Facilitating Brook Trout Outcome Attainability through Coordination with CBP Jurisdictions and Partners

July 2024

Recommended Citation: *Rummel, S.M., M. Mayfield, L.A. Maloney, H.C. Smith, and O.H. Devereux. 2024. Facilitating Brook Trout Outcome Attainability through Coordination with CBP Jurisdictions and Partners. Final Report to the Chesapeake Bay Trust. Trout Unlimited, Arlington, Virginia.*

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement CB 96374201 to the Chesapeake Bay Trust. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does the EPA endorse trade names or recommend the use of commercial products mentioned in this document.

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List of Abbreviations

ACB – Alliance for the Chesapeake Bay

AMD – Abandoned mine drainage

AOP – Aquatic organism passage

BKT – Brook trout

BMP – Best management practice

BRN – Brown trout

BTWG – Brook Trout Workgroup

CB – Chesapeake Bay

CBC – Chesapeake Bay Commission

CBP – Chesapeake Bay Program

DEC – Department of Environmental Conservation

DNR – Department of Natural Resources

EBTJV – Eastern Brook Trout Joint Venture

EPA – Environmental Protection Agency

FEMA – Federal Emergency Management Agency

FPWG – Fish Passage Workgroup

FWS – Fish and Wildlife Service

GIS – Geographic Information Systems

GIT – Goal Implementation Team

GPS – Global positioning system

HUC – Hydrologic unit code

LWA – Large wood addition

MD – Maryland

NAACC – North Atlantic Aquatic Connectivity Collaborative

NFWF – National Fish and Wildlife Foundation

NGO – Non-governmental organization

NHD – National Hydrography Dataset

NRCS – National Resources Conservation Service

NY – New York

PA - Pennsylvania

PA DEP – Pennsylvania Department of Environmental Protection

PA LTA – Pennsylvania Land Trust Association

RBT – Rainbow trout

RTE – Rare, Threatened, and Endangered

SARP – Southeast Aquatic Resources Partnership

SD – Standard deviation

STAC – Scientific, Technical, and Advisory Council

SWCD – Soil & Water Conservation District

TNC – The Nature Conservancy

TU – Trout Unlimited

UAW – Unassessed Waters Initiative

UPS - Upstream

US – United States

USDA – United States Department of Agriculture

USFS – United States Forest Service

USGS – United States Geological Survey

VA - Virginia

WV – West Virginia

Executive Summary

The objective for this project was to populate a database to better evaluate progress on the Chesapeake Bay Program (CBP) Brook Trout Outcome, which is to increase occupied brook trout habitat within the Chesapeake Bay watershed by 8% by 2025. This objective included goals to identify collaborations with other CBP Goal Implementation Teams (GITs), to strengthen stakeholder relationships, and to develop a robust tracking and reporting framework. This work was performed by Trout Unlimited (TU) and the Eastern Brook Trout Joint Venture (EBTJV), in collaboration with the Brook Trout Workgroup, the Habitat GIT, and Devereux Consulting. Key findings from the project include:

- **Limited progress towards the CBP Brook Trout Outcome:** Analysis of EBTJV assessment data from 2016 and 2024 revealed a 0.5% increase in occupied brook trout habitat within the Chesapeake Bay watershed. Although this is significantly below the targeted 8% increase, the gain is notable in that it happened despite habitat loss and increasing stressors to the landscape, climate, and water quality.
- **Extensive restoration efforts:** We complied a comprehensive database of 5,419 implementation projects (2016-2022) within the Chesapeake Bay watershed. We then worked with the Habitat GIT and contractors to integrate the database into the Habitat Tracker, providing a valuable resource for tracking and reporting the impact of various restoration activities on brook trout populations.
- **Opportunities for improving data sharing and reporting:** We identified potential synergies and data sharing opportunities with other CBP GITs and workgroups, particularly the Fish Passage Workgroup (FPWG) and its Chesapeake Bay Fish Passage Tool. The CBP GITs share many of the same stakeholders and partners across the watershed. By annually querying upcoming GIT related data requests, the CBP could reduce duplication of requests and centralize reporting by the partners, thereby increasing engagement. Data requests should also be directed at higher level agencies and funders.
- **Recommendations for future management:** In this report we reviewed project types known to benefit brook trout, and made an argument for increased, scientifically based monitoring of projects to better understand their effectiveness. We also argued for improving and conserving existing high-quality habitat and remediating impairments in the most degraded habitats (especially Abandoned Mine Drainage, AMD).

By leveraging the newly established database, tracking system, and collaborative networks, the CBP and its partners can develop more targeted and effective management strategies. To better understand project effectiveness and guide future goals, the CBP should support a scientifically based monitoring plan, and focus on strengthening existing brook trout populations in addition to increasing occupancy. Ultimately, the Brook Trout Outcome is a call to support brook trout not just for related habitat and water quality improvements but for its own sake. This analysis showed that a net gain to brook trout occupancy is indeed possible, but requires the combined efforts of many organizations, practitioners, and funders.

Introduction & Background

In the United States, headwaters make up the majority (79%) of total river lengths and drain over 70% of the total land area (Datry et al. 2014). Headwaters are essential to nearly all ecosystem services (Colvin et al. 2019). Some services they provide are sustaining aquifers and supplying clean water (Sullivan et al. 2015), supporting benthic taxa diversity and unique species only found in the headwaters (Meyer et al. 2007), delivering water, sediment, and organic materials to downstream reaches, contributing to nutrient cycling and water quality, and even contributing to flood protection and mitigation (Colvin et al. 2019). The headwaters also contribute to biodiversity within river networks.

Economically, it has been estimated that the ecosystem services that headwaters provide are worth approximately $15.7 trillion for all 50 states (Nadeau and Rains 2007), it is likely even higher today when adjusted for inflation. There are many threats that headwaters still face: development/urbanization (Meyer and Wallace 2001), logging (Richardson 2019), abandoned mine drainage in Pennsylvania (PA DEP 2016), as well as impassable dams and culverts (Richardson 2019). There is direct influence on downstream conditions by the headwaters. The degradation of headwaters and the loss of their connection to ecosystems downstream, threaten entire river networks (Meyer et al. 2007).

An iconic fish species in many Chesapeake Bay headwater streams is the eastern brook trout, which is prized by anglers and loved for its bright coloration and status as a native species. Brook trout inhabit a variety of habitats across the east coast of the United States and Canada from Georgia to the Great Lakes to Nova Scotia: ponds, lakes, rivers, and coastal streams in northern regions and is limited to smaller, isolated higher altitude watersheds in the southern regions. Although most major strongholds are in the northern portion of the range, many sub-watersheds in the Chesapeake Bay that are heavily forested also contain important brook trout strongholds (Fesenmyer et al. 2017). The current range of brook trout has shrunk substantially compared to its historic range due to pollution, urbanization, sedimentation, and impassable dams and culverts (Hudy et al. 2008). Climate change is of particular concern for brook trout due to its reliance on cold water habitat (Merriam et al. 2019). The decline of brook trout can serve as an early warning that the health of an entire system is at risk. Furthermore, its preference for habitat with cold, clear, well-oxygenated water, has inspired its use as an indicator of stream or watershed health, including within the CBP.

Within the Chesapeake Bay watershed, brook trout primarily inhabit first and second order headwater streams, and populations have declined substantially across the watershed (Hudy et al. 2008, DeWeber and Wagner 2015, Maloney et al. 2022, Merriam et al. 2018). Development is often cited; however, losses are also seen in areas that are currently forested: in the Shenandoah National Park, estimated brook trout abundance declined by 50% or more in approximately 70% of streams across the park over a 27-year period from 1996–2022 (Childress et al. 2024). Brook trout is a named species of greatest conservation need in State Wildlife Action Plans of Maryland, New York, Pennsylvania, Virginia, and West Virginia. Headwater landscapes, habitats, and species including brook trout, are important to the communities where they are found, as well as to the health of downstream reaches and the Chesapeake Bay.

In 2015, the CBP's Habitat Goal Implementation Team developed a management strategy for brook trout which centered on protecting and increasing populations by implementing priority restoration Best Management Practices (BMPs). The Brook Trout Outcome Management Strategy ("Management Strategy") supports the Chesapeake Bay Agreement's Vital Habitats Goal to *restore, enhance and protect a network of land and water habitats to support fish and wildlife and to afford other public benefits, including water quality, recreational uses and scenic value across the watershed*. An additional brook trout outcome was written: *restore and sustain naturally reproducing brook trout populations in the Chesapeake Headwater streams with an eight percent increase in occupied habitat by 2025*. The baseline for change is an assessment of brook trout that was released in 2016. This assessment, a product of the multi-agency collaborative, the EBTJV, was developed at the level of the catchment (small watersheds 2-5 km reach) and patch (aggregations of connected catchments), based on survey data and a model to predict trout occupancy in unsurveyed locations. From it, an area of occupied brook trout habitat was estimated and was used as the baseline for the brook trout outcome.

The Management Strategy acknowledged that collaboration amongst a variety of agencies, groups, governments, nonprofits, and communities is necessary to implement activities that will conserve brook trout. The Strategy also outlined a methodology for tracking changes to brook trout populations, including a watershed sampling strategy that looked at patch metrics as well as genetic diversity and effective number of breeders. To assess progress, pertinent jurisdictions would annually report the amount of habitat (km^2) occupied by wild brook trout that was added to the baseline figure through conservation actions. These annual gains would be combined with the outputs of the monitoring protocol to determine overall progress. Then, after every five-year period, the gains and/or losses of habitat would be presented in a status report. In 2021, the Bay Program recognized that there was insufficient data to prepare the first five-year status report and opened a Goal Implementation Team (GIT) funding opportunity to solicit the development of a method to track current and future progress.

Project Objectives and Goals

The overall objective for this project, as described in the Request for Proposals, "is for Trout Unlimited (TU) and its subcontractor, the EBTJV to work with the EPA Data Center Team, the Brook Trout Work Group, and other partners and stakeholders currently collecting data to populate the database to better evaluate progress on the Chesapeake Bay Program Brook Trout Outcome." The CBP Brook Trout Outcome is to "restore and sustain naturally reproducing brook trout populations in the Chesapeake Headwater streams with an **eight percent increase** in occupied habitat by 2025."

Four main goals were identified during the project kickoff meeting on 9 November 2022 towards the overall objective:

1. Identify opportunities for cross-GIT collaborations with other CBP teams (Maintain Healthy Watersheds GIT, Fish Passage Workgroup, Forestry Workgroup, Stream Health Workgroup) on connected actions, e.g., reforestation, aquatic connectivity, land conservation.

2. Strengthen communication and coordination with other stakeholders (e.g., non-Department of Natural Resources (DNR) state agencies, other non-governmental organizations (NGOs)).

3. Collect and compile existing data from stakeholders and analyze monitoring and implementation data necessary to adequately track progress.

4. Work with the CBP EPA Data Center Team to develop a tracking/reporting application. (Please note that during the project the team identified working with Devereux Consulting to populate a Brook Trout component of the Habitat Tracker application that was recently developed for the Habitat GIT, instead of working on an independent application with the EPA Data Center Team).

Goal 1: Identification of Cross-GIT Collaborations

The objective of this component of the project was to identify ways to increase collaboration between the Brook Trout Workgroup and other GITs, however, we also take a slightly broader approach in looking at brook trout within the CBP in general. This is especially pertinent this year as CBP partners continue to discuss the meaning of a renewed focus on 'shallow water' following the report: Comprehensive Evaluation of System Response, in 2023. Brook trout inhabit watersheds across the Chesapeake Bay, from population centers north of Baltimore to rural Appalachian headwater communities. Brook trout and the headwaters are inherently valuable to these communities, above and beyond the downstream water quality goals that brook trout conservation and habitat projects support.

The cross-GIT discussions highlighted the importance of brook trout as an indicator species, a target species, and an icon for use in public outreach. Each of these roles are important and are reflected across multiple GIT or workgroup priorities including aquatic organism passage (AOP), land protection, land use and stormwater planning, water quality, and climate resilience.

Summary of outreach to other GITs and workgroups

The project team conducted outreach to other Chesapeake Bay GITs and Workgroups, in particular a set of eight that the project Steering Committee suggested have potential overlap with the Brook Trout Workgroup. We also reviewed Management Plans and other documents by these GITs and teams, and broadly summarized areas of overlap and possible future work. We identified that there are specific data sharing needs between the Brook Trout Workgroup and the Fish Passage Workgroup, which are detailed at the end of this section.

As a first step to cross-GIT collaboration, we scheduled introductory conversations with the leadership of six of these eight GITs or GIT workgroups in December 2022 and January 2023. Questions asked included:

a. Does your workgroup have any datasets that might inform our dataset on stream restoration projects that benefit brook trout?

b. Does your workgroup have any data needs that could be helped by our project?

We held 30-60 minute video meetings with the leads of these teams: The Sustainable Fisheries GIT's Fish Habitat Workgroup; Forestry Workgroup; Fish Passage Workgroup; Climate Resiliency Workgroup; Maintain Healthy Watersheds GIT; Stewardship GIT. We gave a five minute presentation at a Stream Health Workgroup meeting in lieu of a call, and the Land Use Workgroup responded by email. In the video calls we discussed potential areas of shared interest or where similar information could be shared across workgroups. This resulted in a list of thirteen items to explore (Appendix 1). Project team members also periodically attended workgroup meetings for the Climate Resiliency Workgroup, Stream Health Workgroup, and Maintain Healthy Watersheds GIT, for awareness of their current activities.

We presented preliminary results at the Brook Trout Workgroup meeting, EBTJV meetings, and Habitat GIT meeting in November 2023. Other opportunities will be identified through the EBTJV and Brook Trout Workgroup coordinators.

We reviewed selected documents from these teams and the Bay Program's Scientific, Technical, and Advisory Council (STAC). The report section immediately below reviews some high-level themes of brook trout or brook trout habitats in the CBP. We also include a more detailed crosswalk of the Logic and Action Plans for the Brook Trout Workgroup and the Fish Passage Workgroup. A more thorough review of all areas of shared interest and synergy across all workgroups and teams, including expanding upon items from our initial discussions is beyond the scope of this report but would be a worthwhile effort.

Summary of review of focal areas of other teams (identifying overlap with Brook Trout Workgroup)

Communication

The Logic and Action Plans of many CBP workgroups point to needs for improved outreach and communication, including coordinating communication points across workgroups and GITs. Although these needs fall across diverse focal areas, there are opportunities to leverage brook trout. Brook trout are an iconic species, often used to help tell the story of how local and landscape-level activities affect watersheds and public water resources. Their presence can motivate a variety of conservation actions by the public, land stewards, and decision makers. A search on chesapeakebay.net for "brook trout" returns over 1,000 pages and documents. However, only one of these hits is also filtered under "take action". We suspect there are numerous places to take action that include stories of brook trout: for example, the Fish Passage Workgroup's document on AOP techniques in Maryland uses examples of brook trout as a target AOP species. The Stewardship GIT is interested in ways to engage landowners in conservation, and brook trout are often used for this purpose, as mentioned in videos about conservation by state and NGO partners in the Upper Potomac watershed (e.g. CBP, 2019 From the Field: Linking land and water in brook trout conservation). The Brook Trout Workgroup could consider compiling such examples and ask that CBP check that all are tagged for brook trout on its website, or possibly linked from the brook trout species page on CBP's website, to increase their visibility. Additionally, all GITs might benefit from maintaining a central glossary of publicfriendly conservation terms and a database of public and agency media and public relations contacts.

Protecting priority watersheds

Understanding relationships between stressors on the landscape and biological endpoints is a shared interest between the Forestry Workgroup, Maintain Healthy Watersheds GIT, Brook Trout Workgroup, and Stream Health Workgroup. Brook trout and brook trout data serve an important role in informing where conservation should happen. Tools and summaries for prioritization of watersheds for conservation – including land protection as well as habitat or watershed improvement projects – often utilize geographic data on brook trout occupancy as one component to help identify priority locations. This is true across GITs and more broadly across organizations and funding initiatives throughout the watershed. Specific to CBP, the Fish Passage Prioritization Tool (by the Fish Passage Workgroup) and the Healthy Watersheds Assessment (by the Maintain Healthy Watersheds GIT) both use data from models of brook trout occupancy.

Understanding the threats of climate change

The needs to prioritize watershed restoration projects in light of climate change and to support climate adaptation for species like brook trout are shared across multiple teams including the Brook Trout Workgroup, Forestry Workgroup, Climate Resiliency Workgroup, Stream Health Workgroup, and Maintaining Healthy Watersheds GIT. A recent STAC report, *Rising Watershed and Bay Water Temperatures - Ecological Implications and Management Responses*, included a section on impacts to brook trout. In general, the report argued that conserving existing healthy watersheds, including those with high percent forest cover, can help promote resiliency to rising water temperatures. The EBTJV included this report in its 2023 hybrid annual meeting at the National Conservation Training Center in WV, presented by Katherine Brownson, US Forest Service Liaison to the CBP. The EBTJV also shared the report via email and EBTJV listserv (~900). In its workplan, the Brok Trout Workgroup includes action items related to understanding the influences of ponds and groundwater on stream temperatures at the reach scale. It also includes working to better prioritize restoration for riparian buffers and culvert replacements, two actions that help brook trout climate resilience.

Selecting appropriate projects and monitoring of project effectiveness

Monitoring project effectiveness is an objective of many CBP teams. Many brook trout restoration projects are performed with the intent to increase miles of stream accessible to and occupied by brook trout, improve habitat conditions, and/or bolster the genetic or population integrity of brook trout. However, as evidenced by the data generated in this study, very few projects have sought to track the effectiveness of practices on brook trout population response through pre and post project biological surveys. Additionally, many projects completed to benefit brook trout, such as riparian plantings to provide shade, cover, erosion control, and woody material, use the same methods as projects done primarily for a water quality benefit. A better understanding of project effectiveness on species response, or “biological uplift”, is desired by practitioners and funders. Recently, several studies in the Chesapeake Bay region sought to track the response of stream and watershed restoration practices on stream ecosystems, including biological response.

For example, Emmons et al. (2024), looked at the response of Maryland stream benthic macroinvertebrates and fish communities to in-catchment management practices implemented primarily for nutrient and sediment reductions such as riparian forest buffers and septic system denitrification. Results were mixed, with negative, neutral, and positive effects across three bioregions. Positive effects were more common in catchments already degraded in the Piedmont region. Management practices, however, could have negative effects in healthy catchments.

In a second example, a 2023 STAC- hosted workshop brought together the stream scientific and management communities to synthesize their understanding of practices, assessment approaches, and ecosystem outcomes to inform and improve stream restoration practices (Noe et al., 2024). Restoration outcomes summarized at the workshop showed a mix of positive and negative outcomes. Projects rarely improved stream biota, some resulted in channel stabilization and had moderate benefits for water quality, and some negatively impacted riparian vegetation in the short term. Recommendations included: avoid harming intact habitat during project implementation, especially on higher quality streams; if biological uplift is the goal, make that the goal, and use appropriate approaches for that goal; target in-stream work to more degraded streams; and design for the location. A key recommendation was to identify the stressors at a project location in order to target those stressors using appropriate stream or watershed restoration approaches.

Extending these findings and recommendations to habitat restoration in brook trout watersheds would support prioritizing projects that restore brook trout habitat in very degraded catchments (such as Abandoned Mine Drainage) or that restore or enhance brook trout populations in stream reaches that are known or likely to support the species, such as by increasing AOP within high quality brook trout patches. Finally, the stream restoration practices workshop recommended the use of scientifically driven monitoring plans, and that monitoring should account for lag times in biological response. These recommendations match very well with recommendations that developed out of the data analysis efforts of this report. Importantly, we also make a recommendation for a scientifically based, watershed specific monitoring plan to support the tracking of future brook trout recovery goals (see Goal 3 Recommendations and Summary of Recommendations Sections).

In this project we focused on specific project types most likely to result in benefits to brook trout populations, based on multiple discussions with the project Steering Committee, contractors, and stakeholders. Of the project types considered, AOP perhaps has the potential to most immediately benefit brook trout occupancy, if performed to appropriate design standards, and in places where brook trout inhabit below but not above a barrier. Removing barriers to connectivity is also important for brook trout population health and climate resilience (Warren and Pardew 1998; Whiteley et al. 2013). Rather than detail every possible area of overlap with other GITs and workgroups, we include a more detailed crosswalk and listing of data sharing opportunities with the FPWG.

