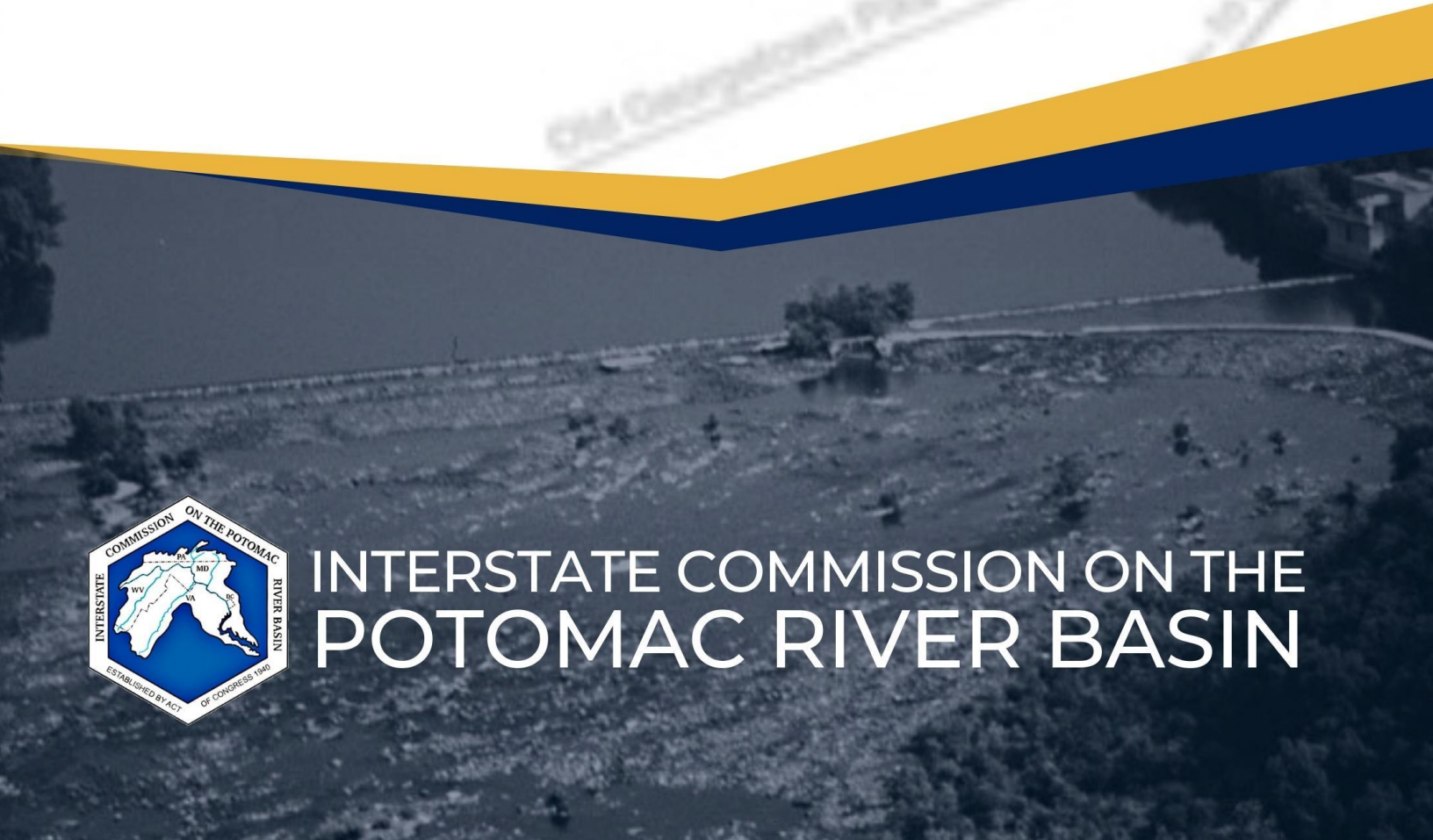
POTOMAC ENVIRONMENTAL FLOWS WORKSHOP

2022



INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN

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ACKNOWLEDGMENTS

The workshop was made possible by the close cooperation of individuals from federal, state, academic and local organizations. ICPRB staff organized and convened the workshop, prepared several of the workshop presentations, assembled a bibliography of recent environmental flow publications and reports, and wrote the workshop summary report. Claire Buchanan (ICPRB, retired) was the principal architect of the workshop. General guidance and advice were provided by the workshop planning committee members: Jeffrey Seltzer (DOEE), Andrew Roach (US ACOE), Greg Busch (MDE), Robert Burkholzer (VADEQ), and Michael Nardolilli (ICPRB). The virtual workshop was coordinated and managed by Renee Bourassa (ICPRB). Andrea Nagel (ICPRB) and Claire Buchanan assembled the bibliography. Recordings of the workshop presentations and discussion were made for note-taking purposes. Karin Bencala (ICPRB) drafted the initial version of the workshop report. Cover photo was taken by Curtis Dalpra.

DISCLAIMER

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EXECUTIVE SUMMARY

In 2021, Commissioners of the Interstate Commission on the Potomac River Basin (ICPRB) passed a Resolution on Enhancing Water Supply Resilience for the Washington Metropolitan Area. This resolution is the first step in updating the two foundational agreements of the Washington metropolitan area cooperative water supply system: the Low Flow Allocation Agreement (LFAA) of 1978 and the Water Supply Coordination Agreement (WSCA) of 1982. To facilitate such an update the resolution called for the following action items:

- Develop a Task Force on the WSCA to reinitiate dialogue on revisions that would accurately reflect changing conditions. This includes the need for strengthening water security against spills, cybersecurity attack, and water scarcity and the ability to include additional suppliers;
- Convene a Work Group to discuss the ten sets of options identified in the 2018 review of the LFAA; and
- Convene scientific workshops on state-of-the-art approaches to environmental flows for large river systems.

To address the third action item, a virtual workshop was held over one-and-a-half days in May 2022, with the explicit purpose of answering the following questions with respect to the Potomac River, which supplies most of the Washington, D. C., metropolitan area drinking water:

- Are there other approaches now for determining environmental flows in large, relatively unregulated rivers like the Potomac?
- If there are, what data, analysis tools, and assessments are needed to make a scientifically defensible change?

The information presented and discussed during the workshop provides input to the LFAA workgroup in the event the group recommends revisiting the current environmental flow-by target used during low flow periods. The question of whether or not to study the flow-by was informally discussed during the workshop but the intent of the workshop was to gather the relevant information, not recommend a course of action.

Following a compilation of the recent literature, a day of presentations on approaches for determining environmental flows and on the availability of data for Potomac River fish and macroinvertebrates, and a half-day of discussion, ICPRB staff has summarized the answers to the workshop's questions here:

ARE THERE OTHER APPROACHES NOW FOR DETERMINING ENVIRONMENTAL FLOWS IN LARGE, RELATIVELY UNREGULATED RIVERS LIKE THE POTOMAC?

New methods have been developed in the last decade to evaluate environmental flows and habitat in large rivers like the Potomac (**Figure 1**). While these methods warrant further review for application in the Potomac basin, conclusions from other studies should not necessarily be applied to the Potomac as most other large river systems are highly regulated, whereas the Potomac is largely unregulated. Many participants expressed an interest in using some version of the Structured Decision-Making process to drive data collection and analysis tool selection to facilitate potential investigation of the environmental flow-by on the Potomac River mainstem at Little Falls dam.

