrations
- During juvenile excystment, high flows and associated sheer forces may prevent juvenile settlement
- Growth and fitness are influenced by high and low flow conditions
- Decreased magnitude or frequency of high flows can lead to habitat degradation including embeddedness, siltation and aggrading channel morphology
- Natural flow regimes can reduce risk of establishment of non-native mussels

Maintain overwinter thermal regimes for mussels

- Seasonal flows support thermal regimes critical in cueing gamete development and release
- Seasonal and low flows maintain surface and hyporheic temperatures and dissolved oxygen conditions



illustrations: Ethan Nedeau; glochidia image: U.S. Geological Survey; encysted glochidia and juveniles: Chris Barnhart

Freshwater Mussel Eco-Hydrologic Conceptual Model

Large-scale Processes: Biogeography | Flow regime | Geomorphology | Mussel traits

E-Flows:

- **Low flows** — Seasonal Flows #4, #5, & 1720 cfs: Summer & Winter Low Flows Biological Target @ Franklin
- **Seasonal flows** — Provisional Flows #3, #4, #5: Spring, Summer & Winter Seasonal Flows
- **High flows** — Provisional Flows #1 & #2: Bankfull & Spring Pulse Flows

Habitat & life history:

- Water quality and habitat at low flows during summer and winter periods
- Habitat connectivity, spawning, and host fish interactions
- Habitat maintenance and juvenile settlement

Underlying needs and processes:

Low flows

- Habitat persistence and diversity at low flows, including areas for juvenile settlement. Wetted habitat is needed for lateral movement. Stranding, predation, and exposure to extreme temperatures if depth and wetted habitat are reduced.
- Dissolved oxygen, water temperatures, and water quality parameters within physiological range during low flows. Stress and increased mortality if low dissolved oxygen, high temperatures, and increased ammonia at low flows.

Seasonal flows

- Habitat connectivity for interaction between host fish and mussels. Migration of fishes during spring seasonal flows ensures host fish availability. Habitat diversity needed for host fish and mussels.
- Seasonal flows support water quality and temperatures related to mussel spawning. Reduced spawning if flows during spawning period alter temperatures

High flows

- Areas within the range of sheer stress tolerance provide refuge during high flows. Excessive sheer stress dislodges mussels, prevents juvenile settlement, and scours habitats. Persistent high flows could disrupt encystment on host fish.
- High flows maintain habitat diversity and flush fine sediments. Embeddedness and siltation result from lack of flushing flows.

Key components of the Provisional Ecosystem Flow Recommendations (*see Slides 9-11*) include:

1. Bankfull Flow
2. Spring Pulse Flow
3. Spring Baseflow
4. Summer Baseflow
5. Fall/Winter Baseflow

Floodplains, Flood Scour, and Riverine Grasslands

Floodplain communities including forest, shrubland, herbaceous meadows, cobble scour, and emergent riparian wetland associations occupy the low-lying and inundated areas adjacent to the Allegheny River and its tributaries and are driven by a cycle of erosion and deposition caused by hydrodynamic processes. These plant communities are distributed based on several interrelating factors including the frequency and duration of flooding and scour (ice and flood), the amount of energy received as flood or ice flows, the position of the site within the watershed network, physiography, substrate stability and available propagules (Oliver and Larson 1996, Toner and Keddy 1997, Perles et al. 2004, Zimmerman and Podneisinksi 2008). Per the 2013 Report, floodplain communities were summarized into twenty major community types that can be organized into four major physiognomic groups: submerged and emergent bed, herbaceous, scrub-shrub and floodplain forest (see Slide next slide) (Zimmerman and Podniesinski 2008).

The species composition and structure of floodplain communities is greatly influenced by fluvial processes and in addition to physiognomy, plant communities can be arranged by fluvial geophysical settings in which they occur – shores and bars of gravel and cobble, levees and tops of islands, floodplains of the mainland and larger islands, sloping shorelines adjacent to steep uplands, and emergent wetlands of inlets and ponds.