Finally, AMD remediation can remove chemical barriers to brook trout occupancy and expand habitat for brook trout a suite of other species (Underwood et al. 2014; Williams and Turner 2015). To our knowledge the Brook Trout Workgroup is the only workgroup to explicitly include an AMD related action in its workplan. This project's data analysis did not show any gains to brook trout attributable to AMD remediation, however this may be due to exclusion of pre-2016 projects and lag times of brook trout response and that few AMD projects are funded through traditional Chesapeake Bay funding sources. Given that in PA alone there are 5,500 miles of AMD-impaired stream (PA DEP 2022), more attention could be given to setting and tracking goals for biological uplift and water quality gains from AMD remediation.

Data sharing and recommendations for opportunities and collaborations other workgroups – focus on the Fish Passage Workgroup

The Fish Passage Workgroup articulates a goal to open 1,000 stream miles for fish passage by 2025. Its 2015-2025 Management Strategy primarily focuses on anadromous species and removing dams; however, it also includes language on brook trout and references the Brook Trout Workgroup.

The Fish Passage Workgroup monitors progress through 1.) miles opened to fish passage, and 2.) species presence. Both workgroups can benefit by reporting and sharing these metrics. Miles opened towards the Fish Passage Workgroup's goal of 1,000 stream miles by 2025 are tracked through the Workgroup's Chesapeake Bay Fish Passage Tool, developed with The Nature Conservancy (TNC). The Brook Trout Workgroup does not directly track miles of stream opened for brook trout, but instead through the EBTJV catchment data, seeks to track area (km^2) of brook trout habitat gained across the watershed through changes in catchment-level occupancy. As explained in the data and tracking section of this report, the project team anticipates that any potential gains to brook trout habitat would most likely be due to projects to repatriate brook trout, AMD remediation, or AOP projects that remove or replace culverts to increase passage where brook trout did not previously inhabit the catchment above the barrier. In the past, the Brook Trout Workgroup did not have a mechanism to easily track the locations of such projects, and the EBTJV data had not yet been updated to allow reporting of new occupancy. Since the development of the Habitat Tracker and its brook trout project tracking capabilities, it may now be used to identify barrier removal with brook trout as a target species. We recommend that the Brook Trout Workgroup report annually to the Fish Passage Workgroup the location of such barrier removal projects so that the Fish Passage Workgroup may add these points to the Chesapeake Bay Fish Passage Tool.

We also recommend that the Brook Trout Workgroup identify resources to perform pre-and post-project monitoring for brook trout presence, particularly in pre-selected, focal watersheds. The need for better monitoring is also articulated by the Fish Passage Workgroup and is an important recommendation of this GIT funded project.

Review of action items from the Fish Passage Workgroup's 2022-2023 Logic and Action Plan

Action 1.4: Continue road/stream crossing activities (assessments, project development and project implementation) in the Chesapeake Bay.
The need for additional AOP assessments and projects is shared, and many partners are working to increase the number of barriers removed. Bipartisan Infrastructure Law funding is expanding the number of brook trout-related passage projects. Many Brook Trout Workgroup partners conduct culvert assessments and report their new data to the North Atlantic Aquatic Connectivity Collaborative (NAACC, https://naacc.org). Because the Chesapeake Bay Fish Passage Tool uses NAACC as a resource, it should not be necessary for Brook Trout Workgroup partners to also report culvert assessments to the Fish Passage Workgroup (though as indicated above, they should report via the Habitat Tracker any culvert removals).

Action 1.5: Recommendations for AOP at Maryland Road-Stream crossings. (Distribute it; begin discussions with other states to adopt a Chesapeake Bay-wide document).
Although this action is specific to a Maryland document, the Fish Passage Workgroup could solicit review or feedback from the Brook Trout Workgroup and its partners, as the Fish Passage Workgroup drafts a Chesapeake Bay-wide document. It is noteworthy that brook trout and specific brook trout-related projects (including several funded in part by EBTJV) are highlighted in this publication. These pieces can be leveraged for good outreach by brook trout partners. The Brook Trout Workgroup could consider sharing this document along with the Chesapeake Bay Fish Passage Tool.

Action 1.7: Consult with the Chesapeake Bay Program Communications Workgroup to develop communications products.
This Action is one that any Workgroup could adopt. The Fish Passage Workgroup and Brook Trout Workgroup could additionally correspond periodically to ensure consistent messaging. The Brook Trout Workgroup 2024-2025 Plan Action 1 identifies working with the Fish Passage Workgroup and other workgroups on messaging.

Action 2.2. Conduct target species monitoring (+/- and relative abundance) at road culverts in VA
One recommendation of this project is for the Brook Trout Workgroup partners to conduct brook trout monitoring at projects in targeted watersheds. As the Brook Trout Workgroup or CBP identifies focal watersheds, they could consider adding the Rappahannock Watershed based on shared interest with the Fish Passage Workgroup (if this watershed is still a priority for the Fish Passage Workgroup. Data on brook trout monitoring methods and locations will be requested from partners as part of data inputs to the Habitat Tracker (https://habitat-tracker.net/), and thus eventually such information will be available to the Fish Passage Workgroup.

Action 3.1. Continue using the Chesapeake Bay Fish Passage Tool to implement high priority dam removal, culvert and fish passage projects.
The EBTJV and Brook Trout Workgroup should continue sharing information on the Chesapeake Bay Fish Passage Tool so that partners are aware and make the best use of this

important product. The Tool was updated recently. It is noteworthy that the EBTJV's fellow Fish Habitat Partnership, the Southeast Aquatic Resources Partnership, has its own Fish Passage Inventory and Prioritization Tool that pulls information from many sources into one location. In a recent training about the use of the SARP tool, SARP highlighted the value of the Chesapeake Bay Fish Passage Tool and suggested that planners use it as the primary tool in this geography.

According to metadata, the Chesapeake Bay Fish Passage Tool's 2023 update pulled in crossings that were rated as "severe" barriers from the NAACC database. It also utilizes several data sources for brook trout, including EBTJV's catchments (to indicate a culvert that is in a brook trout catchment), and a model of brook trout occupancy (DeWeber and Wagner, 2015), and whether NHD catchments occupied by trout are in one of a barrier's functional networks, using catchments from EBTJV data or predicted DeWeber and Wagner. These combined data are used to create a brook trout barrier priority score; a separately derived score is also available for anadromous fish. We recommend the Brook Trout Workgroup request a meeting with or otherwise communicate with the Fish Passage Workgroup and TNC to understand how the Tool works to prioritize barriers for brook trout restoration so that it may be put to the best use by partners. Additionally, the Brook Trout Workgroup and Fish Passage Workgroup should correspond annually to ensure that the Tool has access to the most recent EBTJV data. The Fish Passage Workgroup may consider adding the EBTJV coordinator as a point of contact for periodic updates to the Tool.

The Brook Trout Workgroup's 2024-2025 Plan does not reference the Chesapeake Bay Fish Passage Tool, and it could consider adding it as a resource to Action 6.

Summary of data the Brook Trout Workgroup should consider sharing with the Fish Passage Workgroup

- Completed fish passage projects (this should be available from the Habitat Tracker)
  - Name
  - Type of barrier
  - Latitude/longitude
- Brook trout watersheds (available from EBTJV coordinator):
  - EBTJV catchment classifications (presence/absence of brook trout and other salmonids); new data are now available following a recent EBTJV range-wide update, and annual updates will be available yearly ~April 1.
- Brook trout monitoring (this should be available from the Habitat Tracker)
  - Location
  - Methods
  - Dates
  - Associated project latitude/longitude or name

Summary of Opportunities for shared work with the Fish Passage Workgroup

- Brook trout population health requires connected streams, and assessing and removing barriers is a key component of most agency management plans across the Eastern US.

- The Brook Trout Workgroup and Fish Passage Workgroup share several priorities for working with partners to assess and remove barriers, and there are likely opportunities for shared messaging.
- The Brook Trout Workgroup could help promote and communicate the Chesapeake Fish Passage Tool.
- The Fish Passage Workgroup should consider consulting the Brook Trout Workgroup as it updates the Maryland Stream Crossing Guidelines for Chesapeake Bay-wide application.
- The Brook Trout Workgroup should request from the Fish Passage Workgroup and TNC a tutorial on how the Fish Passage Tool operates, including the modules specific to brook trout so that they may help put it to best use by partners.
- The Brook Trout Workgroup should ensure the Fish Passage Workgroup and tool developers have the most recent data on barrier removals, brook trout occupancy, and any pre-post project monitoring for brook trout. An annual update would be sufficient.
- The Brook Trout Workgroup and Fish Passage Workgroup should consider working together to fund and develop a monitoring plan for a watershed of shared interest, such as the Rappahannock in Virginia.
- Workgroup chairs should keep a list of items, documents, etc. to discuss and set a date to meet on an annual basis.

Recommendations for collaboration across workgroups and goal implementation teams

We identified several specific recommendations for working with other workgroups and goal implementation teams:

- **Increased communication and coordination across workgroups:** We recommend regular communication to share information, avoid duplication of efforts, and identify opportunities for collaboration. This could be facilitated by naming a liaison between pairs of workgroups. The Brook Trout Workgroup has especially strong shared priorities with the Maintain Healthy Watersheds GIT, Stream Health Workgroup, and Fish Passage Workgroup. Regular communication across those groups is especially valuable.
- **Collaboration on messaging and outreach:** It is important for the Brook Trout Workgroup to continue collaborating with other workgroups to develop consistent messaging and outreach materials and to share important tools with their respective audiences and partners. A collaborative development of a glossary of stream restoration and fisheries terms could be useful.
- **Focus on protecting areas that are relatively healthy:** Several teams (Forestry Workgroup, Maintain Healthy Watersheds GIT, Stewardship GIT) identify the urgent need to conserve land and prevent further loss of forest cover. This is important for brook trout, and additionally, brook trout are often cited as an indicator of these ‘intact’ watersheds.
- **Prioritization of brook trout conservation in watershed restoration projects:** We recommend that brook trout conservation be considered a priority, in addition to its use as an icon or indicator.

- **Scientifically-based and watershed-specific monitoring:** As reflected in the recent Stream Monitoring Workshop, there are good arguments for promoting scientifically sound monitoring methods to track the progress of restoration efforts.
- **Data sharing with the Fish Passage Workgroup:** We recommend annually sharing data on brook trout watersheds (EBTJV data) and completed fish passage projects and brook trout monitoring (through Habitat Tracker) with the Fish Passage Workgroup to support their efforts to maintain its Chesapeake Bay Fish Passage Tool and open stream miles for fish passage.
- **Added focus on Abandoned Mine Drainage:** We highlight the need for a focus in additional workgroups or at the level of the Habitat GIT on planning and tracking the benefits to fish and macroinvertebrate populations and local water quality from AMD restoration.

Goal 2: Communication and Coordination with other stakeholders

Outreach to Other Stakeholders

Throughout this project we have communicated with several audiences including the other GIT teams (above) and members of the EBTJV, and with data stewards and restoration project managers. To organize data gathering and inquiries to the appropriate organizations, the project team and Steering Committee collaboratively developed an online worksheet of stakeholders. These organizations and individuals were selected because they were the most likely stewards of the types of data needed to track brook trout-related projects across the Chesapeake Bay watershed. This included regional biologists and fish passage coordinators at state and federal resource agencies, individuals who manage funding programs that include a brook trout focus, watershed organizations, and managers or watershed specialists at County Conservation Districts in counties that contain brook trout watersheds. The list contained 102 contacts (Appendix 2).

In summary, our outreach to these project contacts included an initial survey to the list of 102 contacts, a more detailed, follow up survey to a narrower group of about 15 data stewards, a webinar, and direct emails and phone calls to request the data and get their feedback on the project. We sought to reduce the difficulty of providing data as much as possible to increase engagement and to be conscious of the time and administrative constraints already facing these groups.

In addition to stakeholder input, data were also compiled from the following sources: US Fish and Wildlife Service (FWS), Fish Passage Program, Environmental Protection Agency (EPA) databases, US Geological Survey (USGS) (Buffer/Ag improvement), Chesapeake Bay Fish passage tool, Wetlands GIT database, the Penn State Center for Dirt and Gravel Road Studies, Natural Resources Conservation Service (NRCS), National Fish and Wildlife Foundation (NFWF) (FieldDoc and EZGrants), and the NAACC.

Initial Stakeholder Survey

TU and EBTJV developed a short online survey using Microsoft Forms to quantify the number and types of brook trout projects each stakeholder group previously identified has completed between 2016 and 2022. The online survey was reviewed and approved by the brook trout workgroup steering committee prior to distribution to the stakeholder groups. The goal of the stakeholder survey was to understand the types of projects that have been completed across the landscape and narrow the broad stakeholder list to a core group of stakeholders that are completing the majority of the on-the-ground projects within the Chesapeake Bay watershed.

The survey was comprised of 19 total questions targeted at obtaining contact information for a representative of each stakeholder group and relevant questions related to brook trout projects that have been completed in the Chesapeake Bay watershed between 2016 and 2022. The full survey is provided in Appendix 3.

The survey was distributed via email to the 102 individuals/organizations on the stakeholder database. A total of 40 responses were received (a 38.6% response rate). On-the-ground restoration projects were categorized into nine project type categories for this survey based on input from the steering committee: instream habitat enhancement, riparian buffers, AOP, land protection, water quality, upland agricultural BMPs, dirt and gravel road improvement, brook trout reintroduction, and competing non-native species removal. The most common project types that stakeholders were engaged in were instream habitat enhancement, riparian buffer restoration, AOP, water quality improvements, upland agricultural BMPs, and dirt and gravel road improvements, with 62-77% of respondents engaged in these project types. A total of 3,612 individual projects were identified in this initial survey. Table 1 shows the total number of projects reported in the survey by project type.

Table 1. *Total number of projects reported in the initial stakeholder survey by project type.*

Project Type	**Total Number of Projects**
Instream Habitat	657
Riparian Buffers	935
Aquatic Organism Passage	145
Land Protection	81
Water Quality	501
Upland Agriculture	822
Dirt and Gravel Road Improvement	448
Brook Trout Reintroduction	18
Competing non-native species removal	5
Total	***3,612***

The results of the stakeholder survey were also used to determine which stakeholders were responsible for the majority of brook trout related projects within the watershed. A core stakeholder group was identified comprised of 15 agencies and organizations that were responsible for over 80% of the projects identified (Table 2). Of that group, four groups were responsible for over 40% of the implementation of on-the-ground projects (Natural Resources

Conservation Service, TU, Headwaters Soil and Water Conservation District, and Western Pennsylvania Conservancy). The core stakeholder group was targeted for additional data collection for the Project Tracking Database described under Goal 3.

Table 2. *Core stakeholder group identified from initial survey.*

Trout Unlimited	PA Fish and Boat Commission
Headwaters SWCD	Clearfield County Conservation District
Western Pennsylvania Conservancy	Berks County Conservation District
Natural Resources Conservation Service	Bradford County Conservation District
York County Conservation District (PA)	Huntingdon County Conservation District
Friends of the Rappahannock	Columbia County Conservation District
Mifflin County Conservation District	Tioga County Conservation District
Lancaster County Conservation District	

Continued Outreach to Stakeholders

We communicated the request for data via email, phone, and webinar. The webinar – offered on two dates and attended by 11 stakeholders directly and made available via pdf to others - reviewed the project rationale, objectives, methods, options to format and submit data, and how the data would be handled and analyzed. We used the webinar and phone conversations to solicit feedback on the relative ease or burden of providing data, and how to facilitate similar data requests in the future. We appreciated the opportunity to discuss with them the type of habitat and brook trout data that should be included, and to hear suggestions for making the process as efficient as possible. We also provided a small incentive of an EBTJV mug or t-shirt for submitting data. This resulted in nine additional partners reporting data and answering questions.

1. Project Update Presentations

We provided an overview of project objectives and methodology to the EBTJV Steering Committee at an EBTJV quarterly meeting, and to data stewards at a webinar in spring 2023. A preliminary analysis of a focal area, the West Branch of the Susquehanna River, was presented to the EBTJV at its November 2023 meeting in Shepherdstown, WV. These results were also presented at the Fall 2023 Habitat GIT Meeting in Leetown, WV.

2. Dissemination of Final Results

Results were presented to the project Steering Committee in September 2024, and to the EBTJV steering committee at its 2024 annual meeting the same month. We recommend the Brook Trout Workgroup hold a webinar for interested stakeholders in the fall of 2024.

Recommendations

We feel we adequately captured the organizations and groups (stakeholders) who should be aware of this project, and collaboration with the Steering Committee helped to develop a well-rounded list. Our approach of using multiple channels to communicate and request data was effective in gathering a large dataset of restoration projects. The task of submitting data, according to set formats and types, on projects from across the watershed was a substantial time investment by these partners. We received low response rates to several surveys (38% to the first, broad survey), had missing data for optional fields in most submissions, and low attendance on the webinar. Two major reasons for this are the lack of capacity for staff to respond to data inquiries, and data sharing limitations. Ultimately, we collected data on 5,419 projects across the Chesapeake Bay Watershed completed from 2016-2022 (See Goal 3). However, since there is no single clearinghouse for all possible in-stream or on-the-land restoration projects, we do not know the true universe of total projects performed.

Throughout the project, the Steering Committee and contractors discussed the option to mandate that grantees provide data directly to the Habitat Tracker in the correct format. Funders who include brook trout in their portfolios (such as NFWF) could require project partners to certify they have uploaded data to Habitat Tracker, as part of their interim or final reporting. The Brook Trout Workgroup could re-evaluate such a mandate if collecting data proves to be difficult despite applying other recommendations.

Many stakeholders we spoke with, particularly county conservation districts in Pennsylvania and New York, shared that they often receive overlapping or duplicative data requests, which are time consuming and perceived as redundant. They also noted that they already report to funders or to their state water quality agency (NEIN) and would prefer that the request go to the funding organization or state agency instead. This approach would be efficient for the Brook Trout Workgroup as well, given that a majority of projects submitted were from higher level organizations. However, these organizations may not currently track all of the project information from their grantees that the Brook Trout Workgroup needs. Those agencies also have capacity limitations, and responding to custom data queries can be time consuming, so good relationship building and discussion of how to incorporate brook trout specific data types going forward will be important.

This project required data at a scale relevant to brook trout. However, some conservation districts and partners could not provide specific location information due to landowner privacy agreements. Specifically, the US Department of Agriculture and US FWS each have project data sets that would require formal data sharing agreements to protect personal identification information. Even with a data sharing agreement, the protection of personal data limits the ability to report projects at a small scale: if a project were reported as located in a watershed small enough to contain only a few landowners – such as a farm or forest owner - it is possible to determine the name of the landowner who received the federal assistance. We do not know the extent to which we are missing data in this analysis because it could not be shared. However as detailed in future sections, 2,115 (39%) of the projects for this analysis were submitted with only a Hydrologic unit code (HUC)12 (subwatershed) code.

Finally, although we narrowed down the project types considered in our data gathering, we still cast a fairly broad net. Initially, we hoped that the project data - along with the EBTJV brook trout assessment by catchment data - would allow a picture to emerge of what constitutes a “brook trout project”. We understand that the Brook Trout Workgroup would prefer to work in the future with projects that are done for the benefit of brook trout.

Below are some recommendations to make it easier for stakeholders to provide data and to increase the fulfillment of data records in future data calls.

1) **Higher-level agencies and NGOs should ideally be the primary point of contact for data requests.** Our recommendation is to avoid mandates and for the Brook Trout Workgroup to proactively and collaboratively work with the higher-level organizations.

2) **The Brook Trout Workgroup should develop relationships with these agencies and funders to incorporate data types and to approach data sensitivity issues.** The Brook Trout Workgroup should request that these higher-level data stewards incorporate a minimum level of data into their own reporting frameworks going forward. It might be possible for agencies to alter their data management designs to allow the inclusion of those data types. Where it is not, the Brook Trout Workgroup could communicate to CBP that approaching these capacity and funding needs is critical to continuing to track the Brook Trout Outcome. Regarding sensitive data, the Brook Trout Workgroup will need to work to either secure data sharing permissions from the lower-level organizations, or to agree to accept data with some details or precise location data omitted.