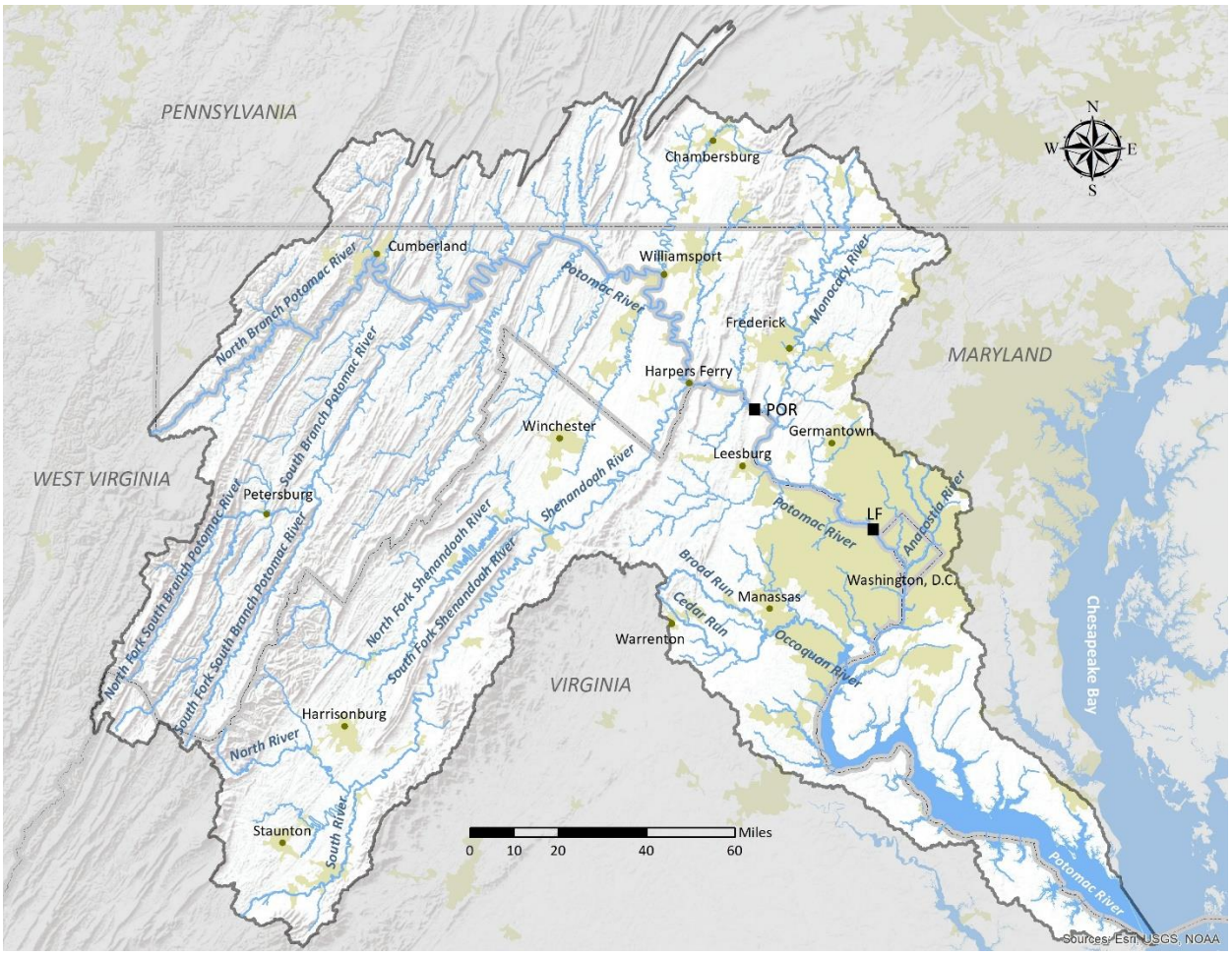

Figure 1. Potomac River Basin. The extent of populated areas around Washington, D.C., and other cities in the basin is indicated by shading. Squares indicate USGS streamflow gages at Point of Rocks (POR) and Little Falls (LF).

IF THERE ARE NEW APPROACHES, WHAT DATA, ANALYSIS TOOLS, AND ASSESSMENTS ARE NEEDED TO MAKE A SCIENTIFICALLY DEFENSIBLE CHANGE?

During the workshop the following tasks were suggested as some of the monitoring and analysis steps that might need to be taken to prepare for a scientifically defensible update of the environmental flow-by at Little Falls dam:

- Review options for selecting a decision-making framework to be used to guide an update.
- Develop a biological monitoring plan for the 18-mile reach between Seneca Pool and Little Falls to implement during very low flow periods. Identify and commit funding and partners. As part of this task, a group of experts will make recommendations for the flora and fauna to be monitored.
- Conduct habitat assessments using the combined LIDAR and sonar data.
- Complete flow modeling using the same LIDAR and sonar data.
- Explore the various methods for setting seasonal or daily environmental flow targets with the aim of maintaining intra- and inter-annual variability in this stretch of the river.
- Contingent on a viable method, look into the Virginia Department of Environmental Quality (VA DEQ) question regarding whether water supply withdrawals are leading to chronic low flow impacts in this stretch of the river.

PARTICIPANT ORGANIZATIONS

Participants in the workshop share an interest in the Potomac and represent expansive organizational participation beyond signatories of the LFAA and WSCA in the process. They included:

American University
DC Water
District Department of Energy & Environment
Fairfax Water
Interstate Commission on the Potomac River Basin
Loudoun Water
Maryland Department of Natural Resources
Maryland Department of the Environment
Metropolitan Washington Council of Governments
Pennsylvania Department of Environmental Protection
Potomac River Fisheries Commission
Potomac Riverkeeper Network
U.S. Army Corps of Engineers
U.S. Department of Agriculture
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey
University of Maryland Center for Environmental Science
Virginia Department of Environmental Quality
Virginia Department of Wildlife Resources
Virginia Tech
WSSC Water
West Virginia Department of Environmental Protection

This summary is submitted as a reference and resource for the consideration of the LFAA workgroup. Nothing here should be construed as a consensus or a binding agreement of any of the signatories to the LFAA or WSCA.

BACKGROUND

The May 2022 workshop follows a September 2010 workshop during which an assessment of Potomac River environmental flow needs (Cummins et al. 2011) was reviewed by 60 hydrologists, biologists, engineers, water resource managers, and regional and national experts on flow and river ecology. Participants concluded that despite the 216-page assessment's ESWM[1] approach and its detailed analyses and review of available literature, more research and monitoring were still needed to better identify ecologically protective flow thresholds for the Potomac River. This was especially the case for the last 18 miles of the free-flowing river before it enters the estuary (**Figure 2**).

This reach is impacted by large water supply withdrawals for drinking water and fire protection in the Washington metropolitan area (WMA). Between 2005 and 2008, total daily withdrawals between Seneca Pool and the Little Falls Dam averaged 371 MGD (Cummins et al. 2011). Lately (2014 – 2018), daily withdrawals from this reach of the Potomac have averaged 354 MGD and ranged between 257 and 503 MGD (Ahmed et al. 2020, Ahmed, pers. comm.). The average daily withdrawals are roughly five percent of the long-term mean flow at Little Falls before withdrawals but are a substantially larger percentage of the flow during dry or drought periods.

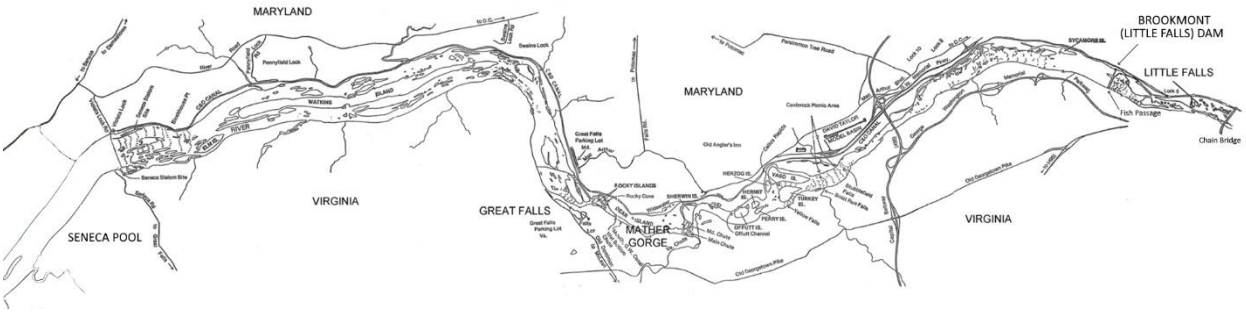

Figure 2. The 18-mile reach of the Potomac River mainstem impacted by water supply withdrawals for the Washington Metropolitan Area. The river drops nearly 200 ft. from Seneca Pool to Chain Bridge at the head of the Potomac Estuary.

The chief recommendation advanced at the September 2010 workshop was to maintain the existing inter- and intra-annual variability in the Potomac flow conditions, as measured by a variety of key flow statistics over a set period of record. Flow in the Potomac River mainstem is to a large extent unregulated and the river experiences mostly natural flows. Mid-range flows provide stable, predictable environments for biological communities while high and low flow events intermittently disturb the communities, simultaneously imparting negative or positive impacts on different ecosystem components (**Figure 3**). Over time, the variability caused by natural high and low flow events coupled with the stability afforded by mid-range flows is thought to create and sustain diverse in-stream and riparian habitats, increase overall biological productivity, and protect the density and richness of the river's biological communities.

[1] Ecologically Sustainable Water Management, developed by The Nature Conservancy and described in Richter et al. (2003), identifies flow-ecology relationships by relating critical life history traits such as species' spawning times and habitat requirements to metrics characterizing the magnitude, duration, frequency, and timing of low, medium, and high flows, also called Environmental Flow Components.

Participants of the September 2010 workshop also recommended maintaining the established minimum flow-by requirements which were identified in a Maryland Department of Natural Resources Potomac River Environmental Flow-by Study (1981) and incorporated into the region's LFAA (1978) agreement. The flow-by requirement at the Brookmont (Little Falls) Dam is a 100 MGD minimum. This recommendation was based in part on the finding that in 2002, when river flows approached these low levels, there did not seem to be a significant loss of habitat in this reach (Versar 2003) and field observations did not identify flow-related stress in the aquatic communities.

For more information on the history of the cooperative water supply system in the Washington metropolitan area and on current water supply studies, visit ICPRB's website about the Section for Cooperative Water Supply Operations on the Potomac (COOP).