Aquatic plant communities are not currently characterized for the Allegheny River; however, it is clear that submerged aquatic vegetation in the Upper Allegheny River can be described as occurring within these three ecological zones: riffles (*fast moving water with cobble substrate*), runs (*somewhat fast moving water with gravel/sand stubstrate*), and pools (*slower moving water in the river channel with a sandy/silty substrate*).

Currently, the PA Natural Heritage Program is working with The Nature Conservancy and U. S. Army Corps of Engineers to investigate the relationship between the fluvial landforms and their vegetation (both aquatic and terrestrial communities) to provide guidance to management of river flows in the Upper Allegheny River.

Fact Sheets for Flow Sensitive Species Taxa and Guilds are here

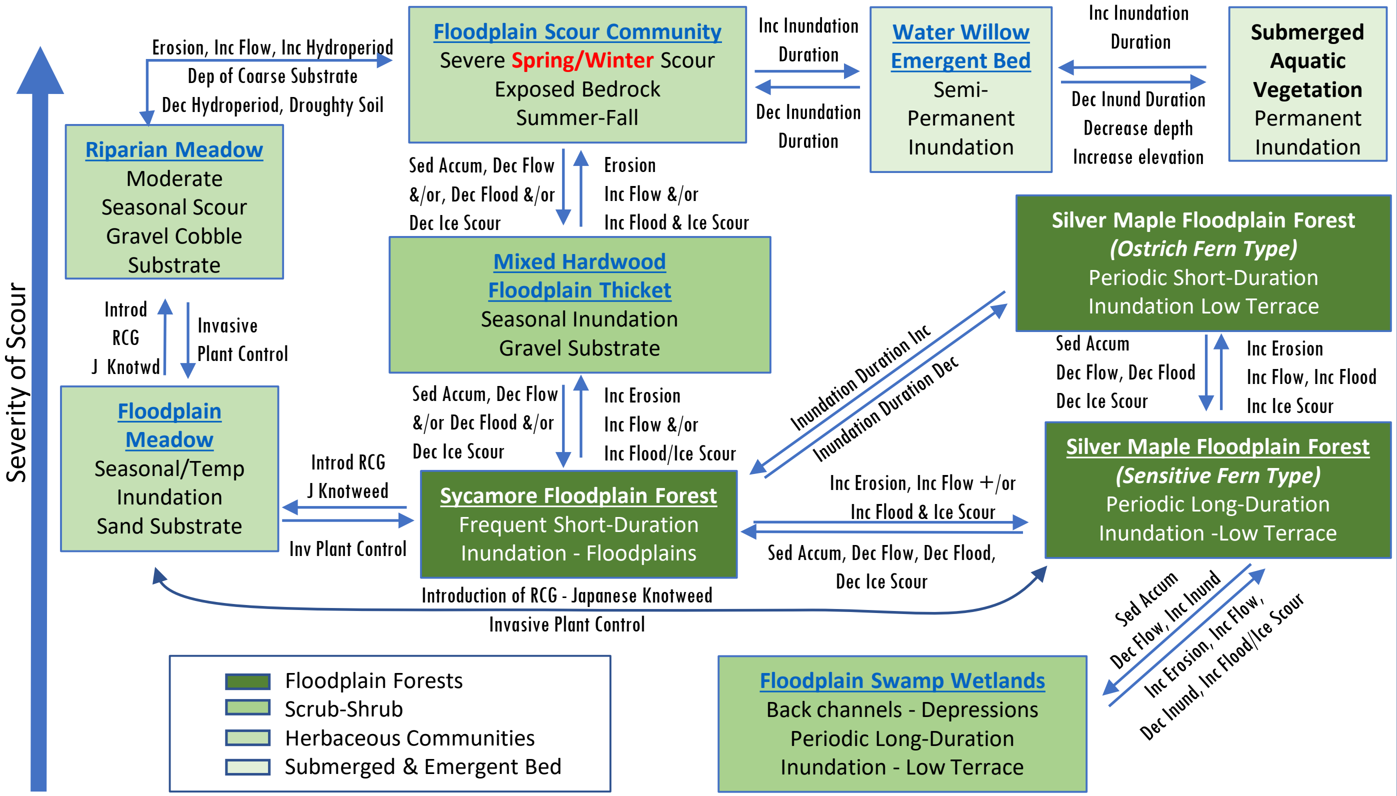
Key Flow-Related Needs for Ohio Basin Floodplain, Riparian and Aquatic Vegetation