3) **The Chesapeake Bay Program should consider an annual call for data requests that are needed to fulfill GIT projects, to avoid duplication or overlapping requests.** A set of GIT staffers would solicit annual lists and/or compile a list from GIT project proposals, summarize the data needs and partners who would be contacted, ensure that in aggregate the requests are not overly duplicative or redundant, and send them out at the same time. This could impart efficiencies for the partnering agencies: they would receive requests on a known schedule, from a single point of contact with the CBP. This can help the partner evaluate in one location the needs, recipients, submittal methods, and due date of the request, and improve response rates. Although this would result in needing to wait for a dedicated time to request data and possibly slow down a GIT project, it could result in higher return rates.

4) The Brook Trout Workgroup **should be very precise in what types of projects are defined as "brook trout projects"**. This includes re-evaluating which fields in the Habitat Tracker should be required, e.g., length of in-stream habitat project, to achieve data that are meaningful.

5) Regardless of the mechanism of requesting and submitting data, it will be important to **report back to the stakeholders and partners with how their data were used, and to request their feedback on the process.**

6) As we describe in later sections, **we recommend that rather than the broad approach taken here, the Brook Trout Workgroup solicit a well-designed experimental study with pre-and post-project monitoring, to better understand which project types are expected to benefit brook trout.** This would greatly help focus which projects partners and data stewards would submit to the Habitat Tracker for future data requests. Additionally, there may be opportunities to leverage other programs to assist with future data gathering and/or data analysis, including the Maryland Whole Watershed Act, and the USGS status and trends program. The Brook Trout Workgroup should continue to communicate with the USGS, university researchers, state and federal agencies, and NGOs to develop plans for monitor project outcomes.

It is often recommended that early engagement with relevant stakeholders (including data stewards) is important, and this project is no exception. However, the 1-year timeframe of this effort to gather data to track the CBP's Brook Trout Outcome may have been too short given the capacity limitations and other reasons it was difficult to gather data. The Brook Trout Workgroup is now in a position to begin a routine process, and this project has established the use of the Habitat Tracker. **We recommend annual updates solicited via the Brook** Trout Workgroup **chairs using the contact list, which will need to be updated and maintained by the workgroup.** The Brook Trout Workgroup will also need to continue the discussion to decide how to motivate these project updates through the Habitat Tracker. Incentives, mandates (through funders), and good communication and relationship building were discussed throughout this project's development. Regardless of the approaches selected to motivate stakeholders and help meet their needs, **it will be necessary for the** Brook Trout Workgroup **to be very precise in what types of projects are defined as "brook trout projects".** This includes re-evaluating which fields in the Habitat Tracker should be required, e.g., length of in-stream habitat project, to achieve data that are meaningful.

Goal 3: Project Tracking Database Development and Analysis of EBTJV Brook Trout Assessment Data

Project Tracking Database, Development and Results

Overview

The initial stakeholder survey was used as a starting point for the development of a project tracking database for implementation projects completed throughout the Chesapeake Bay watershed. With input from the steering committee and other stakeholders, we developed a template for the compilation and collection of project specific data. This database includes information on individual project types, location, and other relevant metrics related to the specific project type. The primary objective of this database was to serve as a template for the development of an online project tracking system (see Goal 4) and to initially populate that database. The data compiled into this database includes projects that were completed between 2016 and 2022. It is important to note that although we made our best attempt at collecting and compiling as much project data as possible, the database should not be considered as a comprehensive record of all brook trout implementation projects completed within the watershed.

Project Types

The following project types were included in the final project tracking database following approval by the Brook Trout Workgroup steering committee:

Abandoned Mine Drainage (AMD)

Projects reported for this project type only included passive treatment, but this category could possibly include mine land reclamation and active treatment. A passive treatment system is a gravity fed system that treats water polluted by AMD. A series of settling ponds, vertical flow ponds, wetlands, and/or limestone beds typically aim to remove metals and raise the pH back to a biologically suitable level. The majority of AMD polluted waters have high levels of aluminum, iron, and/or manganese and have a pH that is below 3.5, which is not biologically suitable level for fish. Active treatment systems aim to do the same, however they are staffed by full-time employees and continually treat the water, typically using chemistry. These systems are usually used when the amount of water flow and metals are very high and cannot be treated with a passive treatment system. Abandoned mine land reclamation typically involves removing old coal spoil piles so contaminants, such as metals or acidity, can no longer leach off the spoil into nearby waterways.

Results from passive and active treatment can be seen very rapidly in terms of water quality (Underwood et al. 2014). Typically, the macroinvertebrate community then recovers in a few years (Walter et al. 2011), though there are not many long-term biological improvement studies in watersheds with passive treatment. Eventually trout and other fish species can recolonize previously polluted stretches, especially if there is a source population of fish nearby. Distance from the treated water source also plays a role in biological recovery, with more recovery seen farther downstream from where the treated water enters a stream (Kruse et al. 2013; Underwood et al. 2014). However, many factors, such as episodic acidification events, determine the length of time until biological recovery occurs (Underwood et al. 2014).

Aquatic Organism Passage (AOP)

This category of projects includes culvert replacement or removal projects. This involves identifying culverts that are acting as barriers to fish passage, typically through inventory and prioritization rubrics such as those maintained by the NAACC. The work involves removing the old crossing structure and replacing it with an AOP design. A common practice is to use the US Department of Agriculture (USDA) Forest Service stream simulation method to increase the width of the structure to encompass the bankfull width of the stream, and in most cases slightly wider than the bankfull width. Stream simulation design aims to re-create the natural stream channel throughout the length of the new structure where slope and natural substrate are matched to the existing stream (USFS 2008). Recolonization by fish species can happen very rapidly after the culvert has been removed or replaced (Wood et al. 2018; Knoth et al. 2022).

Brook Trout Reintroduction

Brook Trout Reintroduction projects involve reintroducing brook trout to waters where they may have been extirpated, often following the removal of non-native salmonids. Success is determined from surveys in subsequent years. Within the Chesapeake Bay Watershed, Brook Trout reintroduction is most common in West Virginia. To consider reintroducing brook trout, suitable habitat must exist without competition from other salmonids (Markowitz and Loski 2014), and increasingly, biologists are employing genetic information to guide the selection of source stock (White, 2022). One study suggested that for reintroduction to be considered, that land cover be 94.9% or greater forested, and less than 0.8% and 4.6 % of urban cover and agricultural cover respectively (Markowitz and Loski 2014). For these and other reasons, the practice appears to be more common in the southernmost range of brook trout (Matt Kulp, pers. comm; see https://easternbrooktrout.org/science-data/ebtjv-assessment-data/eastern-brook-trout-restoration-summary-table/view). There are some concerns with reintroductions such as outbreeding depression and/or introduction of harmful parasites/microbes (Kazyak et al. 2021). Population responses in trout are hard to quantify (Ogren and Huckens 2015), therefore the length of time to determine if reintroduction has been successful could be highly variable.

Dirt and Gravel Road Improvement

A dirt and gravel road improvement project typically involves replacing the driving surface with an improved surface aggregate with the aim of reducing sediment runoff during storms. A road crown at a small slope can be added to assist with drainage, along with improvements to or additions of cross pipes to help direct water off and away from the road. Any potholes or scouring of the roadway by water will be fixed when the improved driving surface aggregate is added. There have not been many studies that have looked at dirt and gravel road improvements in terms of brook trout response. However, sediment runoff during rain events has decreased and can be attributed to this type of work (Foltz 1996). Due to the brook trout's sensitivity to sediment (Reid et al. 2002), road runoff that occurs near streams can directly impact a brook trout population, so this work is important in watersheds with brook trout.

In-Stream Habitat Improvement

This category includes traditional structures (mud sills, cross-veins, log-framed deflectors, etc.), and Large wood additions (LWAs) in the form of unanchored chop and drop. The traditional structures typically aim to assist with stabilizing stream banks and creating habitat for trout and other species within the stream by creating cover and enhancing scour for pool formation. Traditional structures have been found to increase leaf litter retention (Laasonen et al. 1998), create pools (Miller 1997; Pagliara and Kurdistani 2018), increase habitat heterogeneity (Van Zyll De Jong et al. 1997), and increase stream bed diversity and trap gravel (House and Boehne 1985). Trout populations have also shown positive changes due to traditional structures such as abundance and biomass increases (Gowan and Fausch 1996; White et al. 2011). One study recommended waiting until at least one bankfull flood event has occurred after installation to see geomorphic stream channel changes after bank stabilization (Biedenharn et al. 1997). Due to variations in populations on an annual basis for a variety of environmental factors (Karr 1981; Dauwalter et al. 2021), any type of biotic sampling is complicated.

Unanchored large wood is added back into a stream by crews with chainsaws through the felling of trees (chop and drop). Large wood is typically considered anything greater than 1.5 meters in length, and 0.1 meters in diameter. The goal of this is to restore a stream's natural wood loading that has been reduced following historical logging practices. Large wood is a natural part of a stream system, and maximum recorded wood loading in New England is 19-20 pieces per 100 feet of stream (Warren et al. 2009; Kratzer and Warren 2013). Kratzer and Warren 2013 also found that brook trout biomass increased with increasing wood when wood loading exceeded the minimum response level of 80 pieces per acre. Large wood also increases organic matter retention (Hoekwater 2020), creates a more natural flood regime (Turunen et al. 2017), and increases spawning substrate (Davidson and Eaton 2013). Length of time to see results is variable due to the variations in populations due to environmental factors (Karr, 1981; Dauwalter et al. 2021), but one study saw brook trout biomass triple in the second year after a LWA (Kratzer 2018).

Land Protection

The only recorded land protection type for this project was a conservation easement. A conservation easement is a voluntary legal agreement between a private landowner and a land trust or governmental agency with a goal of keeping the conservation values associated with the property's natural resources and wildlife habitat (Heritage Conservancy 2024). This keeps the property in the landowner's hands but creates restrictions on the land use that can occur on the property. They can help safeguard resources like water quality, farmland, scenic views, and habitat benefits (Heritage Conservancy 2024).

Riparian Restoration

Riparian restoration in this report is considered either a grass or forested buffer planting, and/or livestock exclusion fencing. A riparian buffer planting of either grass or forest aims to re-vegetate a streambank that otherwise has little or no riparian vegetation zone. The riparian zone is the area adjacent to a waterway on the streambanks, and the current recommendation from the CBP is to have a 75-150 foot-wide buffer on both banks of a stream for the greatest benefits (ACB 2004). A forested buffer is the more efficient of the two techniques for nitrogen reduction (Osbourne and Kovacic 1993; CBP 2018) and offers more shade than a grass buffer if the stream is wide once the trees are mature. A study by Cross et al. (2013) found that streams with trees were significantly cooler than streams with grass vegetation. There is some time lag until buffers will perform as designed and it depends on how quickly a dense stand of vegetation can be established; but some benefits may appear in a short time frame (Helmers et al. 2008). In order to see the full impacts of a forested buffer, many more years and perhaps even decades will be required to see the full effects (Davies-Colley et al. 2009). However, once mature, the trees will shade the stream, filter contaminants, trap sediment, increase natural wood loading, and provide habitat for terrestrial animals and insects as well (PA LTA 2014).

Livestock exclusion fencing aims to fence stream banks to prevent livestock from having access to the stream and is a common BMP. This BMP prevents excess nutrients and sedimentation from entering the stream due to livestock damaging the streambank or defecating directly into the stream, and when combined with buffers the benefits are even greater (CBC 2015). Benefits to the animals also occur, farmers that have implemented this practice have reported decreases in injury and disease in their herds (CBC 2015). Impacts from this practice, such as nutrient and sediment reduction, can be seen fairly rapidly from the time the fencing is installed, however sometimes it takes 5-10 years to see lasting results if implementation does not happen all at once (CBC 2015).

Methods

Project location as well as descriptive information and quantitative variables are stored in a Geographic Information Systems (GIS) database. In order to obtain as much project information as possible we provided multiple options for stakeholders to submit project data. First, a spatially-informed survey was built on the ArcGIS Survey123 platform. The survey was designed to facilitate collecting as much relevant information about the projects as possible, while actually requiring only the minimum amount of information that allows us to extract insight from the data (Table 2). Here again the intent was to encourage broad participation in our data gathering effort by making the process manageable for stakeholders.

Recognizing that completing a unique survey entry for each project would be onerous for stakeholders who have multiple projects to submit, we also distributed a template in Excel replicating the survey database schema that allowed stakeholders to provide project information in bulk. Data submitted using this template was directly consumable by the project database.

Finally, for stakeholders who were unable to either complete the survey or fill out the Excel template we accepted project information in any format they were able to provide. We received this data in Excel and shapefile (GIS) formats and processed the data to make it compatible with our database. In addition to stakeholder input, data were also compiled from the following sources: US FWS, Fish Passage Program, EPA databases, USGS (Buffer/Ag improvement), Chesapeake Bay Fish passage tool, Wetlands GIT database, the Penn State Center for Dirt and Gravel Road Studies, NRCS, NFWF (FieldDoc and EZGrants), and the NAACC.

The project database contains all relevant submitted information for projects in the Chesapeake Bay watershed, including a point location designating the central point of each project. Project variables were selected with input from the steering committee as well as cross-referencing available data in other project tracking databases. The variables used in this database are listed in Table 3.

__Table 3.__ Project Database Fields

Section	Variable	Required?
Project Information	Lead Organization Name	Required
	Organization Type	-
	Name	-
	Email	-
	Phone Number	-
	Project Name	-
	Project Description/Narrative	-
	Project Implementation Start (Year)	-
	Project Implementation End (Date)	-
Project Location	State	-
	Latitude	Required
	Longitude	Required
	Reference Point (Start, Midpoint, End)	Required
	Stream Name	-
	Watershed	-
Project Details	Project Type	Required
	Other Project Type	-
	Project Objective	Required
	Other Project Objective	-
	Project Funding Source	-
	Grant ID	-
	Project Partners	-
	Total Project Cost	-
	Land Ownership	-
	Presence of Brook Trout	Required
	Was brook trout monitoring a part of this project?	-
	Brook Trout Monitoring Study Design	-
Instream Habitat Projects	Project Goal	-
	Structure Type(s)	-
	LWA Types	-
	Project Length	-
Riparian Restoration Projects	Includes Livestock Exclusion Fencing?	-
	Acres Excluded	-
	Type of Riparian Planting	-
	Length of Riparian Restoration (feet)	-
	Width of Buffer Planted (feet)	-
	Acres restored	-

Results

A total of 7,790 projects were compiled into the full database with 5,419 of those projects within the boundaries of the Chesapeake Bay watershed. Only projects that were within the Chesapeake Bay watershed boundary and were completed between 2016 and 2022 are included in the results presented in this report. Figure 1 shows the project locations within the Chesapeake Bay watershed. While many of the project locations were submitted using precise coordinates or explicit spatial data, 2,115 (39%) of the projects were submitted with only a HUC12 (subwatershed) code. In our database these projects were located at the center point of the specified subwatershed. This shows us the general location of the project but does not allow us to know exactly which catchment(s) the project occurred in. Projects were completed by a diverse group of entities including federal, state, and local agencies, non-governmental organizations, and academic institutions. Roughly 35% of the projects were completed by non-governmental organizations. A full list of agencies and organizations represented in the database is provided in Appendix 4.

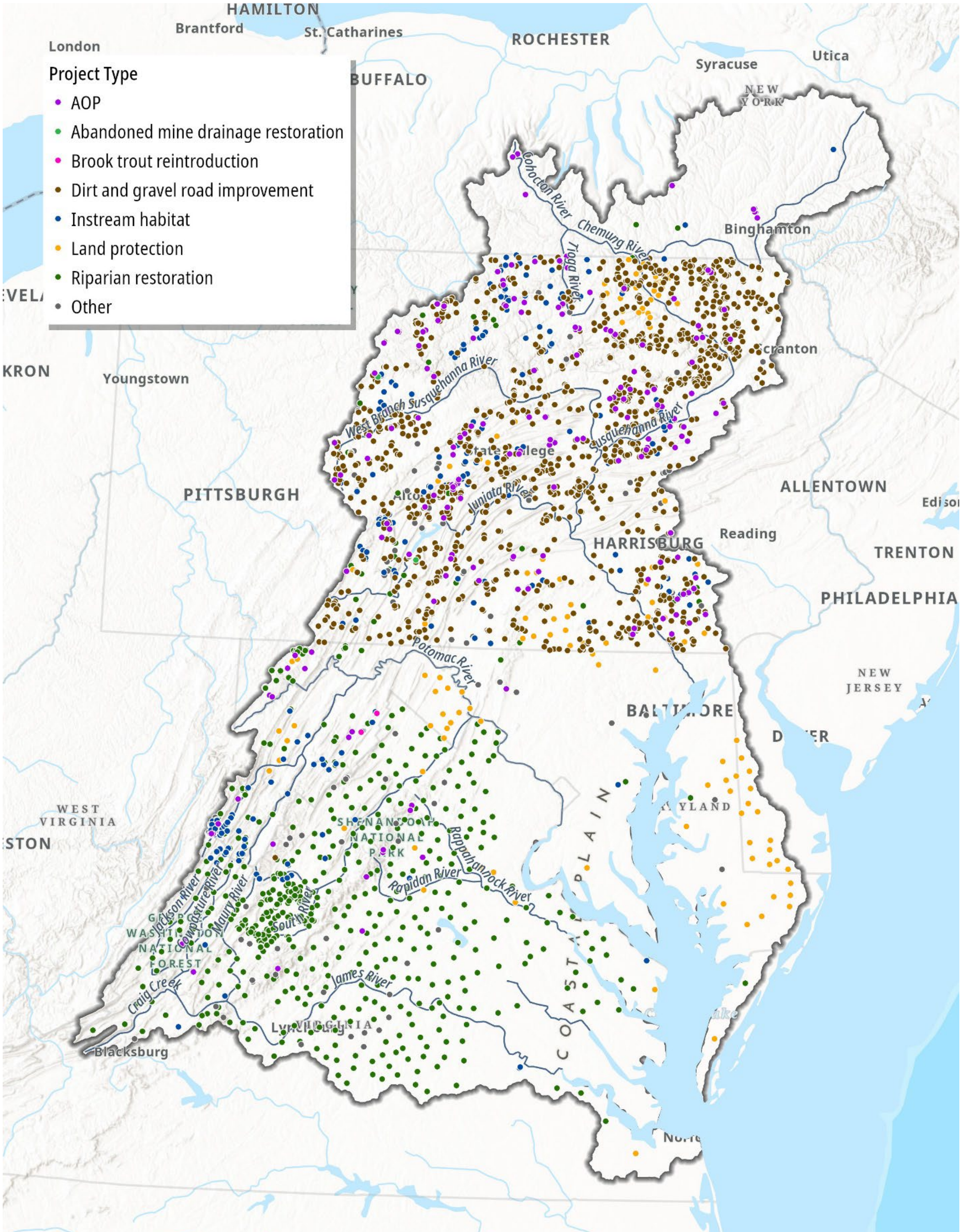

__Figure 1.__ Project type and location within the Chesapeake Bay watershed.

Project Types and Project Objective

Table 4 shows the total number of projects for each project type in the database and Figure 1 shows the project locations within the Chesapeake Bay watershed. Projects denoted as "Other" included activities such as upland habitat improvement, technical assistance, agricultural BMPs, road decommissioning, acid deposition mitigation, etc. The Objective field of the database was included as a required field to understand why individual projects are being completed. A total of 506 of the projects did report an objective. The most common objectives were "Restore Habitat" (77%) and "Restore Water Quality" (21.5%) (Table 5). Although it was required, the majority (90%) of data input to the database had no response to this field (Table 5). Other fields in the database that had high rates of missing data include; project funding source (94%), project partners (99.5%), total project cost (97.4%), land ownership (98.3%), presence of brook trout (65.6%), and "was brook trout monitoring part of this project" (98%).

Table 4. *Total number of projects for each project type in database*

Project Type	Total Number of Projects
Abandoned Mine Drainage Restoration	5
Aquatic Organism Passage	233
Brook Trout Reintroduction	3
Dirt and Gravel Road Improvement	1,566
Instream Habitat Enhancement	678
Land Protection	157
Riparian Restoration	2,555
Other	222
Total	**5,419**

Table 5. *Total number of projects for each primary project objective.*

Project Objective	Total Number of Projects
Restore Habitat	391
Restore Water Quality	109
Reconnect Fragmented Habitat	44
Protect Existing High Quality Waters	7
Other	9
Missing Data	4,859
Total	**5,419**

Brook Trout Presence and Project Specific Monitoring

Only 94 of the 5,419 projects (1.7%) in the database indicated that brook trout were known to be present at the project location prior to project implementation. Brook trout were reported as absent at 123 sites, brook trout presence or absence was unknown at 1,645 project sites, and data concerning the presence of brook trout was missing for 3,557 projects. Project-specific brook trout monitoring was only completed at 12 of the projects and 88 projects indicated that brook trout monitoring was not part of the project. A total of 5,319 projects did not indicate if brook trout monitoring was part of the project

Project Funding and Costs

Only 138 projects (2.5%) reported costs associated with project implementation (Table 6). Over $25 million was spent on project implementation for the projects that reported this metric with an average project cost of $181,658. The majority of projects reporting on funding and sources of funding indicated that the NFWF and various state funding sources were the main sources of project implementation funding.