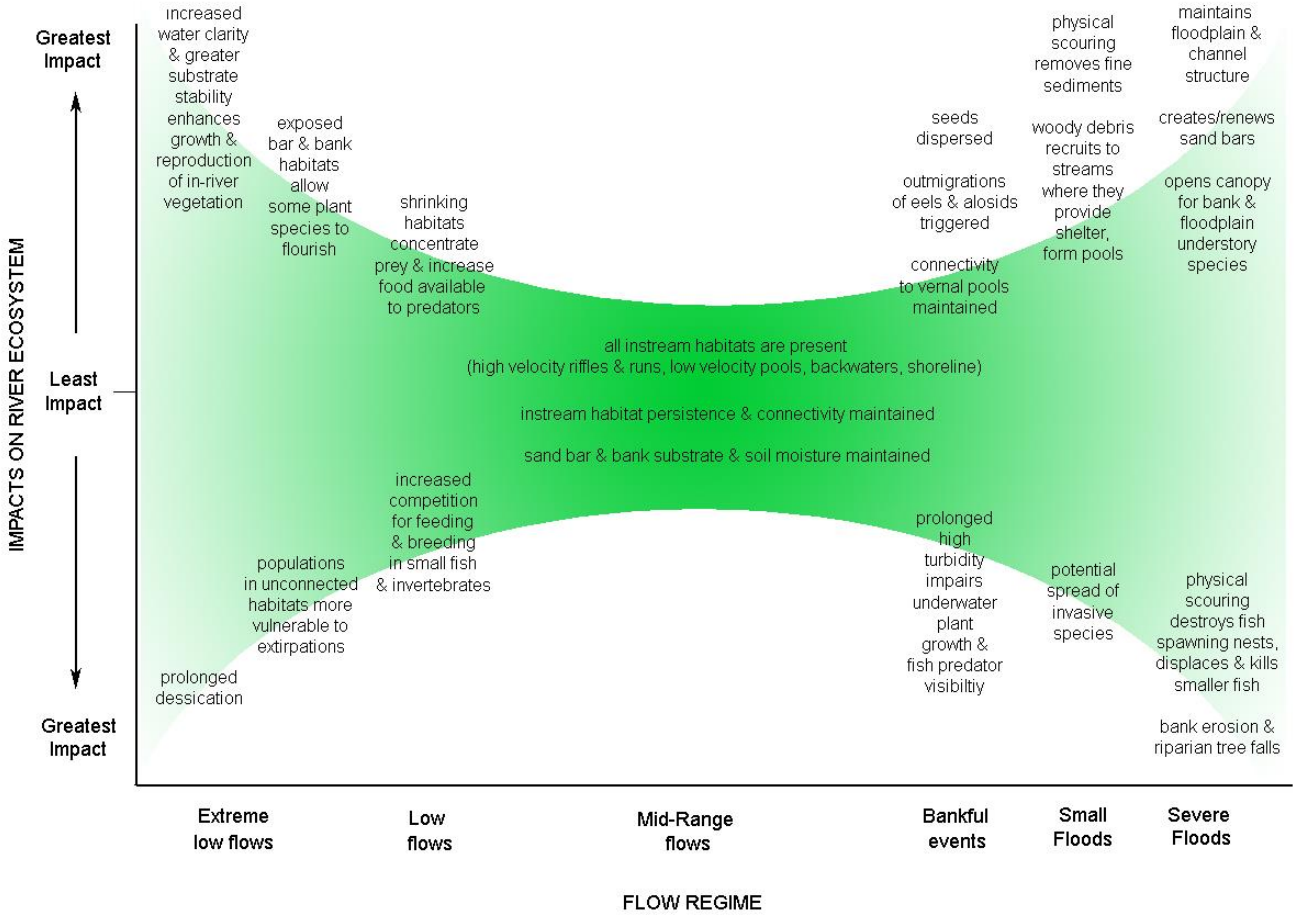

Figure 3. Conceptual diagram of flow impacts on riverine ecosystems in the Potomac River basin (Figure 39 in Cummins et al. 2011).

SUMMARY OF PROCEEDINGS

This report section summarizes the proceedings of the May 2022 workshop and covers the data, analysis tools, and assessments that could be used to update or revise the flow-by requirements if the LFAA governing body chooses to do so.

ARE THERE OTHER APPROACHES NOW FOR DETERMINING ENVIRONMENTAL FLOWS IN LARGE, RELATIVELY UNREGULATED RIVERS LIKE THE POTOMAC?

Participants generally agreed that there are indeed new methods being used for other large rivers to evaluate environmental flows and habitat conditions. While these warrant further review, many made the point that conclusions from other studies should not necessarily be applied to the Potomac as most other large river systems are highly regulated, whereas the Potomac is largely unregulated. The importance of maintaining the natural inter- and intra-annual flow variability was frequently mentioned during presentations and open discussion. The impact of climate change on flow was raised as an important issue to consider going forward.

Many participants also expressed an interest in following an agreed-upon decision-making process to drive data collection and analysis tool selection to facilitate a potential change in the flow-by requirement. Steven Kyle McKay (USACE) presented a Structured Decision-Making process with the overall goal of looking for management options that increase ecosystem integrity while satisfying the region's water supply needs.

IF THERE ARE, WHAT DATA, ANALYSIS TOOLS, AND ASSESSMENTS ARE NEEDED TO MAKE A SCIENTIFICALLY DEFENSIBLE CHANGE?

The lack of biological data collected in the 18-mile-long Potomac gorge during low flows was highlighted over the two days of the workshop. There appeared to be agreement among participants that a monitoring plan should be developed in advance of low flow conditions and funding should be identified so that data collection can begin in a coordinated manner whenever low flows develop. Suggestions for such a plan included:

- Frame any study with stakeholder input, including clearly stating objectives as part of a structured decision-making process.
- Assemble a group to agree on a set of species to monitor.
- The species targeted for monitoring should include both migratory and stationary species. Migratory ones (e.g., American eel, American shad) use this stretch of river at different times in their lifecycle. Stationary ones (e.g., mussels) are least able to move to refugia during low flows.
- Species should be analyzed at a finer scale than indices of biotic integrity (IBIs).
- Review the availability of riparian community data and how they should be accounted for in any future analysis.
- Develop a monitoring plan for both single-year and multi-year low flow events.
- Look at the effects of a low flow event over multiple years as species may be able to recover following an acute event.
- Look into the benefits of the Little Falls fish passage during low flows as this was not available to migratory species during the 1981 MD DNR study.
- Consider expanding the scope beyond the withdrawal-affected 18-mile stretch of river to allow the connectivity of the system to be assessed.

There is newly available LIDAR and sonar data and new modeling approaches that can be used to enhance the understanding of the river's habitat. Two applications for the data were discussed: 1) conduct an analysis of habitat potential to understand which species could potentially use specific areas in and along the river, and 2) conduct flow modeling to understand how and where water will flow during low flow periods.

Virginia DEQ stressed the need to understand the frequency and duration of low flows and their related impacts, specifically on water quality and habitat space. While the general sense of the participants was that low flows do not seem to be a serious concern given that corridors for movement are available through the fish passage and the C&O Canal, many voiced agreement that the impacts of acute low flows should be further investigated. DEQ also wants to explore the possibility that this portion of the river is experiencing chronic low flows due to water withdrawals and if chronic low flows could be mitigated without increasing risks to water supply availability. Any analysis would require agreement on what constitutes chronic low flows.

Over the course of the workshop, a single analysis tool or assessment did not rise up as the proverbial silver bullet for making scientifically defensible changes to the current 100 MGD environmental flow-by at Little Falls; however, as noted previously, there was general agreement on the need for a structured decision-making process to answer the question of whether or not the 100 MGD flow-by should be updated. Given that any change to the flow-by recommendation would have implications for the LFAA, and that the analyses are complicated and resource-intensive, participants were aware that key stakeholders should be on board at each step of the decision-making process.

The presentations made on Day 1 and the discussion on Day 2 made it clear that there are both new data that could be used in an analysis to update the 100 MGD Little Falls flow-by and new methods that could be considered. An overview of the available data, analysis tools, and assessments that were covered in the presentations and discussions is summarized below.

DATA

Although gaps exist, there is a significant amount of data available today that was not available for the 1981 study or subsequent environmental flow studies. These data cover physical attributes of the river itself, water quality, and the flora and fauna.

- Habitat data in the free-flowing mainstem
    - Discharge (flow) and gage height have been continuously recorded at Point of Rocks since 1895 and at Little Falls dam since 1930.
    - ICPRB, USGS, and other partners have acquired two new sets of LIDAR data and a third is in the planning stages. This was one of the research needs highlighted in the 2011 ICPRB report.
    - Sonar data from 2002-2003 Versar report has become available. This could enable gaps in the LIDAR data to be filled, particularly in the Great Falls area where LIDAR could not be gathered due to turbulence.