Maintain ice scour events and floodplain connectivity

- During winter, seasonal and high flow events maintain ice scour disturbance necessary for preparing riparian, island, and floodplain seed beds and sustaining the riverine scour community
- High flows provide lateral connectivity to backwaters, providing inundation and soil moisture conditions that support seed dispersal and recruitment

Support establishment and growth of floodplain, riparian and aquatic vegetation

- During winter and spring, seasonal and high flow events provide disturbance to sustain communities with a high scour disturbance fidelity such as sycamore and silver maple floodplain forests
- High flows transport water-dispersed seeds and prepare seedbeds for propagules
- During the low flow season, flows must be adequate to support growth and maintain the extent of submerged aquatic vegetation



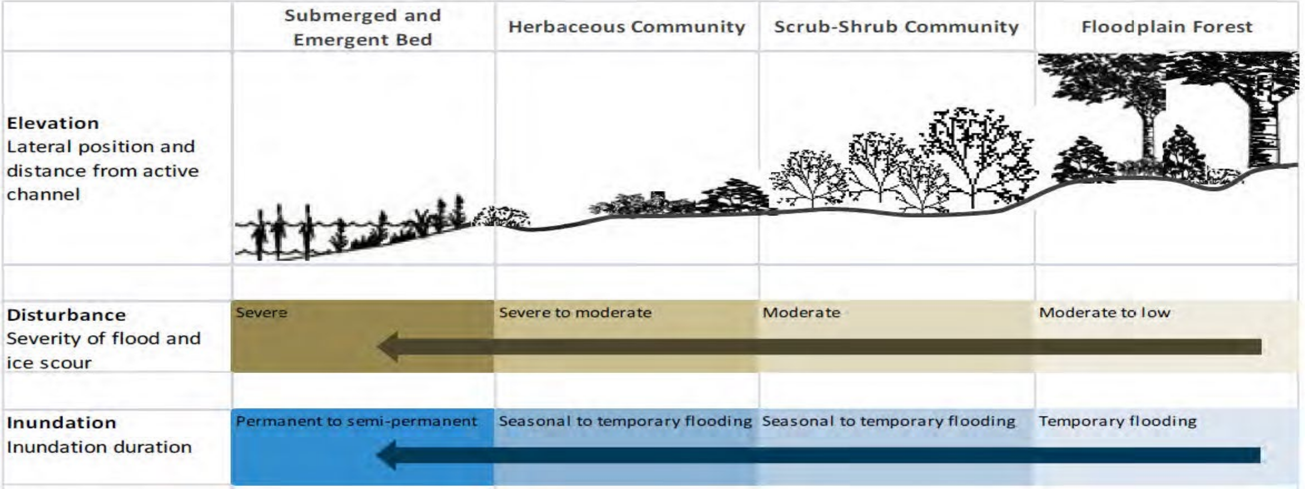


Fig 1 (top) Fig 2 (bottom). Floodplain, riparian and aquatic vegetation of the Ohio Basin – Floodplain Community disturbance fidelity and shared life history requirements illustrated.