Table 6. *Costs reported in database by project type.*

Project Type	**Total Number of Projects**	**Number of Projects Reporting Costs**	**Sum of Total Project Cost**	**Average of Total Project Cost**
Abandoned Mine Drainage Restoration	5	0	NA	NA
AOP	233	11	$1,895,377	$172,307
Brook Trout Reintroduction	3	1	$184,969	$184,969
Dirt and Gravel Road Improvement	1566	1	$333,187	$333,187
Instream Habitat	678	38	$6,400,383	$168,431
Land Protection	157	25	$741,099	$29,644
Other	222	28	$6,715,291	$239,832
Riparian Restoration	2555	34	$8,798,490	$258,779
Grand Total	**5419**	**138**	**$25,068,796**	**$181,658**

Instream Habitat Improvement Projects

Instream habitat enhancement type projects accounted for 678 of the 5,419 (12.5%) total projects documented within Chesapeake Bay. Additional metrics within database regarding instream habitat enhancement included; project goals (habitat enhancement or streambank stabilization), structure type (traditional or LWA), type of LWA and the length of the project. Project goals and structure type data are summarized in Table 7. These metrics are largely underreported in the database with 596 projects missing these data. In addition, no data were reported to the database regarding the type of LWA.

__Table 7.__ Project goals and structure type data summary for instream habitat enhancement projects in the database.

Project Goal	Structure Type			Total
	Large Wood Addition	Traditional Structures	Missing Data	
Habitat Enhancement	2	21	6	29
Streambank Stabilization	--	42	11	53
Missing Data	--		596	596
Total	**2**	**63**	**613**	**678**

Approximately, 60% (411 of 678 projects) reported a project length for instream habitat improvement. A total of 78 miles of instream habitat improvement was captured in the database, with a mean project length of 1,004 linear feet (SD = 3,753).

Riparian Restoration Projects

Riparian restoration projects accounted for 2,555 of the 5,419 total projects (47.2%) in the database. Only 72 projects (2.82%) reported the type of riparian planting completed, with 71 reporting as forested buffers and one project indicating a grass buffer was completed. Area restored by riparian restoration projects was reported on 430 of the 2,555 projects (16.8%). The total acres restored, as reported to the database, was 3,421.3 acres with a mean of 7.95 acres per project (SD = 28.49). Livestock exclusion fencing was reported to have been part of 279 riparian restoration projects of the 303 total riparian projects that reported on this metric and excluded a total of 553 acres.

Aquatic Organism Passage Projects

Aquatic organism passage projects (AOP) accounted for 4.3% of the total projects in the database (233/5,419 projects). The number of upstream miles opened was reported for 161 of the 233 AOP projects (69%) and a total of 232.28 upstream miles opened throughout the Chesapeake Bay watershed by AOP projects was reported. The mean (SD) number of miles opened was 1.44 (2.07) miles per project. Other metrics that were included in the database, but were largely under-reported include; NAACC survey completion, longitudinal profile completion, bankfull widths, and the type of structure. Therefore, these metrics are not included in the results. However, these metrics would be important to capture in the future to better understand AOP project implementation in the watershed.

Dirt and Gravel Road Improvement

Dirt and gravel road improvement projects were largely reported to the database by the Penn State Center for Dirt and Gravel Road Studies. A total of 1,566 dirt and gravel road improvement projects were reported in the final database (29% of the total projects). A total of 729.6 miles of road improvements were reported by 1,557 of the 1,565 (99.4%) projects. The mean length of road addressed was 0.46 miles per project with a standard deviation of 0.46 miles.

Land Protection

Land protection projects accounted for 157 of the total projects in the database (2.9%). Three of the projects within this category were identified as conservation easements and the project type field was left blank for the remainder of the projects. A total of 100 of the 157 projects reported on the total acres protected with a total of 13,550.6 acres protected. The average acres protected per project was 138.8 acres, with a standard deviation of 182.2 acres.

AMD and Brook Trout Reintroduction Projects

No additional metrics were captured for AMD and brook trout reintroduction projects. A total of five AMD projects and three brook trout reintroduction projects were reported to the database within the Chesapeake Bay watershed. Table 8 provides a summary of the key metrics associated with project implementation captured in the database.

Table 8. *Summary of key metrics associated with the type of project for the entire Chesapeake Bay Watershed.*

Project Type	**Metric**	**# Projects reporting/Total Projects in Database**
Aquatic Organism Passage	232.28 UPS miles opened	161/233
Instream Habitat Enhancement	78 miles improved	411/678
Riparian Restoration	3,421 acres	430/2,555
Dirt and Gravel Road Improvement	729.6 miles of road improved	1557/1565
Brook Trout Reintroduction	3 reintroduction projects	--
Abandoned Mine Drainage Mitigation	5 total projects	--
Land Protection	13,881 acres protected	100/157

Limitations of Data

- Numerous "optional" metrics included in database were under-reported, but we feel they are useful metrics that would enhance the understanding of implementation projects and their benefits for brook trout in the future.
- Exact project location not always reported – HUC12, County etc. rather than exact latitude/longitude coordinates – can be due to data privacy issues.
- Only projects completed between 2016-2022 were included in the database. Projects completed prior to 2016 may also be contributing to current gains in brook trout habitat.
- The database is not meant to be a complete dataset of all projects completed, but rather used as a template for future project tracking.

- Not all projects may have been designed or implemented with the goal of eliciting a brook trout response.

EBTJV Data

Overview

The EBTJV range-wide assessment is an important tool for brook trout conservation planning. It pulls together a vast amount of field survey data from a variety of state, federal, and local resource agencies and partners into one tool for describing and predicting the occupancy of brook trout and other salmonids within what is considered the historic footprint of wild brook trout in the eastern United States. It is important to understand that the assessment is a model of salmonid presence-absence and is not a census. It is based on empirical data from thousands of field surveys, and species occupancy is assigned to catchments - small watersheds containing a 2-5 km stream reach. These catchments are rolled up into groupings of contiguous catchments called patches, which are assumed to be genetically isolated populations.

The first assessment at the subwatershed scale (Hudy, 2008) was the first comprehensive analysis of its kind documenting the loss of historic brook trout habitat and has been cited 297 times. It was followed by an assessment and analysis at the catchment and patch scale in 2016 (Coombs and Nislow, 2015; EBTJV, 2016), which not only provided a management-relevant picture of the state of brook trout across the range, but provided comprehensive data that are utilized by agencies, conservation groups, and funders. It also helped refine the EBTJV range-wide, numeric conservation goals and objectives.

In creating the CBP's 2015-2025 Brook Trout Outcome Management Strategy, the Brook Trout Workgroup utilized the EBTJV catchment and patch information to derive a starting point for the 2025 outcome. The strategy further outlined that to assess progress, " pertinent jurisdictions will annually report the amount of habitat (km^2) occupied by wild brook trout only that was added to the baseline figure through conservation actions". Furthermore, genetic and population monitoring data would be collected and compiled. According to the Steering Committee for this GIT project, and the project announcement, adequate data had not been gathered and/or submitted to the Brook Trout Workgroup to date. Around the time of the GIT funding opportunity, the EBTJV was in the process of developing a web-based data portal for updating the EBTJV assessment at the catchment and patch scale, and the Steering Committee identified that it could be useful in tracking changes to brook trout catchment and patch area.

Development and use of the web-based Catchment Updater Tool

An update to the EBTJV salmonid assessment at the catchment and patch scale has been underway since approximately 2020.The EBTJV developed a web-based Catchment Updater Tool so that biologists could enter and view data from their jurisdictions from their own computer, thereby facilitating a large compilation of records. Agency biologists were trained on a beta version of the tool in spring 2023 with the anticipated completion date of the tool and assessment of October 2023. Improvements were made to the beta version based on feedback. In late 2023 it became clear that due to a combination of the biologist's time investment in states with vast brook trout waters, and hand editing of catchment classifications above what the algorithm assigned, it was necessary to extend this deadline first to March 2024, and then to October 2024. In June 2024, the Chesapeake Bay member states completed their work. In some areas (detailed below) the data have not been fully vetted, and it is best to consider these data provisional.

Data sources and process for the catchment classification:

The EBTJV Eastern Salmonid Assessment is based on an algorithm that determines which salmonid species were present in a sample, and how long ago the sample was conducted. All samples occurring greater than 10 years from the analysis year are given a 'P' after the code representing 'predicted'. Catchments upstream of a sample point were inferred from the downstream catchment, and given the classification code of that catchment, until a barrier, different sample, or stream end was encountered. The field data required for salmonid species include count or presence/absence from jurisdictional records, species, GPS location, and sample date. Other data layers employed include the National Hydrography Dataset (NHD) + version 2 for catchments, flowline and flow direction; point data on dams from the National Anthropogenic Barrier dataset; and waterfalls from TNC and state data. This algorithm was first employed for the 2016 Assessment at the catchment scale (Coombs and Nislow, 2015) for states from Pennsylvania north. Southern catchments were hand coded with biologist data and knowledge. The 2016 geodatabase layers are available for download at https://rpccr.ebtjv.de/. The algorithm for the new web-based Catchment Updater works on the same ruleset as 2016 but is applied to all states. The same NHD catchments are used to facilitate comparison between 2016 and 2023.

There are some important considerations about the update and comparisons to 2016 data:

1. **North-south difference in connecting catchments upstream.**

In the 2016 assessment the catchments for Maryland and states to the south were all hand-coded by Mark Hudy in collaboration with biologists. This was done prior to the algorithm because the EBTJV started the assessment in the south and realized an algorithm was necessary to make the coding feasible for the northern states. Therefore, Maryland, Virginia, and West Virginia data for 2016 were based on a combination of field data and biologist understanding and did not use connected upstream catchments to predict occupancy. For these states, in the 2016 assessment, it is not possible to determine which catchments contained the field sample and which catchment classifications were inferred from downstream samples. This has implications for teasing out the reasons for changes to catchment classification.

2. **Sample date selection and manual override**

The new algorithm looks at the sample date and assigns the species presence based on the most recent sample taken. If there are repeated samples, the most recent sample supersedes the classification from any prior sample. In the new Updater Tool, the biologist who enters data may determine that an earlier date is more representative. The EBTJV has developed guidance on such manual edits, including a list of common reasons an edit may be justified, in order to standardize decisions (**Appendix 5**). These reasons are provided in a notes field and are accessible in the output files. Records from the 2016 Assessment - sample date and code - are also retained in the files.

3. **Date window of acceptable data**

In both versions the classifications are marked "P" for predicted if data are more than 10 years old. In 2016, some analyses were completed in 2014, meaning that the 2016 data are in some cases based upon data from 2004. Thus, when comparing the new dataset to 2016, a change in occupancy could be reflective of a 20-year-old condition, unless the data analysis explicitly pulls the sample date from the 2016 records.

4. **Barriers**

The EBTJV catchment and patch classifications are dependent on barrier restriction steps; we know that in addition to dams and waterfalls, many culverts provide impassable barriers to brook trout movement upstream and between catchments. Data on culvert passability for brook trout requires in-person field data, and thus inclusion of culvert barriers rangewide is not possible at this time. It may be possible for future data projects to look at selected, focal watersheds where all culverts have been inventoried and scored; this could be a useful analysis to estimate just how far average patch size is overestimated (and total patch number is underestimated) due to the lack of complete barrier data.

5. **Catchments and patches, and the Brook Trout Outcome**

Rangewide, the 2016 database has over 270,000 catchments classified, at least 70,000 which are based on field survey data (about half of those since 2005). The average patch size is 19 square kilometers. We do not yet know the rangewide totals for the 2023 update. For the Chesapeake Bay watershed, the 2016 assessment identified 1,552 Wild Brook Trout patches, with a combined area of 34,431 square kilometers. There are 952 "Wild Brook Trout Only" patches (brook trout without co-occurring rainbow or brown trout) and the area of these patches is 13,495 square kilometers with an average patch size of 14 square kilometers. This occupied habitat is the baseline for the CBP's Brook Trout outcome, and thus the baseline for this GIT project. Upon discussion with the GIT project Steering Committee in developing the analyses, we used catchments, not patches, as the unit because that is the more management-applicable scale for identifying changes. We also considered all brook trout catchments (those alongside brown and rainbow trout), not just brook trout only.

Methods

To quantify gains and losses in brook trout habitat in the Chesapeake Bay watershed we first established a baseline of brook trout occupancy using the 2016 EBTJV data based on NHD medium-resolution catchments. Catchments are assigned a code identifying trout species present in the catchment (Table 9), assigned either by sampling within the catchment or by modeling from downstream catchments that have been sampled. Based on these species codes, the baseline brook trout occupancy within the Chesapeake Bay watershed is 33,213 square kilometers (*20.3% of Chesapeake Bay watershed*), of which 19,402 (*8.5% of Chesapeake Bay watershed*) are allopatric (brook trout-only) populations and 13,811 (*11.9% of Chesapeake Bay watershed*) are sympatric (brown and/or rainbow trout are also present).

Table 9. *Species coding from the EBTJV dataset. Note: the EBTJV codes may be modified with a 'P' suffix (e.g., '1.2P') indicating that the sample is greater than 10 years old at the time of the assessment.*

EBTJV Code	Species
-1	Not Classified
0	None
0.2	brown trout
0.3	rainbow trout
0.4	brown & rainbow trout
0.5	Stocked brook trout
1.1	brook trout
1.2	brook trout & brown trout
1.3	brook trout & rainbow trout
1.4	brook & brown & rainbow trout
1.5	brook trout & stocked brook trout

Draft results of the updated 2024 EBTJV catchment data were then compared with the 2016 baseline. While it is possible to simply sum the area of catchments with brook trout occupancy in 2016 that did not have brook trout in 2016 and subtract the area of those that had brook trout in 2016 but not 2024, there are several factors that complicate this straight comparison. We introduce these factors in the data section above. There are 78,292 catchments in the Chesapeake Bay watershed. It would be impossible to sample all of them to establish presence of brook trout, which necessitates the use of a spatial model to interpolate species presence from catchments that have been sampled. EBTJV uses an algorithm to infer species occurrence upstream from catchments that have been sampled. We can use this information to flag whether a brook trout gain or loss can be attributed directly to sampling or if it is interpolated from a downstream sample. Additionally, it is important to understand whether a catchment is coded for brook trout presence due solely to new sampling in the 2024 assessment. If a brook trout code is assigned based on new sampling (since 2014) in the 2024 assessment, but a non-brook trout code was assigned in the 2016 assessment, we do not know whether the catchment truly did not have brook trout previously and now does, or if the catchment always had brook trout but it wasn't known previous to the new sampling.

We developed a logic flow model to track this information given three data elements within both the 2016 and 2024 EBTJV catchment data *(*Figure 2 and Figure 3*):*