- Biological monitoring in the free-flowing mainstem (Maryland Department of Natural Resources)
    - Juvenile recruitment of freshwater fish populations in the Upper Potomac basin has been annually surveyed since 1975. A focus has been smallmouth bass populations. This is a popular game fish that is economically important in the region. The juvenile recruitment surveys cover approximately 150 river miles along the mainstem but do not take place between Seneca Pool and Little Falls. Recently, recruitment has been negatively impacted by high flows in the months of May and June.

    - Invasive species, specifically the flathead catfish, have increased in abundance and distribution over time. Additionally, natural reproduction is now occurring.
    - Monitoring is being done for some migratory species such as American eel. These mostly move upstream in the spring when low flows are not an issue.
    - Benthic macroinvertebrate data are collected once annually at six stations on the mainstem and six on the North Branch. Some data go back as far as 1976. Data collected are total number of taxa; Shannon Weiner Diversity Index; Modified Hilsenhoff Biotic Index; Percent Ephemeroptera, Plecoptera, and Trichoptera; and Non-Parametric tests for trends (Spearman Rank and Kendall Tau $p<0.10$).
    - Monitoring is occurring for harmful algae blooms (HABs) and for the presence of the algal toxin microcystin.
    - Rare, threatened, and endangered species are being documented on the mainstem from Harpers Ferry to Bryan Point. This includes freshwater mussels, odonates (dragonflies and damselflies), plants such as cypress-knee sedge, yellow nailwort, Nantucket shadbush, buffalo clover, Virginia fanpetals, and racemose goldenrod.

- Ambient water quality data in the free-flowing mainstem
    - Ambient water quality data are collected by MD DNR at 35 non-tidal (and 13 tidal) stations in the Potomac basin. Data are collected monthly. All stations collect the following: water temperature, dissolved oxygen, pH, specific conductance, particulate nitrogen, total dissolved nitrogen, nitrate + nitrite, nitrite, ammonium, particulate phosphorus, total dissolved phosphorus, orthophosphate, particulate carbon, and total suspended solids. There are five stations collecting chloride and sulfate data, 20 with biological oxygen demand data, and six with nutrient and sediment load data.
    - The USGS Point of Rocks gage collects the following water quality data beginning in May 2021: dissolved oxygen, pH, specific conductance, temperature, and turbidity.
    - The USGS Little Falls gage collects the following water quality data: dissolved oxygen (since 2013), nitrate + nitrite (2011), pH (2013), specific conductance (2007), temperature (2007), and turbidity (2013).
    - Fairfax Water makes its source Water Quality Analytical Reports data publicly available online
    - Washington Aqueduct Water Quality reports are publicly available online
    - Other water supplier data sets may be available upon request

ANALYSIS TOOLS AND ASSESSMENTS

At all hydrologic scales, there are new and improved tools and approaches being used to understand changes in flow characteristics and the impacts of climate change and land use, make long- and short-term flow predictions, and model relationships between flow and the health of fish and macroinvertebrate communities. The following initiatives were discussed during the workshop.

- The U.S. Army Corps of Engineers has developed an approach for making withdrawal decisions based on the tradeoffs between water supply and ecological health. They use conceptual models and various analytical methods to weigh management options that increase ecosystem integrity while allowing as much water as possible to be withdrawn. Their structured decision-making process involves five steps: problem statement, objective setting, alternative development, consequence assessment, and trade-off analysis.

- The USGS has conducted a nationwide analysis of stream and river flow modifications by comparing observed and expected (reference) conditions by geographic region. The study's analytical methods and results can be used in the Potomac to characterize and quantify anthropogenic modifications to flow regimes and help distinguish them from impacts on aquatic life by other environmental stressors.

- The more accurate and comprehensive LIDAR (USGS) and sonar (Versar) data allows for better mapping than transect measurements of the aquatic habitats in the Seneca Pool to Little Falls reach. ICPRB has a preliminary version of a 2-D model that can run for high and low flows and produce variability in flow paths. The model was built to prepare for and respond to hazardous spills of floating contaminants.

- VA DEQ and the USGS have developed a tool for predicting low flows at USGS gages in Virginia. Low flow predictions are also being developed for the Potomac River mainstem by Penn State under a contract with ICPRB.

- Pennsylvania DEP has developed the Semi-Wadeable Macroinvertebrate Multimetric Index (SWMMI) that can be used to characterize the status of macroinvertebrate communities in large, semi-wadeable rivers, including those in the Potomac basin. Where possible, PADEP has paired the SWMMI index scores with streamflow percentiles to investigate relationships between macroinvertebrates and flow. Further investigation is still needed to characterize these relationships as many other factors affect macroinvertebrate condition.

- A USGS analysis of MD DNR Potomac River fish data has identified three life history strategies in fish that allow individual species to benefit from different components of the river's flow regime. The study is finding that species which require relatively predictable hydrologic conditions (periodic and equilibrium strategists) are declining in abundance while those that can take advantage of more variable conditions (opportunistic strategists) are doing better. An understanding of life history strategies provides a framework for understanding the impacts of environmental change, including chronic low flows, on fish species.

Six categories of methods for setting water supply withdrawal targets were discussed by various workshop participants and summarized in Kyle McKay's presentation. Several of the methods have already been applied in some fashion in the Potomac River watershed.

- Hydrologic Rules
  A commonly applied method for managing flow, this approach relies on hydrologic indices (e.g., minimum, 7Q10) calculated from the observed discharge for various timescales (e.g., daily, monthly, annual). The existing Potomac River minimum flow-by requirement of 100 MGD at Little Falls is an example, as is the "percent of flow" approach investigated by VADEQ.

- Hydraulic Rating
  Hydraulic parameters (e.g., wetted cross-sectional area, velocity, depth, shear stress) are used as metrics for assessing available habitat. Critical breakpoints and apparent thresholds in the relationships between discharge and hydraulic parameters can be used to establish flow targets.

- Habitat Analysis
  Hydrologic and hydraulic parameters can be used with information about the critical, life-stage requirements for key aquatic plant and animal species to quantify and model discharge-habitat

relationships. The Physical Habitat Simulation (PHABSIM) module of the Instream Flow Incremental Methodology (IFIM) is an example of this approach. An early version was used in the 1981 MDDNR study.

- Holistic Methods
  These methods consider more components of the aquatic ecosystem than just the physical habitat. Therefore, they provide a broader perspective of the whole ecosystem. In addition to hydraulic habitat, the approach also considers aquatic biological communities and riparian and floodplain vegetation. The Ecologically Sustainable Water Management (ESWM) approach used in Cummins et al. (2011) is an example.

- Optimization
  This approach usually applies to reservoir operations and involves rule curves that identify reservoir release targets for different times of the year or specific conditions. Environmental flow objectives (e.g., for fish spawning habitat) can be included as components in the rules.

- Regionalization
  This approach incorporates components of the other methods to define flow recommendations at regional scales. The Ecological Limits of Hydrologic Alteration (ELOHA) framework is commonly used. A hydrologic "foundation" of simulated baseline hydrographs and observed (altered) hydrographs is developed and used to calculate the amount of flow alteration in streams and rivers. The amount of flow alteration is then compared to the observed ecosystem conditions and used to establish flow alteration-ecology (FA-E) relationships. The ELOHA approach was used in the Middle Potomac River Watershed Assessment project to explore FA-E relationships in Potomac streams and small rivers, but not in large rivers.

APPENDIX – PRESENTATION SUMMARIES (DAY 1)

The first day of the workshop took place on May 5, 2022 and was intended to provide the information needed to answer the questions posed. A synopsis of each presentation is provided here in the order they were given.

Findings of the 2011 ICPRB Report "Potomac Basin Large River Environment Flow Needs

Claire Buchanan, Interstate Commission on the Potomac River Basin (retired)

The primary recommendation of the 2011 report (Cummins et al. 2011) was to maintain the existing inter- and intra-annual variability in flow conditions as measured by a variety of key flow statistics. Secondarily, the report recommended that the existing Little Falls 100 MGD minimum flow-by requirement should be continued and more studies of river populations during drought should be implemented. While the Potomac River has a relatively intact hydrology above Point of Rocks, with only minimal flow regulation [by dams, withdrawals, discharges] during low flow conditions, the large daily withdrawals below Point of Rocks to Little Falls significantly decrease river flow and riverine habitat during low flow conditions. Water demand in the WMA has remained fairly level since about 1990 due to installation of newer water-saving fixtures and appliances.

Multiple lines of evidence for comparing environmental flows alternatives

Steven Kyle McKay, U.S. Army Corps of Engineers

Kyle spoke about the benefits of the "Structured Decision-Making Process." The process involves stating the problem, setting objectives, developing alternative strategies, assessing consequences, and analyzing trade-offs. He described six analytical methods that can be used in the process for establishing environmental flow targets (above). He also described a case study conducted in the Middle Oconee River. In that system, the approach of "percent of flow" performed better than an annual minimum flow or monthly minimum flows.

> Response to questions: There are many ways you can set the stated objective within the structured decision-making model. In the example presented it was to maximize withdrawals, but it could be the opposite. Other options could be maximizing reliability or meeting demand.