Floodplain Community Eco-Hydrologic Conceptual Model

Large-scale processes

Climate | Flow regime | Plant Characteristics | Geomorphology

E-Flows

Low flows
Provisional Flows #4 & #5: Summer & Winter Low Flows

Seasonal flows
Provisional Flows #3, #4, #5: Spring, Summer, Winter Seasonal Flows

High flows
Provisional Flows #1 & #2: Bankfull & Spring Pulse Flows

Stages of vegetative recruitment & succession

- Low flows: Stand survival and seral succession (1-10 years) sites
- Seasonal flows: Stand initiation and early establishment (0-6 months)
- High flows: Pulse: Seed and stem dispersal onto bare gravel bars and other suitable germination sites
  Flood: Stand recycling (>10 years)

Underlying needs and processes

- Low flows: Extreme low flows linked to base flows and summer mortality. Flows must be adequate to support growth and maintain the extent of submerged aquatic vegetation
- Seasonal flows: Germination on bare bars followed by root elongation in sync with recession rates
- High flows: Geomorphic processes create germination sites; Disturbance sustains communities with a high scour disturbance fidelity such as sycamore and silver maple floodplain forests; plant physiology, climate, and streamflow control seed release and transport

Key components of the Provisional Ecosystem Flow Recommendations (*see Slides 9-11*) include:

1. Bankfull Flow
2. Spring Pulse Flow
3. Spring Baseflow
4. Summer Baseflow
5. Fall/Winter Baseflow

Appendix C. Allegheny River Baseline Mussel and Vegetation Inventory and Workshop and Youghiogheny River Scour Assessment

Interim Progress Report

Allegheny River Baseline Mussel and Vegetation Inventory and Workshop and Youghiogheny River Scour Assessment

September 15, 2020

Submitted by:
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 Award Period Progress toward Outcomes.
Compare actual accomplishments to the Scope of Work Season Task Groupings for the reporting period by listing each applicable Seasonal Task Group as it appears in your subaward and briefly describing the work per grant period, if tasks were not met, explaining why, while noting the work anticipated for the next grant award period.

Task 1. Allegheny River Workshop

WPC scientist completed the following activities during the reporting period. These included developing materials and participating a workshop to advance and target monitoring to Refine Ecological Flow (E-Flow) Prescriptions and Outline an Adaptive Management and Monitoring Plan for Kinzua Dam and the Upper Allegheny River.

Specific tasks included preparing materials for and participating in a workshop September 9-10.

Staff also completed the following

- Researched and developed species life histories abstracts
- Developed Conceptual Ecological Models (CEM) for:
    - Freshwater Mussels
    - Fish
    - Herps
    - Floodplain Communities
    - River Scour Grasslands
- Conducted GIS analyses to investigate inundation models produced by TCN to investigate flood impact to known sites within the two focus areas on the Allegheny River (West Hickory and Tidioute, Pennsylvania).
- Prepared materials for the conference, including:
    - conceptual ecological models,
    - species lists/life history information
    - a PowerPoint presentation.
    - Participated in the Allegheny River Adaptive Management and Monitoring Workshop September 9-10, 2020.

Schedule. Note the percent complete of each Seasonal Task Group, if on-track to be completed on schedule, and if Awardee anticipates the project will take longer than the approved project period. If so, have you formally requested an amendment in writing?

- All objectives proposed in the scope of work were completed. The deliverables, which include data collected during implementation of all activities will be submitted to TNC to be included their final reporting to the Army Corps of Engineers. Our anticipated deliverables outlined in the scope of work have not changed.
- All field objectives proposed in the scope of work are on track to be completed by December 25, 2020.
- Field work; 100% completed. All sites were visited by the mussel diving team (consisting of aquatic ecologist and vegetation ecologists) at least one type during the sample period and field ecologists visited each site multiple times to assess vegetation.

Task 2. Allegheny River Monitoring

WPC scientist completed the following activities to characterize the current condition of priority targets in the Upper Allegheny River downstream of Kinzua Dam – within the study focus areas on the Allegheny River (West Hickory and Tidioute, Pennsylvania).