1. Were brook trout present?
2. Was the determination of brook trout presence based on a sample?

3. Was the catchment itself sampled or was brook trout presence modeled from a downstream catchment?

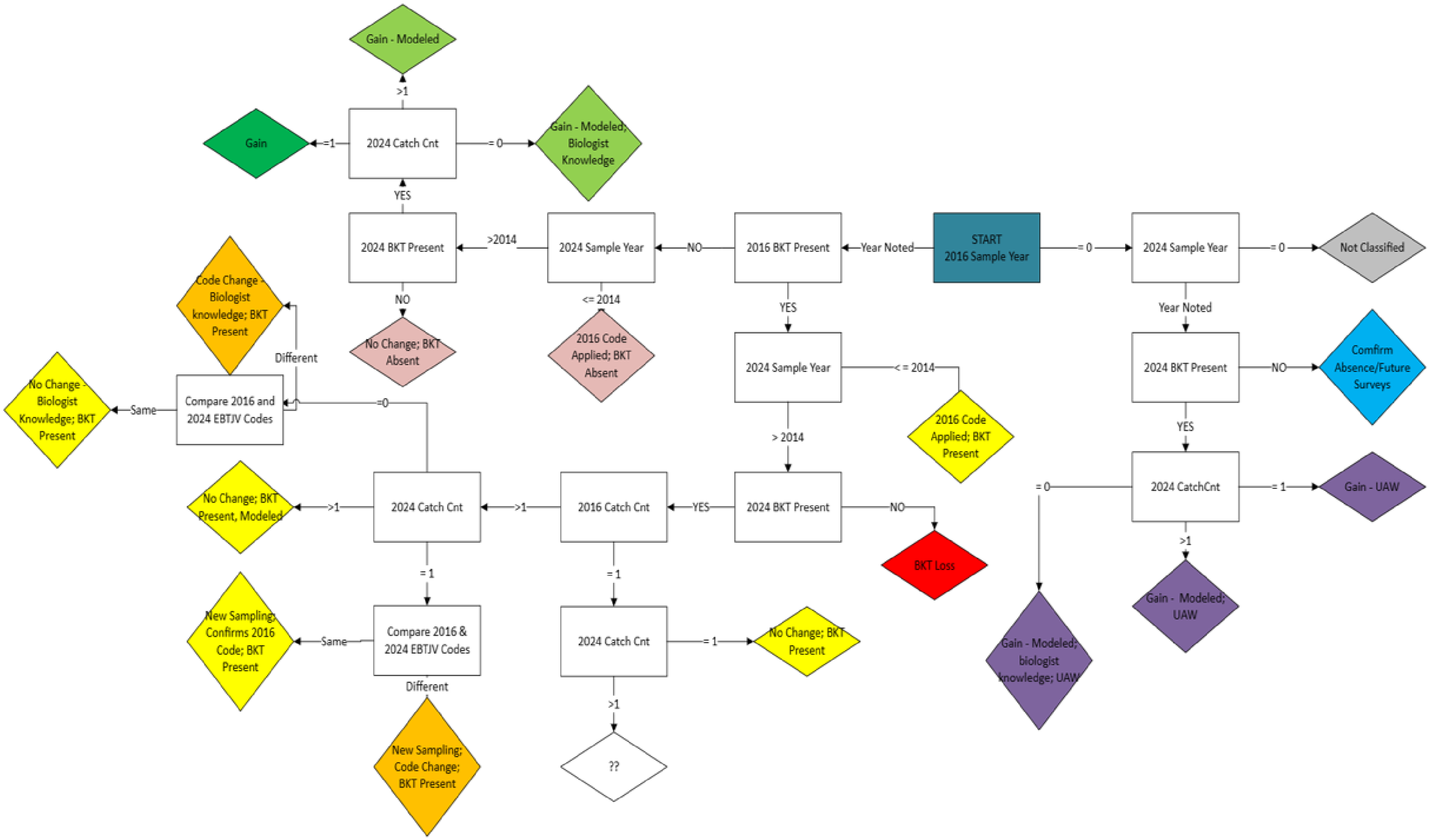

Figure 2. *Northern Region (NY and PA) Logic Flow Model.*

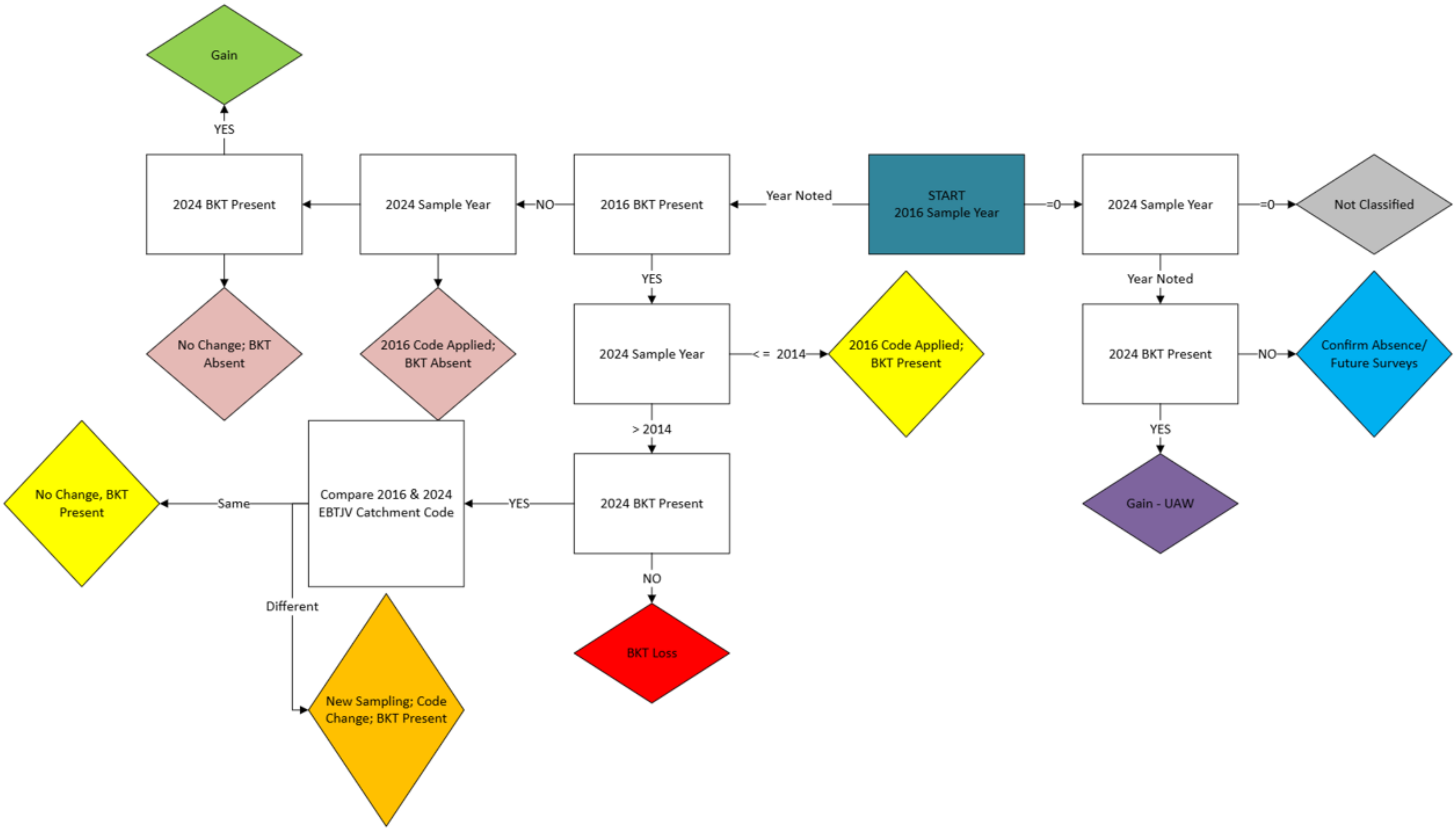

Figure 3. *Southern Region (MD, WV, and VA) Logic Flow Model*

Data Limitations

We reviewed both our logic flow model and a selection of our results with state biologist leads from Maryland, New York, and Pennsylvania. While they agreed that our logic was sound and makes sense to the extent that the data supports it, the review of results revealed serious limitations in the ability of the data to support our assessment. Limitations of the data identified fell broadly into 4 categories:

1. **Catchment count attribute**

The catchment count attribute allows us to determine whether a catchment was directly sampled or if its species code was modeled from a downstream catchment. The modeling algorithm assigns a catchment count of 1 to catchments that were sampled and increments by one with each step as it traverses up the stream network. Higher catchment count values indicate a greater relative distance from the catchment with the sample that determines the species code for the collection of catchments. Due to a known irregularity in the EBTJV model though, the catchment count attribute is not valid for states south of Pennsylvania. For the Chesapeake Bay assessment this means that we are not able to use catchment count to determine whether a catchment was directly sampled in Maryland, Virginia, and West Virginia. This requires a simplified logic flow model for these states (Figure 2) and contributes to errors in potential brook trout habitat gains and losses.

2. **Catchment delineation scale and precision**

The geographic unit for both the 2016 and 2024 EBTJV assessments is the NHD medium resolution (1:100,000 scale) catchment. Each catchment represents the topographical collection area for a single NHD medium resolution reach. The NHD medium resolution dataset is a high quality standard for regional-scale mapping but does not include all small streams that exist on the landscape. This results in small, generally unnamed tributaries being included in the catchment for a single medium resolution stream reach. Due to the inclusion of small tributaries in the catchment representing larger mainstem stream reaches, there can be multiple fish samples in a single catchment that can produce inaccurate species coding results. Most commonly, due to recent efforts to expand fish sampling in previously unassessed waters *(*PFBC 2024; PA Unassessed Waters Initiative (UAW) Program), a newer sample on a small tributary determines the species code in the 2024 assessment while an older sample on the mainstem determined the species code in the 2016 assessment. Our review determined that this causes significant errors in species code assignment and thus in potential gains and losses of brook trout habitat (Figure 4). Using high resolution (1:24,000 scale) NHD catchments in the future would likely greatly reduce this type of error.

Some catchments are large enough to have significant brook trout populations in a portion of the mainstem reach but not the entire reach. Figure 5 depicts a known site where recent AMD restoration has resulted in a healthy brook trout population within the catchment downstream of the project site while brook trout are known to be absent within the catchment upstream of the project site. Depending on whether the most recent sample site occurred upstream or downstream of the project site, such a catchment can be erroneously assessed to be a brook trout loss, gain, or no change.

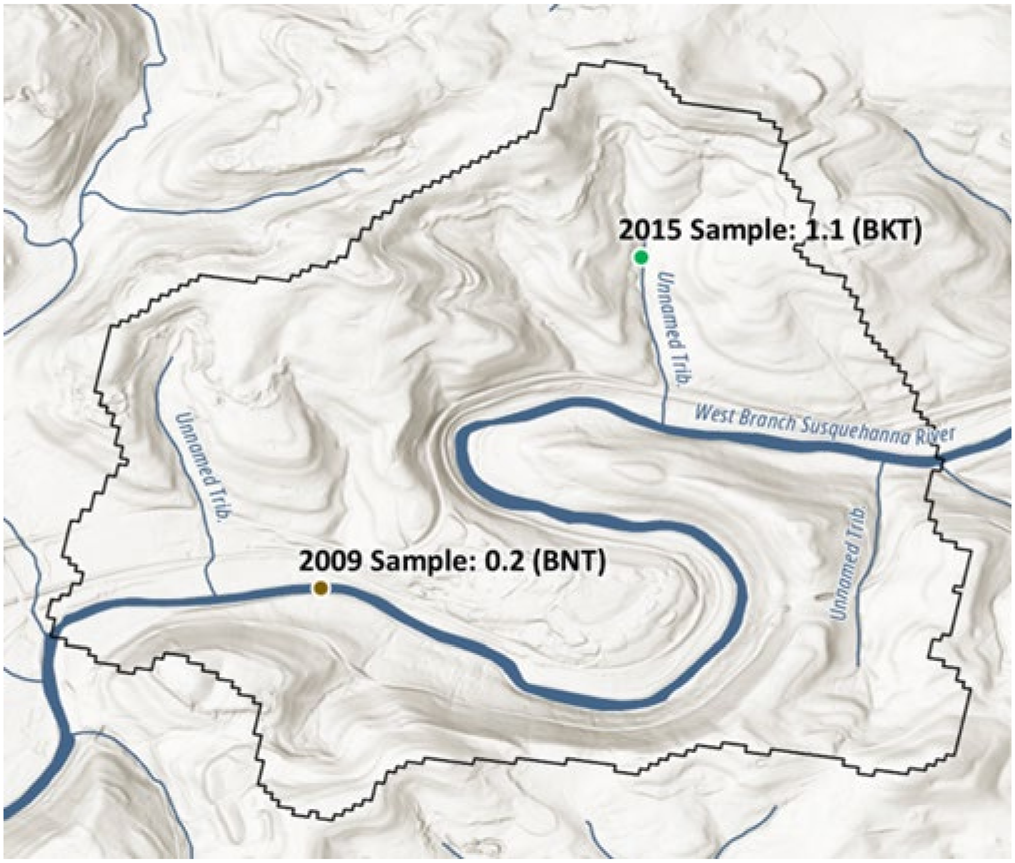

Figure 4. *Data review example of a large catchment that encompasses a mainstem and multiple unnamed tributaries. Earlier sample driving the 2016 assessment species code occurring on the mainstem found only brown trout while the newer sample driving the 2024 assessment species code occurring on the mainstem found only brown trout while the newer sample driving the 2024 assessment species code occurred on an unnamed tributary and found only brook trout. This catchment was erroneously assessed to be a gain in brook trout habitat. It should be recorded as a catchment where new sampling reveals the presence of brook trout and not a true gain.*

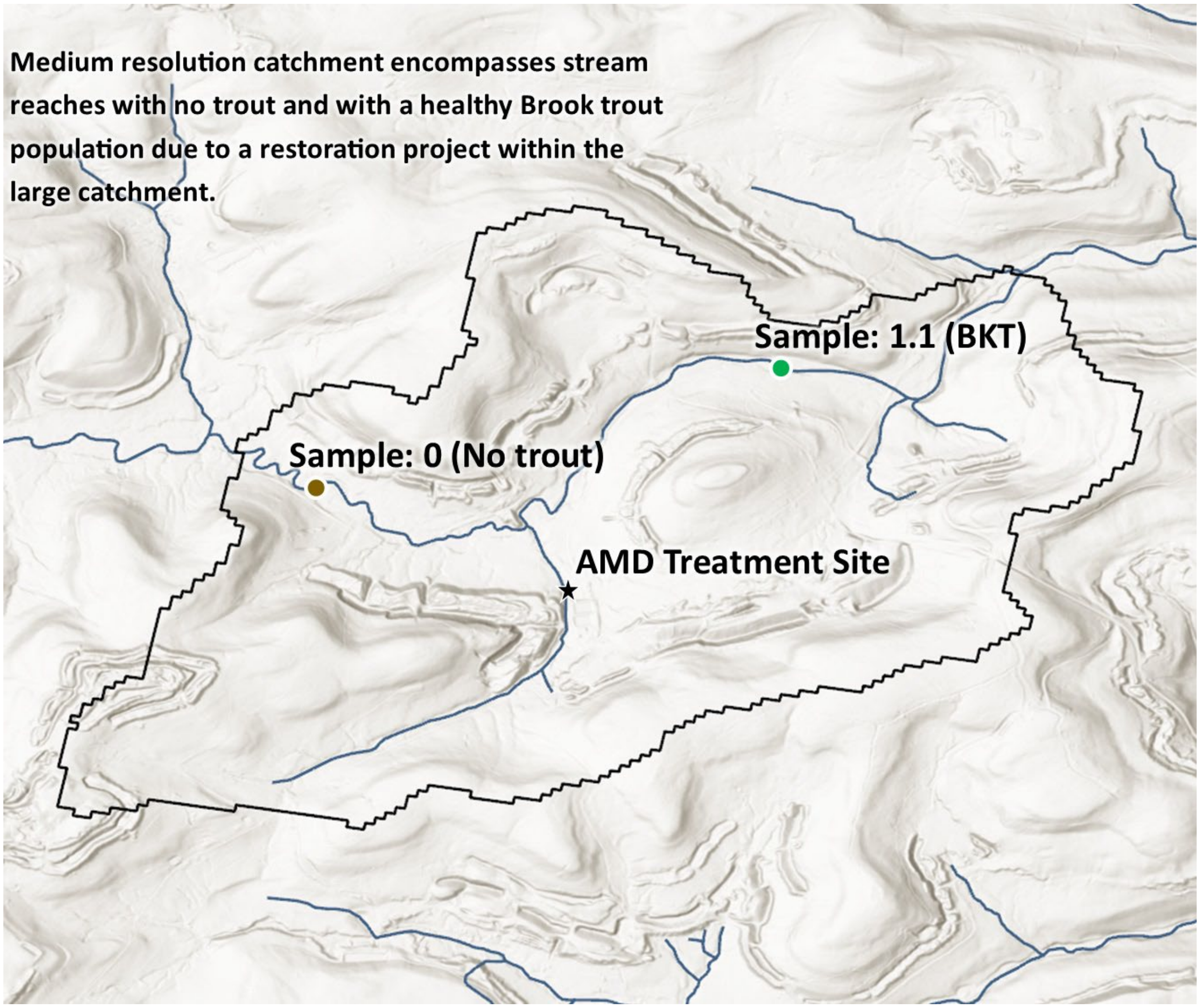

Figure 5. *Example (Potts Run catchment in PA) where recent AMD restoration has resulted in a healthy brook trout population within the catchment downstream of the project site while brook trout are known to be absent within the catchment upstream of the project site.*

The precision of the data used to delineate NHD medium resolution catchments is another source of error in our model. Digital elevation models with a spatial resolution of 30 meters were used by USGS to delineate the catchments. This causes a misalignment of some catchment polygons with the stream lines whose collection area they are meant to depict. The 30-meter "stair step" shape of the catchment can cause a catchment boundary to intercept a portion, usually the mouth, of an adjacent tributary (Figure 6). Since small stream unassessed water sampling efforts often occur at the mouth of these tributaries this causes some sampling points to be assigned to the wrong catchment, contributing to potential error in assessed brook trout habitat gains and losses.

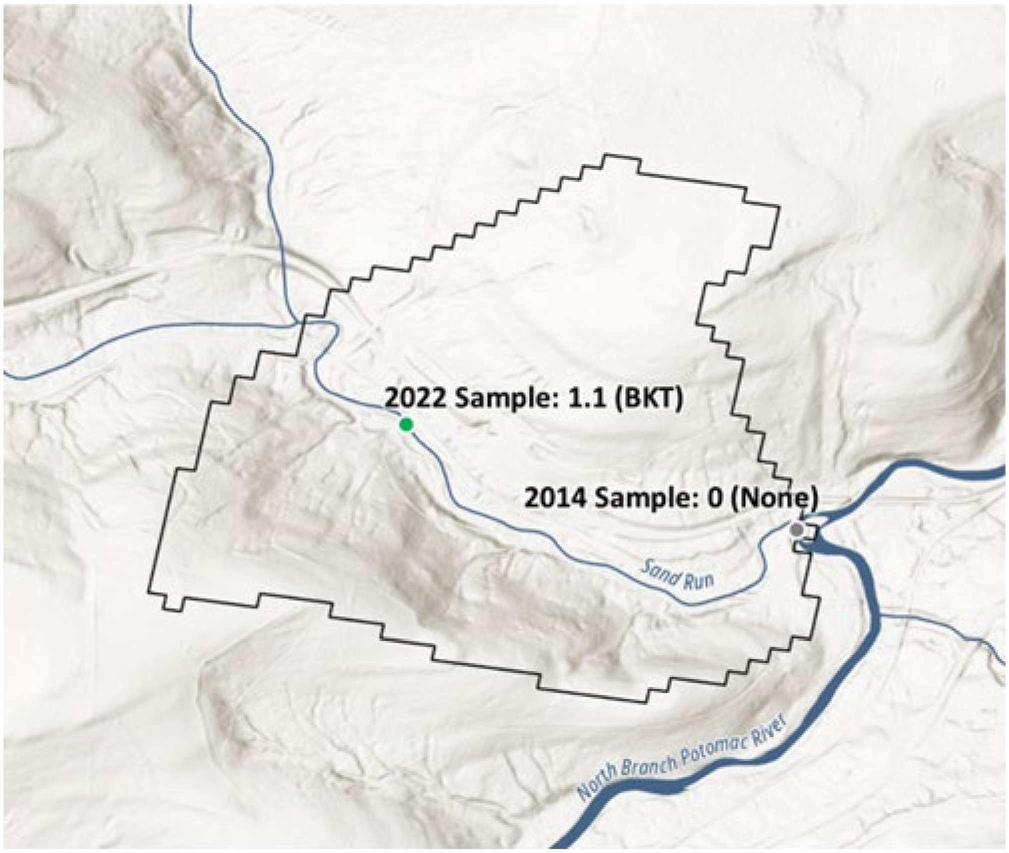

Figure 6. Data review example depicting a catchment that due to the precision of the catchment delineation captures a portion of the downstream mainstem. Earlier sample driving the 2016 assessment species code occurring on the mainstem found no trout while the newer sample driving the 2024 assessment species code occurred on Sand Run and found only brook trout. This catchment was erroneously assessed to be a gain in brook trout habitat. It should be recorded as a catchment where new sampling reveals the presence of brook trout and not a true gain.

3. **Species coding errors**

Our data review with state biologist leads revealed that in some cases species coding in either the 2016 or 2024 assessment appear to have been entered incorrectly. Additionally, we observed some locations where a species change occurs between two catchments while the catchment count attribute continues to increment with no apparent new sample to explain the species change. The data model does not support this apparent deviation from the logic and also contributes to potential errors in brook trout habitat gains and losses.

4. **Inconsistency in sampling methods and reporting in historical samples**

Review of assessment results with state biologist leads revealed catchments that, for instance, were coded as having brook trout in the 2016 assessment while the expert attests that no wild brook trout would have occurred there within the 2016 assessment window. This can sometimes be attributed to stocked brook trout being counted toward wild brook trout presence, or an anomalous occurrence of a single brook trout in a catchment known to not support active populations being encoded as a brook trout presence. These inaccuracies generally present as an overestimation of brook trout habitat loss.

Taken as a whole, these errors and limitations in the data contribute to significant uncertainty in the estimation of brook trout habitat change in the Chesapeake Bay watershed. We are unable to review all 78,292 catchments and adjust species codes, but we were able to review all assessed gains and losses in Maryland, several gain or loss catchments in New York, and all gain or loss catchments in the Upper West Branch Susquehanna subbasin in PA (total 284 reviewed catchments). The rate of occurrence of these errors is presented in Table 10.

Table 10. *Results of logic model review with state biologists.*

Data Review Issues	% reviewed catchments affected
Catchment scale	13.0%
Catchment precision	1.1%
Unassessed waters/new sampling	26.4%
Incorrect 2016 code	29.9%
Incorrect 2024 code	16.2%
Reviewed catchments with a correct gain or loss assessment	13.7%

Results

Given the logic flow model described above, and leaving aside the data limitations also described above, we can describe the changes in brook trout habitat occupancy that the current EBTJV data supports (Figure 7 and Table 11). The apparent net gain (total gain minus total loss) in brook trout habitat across the Chesapeake Bay watershed between the 2016 and 2024 EBTJV assessments is 2,955 square kilometers, representing an 8.9% increase. As previously discussed, a large proportion of that increase can be explained by new sampling of previously unassessed waters. While we don't have the information to determine whether those waters were occupied at the time of the 2016 assessment, our interviews with state biologists confirmed our assumption that nearly all of these likely were occupied by brook trout during that time period and do not represent true gains. Removing those 2,212 square kilometers results in a net gain of 742 square kilometers, or a 2.2% increase. This figure includes catchments that were modeled from downstream sampling and so cannot be confirmed as true gains. Removing catchments whose brook trout presence was determined through modeling leaves 167 square kilometers of habitat that was shown to not be occupied in the 2016 assessment and is occupied under the 2024 assessment, **a 0.5% gain**. Setting aside previously discussed limitations of the data available to us, this represents our best estimate of brook trout-occupied habitat expansion in the Chesapeake Bay watershed during the assessment timeframe.

Other changes from the 2016 to 2024 brook trout assessments include 3,114 km^2 identified as not having brook trout in 2016 were allopatric brook trout in 2024, 1,739 km^2 that were sympatric brook trout in 2016 were allopatric in 2024, 665 km^2 of allopatric catchments in 2016 were identified as no brook trout present in 2024, and 1,347 km^2 changed from allopatric in 2016 to sympatric in 2024.