Flow Modification in the Nation's Streams and Rivers

Daren Carlisle, U.S. Geological Survey

Daren's talk is based on a national USGS study which investigated impacts on riverine ecosystems by land and water management and by climate change by comparing observed versus expected flows. The study compared 868 "natural flow" (reference) gages to 3,355 watersheds with different levels of land and water disturbance. It assessed the impact, i.e., "dose response," of flow modification to ecological conditions for invertebrates and fish and found that nationally, artificially high low-flows are associated with increased impairment. For the Mid-Atlantic, there is also impairment for artificially low low-flows but there are too few observations.

> Responses to questions: There is not a set distance that the ecological data needs to be from the flow gage to be included in the analysis. A manual, gage-by-gage approach was used to select those for inclusion in the analysis. Initially, gages that had an ecological monitoring site within the same river segment were identified, then the basin size of the flow gage and monitoring site were compared. If they were within 80 percent of one another, the gage was included as long as there were not any intervening dams, diversions, etc.

The report covers shifts in the timing of flow events. There are definitely seasonal shifts in when high and low flows are occurring in some regions due to climate change. A regional comparison of the land use effect versus the climate change effect on flows is also included in the report. In most places the land use effect was found to be larger than the climate effect.

Biological impairments that were found in the analysis were largely, but not completely, due to changes in flow. Water chemistry and land use are examples of other factors that were considered. Future analyses will use different statistical model to look further into causality.

The findings for the Potomac basin could be compared to others in the region and nationally. It would also be possible to drill down into the data to get a better sense of the change in flow magnitude seen in the Potomac.

Evaluation of water supply, instream flows, and habitat during drought in the Middle Potomac watershed

Robert Burgholzer, Joseph Kleiner, and Scott Smith, Virginia Department of Environmental Quality

Washington metropolitan area water withdrawals can be more than 20 percent of river flow during a drought and more than 40 percent during an extreme low flow event. While the changes in aquatic habitat identified with IFIM models in the 1981 MDDNR study were modest, with 3/4 of species at Great Falls having less than 20% habitat loss during drought, the species included in that study were largely generalist, and thus, less sensitive to flow alteration compared to many of the important native species in that part of the Potomac River. Virginia DEQ applied the Flow/Habitat model and flow-habitat relationships from the MD DNR 1981 study and observed a corresponding impact on aquatic habitat. They noted the potential for generalist species to gain an advantage over non-generalist species during chronic low flows, resulting in the displacement of native and other important resident species. They suggest using newer models to allow for more precision and efficiency in modeling potential flow-by options and the ability to model water quality, temperature, and HAB impacts.

Response to questions: The analysis looked specifically at habitat changes as a result of decreased flow due to water withdrawals during low flow periods. A similar analysis has not been done for habitat during high flow periods. Box plots show the range of habitat change. Some species gain habitat while others lose it. Duration of events needs to be looked at going forward. The real work is in trying to optimize a flow-by that can work for water supply storage and stream habitat.

Topo-bathymetric LIDAR data acquisition on the Potomac River

John Young, U.S. Geological Survey, and Alimatou Seck, Interstate Commission on the Potomac River Basin

John discussed the LIDAR data that has been collected to-date and discussed potential uses for habitat assessments. Alimatou showed flow and velocity simulation results. The advantage of this dataset and modeling approach is that it could provide two-dimensional results. The Great Falls to Little Falls reach was 95 percent un-surveyed with LIDAR due to turbulence.

Response to question: Under the right conditions Lidar can potentially be used to identify SAV and algal mats. Flows were high when the first data were collected so there were not large patches that could be mapped.

Maryland DNR Freshwater Fisheries monitoring locations and survey data for the upper Potomac River

Michael Kashiwagi, Maryland Department of Natural Resources

Mike talked about Maryland's freshwater fisheries monitoring, with a focus on smallmouth bass (SMB). DNR's most downstream monitoring site is Seneca; there are no monitoring sites in the LFAA's pertinent stretch of the river. DNR is seeing a negative impact from high river flows in May, which have an adverse impact on SMB juvenile recruitment. High flows wipe out and destroy SMB nests and wash away fry. DNR finds a significant difference from the 1935-2007 period versus 2008-2018. Mike talked about SMB stocking efforts to address this adverse impact and covered invasive species and migratory species.

> Responses to questions: American eels generally migrate upstream in the fall and are able to get by Great Falls and over dams 4 and 5. Channel catfish numbers are stable.

Maryland DNR water quality and biological monitoring data from the Potomac River

Scott Stranko and Cathy Wazniak, Maryland Department of Natural Resources

Scott discussed Maryland's "Core Trend" monitoring program, which collects data monthly at 35 stations in the Potomac basin. Nontidal data is available from 1986 to the present. DNR has computed trends from 1999 to present (using BayTrends R package). Scott shows one trend map which shows that water temperature is increasing and several maps showing biological metrics improving along the entire length of the Potomac mainstem. He also discusses Maryland's benthic macroinvertebrate data collection program, which has 12 stations (one of which is Little Falls) in the Potomac, with data available beginning in 1976 for some stations. He lists rare, threatened, and endangered mussels, dragonflies, fish, and plants in the LFAA reach (terrestrials are of significant consideration).

Application of a Large River Semi-wadeable Macroinvertebrate Multimetric Index (SWMMI)

Dustin Shull, Pennsylvania Department of Environmental Protection (presented by Matthew Shank)

The SWMMI index was developed primarily with macroinvertebrate data from large rivers in Pennsylvania but included data from Potomac large river sites. The index is applicable to the Potomac River. The approach distinguishes between semi-wadeable and wadeable rivers. In applications of the index in Pennsylvania, river reaches are divided into domains with different influences linked to their proximal contributing tributary (e.g. left bank, center, right bank). They have modeled responsiveness of the SWMMI index to season, water quality, and flow percentiles. Preliminary work found that SWWMI scores decrease as flow decreases. They conclude that more investigation is needed.

Comparison of the 1981 MD DNR Study to recent surveys in the Potomac River mainstem near Washington, DC

Gordon Mike Selckmann, Interstate Commission on the Potomac River Basin

This presentation revisited the significant research that has been conducted since the preliminary 1981 MD DNR study and the LFAA. Mike pointed out the geographic scope, methods, major findings, and project design limitations of four significant research efforts and publications. He also highlighted the benefits the 2000 fish passage restoration had on American shad and American eel (anadromous and catadromous fishes) and the cascading ecological impact migratory species have on the Potomac River as a whole. He concluded there has yet to be a reproducible study in the 18-mile reach that addresses the needs of the LFAA and asked the group if a task force is needed.

APPENDIX – REACTION AND DISCUSSION

The second day of the workshop took place in the morning of May 17, 2022. It provided workshop participants the opportunity to react to and discuss the information presented on Day 1. The workshop organizers asked a representative group of participants (panelists) to provide reactions to start the discussion. Comments of the panelists (in the order they were given on Day 2) and other participants (in thematical order) during the discussion are summarized below. Also included are the comments expressed on Day 1 or submitted in an online survey before Day 2. All comments are the personal opinions of the speaker and not official agency positions.

PANELISTS (DAY 2)

Jeffrey Seltzer, DC Department of Energy and Environment

There is a strong case for revisiting the flow-by requirements as watershed science has advanced and there is new, relevant data that can be used in an analysis. This effort can be informed by approaches being used on other large rivers and by recent studies in the Potomac basin. The percent of flow method has potential for use as the flow-by requirement. This process should move forward but quick decisions are not needed since the flow-by is only relevant during extreme droughts. There is time to define the objectives, make decisions in a scientifically defensible manner, and reach consensus.

There is a need to drill down on more recent data and results, e.g., impacts of development (USGS), instream habitat loss during drought and options to manage (VA DEQ), impacts of flow on specific species and time of year (MDE). This will help determine the best approach (e.g., potentially use percent of flow) for evaluating and managing low flow.

Greg Busch, Maryland Department of the Environment

There is a path forward on updating the flow-by requirement but more information on the impacts to the biota from low flows is needed before conclusive decisions can be made. Management objectives of the flow-by need to be clearly defined in the next steps of this discussion. The focus should be on long-term consequences and permanent impacts as many populations are able to rebound following a drought. Species that are currently found in this stretch of the river are tolerant of low flows since they have been experienced in the past. IBI scores to assess fish and benthic health are too course for this effort. Consider looking at seasonally adjusted flows, mussels, dragonflies, and the American eel. A monitoring plan needs to be ready to go for when low flows are next seen.

Robert Burgholzer, Virginia Department of Environmental Quality

There is a gap in our understanding of whether ecological changes are due to acute or chronic low flows driven by water withdrawals. The current flow-by fills an acute need. If there is a chronic reduction in flows, we might think about how to address this issue.