Specifically, WPC scientists

- Conducted surveys for freshwater mussels along 10 transects established across the river (see map) within the two project focal areas of West Hickory and Tidioute, Pennsylvania. Along each transect, WPC aquatic ecologists documented the mussels present and their abundance and recorded habitat variables including substrate characteristics, vegetation cover. A list of mussel species and ecological habitat variables will be included with the final report. Allegheny National Forest biologists collaborated with the WPC diving team to assess the mussel population. Mussel surveys occurred on July 8-9, and 28-30.
- Conducted surveys for submerged aquatic vegetation (SAV) beds during mussel inventories and at additional site visits to obtain lists of species occurring within specific zones in the river channel (riffles, runs, pools) and species associated with the freshwater mussels. A species list of SAV communities organized by community will be included in the final report. Vegetation surveys occurred July 8, August 5, August 19-20.
- Conducted plant surveys to map and describe plant communities and rare plant species within floodplain habitats adjacent to the river channel. Plant communities that exist along the floodplain are driven by the intensity and duration of flood waters, as well as the seasonality of flood events. These data will be used to determine potential floodplain communities impacted by modifications to management of Kinzua dam. Vegetation surveys occurred July 8, August 5, August 19-20, 27. Rare and uncommon species of plants documented on the river included
    - *Scirpus pedicellatus*
    - *Deschampsia flexuosa*
    - *Podostemum ceratophyllum*
    - *Potamogeton richardsonii*
- Mapped SAV beds, mussel transects and characteristic floodplain communities by drone, flown from the river. August 5, and August 19-20.

Schedule. Note the percent complete of each Seasonal Task Group, if on-track to be completed on schedule, and if Awardee anticipates the project will take longer than the approved project period. If so, have you formally requested an amendment in writing?

- The deliverables, which include data collected during implementation of all activities will be submitted to TNC to be included their final reporting to the Army Corps of Engineers. Our anticipated deliverables outlined in the scope of work have not changed.

Task 3. Youghiogheny River Riverscour monitoring

WPC scientist completed the following activities to characterize the current condition of priority targets in the Youghiogheny River, downstream of the Youghiogheny River Dam at Confluence, PA.

- WPC selected 5 target areas for survey of flood scour sites along the Youghiogheny River –
    - Drake Run – Ohiopyle State Park/State game Lands #271
    - Dimple Rock – Ohiopyle State Park Bear Run Nature Reserve
    - Double Hydraulic – Ohiopyle State Park
    - Ferncliff Peninsula – Ohiopyle State Park
    - Meadow Run – Ohiopyle State Park (note: cameras are not currently deployed at this site due to potential tampering by park visitors)
- At each of the scour sites, WPC ecologists:
    - Installed field cameras to capture flood images and sync these images with river hydrograph data to figure out the pattern of inundation during the grant period and determine how changes in flow may affect these small and topographically complex sites. These field cameras have been maintained throughout the year, from May – September. In all, there were 20 camera check visits across the four sites, over 9 field days. These checks have been spaced 4-6 weeks apart.
    - Developed preliminary maps of floodplain scour zones using combination of aerial imagery, drone imagery (dependent on permission), LiDAR, and field survey. Drone images were obtained June 1, 2020.
    - Assessed vegetation condition and composition of zones supporting indicators of different flood-scour zones within the sites such as *Marshallia pulchra* and *Osmunda regalis* using plot and transect survey methods.
    - Detailed maps and assessments of the *Marshallia* were conducted in conjunction with a USFWS Section 6 grant to the PA Department of Conservation and Natural Resources.

Schedule. Note the percent complete of each Seasonal Task Group, if on-track to be completed on schedule, and if Awardee anticipates the project will take longer than the approved project period. If so, have you formally requested an amendment in writing?

- All deliverables are on track to be completed by December 25, 2020; however, it may be difficult to complete all deliverables by September 30, 2020. WPC has not formally requested an amendment.