Table 11. *Results of logic flow model comparing 2016 to 2024 EBTJV assessments.*

Logic Flow Model Output	**Square Kilometers**
BKT Loss	1,373
Total Loss	*1,373*
Gain	1,539
Gain - Modeled	568
Gain - Modeled; Biologist Knowledge	8
Total Gain; not UAW	*2,115*
Gain - Modeled; Biologist Knowledge; UAW	232
Gain - Modeled; UAW	1,115
Gain - UAW	865
Total Gain; UAW	*2,212*
Code Change; Biologist Knowledge	19
New Sampling; Code Change; BKT Present	455
Total Code Change	*474*
No Change; BKT Absent	*6,077*
2016 Code Applied; BKT Absent	*53,061*
Total No Change; BKT Absent	*59,138*
Confirm Absence/Future Surveys	4,637
Total Confirm Absence/Future Surveys	*4,637*
2016 Code Applied; BKT Present	22,163
New Sampling; Confirms 2016 Code; BKT Present	550
No Change; Biologist Knowledge; BKT Present	5
No Change; BKT Present	6,253
No Change; BKT Present, Modeled	2,275
Total No Change; BKT Present	*31,247*
Not Classified	62,077
Total Not Classified	*62,077*
Grand Total	***163,273***

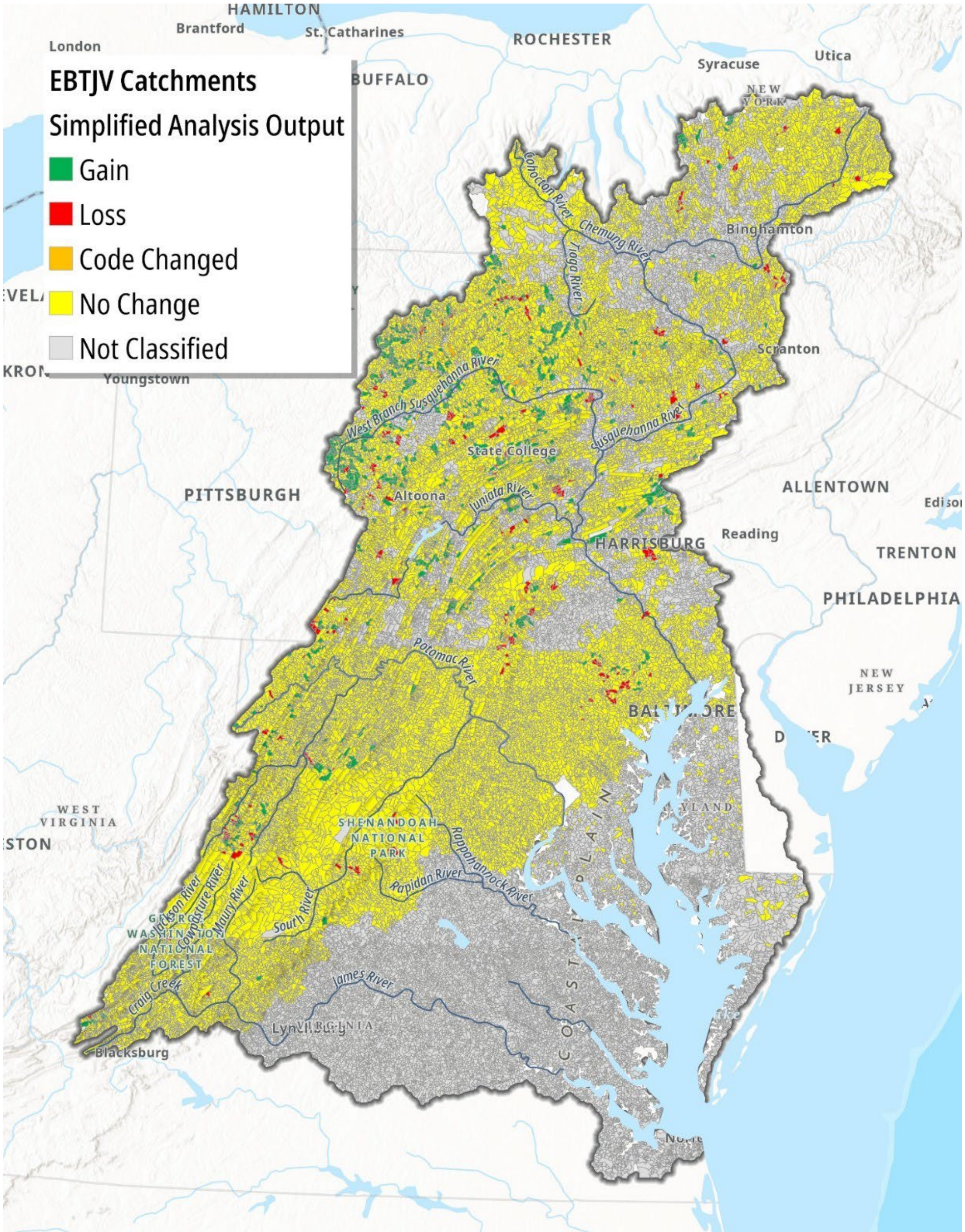

Figure 7. Map of simplified output from the logic flow model analysis.

More detailed results of the logic flow model by HUC6 watershed within the Chesapeake Bay watershed are provided in Appendix 6.

The project type and number of projects completed within each category of the logic flow model are shown in Table 12. As previously described, AMD restoration, AOP, and brook trout reintroduction projects are the major project types that are most likely to lead to brook trout occupying catchments where they were previously absent. All other project types are more likely to enhance a current population by removing limiting factors to the population on the landscape. A large portion (73%) of the projects completed between 2016 and 2022 were located within catchments that do not contain brook trout (44.2%) or are not classified (i.e. lacking brook trout sampling data and not located up-network from an existing sample) (28.9%). However, projects within the 'No Change – BKT Absent' category would have the potential to contribute to a future gain in occupied brook trout habitat, particularly the 51 AOP projects, four AMD projects, and two brook trout reintroduction projects.

Approximately 21% of the reported projects (1,156 projects) were completed in catchments where brook trout were present in the 2016 assessment and continue to be present in the 2024 assessment. These projects would not contribute towards a gain in occupied brook trout habitat; however they may be important for enhancing current populations and increasing their resilience to future stressors. Catchments identified as 'Gains' by the logic flow model contained approximately 2% of the total projects within the database. This included 10 AOP projects and one brook trout reintroduction. However, given the limitations of the data previously described, these catchments should be further reviewed and discussed with state biologists and other project stakeholders to determine if the catchment is a true gain (i.e. confirmed absence of brook trout in the 2016 assessment and confirmed presence by the 2024 assessment) and if the project was a contributing factor to the gain in brook trout occupancy. Table 13 provides the number of projects completed by the EBTJV species composition for both the 2016 and 2024 assessments.

__Table 12.__ Number of projects completed, by project type, within each category of the logic flow model for the Chesapeake Bay watershed. The broader categories within this table include the following decision points from the logic flow model: ***No Change – BKT Present*** *('2016 Code Applied – Present', 'New Sampling – Code Change – Present', 'New Sampling Confirms 2016 – Present', 'No Change – Present', 'No Change – Present – Modelled'),* ***No Change – BKT Absent*** *('2016 Code applied – Absent', 'Confirm Absence', 'No Change – Absent'),* ***Gain*** *('Gain', 'Gain – Modelled', 'Gain – Biologist Knowledge'),* ***UAW*** *('Gain – UAW', 'Gain – UAW Modelled'),* ***Loss*** *('BKT Loss'). 'Code Change – Biologist knowledge' (5 projects) and 'N/A' (18 projects) decision points were not included in this table.*

Project Type	**Total # Projects**	**No Change – BKT Present**	**No Change – BKT Absent**	**Gain**	**UAW**	**Loss**	**Not Classified**
Abandoned Mine Drainage Restoration	5	1	4	0	0	0	0
Aquatic Organism Passage	233	106	51	10	17	5	44
BKT Reintroduction	3	0	2	1	0	0	0
Dirt and Gravel Road Improvement	1566	420	619	56	57	27	382
Instream Habitat Enhancement	678	200	266	23	8	17	164
Land Protection	157	12	52	2	0	1	75
Other	222	88	80	7	3	8	36
Riparian Restoration	2555	329	1320	17	6	16	864
TOTAL (% Total)	**5419**	**1156 (21%)**	**2394 (44.2%)**	**116 (2.14%)**	**91 (1.68%)**	**74 (1.3%)**	**1565 (28.9%)**

Table 13. Total number of projects by 2016 and 2024 species composition from EBTJV data.

2016 Species Composition	2024 Species Composition								
	NA	**BKT Allopatric**	**BKT Sympatric**	**BRN Allopatric and Sympatric RBT**	**None**	**Not Classified**	**RBT**	**Stocked BKT Predicted**	**Grand Total**
NA	18								18
BKT Allopatric		655	30	6	27				718
BKT Sympatric		74	390	33	17	3			517
BRN Allopatric and Sympatric RBT		28	36	640	72	19			795
None		83	91	126	2269	702			3271
RBT		10		6	6	2	37		61
Stocked BKT		6			3		6	24	39
Grand Total	**18**	**856**	**547**	**811**	**2394**	**726**	**43**	**24**	**5419**

Discussion

The CBP's Brook Trout Outcome is to increase brook trout occupied habitat by eight percent by 2025. Based on the available data in the 2016 and 2024 EBTJV brook trout assessments, we estimate the current progress toward that goal to be a maximum of a 0.5% increase based on the logic flow model presented. We have confidence, based on the initial review of these data with state biologists in Maryland, Pennsylvania, and New York, that this estimate likely overestimates the amount of actual habitat that has gained brook trout occupancy since the 2016 assessment. The overestimate comes primarily from the data limitations outlined above. In addition, to accurately track progress towards the Brook Trout Workgroup outcome, fishery survey sites would ideally be replicated in both time and space. The EBTJV data represents only the presence and absence of trout at sample sites that are not commonly sampled repeatedly over time, making the accurate quantification of progress towards the Brook Trout Workgroup outcome difficult. In addition, only 12 of the 5,419 (0.2%) projects captured in the database indicated that brook trout-specific monitoring was part of the project. The lack of monitoring may be due to a variety of factors like feasibility, staff resources, limited funding, etc. Other research has also shown that stream restoration projects are typically not monitored adequately enough to determine whether they were effective (Bernhardt et al. 2005; Rolls et al. 2013). Often funding and staff capacity limit the ability to monitor restoration project efficacy, and some have argued that funding and permitting entities should require accountability for restoration projects through monitoring (Bernhardt et al. 2007). Without proper monitoring, quantifying biological response in a meaningful way is not possible.

While there are several limitations to obtaining a precise estimate of the increase of occupied brook trout habitat, the results from this project offer an initial estimate of progress to date. The results also provide a starting point for the Brook Trout Workgroup to potentially continue an evaluation of gains and losses of brook trout habitat identified by the logic flow model with state biologists and stakeholders that are responsible for restoration projects in those catchments. It is recommended that a thorough review of these results be completed with state biologists similar to the review process that was undertaken during this project.

Recommendations

- The results of this project for the quantification of progress towards the overall 8% increase in occupied brook trout habitat by 2025 should be interpreted with caution given the limitations of the data previously described. In addition, much of the EBTJV 2024 assessment data should be considered to be provisional at the time of the writing of this report and are subject to further revision by the EBTJV and state biologists.
- There was agreement amongst the state biologists and Brook Trout Workgroup steering committee that the logic flow model used in this project correctly categorized the EBTJV data and can be used to evaluate changes in the EBTJV data between the 2016 and 2024 assessment as the 2024 assessment data is finalized. It is recommended that these analyses be re-run following the final release of the 2024 assessment data.
- The logic flow model presented in this project should also be used as an initial step to identify where gains/losses in brook trout habitat may have occurred in the watershed. A more thorough data review with state biologists to identify areas where actual gains have occurred and what projects may have been completed in those areas is recommended.
- The project database was developed primarily to assist in the development of the habitat tracker tool to track brook trout related projects (see Goal 4). Given the low response rate to metrics that were not required in the database template, it is recommended that the Brook Trout Workgroup evaluate which metrics should be required with the habitat tracker database moving forward.

Goal 4: Development of a Tracking/Reporting Application

Overview

The objective of a tracking system for brook trout is to support data submission from partners for tracking progress toward the 2014 Chesapeake Bay Agreement's Vital Habitats goal for the Brook Trout Outcome and to provide information about projects, practices, benefits, and data for analysis of project impact. The tracking system includes all areas of the Chesapeake Bay watershed. Projects include preservation and restoration of habitat appropriate for brook trout in natural, urban, and agricultural areas. Data includes information submitted to major jurisdictions in the Chesapeake Bay watershed including New York, Pennsylvania, West Virginia, Maryland, Delaware, Virginia, and the District of Columbia. Other submitters may include federal agencies and non-governmental organizations. The project team submitted the first set of data including projects completed from 2016-2023 as part of this GIT project to track brook trout projects and monitoring information. These data are used to inform the data fields and functionality of the Habitat Tracker for brook trout, and it is anticipated that jurisdictions and other NGOs will provide data as well. Below we provide methods for developing the tracking system for the data to inform the Brook Trout Outcome and analyses to inform and support future environmental protection, mitigation, and restoration activities. This tool was developed by Devereux Consulting Inc.; it also tracks projects related to wetlands and black duck outcomes including associated co-benefits.

Project Scope

Table 14 shows the data elements that are necessary for tracking progress toward the 2014 Chesapeake Bay Vital Habitat Wetland, Black Duck, and Brook Trout Outcomes as defined by the workgroup co-chairs.

Table 14. *Data elements necessary for tracking progress toward the 2014 Chesapeake Bay Vital Habitat Wetland, Black Duck, and Brook Trout Outcomes.*

Project Identifier	Geographic location (lat/long, county, or HUC12)	Partner Organizations
Project Name	Primary Objective	Private landowner (yes or no)
Project Type	Construction start date	Project publicly accessible (yes or no)
Description	Construction end date	Project creates a recreation area (yes or no)
Wetland Type	At risk species (multiple, null is okay)	Brook trout present (pre-project; yes or no)
Lead organization	Underserved communities impacted (multiple, null is okay)	Brook trout monitoring study design (both, pre-project only, post-project only)
Total project cost	Planning Priorities (multiple, null is okay)	Black duck present (pre-project; yes or no)
Reference Point	Funders (multiple including "voluntary", null is okay)	Project includes an environmental literacy component (yes or no)
Climate resiliency considered (yes or no)	Project meets Federal Emergency Management Agency (FEMA) Special Flood Hazard Area guidelines (yes or no)	Presence of Rare, Threatened, Endangered species (yes or no)
Pre- and Post-project land uses	Project Areas	BMPs (type, land use, installation date, amount, unit, inspection date, inspection status)

Physiographic province will be assigned based on geographic information data.

With these data, progress toward achieving the brook trout outcome can be quantified in terms of amount of brook trout habitat improvements, classified by several project types and geographic location over time. The project funders also can be identified to help remove duplicate projects and track funding sources and amounts.

However, data to assess the capacity of these habitats to achieve functional gains cannot be assessed directly using data in the project tracking tool. Instead, we count the number of projects and those projects' amounts and locations as it relates to capacity. Further data analysis using the data tracked in the tool and habitat characteristics outside the tool will be required to assess functional gains.

Users

The primary users are the CBP staff managing data inputs from members of the Wetland, Black Duck, and Brook Trout workgroups, jurisdictions and the other partners/data reporters listed below.

Partners/Data Reporters

Partners supplying data are:

- States
- Local governments
- Federal agencies including FWS, USDA, United States Forest Service (USFS)
- Nongovernmental organizations, such as Ducks Unlimited, TNC, and TU
- Others

Minimizing duplication is important for data accuracy. It is expected that the lead agency for projects that have multiple partners will provide data. The tracking system includes the ability to report all project partners to help identify and reduce duplication of records.

User Management and Security

All application pages except the landing and home page require authentication to be accessed. Authentication is in the form of a user ID and password. The system is available to any potential user using the Internet.

Functionality

The system:

- Allows for online access with data stored in the cloud requiring no new hardware purchases
- Allows users to upload tables in a standard format with both required and optional fields.
- Allows users to generate pre-defined reports as downloadable Microsoft Excel files. Current report types are listed below and additional reports will be added as needs arise.
    - Environmental Literacy Report

    - FEMA Flood Hazard Acres
    - Project Funders
    - RTE Species Report
    - Wetland and Black Duck Acres
    - BMP Summary
    - More to be developed (e.g. brook trout habitat acres)
- Allows an upload of data by an administrator.
- Allows replacement of GIS data including physiographic region to update all data attributes that rely on those data.

Data

The data required to track brook trout includes habitat improvement projects and geographic information. These are the data inputs. The tracking system provides logic to help identify duplication of projects and attribute data with geographic information. The tracking system reports out data in multiple formats to inform the CBP's Indicators, annual progress toward Chesapeake Bay Vital Habitats Outcomes, and the two-year Milestones, among others. These reports allow for user-specified date ranges, project type, project funder(s), and the geography. The data inputs and reports are described in the following sections.

Data Input

Data inputs are uploaded using the linked spreadsheet. The data inputs are assessed for validity by checking for completion of required fields, data type (integer, other numerical, text), and the defined domain for the fields. All of these are specified in the spreadsheet. Domains can be updated as needed by the tool manager.

Practices

There are multiple practices that support brook trout habitat. These include:

- Instream habitat
- Riparian restoration
- AOP (aquatic organism passage)
- Land protection
- AMD (Abandoned mine drainage) restoration
- Dirt and gravel road improvement
- Brook trout reintroduction
- Non-native salmonid removal (brown trout and/or rainbow trout)
- Other

Recommendations for Implementation

We worked with consultants to enable the Habitat Tracker - a web-based tool already in development for tracking black duck and wetlands outcomes for the CBP, to accept data on

brook trout-related habitat projects, and brook trout monitoring. Data reports may be used in future Strategy Review Cycle documents, Management plans, and the next set of goals and outcomes for the Brook Trout Workgroup and Habitat Goal Implementation Team. Our collaborative work has set up the framework to facilitate upload of data by partners, with data types decided after multiple discussions with the project Steering Committee and other stakeholders such as Conservation Districts and conservation organizations. Several steps remain before the procedure is set, these include setting up the data reporting framework and drafting a process with time steps and points of contact for recruiting data from partners (preferably higher-level partners) and ultimately integrating those data back into program documents and goal setting. It is expected that the Brook Trout Workgroup and Habitat GIT will use these data to track current and future iterations of the Brook Trout Outcome.
Immediate next steps to implement the Habitat Tracker for brook trout:

- Our team has been in close communication with Devereux Consulting and will correspond to request the correct format for data reports. We will collaborate with the project Steering Committee to provide a document listing the fields needed. This document will also include the ecological or management questions being addressed by each field, to help guide the development of the reports. For example, if a report is to include "funding spent", we would indicate that the workgroup wants to understand the total funding spent across different geographies, across different project types, and/or overall. This data use document should also include basic definitions for common fisheries and habitat project terms.

- **The Brook Trout Workgroup should appoint a position** responsible for sending an annual request, with guidance and a due date, to submit data to the Habitat Tracker. This could be a Brook Trout Workgroup co-chair or member. Alternately the Brook Trout Workgroup could request this duty of the Habitat Tracker Manager. Currently the Habitat Tracker Manager is a liaison with the Chesapeake Bay Program employed through the Interstate Commission on the Potomac River Basin.
- **The Brook Trout Workgroup should set a date for annual correspondence with the manager(s) of the Habitat Tracker,** to request reports and to ensure these reports continue to provide the needed information to track the current or future outcome. This is a requested duty of the Habitat Tracker Manager.
- **Review the annual process below** and identify and address any outstanding needs, in particular who is responsible for each step.

Future steps to implement the Habitat Tracker for brook trout (Figure 8):

- **Continue annual requests to partners.** The Brook Trout Workgroup will need to appoint a person to manage and coordinate these requests of stakeholders. Data requests should be directed to higher-level agencies and funders who are already tasked with compiling grant progress reports and metrics. It will be necessary to also ask about any data sharing limitations and address them with the primary organizations who own the data. Additionally, as mentioned in section I, we suggest coordinating this data call with other related data inquiries by Chesapeake Bay Goal Implementation Teams.