DEQ is able to use USGS gage data to predict future low flows in Virginia rivers. A similar analysis should be done at the Point of Rocks gage. This would allow for low flows to be predicted in the 18-mile stretch of the river and for the ecology to be protected. Adaptive flow measures may be able to mitigate risks to water supply if there is in fact a chronic low flow issue.

There are concerns about both water quantity and water quality impacts from withdrawals during low flows. DEQ would like to know the degree of impact flows have on species richness and abundance, particularly which ones are most sensitive to low flows. There is no evidence that the flow-by is protective. Suggestions for next steps are to:

- Fill in data gaps.
- Explore the new LIDAR data to improve our understanding of habitats and the costs and benefits of different flow-by levels.
- Use an approach that allows for scenario analysis.
- Analyze the frequency and duration of low flows and the resulting impacts.
- Determine if flow alterations are acute or chronic.
- Gain a better understanding of how release decisions from upstream storage are made and what the effects are.
- Consider impacts to the tidal-fresh portion of the river down to the Anacostia.

John Mullican, Maryland Department of Natural Resources

Climate change is expected to increase low flows and shift seasons. Land use changes are already influencing mid to high flows, resulting in increased flashiness. These higher flows are having a negative impact on smallmouth bass. DNR is committed to protecting this fishery as it is culturally and economically important. Using a percent of flow approach might be very important for reducing habitat loss for a broader range of species and would meet the recommendation of the 2010 workshop to maintain intra- and inter-annual flow variability. Data during drought conditions is needed to assess the impacts of low flows. Using the new LIDAR data to assess flow-related changes in habitat availability is promising. This could allow for modeling habitat availability impacts at various flow levels. This type of modeling seems to be a great mechanism for decision-support tools and could be done quickly.

Anne Spiesman, U.S. Army Corps of Engineers, Washington Aqueduct

The majority of the time, Aqueduct's withdrawals come from Great Falls. The Great Falls intake uses gravity to move water from the river to the treatment plant. The Little Falls intake is used to protect flows between Great Falls and Little Falls during droughts. This is at a financial cost to the Aqueduct as pumping is required to move the water to the treatment plant. Decisions about which intake to use requires balancing power consumption with low flow protections.

Many interesting ideas were presented on Day 1 -- particularly counterintuitive findings, such as not observing biological impacts during the 1999-2002 drought, or in some situations seeing larger problems with high flows than with low flows. There are potential opportunities to be found in new approaches, data, and methods. A drought monitoring plan should be part of a holistic approach to addressing data gaps. How science and policy questions are framed is important and help stakeholders understand trade-offs and hopefully arrive at a decision that is better than the status quo.

Greg Prelewicz, Fairfax Water

The recommendations developed in the Potomac Basin Large River Environmental Flow Needs (ICPRB, 2011) to maintain variability in flow between Seneca Pool and Little Falls, as measured by a variety of key flow statistics over the period of record, were made as a precautionary measure to maintain the current suite of aquatic communities. The recommendation to manage withdrawals in the Potomac River so that Potomac River flows do not fall below those experiences in the 1999 and 2002 droughts had limited supporting scientific studies to justify

the position and concerns were raised regarding the implications of these recommendations at that time. We support additional monitoring work and it remains imperative that peer-reviewed scientific journals and studies be used to verify the opinions on the needs of various species. The flow recommendations need to be based on sound scientifically defensible research specific to the Potomac River. The environmental flow recommendations should consider minimum flows required to allow biota to recover from drought periods. As a largely unregulated River, the Potomac River's large variability in flow throughout the year needs to be considered a strong asset in allowing biota to recover from drought periods. From the May 5th presentations, we learned that the USACE has expertise to assist with multi-objective decision making. This type of framework can be used to evaluate the water quality portion of Jennings Randolph storage. While it's been difficult to define the Corps operating strategy at Jennings Randolph Reservoir, we understand the maintenance of flows in the Potomac River for the stretch between the Seneca Pool and Chain Bridge has largely been the responsibility of the water supply component of the Jennings Randolph Reservoir storage.

No new environmental field studies during low flows have been conducted in the Potomac River since the early 2000s despite the fact that water supply releases were made in 2007 and again in 2010. Are the methodologies and sampling plans prepared and funding sources identified to conduct the additional studies recommended in the Environmental Flows workshop? FW does not oppose studies by MDNR or ICPRB or other appropriate agencies to update the science underpinning the 100 MGD flow-by to protect ecosystems downstream of Little Falls, through more robust fieldwork. It is anticipated that significant funding would be required (by States or the Federal Government) to undertake such work. Finally, there is a need to better evaluate existing water quality and flow data gathered on the Potomac River.

Thomas Hilton, WSSC Water

The environmental flow requirement question is very important, but WSSC also has a duty to its rate payers. Any changes to the flow-by requirement must be carefully evaluated against public health, safety, costs, and environmental benefits, each of which depends on an adequate, reliable, and safe water supply. The volume of additional stand-by water supply from the water supply reservoirs has been based on the 100 MGD flow-by, at a significant sum, and even more is anticipated to be spent given the likely development of Travilah quarry. An increase in the flow-by will require additional significant resources and therefore the basis of evaluating the flow-by must include extensive scientific analysis, careful interpretation of the results, and careful consideration of all impacts. The Pennsylvania study reflects the extreme difficulty of quantifying a low flow value. For this reason and others WSSC Water is not optimistic that a modeling approach will be helpful in establishing a scientifically defensible flow for the ecology of the river without extensive data, especially field data that quantify conditions before, during, and after low flow events.

The low flows experienced in 1966 were prior to any of the cooperation agreements or water storage reservoirs being in place. It also was before the ICPRB CO-OP Section was established, which, along with the commitments of the major water utilities under the WSCA, can greatly mitigate the effects of drought and low flows for short periods. In 2002, flows approached 100 MGD for short period but the reservoirs and ICPRB were able to help meet the flow-by, thus illustrating that the current system is working. As far as we are aware, with both events there hasn't been any data collected or surveys performed immediately prior to, during, or immediately after the 1966 or the 2002 events. But as far as we know, it seems that the river ecology was either not heavily impacted or was resilient and recovered quickly from these rare but relatively short-lived events. This could suggest that the 100 MGD flow may be a reasonable protective value.

Than Hitt, U.S. Geological Survey

An analysis of MD-DNR's smallmouth bass dataset with empirical data for the Potomac River shows that as spring flows go up, there is a consequence for the abundance of fish. This impact can be predicted based on the life history theory in ecology (the idea that species strategies for survival and reproduction are linked to environmental stability and predictability). For the smallmouth bass, problems can be linked to increased flows during the spring that lead to scouring and egg/larval mortality. Furthermore, the analysis shows that species requiring stable conditions are declining and that opportunistic species (ones that can take advantage of rapidly changing environmental conditions) are doing better. These high flows are not necessarily attributed to climate or land use change even though both can be a cause. Other analyses show that karst groundwater systems have stable flows and more equilibrium species are observed.

Looking ahead, managers should consider multi-year flow effects for fish population dynamics, not just what happens during a single year. The referenced studies can be found here and here.

Martin Gary, Potomac River Fisheries Commission

PRFC manages fishery resources from the Woodrow Wilson Bridge to the mouth of the Potomac River. The biggest issues in this area are anthropogenic influences, storms, turbidity, conductivity, increased nutrient loads, and high surface water temperatures. These are all affecting important fisheries, including oysters and striped bass. Innovative management efforts are needed to address these issues.

Louis Reynolds, U.S. Environmental Protection Agency

Any discussion of changing the flow-by should include determining what types of ecological processes we want to protect, as was part of the ELOHA process. Given all that has been learned over the last 20 years, we need to see if there are new questions that need to be asked. In addition to habitat loss due to low flows, impacts on water quality from low flows needs to be part of the analysis.

There has not been a lot of discussion on water use demand. There is not a compelling need for more water as demand is flat. Are we doing as good as we can at reducing demand and reducing pollution from wastewater treatment plants and agricultural sources?

PARTICIPANTS

Summarized below are comments from the workshop participants made verbally on Day 1 or Day 2 or in writing (online survey or directly). Comments are grouped by topic: Biology, Water Quality, Habitat, and Flow Management.

BIOLOGY

Jim Cummins, Interstate Commission on the Potomac River Basin (retired)

New information on fish populations between Great Falls and the tidal fresh estuary is needed, especially during low flows.

Daren Carlisle, U.S. Geological Survey

Written comments: I would focus on key species that are reliable indicators of ecological conditions in the target section of the river. It sounds to me like there are several mussel species, some of which are candidate T&E, in that river reach. I would invest in the research and monitoring required to understand the flow and water-quality (e.g., temperature) needs of the mussel assemblage. Much work has already been done for mussels in the Delaware River--and there may be opportunities to leverage that work. The benefits of this approach are that the indicator species have high societal and policy relevance, and are relatively stationary within the reach--relative to fish.

Jason Hill, Virginia Department of Environmental Quality

A group is needed to decide on the set of species that should be monitored in any plan that is written. Immobile and mobile species were not considered in the 1981 study, though the authors offered some suggestions.