Challenges and Opportunities: If applicable, note significant developments, problems, delays, adverse conditions, cost overruns or high unit costs, and actions taken to correct it that are anticipated to impair meeting the tasks and timelines of the scope of work. Also note favorable developments or alternatives that could result in meeting the objectives sooner or at less cost than anticipated.

- For Task 1. The COVID19 pandemic made it impossible to hold and in person workshop in September 2020. However, the team held a virtual workshop with several local and regional experts.
- For Task 2.
    - COVID19 made conducting field work more difficult. While the weather cooperated with field activities (no extreme weather events during the sample period), logistically, the field work was much more difficult as traditional practices of transportation, hotel stays, and meals were unavailable. Schedules were modified and transportation/meals/lodging funds were altered within these categories to allow field operations to continue.
    - In addition to the field work conducted by WPC, the Army Corps of Engineers obtained high resolution hyper-spectral images of floodplain and aquatic vegetation in the two project focus areas. With additional funds and effort to process this imagery, it may provide a critical component to projects seeking to understand the extent and composition of aquatic vegetation in the Middle to Upper Allegheny River ecosystem.
- For Task 3. Because of COVID-19, WPC was not able to hire an intern (associated with the University of Pittsburgh) to assist with field work through camera maintenance, mapping of scour sites, and data analysis. While this put an additional strain on WPC staff and resources, all proposed work was accomplished.

 Quantify Results. As applicable, please note quantifiable measures, such as # of monitoring sites, # of completed habitat assessments, # of stream miles evaluated, # of mussel, floodscour or SAV beds surveyed/inventoried.

These results only apply to the monitoring objectives.
For Task 1:

- 4 WPC science staff participated in 1, 2-day long workshop
- 5 species fact sheets developed; Conceptual Ecological Models developed for all 5 species/community groups.

For Task 2:

- 10 mussel survey transects completed over the course of 5 days.
- Three drone visits in which transect mapping was conducted.
- Five vegetation surveys of floodplain and submerged aquatic vegetation.
- Three drone visits in which transect mapping was conducted.
- Five vegetation surveys of floodplain and submerged aquatic vegetation.

For Task 3.

- 6 days of vegetation monitoring survey at 5 sites on the Youghiogheny River
- 20 camera check visits over the course of 9 field days
- 1 day of drone imagery acquisition.

 Photos: If available, please provide 3-5 high-quality photos showcasing the work, etc.

Photo 1. Mussel survey team preparing to conduct survey of West Hickory section of Allegheny River July 8, 2020. (Photo by Ephraim Zimmerman, WPC)

Photo 2. Botanist Scott Schuette conducts a plant community inventory of floodplain grasslands and cobble scour zones on the Allegheny River in the Tidioute section of the Allegheny River, August 27, 2020. (Photo by Ephraim Zimmerman, WPC)

Photo 3. Exposed cobble scour areas are typical on island tails on the Allegheny River in the Tidioute and West Hickory sections of the Allegheny River, August 27, 2020. (Photo by Ephraim Zimmerman, WPC)

Photo 4. WPC GIS manager, Brad Georgic, lands the WPC drone following mapping transects and floodplain vegetation within the Tidioute section of the Allegheny River, September 28, 2020. (Photo by Ephraim Zimmerman, WPC)

Photo 5. Ecologist Christopher Tracey conducts a plant community inventory of submerged aquatic beds and cobble scour zones on the Allegheny River in the Tidioute section of the Allegheny River, August 27, 2020. (Photo by Ephraim Zimmerman, WPC)

Photo 6. Riverweed (*Podostemum ceratophyllum*) and other indicators of high water quality was documented by WPC ecologists during inventories of inventory of submerged aquatic beds and cobble scour zones on the Allegheny River in the Tidioute and West Hickory sections of the Allegheny River, Summer 2020. (Photo by Ephraim Zimmerman, WPC)