- **Submit data to the Habitat Tracker by an annual deadline.** This is a requested responsibility of the individual data stewards and stakeholders.
- **Produce reports from the Habitat Tracker.** The Brook Trout Workgroup co-chairs should make this request of the Habitat Tracker Manager. Currently this position sits within the Interstate Commission on the Potomac River Basin.
- **Share the reports.** Share report findings with the Habitat GIT, FPWG (specifically barrier removal data), Chesapeake Progress, Bay Program press relations, and the EBTJV. Acknowledge the data sources. This is a requested task of the Habitat Tracker Manager.
- **Annually review the reports.** The Habitat Tracker data reports will follow a standard format and do not contain analyses. The workgroup will need to review the data reports and provide interpretation for any end users (including its own members and outside audiences). Ensure that any data that need to be kept private are handled appropriately in any summary reports.
- **Assess and revise this process.** Periodically, the workgroup will need to evaluate if the data and response rates are sufficient to track progress. If they are not, we recommend working with other Goal Implementation Teams to address capacity limitations of partners and/or to work with the partners' data teams to determine if alternate data submission frameworks would be preferable. The Brook Trout Workgroup will also need to assess if the data types and reporting framework are sufficient to meet its needs and those of other parties. For example, if an objective is to increase the miles of streambank reforested, then length of the habitat project would be a required field.
- Share project results with the originators of the data, and otherwise confirm with those who submitted data that their data were used, why the data are important.
- As we near the next set of outcomes (engaging in "Beyond 2025" discussions), we recommend the Brook Trout Workgroup **re-evaluate which data types are necessary to track proposed goals,** especially which ones need to be mandatory.
- **Consider performing another in-depth analysis of project data in about five years.**

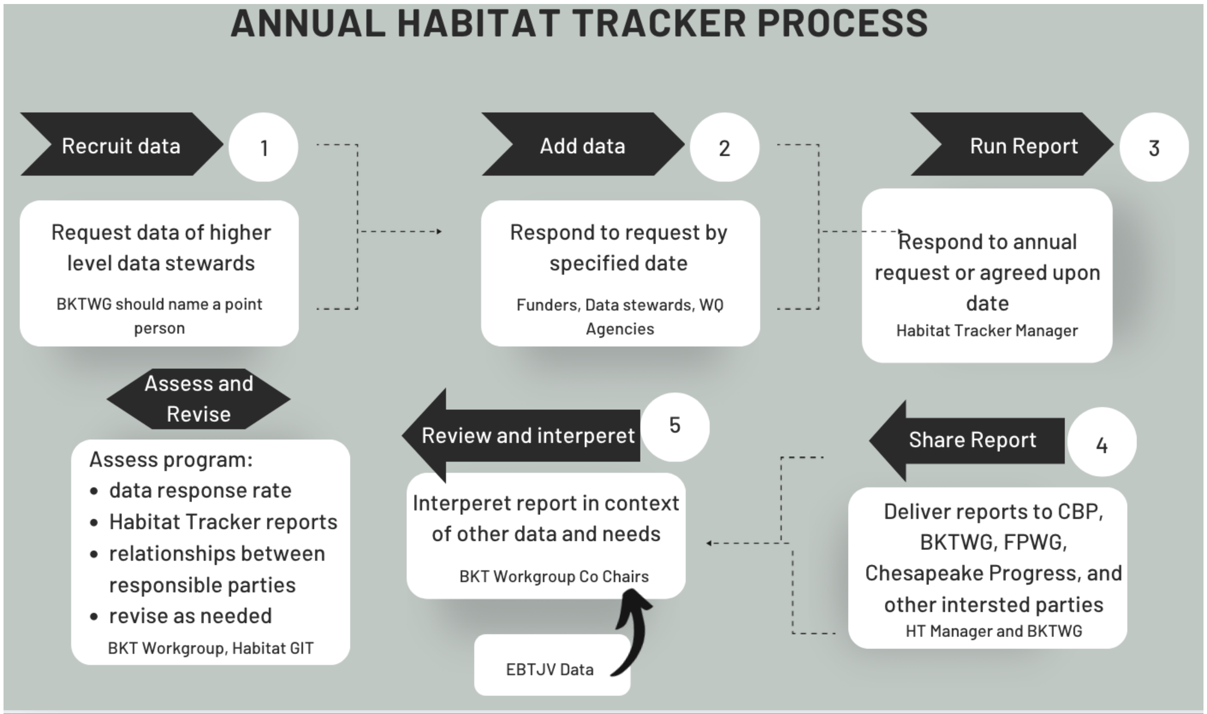

Figure 8. Process diagram for brook trout data in the Habitat Tracker.

Summary of Project Recommendations

Numerous recommendations based on the findings of this project are discussed throughout this report. We provide a summary of recommendations for the Brook Trout Workgroup below:

<u>Increase cross-GIT collaborations</u>

- Complete a more thorough review of all areas of shared interest and synergy across all workgroups and teams, including expanding upon items from the initial discussions during this project as outlined in Appendix 1.
- We recommend regular communication to share information, avoid duplication of efforts, and identify opportunities for collaboration. This could be facilitated by naming a liaison between pairs of workgroups.
- It is important for the Brook Trout Workgroup to continue collaborating with other workgroups to develop consistent messaging and outreach materials and to share important tools with their respective audiences and partners. The collaborative development of a glossary of stream restoration and fisheries terms could be very useful.
- **Data sharing with the Fish Passage Workgroup:** We recommend annual sharing data on brook trout watersheds (EBTJV data) and completed fish passage projects and brook trout monitoring (through Habitat Tracker) with the FPWG to support their efforts to maintain its Chesapeake Bay Fish Passage Tool and open stream miles for fish passage.

Tracking Progress

- We do not recommend at this time that the EBTJV catchment data be used to identify the causes of changes to occupancy at the level of the catchment or reach. The limitations of these data are discussed under Goal 3. Instead, we recommend that the Brook Trout Workgroup identify resources to perform pre-and post-project monitoring for brook trout presence, particularly in pre-selected, focal watersheds. This focus on monitoring is a straightforward overlap with that of the Fish Passage Workgroup, and an important recommendation of this GIT funded project.
- We understand that the Brook Trout Workgroup would prefer to work in the future with projects that are done for the benefit of brook trout. Initially, we hoped that the project data - along with the EBTJV brook trout assessment by catchment data - would allow a picture to emerge of what constitutes a "brook trout project". As we describe in later sections, **we recommend that rather than the broad approach taken here, the Brook Trout Workgroup solicit a well-designed experimental study with pre-and post-project monitoring, to better understand which project types are expected to benefit brook trout.** This would greatly help focus which projects partners and data stewards would submit to the Habitat Tracker for future data requests.
- The results of this project for the quantification of progress towards the overall 8% increase in occupied brook trout habitat by 2025 should be interpreted with caution given the limitations of the data previously described. In addition, much of the EBTJV 2024 assessment data should be considered provisional at the time of the writing of this report and are subject to further revision by the EBTJV and state biologists.
- There was agreement amongst the state biologists and Brook Trout Workgroup steering committee that the logic flow model used in this project correctly categorized the EBTJV data and can be used to evaluate changes in the EBTJV data between the 2016 and 2024 assessment as the 2024 assessment data is finalized. It is recommended that these analyses be re-run following the final release of the 2024 assessment data.
- The logic flow model presented in this project should also be used as an initial step to identify where gains/losses in brook trout habitat may have occurred in the watershed. A more thorough data review with state biologists to identify areas where actual gains have occurred and what projects may have been completed in those areas is recommended.
- The project database was developed primarily to assist in the development of the habitat tracker tool to track brook trout related projects (see Goal 4). Given the low response rate to metrics that were not required in the database template, it is recommended that the Brook Trout Workgroup evaluate which metrics should be required with the habitat tracker database moving forward.

Habitat Tracker Database Implementation/ Data Reporting

- **Consider capacity limitations and seek funding** for project administration and brook trout monitoring.
- **Approach higher level agencies and NGOs** as the primary point of contact for future data requests, but first address the need for data sharing agreements.

- Partner with agencies responsible for project reporting to align reporting metrics with habitat tracker.
- **Consider defining what types of projects constitute "brook trout projects"**. This will help to focus the data types collected and tracked.
- **Streamline and combine data requests that will go to a common recipient** (e.g. a state water quality agency) by holding a call for data needs across all GIT programs on a set schedule. This would reduce redundant or seemingly repetitive requests, and possibly improve response rates.
- **Report the findings from the Habitat Tracker back to stakeholders** so they can share in successes and/or help collaborate on new approaches.
- We recommend the Brook Trout Workgroup chairs **use the contact list provided,** which will need to be updated and maintained by the workgroup.

Future Projects and Monitoring

- **Focus on protecting areas that are relatively healthy:** Several teams (Forestry Workgroup, Maintain Healthy Watersheds GIT, Stewardship GIT) identify the urgent need to conserve land and prevent further loss of forest cover. This is important for brook trout, and additionally, brook trout are often cited as an indicator of these 'intact' watersheds.
- **Prioritization of brook trout conservation in watershed restoration projects:** We recommend that brook trout conservation be considered a priority, in addition to its use as an icon or indicator.
- **Added focus on Abandoned Mine Drainage (AMD):** We highlight the need for a focus in additional workgroups or at the level of the Habitat GIT on planning and tracking the benefits to fish and macroinvertebrate populations and local water quality from AMD restoration.
- **Scientifically based and watershed-specific monitoring:** As reflected in the recent Stream Monitoring Workshop, there are good arguments for promoting scientifically sound monitoring methods to track the progress of restoration efforts.
- **Fund or otherwise support pre- and post-project monitoring that is specific to outcome.**

Goal Setting (Beyond 2025)

- New goals should be clear and concise and most importantly, quantifiable by easily tracked metrics. Careful consideration should be given to the development of any new goals/outcomes by the Brook Trout Workgroup.
- The results of this project demonstrate that more attention could be given to setting and tracking goals for biological uplift and water quality gains from AMD remediation.

Under a warming climate scenario, the current outcome of increasing occupied habitat area significantly in the Chesapeake Bay watershed may not be feasible. Furthermore, simply expanding habitat as a goal may not be a wise investment of limited conservation resources and may direct work to more marginal habitats. Therefore, we recommend the following:

- We recommend that the Brook Trout Workgroup **consider focusing on the restoration and protection of resiliency within existing populations,** with potential expansion of occupied habitat limited to appropriate areas through removal of AOP barriers, brook trout reintroductions, and improvement of water quality and habitat.
- The Brook Trout Workgroup should also consider **partnering with other relevant agencies and groups involved in brook trout conservation and align goals** with those organizations (ex: TU, EBTJV, USFWS, state agencies, etc.). For example, one of TU's long-term conservation goals is to "maintain existing large, interconnected populations with limited non-native trout, minimal habitat impairments, low vulnerability to climate change, and access to diverse habitats ("strongholds") and use restoration techniques to create new strongholds (improve existing habitat and populations and reconnect and combine existing isolated brook trout populations" (Fesenmyer et al. 2017).
- We recommend that the results of this project along with other decision support tools available be used to **develop focal areas for the Brook Trout Workgroup where thorough pre- and post-project monitoring** may be implemented to adequately track progress towards brook trout outcomes.

Acknowledgments

This project was funded by the Chesapeake Bay Trust and the U.S. Environmental Protection Agency as part of the Chesapeake Bay Program Goal Implementation Team Funding Program. The project would not have been possible without the contribution of many individuals. We would like to thank the project steering committee; Gina Hunt (MD DNR), Stephen Faulkner (retired, USGS, past Brook Trout Workgroup co-chair), Katie Ombalski (Woods and Waters Consulting and Brook Trout Workgroup co-chair), Daniel Goetz (MD DNR and Brook Trout Workgroup co-chair), Katlyn Fuentes (Habitat Goal Implementation Team staffer) and Megan Thynge (U.S. EPA) for their input and guidance throughout this project. We would also like to thank Jason Coombs (USFWS) for leading the compilation of the state brook trout data for the EBTJV. Jason Detar (PFBC), Matt Lawrence (MD DNR), Fred Henson (NY DEC), David Thorne (WV DNR), and Brandon Kepinger (WV DNR) provided valuable time and energy reviewing the data analysis from this project along with valuable input into the nuances of the data. Olivia Devereux and Helen Golominski, both of Devereux Consulting, Inc. attended numerous meetings and worked on the development of the habitat tracker tool. Numerous other individuals contributed to this project by providing input and recommendations, feedback, datasets and other important contributions including Jill Whitcomb (PA DEP), Kate Bresaw, PA DEP, Joseph Quatrini (Bradford County Conservation District), Tyler Upham, Tioga County Conservation District, Abby Sieg, Columbia County Conservation District, Nat Gillespie (USDA Forest Service), Jacob Rash (North Carolina Wildlife Resources Commission), Lee Simard (Vermont Fish and Wildlife Department), Jim Thompson (Maryland DNR), Ray Li (USFWS), Cathy Bozek (USFWS), Amanda Bassow (NFWF), Jake Reilly (NFWF), Kelly Maloney (USGS), Amy Wolfe (TU), Chris Guy (USFWS), Eli Long (WPC), Aaron Lucas (Headwaters Conservation District), Emily Neideigh and Chris Tanczos (York County Conservation District), Kelly Williams, Clearfield County Conservation District, Bryan Hoffman (Friends of the Rappahannock River), Aaron Lucas (Augusta Virginia), and Amanda Goldsmith and Matt Koforth, (Lancaster County Conservation District). Finally, we would like to thank the countless others that participated through stakeholder meetings and various other correspondence regarding this project.

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Appendices

Appendix 1: Comments from teams and workgroups meetings.

Meetings in December 2022-January 2023 between the Project Team and the leads of select Chesapeake Bay Program Goal Implementation Teams and Workgroups. Comments arose from the question of how the GIT funded project or Brook Trout Workgroup in general may overlap with the interests of their GIT or workgroup. Most of these items were out of the scope of this GIT project but are important to track.

GIT/Group	Leads	Comments
The Sustainable Fisheries Goal Implementation Team's (GIT 1) Fish Habitat Workgroup	Chris Moore, Justin Shapiro	This workgroup did a stakeholder survey in 2019: https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/CB_Fish_Habitat_Stakeholder_Summary_final.pdf
		How might this inform tracking of water quality changes?
		How might freshwater mussel work fit into project tracking piece, in particular species that use brook trout as host? (This question also came up in a GIT meeting in 2024, though no GIT1). Bigger picture we can ask if there are any data that might inform mussel restoration plans or reflect on their utility.
GIT 2: Stream Health Workgroup	Alison Santoro	CB Trust is developing SOW for stream restoration techniques and climate research review. There were a few talks on RSC's - take home is that these don't yield full ecological uplift in 5 yrs time.
Forestry Workgroup	Rebecca Hanmer, Katie Brownson	Rising Temps Report, Brook Trout mapping. They requested to present their report at the EBTJV meeting in November 2023, and did.
		Future goal setting (using land conservation)
Fish Passage WG	Jim Thompson, Ray Li	Jim and Ray and very interested in the database developed from this project. They requested that the Brook Trout Workgroup send any projects lat/long and name in meantime to populate CB Fish passage tool.
Climate Resiliency WG	Mark Bennett (Chair), Julie Reichert-Nguyen (Coordinator), Jamileh Soueidan (staffer)	CRWG can help with cross-GIT meetings (give 2 months advance notice); they are working to integrate many WG priorities and finding capacity is the limiting factor. e.g. discuss stream temperature climate change indicator related to climate resilience factors of interest (e.g., forest cover, brook trout habitat.)

		This group is extremely interested in the database and in continuing conversations. Resilience indicators? Interested in thresholds of temp, forest, etc for sustainable Brook trout. Finding the nexus between watersheds we would like to see protected due to their intactness and Brook trout refugia might be one direction we could pursue.
		Policy for land protection. Example from PA. Telling stories to managers to make a case for management.
Maintain Healthy Watersheds GIT	Jeffrey Lerner, Renee Thompson, Sophie Waterman	Look at watersheds that are "on the edge" (currently healthy but may easily become unhealthy) and strategic protection or restoration could keep them healthy. Here again we might ask, where does that overlap with brook trout protection or restoration efforts?
Land Use workgroup	KC Filipino	The Land Use Workgroup's role is to have eyes on the landuse/landcover data produced by USGS and the Chesapeake Conservancy. We do our best at ground truthing the land cover and land use data from a local perspective across the watershed.
		This GIT would be interested in leads we have about partners in the watershed. They would like to identify small gaps with volunteers, figures out needs. Which orgs have programs that do outreach to stewards? What kinds of projects need volunteers?
Stewardship GIT	Britt Slattery, Mike Weyand	Suggest we talk to J. Wolf regarding protected lands, can we triple the rate of land conservation. Engaging landowners is a critical need for land conservation; a topic that is shared frequently in the brook trout world.

Appendix 2: Chesapeake Bay Brook Trout project contact list full CB project partners list.

Organization name	Primary contact name	Contact email	Geographic Area
Adams Co Conservation District	Adam McClain	amcclain@adamscountypa.gov	Adams County PA
American Rivers	Lisa Holligsworth-Segedy	lhollingsworth-segedy@americanrivers.org	Entire CB
Berks County Conservation District PA	Kent Himelright	kent.himelright@berkscd.com	Berks County PA
Blair County Conservation District PA	Chelsey Ergler	cergler@blairconservationdistrict.org	Blair County PA
Blue Ridge SWCD	Kathy Smith, Mgr	ksmith@brswcd.org	Blue Ridge; (Roanoke)
Bradford Co. Conservation District PA	Joe Quatrini	joe.quatrini@pa.nacdnet.net	Bradford Co. PA
Broome Conservation District		obroomecountys@stny.rr.com	Broome Co NY
Cambria Co Conservation District PA	Bryan Rabish	brabish@co.cambria.pa.us	Cambria County PA
Cameron Co Conservation District PA	Todd Delucca	tdeluccia@cameroncd.org	Cameron Co PA
Capacon and Lost River Land Trust	Emily Warner	emily@cacapon.org	Cacapon watershed
Centre Co. Conservation District PA	Justin Kozak	jmkozak@centrecountypa.gov	Centre County PA
Chemung Conservation District		karentillotson@stny.rr.com	Chemung Co. NY
Chesapeake Bay Program	Jim Thompson, Ray Li	jim.thompson@maryland.gov; ray_li@fws.gov	entire CB watershed
Clearfield County Conservation District PA	Kelly Williams	kellyw@clfdccd.com	Clearfield County PA
Columbia County Conservation. District PA	Aaron Eldreg	aaron.eldred@columbiaccd.org	Columbia County PA
Columbia County Conservation. District PA	Abby Sieg	abby.sieg@columbiaccd.org	Columbia County PA
Cortland SWCD	Amanda Barber	amanda.barber@cortlandswcd.org	Cortland County NY
Dauphin Co Conservation District PA			Dauphin Co. PA
Delaware Conservation District		rick-weidenbach@dcswcd.org	Delaware County NY
Eastern Panhandle Conservation District		EPCD@wvca.us	Eastern Panhandle WV
Elk Conservation District		ECD@wvca.us	local Soil and Water Conservation. District
EPCAMR	Bobby Hughes	rhughes@epcamr.org	Scranton-Wilkes Barre PA
Franklin Co Conservation Dist PA	Emily Hartley	eyoung@franklinccd.org	Franklin County PA
Friends of Rappahannock	Bryan Hoffman	bryan.hofmann@riverfriends.org	Rappahannock watershed, VA
Fulton County Conservation District PA	Scott Alexander	scott@fultoncountyconservationdistrict.org	Fulton County PA
FWS Fish Passage Program	Cathy Bozek	catherine_bozek@fws.gov	entire CB watershed
Greenbrier Valley Conservation District		GVCD@wvca.us	Greenbrier Valley WV
Headwaters Conservation District	Aaron Lucas	alucas@co.augusta.va.us	Augusta County/Staunton area VA
Huntingdon Co Conservation District PA	Logan Stenger	watershed@huntingdonconservation.org	Huntingdon County PA
ICPRB	Mike Selkmann	gmselckmann@icprb.org	Upper Potomac
Indian Co Conservation District PA		info@iccdpa.org	Indiana County PA