Written comments: I work more on the biology side of water quality management and do not have a deep knowledge of the latest literature for modeling large unregulated rivers like the Potomac for healthy environmental flow by. It does appear from the workshop that there are a lot of new strategies and tools to modernize an agreement from 40 years ago. The flow that is currently agreed upon as a flow by occurs less than 1% of the time so it would seem we could evaluate new strategies and model different species to guide a process to lead to a new flow by requirement(s).

I would review strategies that promote taking a certain percentage of flow based on the daily flow. I think modeling more native species for habitat evaluation is a good idea (white sucker is the only native species modeled in the 1981 report). Perhaps native darter such as tessellated darter or shield darter would be good additions. I would add more anadromous (sturgeon and/or American shed) and catadromous (American eel) fish. A group of experts could pick the species, just a few suggestions.

WATER QUALITY

Durelle Scott, Virginia Tech

If we are taking another look at the 1981 study, we need to factor in changes in water quality that have occurred. There have been increases in conductivity, changes in land use, and changes in water temperature. These all compound the effect of water quality and low flow.

Claire Buchanan, Interstate Commission on the Potomac River Basin (retired)

The effect of low flows on water quality should be one focus of any new analyses. Water suppliers are collecting raw water quality data that would be useful in these analyses. Priority parameters could include conductivity, nutrients, temperature, and turbidity in the 18-mile free-flowing reach and the tidal fresh estuary.

Jim Uphoff, Maryland Department of Natural Resources

Beginning in 2008, researchers have seen diminished recruitment of striped bass, a migratory fish. This has coincided with earlier warming of their spawning grounds in tidal fresh waters and is partially reflective of below average stream flows in April. It would be interesting to know if anyone has looked into water temperature changes during spawning periods. A paper Hinson, et al. shows that temperatures in the Chesapeake Bay regions have started warming earlier than they used to, particularly in April and May.

The habitat models that have been discussed have been built around hydrology. It would be interesting to know if flow releases could be used to modify water temperatures and conductivity.

HABITAT

Scott Smith, Virginia Department of Wildlife Resources

Little Falls is an example of an area where the entire reach is not uniform in responding to flow changes. The area is of particular importance because it is at the head of tide and is a migration barrier to some species. As with all partial or complete barriers there is a large aggregation of fish below it, making it a fairly critical habitat.

Written comments: There are a wide range of options, including updated PHABSIM studies, Percent of Flow approaches, etc. Impacts to aquatic species beyond the species selected in the 1981 work.

Other impacts of concern are those to tidal segment between Little Falls and Anacostia River in terms of water quality/salinity changes, those to connectivity (longitudinal and lateral) at low flows for multiple species, and those to recreational activities.

Curtis Dalpra, Interstate Commission on the Potomac River Basin

Data needs for assessing chronic low flows need to be determined. What happens if today's acute low flows become chronic low flows in the future?

Jim Cummins, Interstate Commission on the Potomac River Basin (retired)

There is a pool below the American Legion Bridge that dips down to 100 feet deep. It is a good refugia for organisms that can move, and no problems related to temperature or dissolved oxygen were observed there during the 2002 low flow period.

Claire Buchanan, Interstate Commission on the Potomac River Basin (retired)

The question of how the opening of the fish passageway (2000) at Little Falls has changed the biological communities between Little Falls and Great Falls should be addressed. It has likely led to increased exchanges and healthier populations since the 1981 MDDNR study was performed.

Mike Selckmann, Interstate Commission on the Potomac River Basin

The 18-mile stretch of the river is too small of a scope for studying the flow-by protectiveness because the fish ladder at Little Falls dam has opened the free-flowing river to the estuary. The Washington, D.C., area and a small stretch of river below Little Falls dam are now a corridor and a doorway, respectively, to an important upstream nursery area for migratory fish in the Potomac gorge.

FLOW MANAGEMENT

Jeffrey Seltzer, DC Department of Energy and Environment

Written comments: Various models and types of analysis approaches are being evaluated in other regions of the country and seem to be relevant to the Potomac.

Greg Prelewicz, Fairfax Water

Written comments: Need to be careful not to focus on statistical approaches for other rivers nationwide, these might not apply to unique rivers like the Potomac, with deep pools and channels in the Great Falls to Little Falls stretch. Need to be careful of assuming that relationships for small rivers in the Potomac basin can be scaled to the Potomac.

Jim Cummins, Interstate Commission on the Potomac River Basin (retired)

ICPRB CO-OP flow-by management decisions are conservative during low flows. They essentially manage reservoir releases for a 200 MGD flow-by since flows from the Jennings Randolph reservoir take about nine days to get to Great Falls and flows during those nine days are hard to predict. The concern is that as the technology to predict flows gets better, decisions will be made that lead to a flat 100 MGD flow. A variable 200 MGD flow is considered better for the ecology.

Written comments: In regards to your summary of the findings of our report, I feel strongly an emphasis is made that the current 100 MGD Env. Flow-by below the Brookmont dam to tide, easily scientifically argued as too low a flow, has fortunately and effectively been (and still is?) a 200 MGD flowby due to the CURRENT (i.e., 2011) limits of our technology to predict water arrivals from JRR releases and the very wise/conservative approach to flow management of ICPRB's CO-OP, i.e., they don't want to violate the 100 MGD so they, except on very rare occasions, don't go much below 200. During the 1999-2002 drought series we didn't find any overtly bad ecological conditions in that short Little Falls stretch, but our data is somewhat limited (mostly we need more data on fish from GFs to tidal influence, which MD DNR was correcting when I retired). The longer stretch from G. Falls to L. Falls has plenty of deep, indeed very deep (100'!), pools, providing good refugia for mobile aquatic life. In addition, largely due to that stretch's shallow benthic habitat being very storm-managed due to the constricted nature of that gorge, there is relatively little quality habitat for non-mobile aquatic life such as SAVs and freshwater mussels- basically the shallow areas are mostly bedrock rock.

However, the main issue in my mind is that as our technology improves, some through math and computers (predictive modelling), but also through both satellite improvements and more management experience, we should still work to not dip to the 100 MGD. Hopefully "new" water resources, like the Leesburg quarries, will help fill in the water needs for a good while and no new and always problematic reservoirs will need to be constructed.

Durelle Scott, Virginia Tech

The margin-of-safety that ICPRB uses in making release decisions should be evaluated. We should not lose sight that there may be opportunities to improve things for water consumers.

Lou Reynolds, U.S. Environmental Protection Agency

Given that demand is leveling off despite population growth, maybe we should be thinking about minimizing water withdrawals and maximizing habitat potential. Maintaining flows are also important from a pollution perspective.

Written comments: ELOHA was mentioned in both the 2011 Environmental Flows Study and the 2014 Middle Potomac study. I don't think I heard ELOHA mentioned at all in this workshop. In that study, the Executive Summary includes: "For large rivers, the project team concluded, based on currently available information, there has been no discernible adverse ecological impact on focal species due to human modification of flows. As a precautionary measure, the team recommended that the current large river flow regime be maintained for the entire range of flows as defined by 20 flow statistics based on a 21-year period of record (1984-2005)." Is this still the case? Was it even the case then?

I like the idea of updating the models particularly to variable minimum instream flows. Also, models might include new or different species. There are indications that the current pass by flows are not enough. It seems necessary to really figure out what flow is needed for what processes and for how long.

What do you want to change and why? I am not convinced of a need for more water. It seems that there is evidence that the flows in the river right now are inadequate to support the ecological processes that we want. We lack information on the tidal-fresh area. And I have seen little analysis of the water quality impacts in low flow periods.

Mike Selckmann, Interstate Commission on the Potomac River Basin

I would be interested in a planning objective within the structured decision-making process that optimizes connectivity of habitat through flow targets across longer reaches of the river. The Maryland 1981 report looked at habitat availability from Seneca Pool to Great Falls. Interestingly, as flows drop, habitat at Little Falls decreases, but upstream habitat increases. Little Falls could be thought of as a doorway to potentially more important upstream habitat.

Scott Kudlas, Virginia Department of Environmental Quality

The analysis that Rob Burgholzer presented is just the starting point. Making the trade-offs of different flow-by levels transparent is how this analysis is implemented on a daily basis in Virginia. The next steps would be to work with water suppliers and others to identify which species are of particular concern at different times of year and relate their needs to water supply demands. The potential costs, benefits, and associated risks need to be identified. Virginia's process is very similar to the structured decision-making process Kyle McKay presented.

Virginia has not reached the conclusion that new storage is needed; that would be premature at this time. Storage is looked at comprehensively in order to meet the multiple needs of the beneficial uses of each watershed.

The analysis looked at Little Falls and Great Falls because the river between these two locations was a focus of the 1981 Maryland study and Washington Aqueduct intakes are near these locations. There may be more important reaches to look at that may or may not be impacted by these water withdrawals.

Cherie Schultz, Interstate Commission on the Potomac River Basin

ICPRB is happy to explain CO-OP policies on water supply releases during drought, and these are also documented in CO-OP water supply studies. Basically, water supply releases are based on the need to meet the flow-by at Little Falls as predicted by flow and water demand forecasts. The margin-of-safety used for meeting the flow-by

requirement is 120 MGD. There may be some trade-offs that could be considered that might mean missing the flow-by more often.

Climate change is a big uncertainty in planning for future storage needs. The 2020 water demand study showed that in an extreme drought in 2050, under the most severe climate scenario considered, there would be no water left in storage and no water held back for environmental purposes.

ICPRB has contracted with Penn State to work on a new coupled surface water/groundwater flow prediction model for the Potomac basin which may improve our ability to forecast low flows.

Steven Kyle McKay, U.S. Army Corps of Engineers

The structured decision-making approach can be applied at any level. A clear set of objectives is essential. While objectives do not change, interpretation and confidence in the results might. Different objectives can be set for different portions of the river. Models can be developed to answer specific questions.

Written comments: The body of knowledge in the river (and large rivers generally) has expanded enormously, and many lines of evidence could be developed addressing different outcomes (e.g., separate models for habitat, fish, bugs, etc.). Additionally, computational power has increased such that dozens or hundreds of flow management schemes could be simulated and passed through these models. Flow management alternatives could be examined through the lens of many different criteria to identify actions that are more/less efficient than the current strategy.

The main investment may be in a hydrologic simulation approach, where the ICPRB and partners could test the effects of different flow management proposals. From these simulated hydrographs, outcomes of interest could be compiled through different modeling approaches. The challenge then becomes how to "roll-up" data to decision makers.

APPENDIX – WORKSHOP PARTICIPANTS

Name	Day 1	Day 2
Sarah Ahmed, Interstate Commission on the Potomac River Basin	x	x
Fatemah Bahabib, U.S. Army Corps of Engineers		x
Karin Bencala, Interstate Commission on the Potomac River Basin	x	x
Steven Bieber, Metropolitan Washington Council of Governments	x	x
Renee Bourassa, Interstate Commission on the Potomac River Basin	x	x
Willem Brakel, American University, ICPRB Commissioner	x	x
Claire Buchanan, Interstate Commission on the Potomac River Basin (retired)	x	x
W. Brandon Bull, Virginia Department of Environmental Quality	x	x
Robert Burgholzer, Virginia Department of Environmental Quality	x	x
Greg Busch, Maryland Department of the Environment	x	x
Daren Carlisle, U.S. Geological Survey (Kansas Water Science Center)	x	
Joel Caudill, WSSC Water	x	x
Rudy Chow, U.S. Army Corps of Engineers	x	
Jim Cummins, Interstate Commission on the Potomac River Basin (retired)	x	
Curtis Dalpra, Interstate Commission on the Potomac River Basin	x	x
Laura Felter, U.S. Army Corps of Engineers	x	x
Julie Fritz, U.S. Army Corps of Engineers	x	x
Mark Frondorf, Shenandoah Riverkeeper	x	x
Martin Gary, Potomac River Fisheries Commission		x
Ryan Green, Virginia Department of Environmental Quality		x
Jason Hill, Virginia Department of Environmental Quality	x	x
Than Hitt, U. S. Geological Survey		x
Thomas Hilton, WSSC Water		x
Paul Holland, ICPRB Commissioner	x	
Rikke Jepsen, Interstate Commission on the Potomac River Basin	x	
Renee Karrh, Maryland Department of Natural Resources	x	
Michael Kashiwagi, Maryland Department of Natural Resources	x	x
Anna Kasko, Maryland Department of the Environment	x	x

Name	Day 1	Day 2
Joseph Kleiner, Virginia Department of Environmental Quality	x	x
Scott Kudlas, Virginia Department of Environmental Quality, ICPRB Commissioner	x	
Jonathan Leiman, Maryland Department of the Environment	x	x
Catherine McCabe, ICPRB Commissioner, LFAA workgroup chair	x	
Steven Kyle McKay, U.S. Army Corps of Engineers	x	x
Heidi Moltz, Interstate Commission on the Potomac River Basin	x	x
Scott Morris, Virginia Department of Environmental Quality	x	x
John Mullican, Maryland Department of Natural Resources	x	x
Andrea Nagel, Interstate Commission on the Potomac River Basin	x	x
Michael Nardolilli, Interstate Commission on the Potomac River Basin	x	x
Stephanie Nummer, Interstate Commission on the Potomac River Basin		x
Robert Peoples, Maryland Department of the Environment	x	x
Mark Peterson, Loudoun Water, ICPRB Commissioner	x	x
Greg Prelewicz, Fairfax Water	x	x
Lainey Reed, Maryland Department of the Environment	x	x
Lou Reynolds, U.S. Environmental Protection Agency	x	x
Andrew Roach, U.S. Army Corps of Engineers	x	x
Daniel Ryan, District Department of Energy & Environment	x	
Niffy Saji, Fairfax Water		x
Luis Santiago, U.S. Army Corps of Engineers	x	
Leonard Schugam, Maryland Department of the Environment	x	
Cherie Schultz, Interstate Commission on the Potomac River Basin	x	x
Durelle Scott, Virginia Tech	x	x
Alimatou Seck, Interstate Commission on the Potomac River Basin	x	x
G. Mike Selckmann, Interstate Commission on the Potomac River Basin	x	x
Jeff Seltzer, District Department of Energy & Environment, ICPRB Commissioner	x	x
Matt Shank, Pennsylvania Department of Environmental Protection	x	x
Dustin Shull, Pennsylvania Department of Environmental Protection	x	
Scott Smith, Virginia Department of Wildlife Resources	x	x
Anne Spiesman, U.S. Army Corps of Engineers	x	x
Megan Spindler, U.S. Army Corps of Engineers	x	

Name	Day 1	Day 2
Scott Stranko, Maryland Department of Natural Resources	x	
Guido Yactayo, Maryland Department of the Environment	x	x
John Young, U.S. Geological Survey	x	
Jim Uphoff, Maryland Department of Natural Resources	x	
John Wirts, West Virginia Department of Environmental Protection	x	

APPENDIX – LINKS TO AGREEMENTS, PUBLICATIONS, REPORTS, DATA

A history of the water sharing agreements for the Washington Metropolitan area, with links to relevant documents

- https://www.potomacriver.org/focus-areas/water-resources-and-drinking-water/cooperative-water-supply-operations-on-the-potomac/co-op-history/

The 1981 Maryland Department of Natural Resources' Potomac environmental flows report

- https://pprp.info/Potomac/1981report.htm

Versar (2003) Potomac River habitat assessment report, data, and photos

- https://pprp.info/Potomac/2002report.htm

MD DNR/ICPRB workshops (2003-2005)

- Potomac Instream Flow Methods Workshop (2003)
- Potomac Low Flow Update Workshops (2004-2005)

ICPRB large river environmental flow report

- Potomac Basin Large River Environmental Flow Needs (2011) - includes the 2010 workshop summary

ICPRB biological survey report

- Biological Surveys of Three Potomac River Mainstem Reaches (2012-2014) with Considerations for Large River Sampling (2018)

ICPRB water supply demand studies

- https://www.potomacriver.org/focus-areas/water-resources-and-drinking-water/cooperative-water-supply-operations-on-the-potomac/long-term-planning/

ICPRB report on Potomac River Water Quality at Great Falls: 1940 – 2019

- https://www.potomacriver.org/wp-content/uploads/2021/11/PRWQ_Final.pdf

ICPRB partial bibliography of sustainable flow articles and reports from circa 2010 to present.

- https://www.potomacriver.org/wp-content/uploads/2022/07/EnvFlows_Workshop_Lit_July2022.xlsx

Links shared by participants over the two days of the 2022 workshop:

Joseph Kleiner, Virginia Department of Environmental Quality

- Links to the recent species-richness based instream flow framework developed by DEQ-USGS-VT.

  Methodology: https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12876

  Application: https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12877

John Young

- The lidar DEMs can be downloaded here: http://prd-tnm.s3.amazonaws.com/index.html?prefix=StagedProducts/Elevation/OPR/Projects/MD_PotomacRiverTopoBathy_2019_D19/MD_PotomacRiver_Bathy_2019
- The lidar point cloud data can be downloaded here: https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/MD_PotomacRiverTopoBathy_2019_D19/MD_PotomacRiver_Bathy_2019/
- Jon Nelson's USGS YouTube video describing the use of the bathymetric lidar data for flow modeling with the iRIC platform: https://youtu.be/fO_y4o2v0-c

Lou Reynolds

- This is the kind of info that can come up with an ecosystem perspective. https://www.nature.org/media/pa/ecosystem-flow-recommendations-upper-ohio-river-pa-2013.pdf

Than Hitt

- Land use x climate change: https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14961
- Our study of Potomac River fish abundance trends (1975-2017) indicates destabilized river flows: https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.3026
- Here's our recent work from the Potomac River basin reinforcing the idea that flow stability predicts fish communities via survival and repro strategies: https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.8861