Juniata Co Conservation District PA	Mindy Musser	mindy-musser@juniataccd.org	Juniata County PA
Kettle Creek Watershed Association	James Toth	jtoth514@comcast.net	Northcentral PA
Lancaster Co Conservation District PA	Amanda Goldsmith	amandagoldsmith@lancasterconservation.org	Lancaster County PA
Lebanon Co Conservation District PA	Katie Hollen	katie.hollen@lccd.org	Lebanon County PA
Lock Haven University	Steve Seiler	sseiler@commonwealthu.edu	West Branch Susq. River Watershed
Luzerne Co. Conservation District PA	John Levitsky	john@luzcd.org	Luzerne County PA
Lycoming Co. Conservation District PA	Carey Entz-Rine	CEntz@lyco.org	Lycoming County PA
Madison SWCD		patricia-casler@verizon.net	Madison Co NY
Maryland DNR	Dan Goetz	danielb.goetz@maryland.gov	MD
Maryland DNR	Anne Hairston-Strang	anne.hairston-strang@maryland.gov	MD
MD Conservation District Frederick & Catoctin	Heather Hutchinson, Dist Mgr	HHutchinson@frederickcountymd.gov	Frederick/Washington Counties MD
MD Conservation District Harford	Quintin Cornwell	quintin.cornwell@maryland.gov	Harford County MD
MDE	~~Heather Nelson~~	hnelson@maryland.gov	MD
Mifflin Co Conservation District PA	Bailey Coder	bcoder@mifflinccd.com	Mifflin County PA
Monongalahela Conservation District		MCD@wvca.us	Marion, Monongalia, and Preston counties WV
Montour County Conservation District PA	Todd Deroba	tderoba@ptd.net	Montour County PA
Mountain Castles SWCD	Jeff Mutter, Technician	jeff.mutter@mountaincastles.org	Craig and Botetourt Counties VA
Natural Bridge SWCD	Robert Hickman, Mgr	robert.hickman@vaswcd.org	Buena Vista (City); Lexington (City); Rockbridge VA
New York DEC	Fred Henson	fred.henson@dec.ny.gov	NY
NFWF	Amana Bassow	amanda.bassow@nfwf.org	NFWF Northeastern region
Northcentral PA Conservancy	Renee Carey	rcarey@npcweb.org	Central and Northern PA
Northumberland County Conservation. District PA	Ben Paul	bpaul@nccdpa.org	Northumberland County PA
NRCS	Leon Tillman	leon.tillman@usda.gov	Chesapeake Bay Watershed
NRCS	Steve Strano	steve.strano@usda.gov	Maryland
NY Council of TU		hello@newyorkcouncil-tu.org,	NY
Oneida SWCD			Oneida Count NY
Ostego SWCD			Ostego Co. NY
PA Council TU - Conservation. committee	Brian Wagner	bewagner482@gmail.com	PA
PA DCNR - Forestry	Emily Domoto	edomoto@pa.gov	PA
PA Dirt and Gravel Roads Program	Ken Corradini	kjc139@psu.edu	PA
Peidmont Env. Council	Linnea Stewart	lstewart@pecva.org	nine counties and one city in the northern Piedmont of Virginia
Pennsylvania FBC	David Dippold	ddippold@pa.gov	PA
Pennsylvania FBC	Geof Smith	geofsmith@pa.gov	PA
Pennsylvania FBC	Jason Detar	jdetar@pa.gov	PA
Perry Co Conservation District PA		perrycd@perryco.org	Perry County PA

PFBC - Habitat Section	Mark Sausser	msausser@pa.gov	PA
Potomac Valley Conservation District		PVCD@wvca.us	Grant, Hampshire, Hardy, Mineral, and Pendleton counties WV
Potter Co. Conservation District	Emily Shosh	e.shosh@pottercd.com	Potter County PA
Potter Co. Conservation District	Jason Childs	j.childs@pottercd.com	Potter County PA
Robert A Lee SWCD	Jonathan Wooldridge, Mgr	jonathan.wooldridge@releeconservation.com	Amherst; Appomattox; Campbell; Lynchburg (City) VA
Shenandoah Valley SWCD		svswcd@gmail.com	Harrisonburg (City); Page; Rockingham
Snyder County Conservation. District PA		manager@snydercd.org	Snyder County PA
Southern SWCD		SCD@wvca.us	Fayette, McDowell, Mercer, Raleigh, Summers, and Wyoming counties WV
Steuben Conservation District		jgparker@stny.rr.com	Steuben County NY
Sullivan Co. Conservation District PA	Quinn Hartung	qhartung@sullivancountypa.gov	Sullivan County PA
Susquehanna Co. Conservation District PA	Nate Harpster	nharpster@suscondistrict.org	Susquehanna County PA
The Nature Conservancy	Jonathan Niles	Jonathan.niles@tnc.org	PA
The Nature Conservancy	Su Fanock	sfanok@tnc.org	PA
Thomas Jefferson Conservation District	Anne Coates, Dir.	anne.coates@tjswcd.org	4 counties in VA near Charlottesville
Tioga Co. Conservation District PA	Tyler Upham	tupham@tiogacountypa.us	Tioga County PA
TU regional programs	Seth Coffman	seth.coffman@tu.org	Shenandoah Headwaters
TU regional programs	Abigail McQueen	abigail.mcqueen@tu.org	MD/WV
TU regional programs	Dustin Wichterman	dustin.wichterman@tu.org	WV/MD
TU regional programs	Scott Koser	scott.koser@tu.org	PA
Tygarts Valley Conservation District		TVCD@wvca.us	Barbour, Randolph, Taylor, Tucker, and Upshur counties WV
UMBC	Tamra Mendelson	tamram@umbc.edu	
Union Co. Conservation District PA	Savannah Rhoads	srhoads@unionco.org	Union Co. PA
Upper Susquehanna Conservation Alliance	David Stilwell	david_stilwell@fws.gov	Upper Susquehanna watershed NY/PA
USDA_Allegheny Co.	Chad Bucklew Dist. Conservationist USDA	Chad.Bucklew@usda.gov	Allegheny County MD
USDA_Baltimore	Eric Hines Dist. Conservationist USDA	eric.hines@usda.gov	Baltimore area MD
USDA_Carrol Co.	Eric Hines Dist. Conservationist USDA		Carrol County MD
USDA_Garrett Co.	Chad Bucklew Dist. Conservationist USDA		Garrett Co MD
USDA_Howard	Sam Engler, Dist. Conservationist	samuel.engler@usda.gov	Howard County MD
USFWS Partners for Wildlife	Gian Dodici	gian_dodici@fws.gov	NY
VA Conservation District Lord Fairfax		dana.gochenour@lfswcd.org	Counties of Clarke, Frederick, Shenandoah, and Warren, and the City of Winchester
Virginia DWR	Alan Weaver	Alan.Weaver@dgif.virginia.gov	VA
Virginia DWR	Brad Fink	brad.fink@dwr.virginia.gov	VA
Virginia DWR	Clint Morgeson	clinton.morgeson@dwr.virginia.gov	VA
West Virginia DNR	Brandon Keplinger	brandon.j.keplinger@wv.gov	Eastern West Virginia
West Virginia DNR	David Thorne	david.w.thorne@wv.gov	WV

Western Pennsylvania Conservancy	Eli Long	elong@paconserve.org	Western and Central PA
WV Council TU - Conservation cmtee	Randy Kesling	rkesling@ma.rr.com	WV
Wyoming Co. Conservation. District PA	Bernie Scalzo	bscalzo@wycopa.org	Wyoming County PA
York Co Conservation District PA	Emily Neighdeigh	eneideigh@yorkccd.org	York County PA

Appendix 3: Survey123 for brook trout projects in the Chesapeake Bay.

Chesapeake Bay Program - Brook Trout Project Survey

The survey will take approximately 8 minutes to complete.

* Required

Contact Information

1. Name of your organization/agency. *

2. Your Name *

3. Email Address *

4. Phone Number

Restoration/Conservation Project Types (only include projects that your organization led)

5. What types of stream restoration/conservation projects have your organization/agency completed since 2016? (Check all that apply) *

- [ ] In-stream habitat enhancement (in-stream wood, boulders, channel modification, etc.)
- [ ] Riparian Buffer Restoration (vegetative planting, including livestock exclusion fencing where done together)
- [ ] Aquatic Organism Passage (culvert/dam removal and/or replacement)
- [ ] Land protection in coldwater watersheds
- [ ] Water quality improvements (AMD, nutrient reduction, etc.)
- [ ] Upland Agricultural BMPs (barnyard mangement, soil health, etc.)
- [ ] Dirt and gravel road improvements
- [ ] Brook trout reintroduction
- [ ] Competing nonnative fish species removal
- [ ] Other

Please enter the approximate number of projects completed between 2016-2022 for each type.

Enter "0" if no projects of that type were completed. NOTE: only include projects that your organization was the project lead).

6. In-stream habitat enhancement (in-stream wood, boulders, channel modification, etc.) *

The value must be a number

7. Riparian Buffer Restoration (vegetative planting, including livestock exclusion fencing where done together) *

The value must be a number

8. Aquatic organism passage (culvert/dam removal and/or replacement) *

The value must be a number

9. Land protection in coldwater habitats *

The value must be a number

10. Water quality improvement projects (AMD remediation, nutrient reduction, etc.) *

The value must be a number

11. Upland agricultural BMPs (barnyard management, soil health, etc.) *

The value must be a number

12. Dirt and gravel road improvement *

The value must be a number

13. Brook trout re-introduction *

The value must be a number

14. Competing nonnative fish species removal *

The value must be a number

15. Other(s) - Please specify project type and approximate number of projects completed between 2016-2022.

Data Sharing

16. Would you be willing to share project type and location data as part of this project? *

- ◯ Yes
- ◯ No
- ◯ I would need more information.

17. Has your organization collected brook trout specific data related to these conservation/restoration projects? *

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ No, but another organization/agency did.

18. Would you be willing to share brook trout specific data as part of this project? *

- ◯ Yes
- ◯ No
- ◯ I would need more information.

19. Are there any other conservation partner organizations that you would suggest we reach out to?

Appendix 4: Agency acknowledgements for this project.

Agency Acknowledgements		
Adams County Conservation District	Friends of the Rappahannock	PA DEP
Alliance for the Chesapeake Bay, Inc.	Fulton County Conservation District	Parks & People Foundation, Inc.
American Rivers, Inc.	Gunpowder Valley Conservancy, Inc.	Penn State University
Antes Creek Fishing Club (ACFC)	Headwaters SWCD	PA Game Commission
Arundel Rivers Federation, Inc.	Huntingdon County Conservation District	Potter County Conservation District
Bald Eagle Creek Watershed Association	Intergovernmental Stormwater Committee	Private Landowners
Bedford County Conservation District	Ironwood Forestry	PSU Center for Dirt and Gravel Roads
Blair County Conservation District	James Madison University	Rivanna Conservation Alliance, Inc.
Borough of Spring Grove	James River Association	Schuylkill County Conservation District
Bradford County Conservation District	Jessup Township	Shorerivers, Inc.
Cambria County Conservation District	John Kennedy Chapter, TU	Spring Creek Chapter, TU
Centre County Conservation District	Juniata County Conservation District	Spring Garden Hunting Club
Centre Hills Country Club	Kettle Creek Watershed Association	Stroud Water Research Center
Chesapeake Bay Foundation, Inc.	Kings Gap Env. Ed Center, PA Bureau of State Parks	Susquehanna County Conservation District
City of Hopewell	Lackawanna Valley Chapter, TU	Swatara Beagle Club
Clearfield County Conservation District	Lancaster County Conservation District	The Feathered Hook
ClearWater Conservancy	Lancaster Farmland Trust	The Nature Conservancy
Clinton County Conservation District	Lewis Ginter Botanical Garden	The Piedmont Environmental Council, Inc.
Clukey Camp	Little Shamokin Creek Watershed Association	The Trust for Tomorrow
Columbia County Conservation District	Living River Restoration Trust	Thomas Roberts, Roberts Family Camp
Cornwall Mountain Hunting Club	Luzerne Conservation District	Tiadaghton Chapter, TU
Cumberland County Conservation District	Manheim Township	Tioga County Conservation District
Cumberland Valley Chapter, TU	Marykay Fuller	Tioga County SWCD of New York
CV Anglers Club	Maryland Department of Agriculture	Town of Broadway
DCNR	Maryland Department of Natural Resources	Travis Bobik and Megan Turner
DCNR Moshannon	Mifflin County Conservation District	Trout Unlimited, Inc.
DCNR Prince Gallitzin State Park	Morris Rod and Gun Club	Union County Conservation District
DCNR Rothrock State Forest	Mountain Laurel TU	Upper Susquehanna Coalition
DCNR Tiadaghton State Forest	Nate Anderegg	US Youth Fly Fishing Team
Dennis West	National Forest Foundation	USFS
Dickinson Township	NFWF	USFWS
Doc Fritchey Chapter, TU	Northern Swatara Creek Watershed Association	Virginia Department of Game and Inland Fisheries
Falling Spring Chapter, TU	Northumberland County Conservation District	Virginia Polytechnic Institute and State University
Fisher	NPC	Washington College
Flooks Run Road property owners	NRCS	Western Pennsylvania Conservancy
Fort Bedford Trout Unlimited	Owls Club of Waynesboro Inc	WVDNR
Franklin County Conservation District		

Appendix 5: EBTJV Catchment Updater tool.

Background

The EBTJV Catchment Updater is a data visualization and decision support tool that was developed to assist with updating of EBTJV catchment codes representing salmonid species presence. This tool was designed to assist federal and state agencies, local decision-makers, regional planners, conservation organizations, and natural resource managers using open-source software.

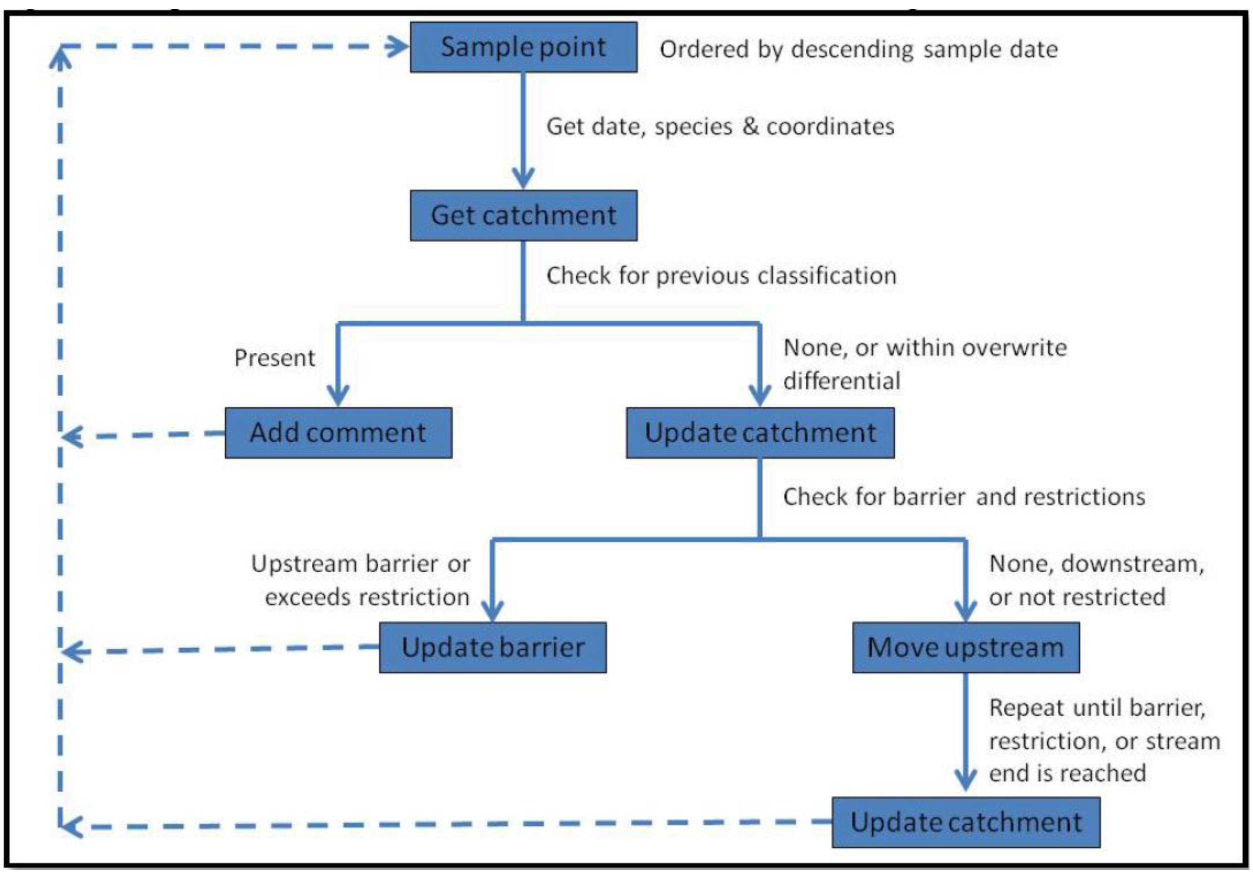
Overview

The EBTJV Catchment Updater presents coldwater resource managers with a means to update the species occurrence classification code through an intuitive browser-based mapping interface.

Rule Set

The Updater is a continuation of the 2015 EBTJV catchment classification effort in that it uses the most recent classification data and fields produced by that algorithm.

2015 Assessment catchment classification algorithm



2015 Assessment catchment classification data fields

Field	Description
EBTJV_Code	The classification code of the catchment based on salmonid species present
Catch_Cnt	Sequential upstream catchment count from the catchment containing the sample point used for classification
Cum_Length	Cumulative stream length from the catchment containing the sample point used for classification
Samp_Year	The year in which the sample point used for classification was conducted
Samp_Dist	The Euclidian distance of the sample point location from the flowline (only calculated for catchments containing the sample point used for classification)
Samp_OID	The object identifier (fid) of the sample point used for classification
Dam	Whether or not the catchment contains a barrier
Samp_Loc	Whether the sample point is above or below the barrier (only determined for catchments containing the sample point used for classification and a barrier)
Str_Order	The stream order of the flowline associated with the catchment
Comment	Adds the classification code and sample year for additional sample points located in the catchment

Catchment classification consisted of determining which salmonid species were present, and how long ago the sample was conducted. All samples occurring greater than 10 years from the analysis year were given a 'P' after the code representing 'predicted'. Catchments upstream of a sample point were inferred from the downstream catchment, and given the classification code of that catchment, until a barrier, different sample, or stream end was encountered. The below table details the different classification codes (BKT = brook trout, BNT = brown trout, RBT = rainbow trout):

Species Present	Code
Not Classified	-1
None	0
None	0P
BNT	0.2
RBT	0.3
BNT & RBT	0.4
Stocked BKT	0.5
BKT	1.1
BKT & BNT	1.2
BKT & RBT	1.3
BKT & BNT & RBT	1.4
BKT & Stocked BKT	1.5

Certain accommodations ended up being necessary due to the sometimes absence of smaller streams in the flowline layer, and the occurrence of multiple stream reaches in a single catchment.

Examples of likely scenarios in which users may need to manually edit a catchment's classification are listed below, along with a supplied reason that should be used as justification in order to standardize data across the range.

- If a catchment includes a portion of the mainstem and tributary and two data points occur in the same catchment in the same year with conflicting results (e.g., Brown Trout in mainstem and Brook Trout in tributary), manually update to the catchment code that best describes the trout community and select "**Conflicting data**". In some cases, this may result in a sympatric patch code.
- If a biologist knows that a barrier is present which changes trout community upstream of the barrier but it is not reflected in the data, manually update catchment code to reflect their knowledge of the stream and in comments for manual edit, select "**Known barrier**".
- The most recent survey results (e.g., allopatric Brook Trout) conflicts with knowledge from prior surveys (e.g., sympatric Brook Trout and Rainbow Trout) and biologist knows Rainbow Trout are still in the stream but the sampling did not pick them up this year because they occur in low density, manually update to the code that best describes the trout community and select "**Biologist knowledge**".
- If data is outdated and includes an inaccurate entry for a trout species present, (e.g., only data available was from 1981 and includes a hatchery rainbow trout that was recorded as a wild Rainbow Trout and is changing the catchment to sympatric Brook Trout and Rainbow Trout, manually update to the code that best describes the trout community and select "**Outdated data**".
- If a situation occurs in which a manual edit is needed and does not fall within the categories outlined above, manually update to the code that best describes the trout community and select "**Other**" and provide brief rationale for why update was made.

Quick Start

Throughout the Updater tool, additional information about a tool or an item can be found by hovering over the icon or the object itself to display a tooltip.

Given the high number of classification scenarios possible from complex spatial and temporal datasets involved with this project, we recommend the following steps as a means to better control and track the update process:

1. Only use sample data that has been collected since the last catchment update
2. Parse the sample data into hydrologic units (e.g. HUC8 or HUC10) to avoid overwriting previous edits
3. Import data using the file import method first, followed by manual edits to prevent overwriting updates.

4. For file imports, download the 'Confirm Edits' table as a CSV file to keep as a record of the updates.

Data Format

When using the 'Import File' method to make updates, the data can be saved as either an Excel or CSV file. Excel files with multiple worksheets will require the user to select the appropriate one. **IMPORTANT**: CSV files cannot have internal commas in any field.

Data should be formatted in rows, where a row represents a sampling event, and must contain information on:

- **Sample location**
  - Coordinates (decimal degrees), or
  - Catchment feature ID
- **Salmonid species present**
  - EBTJV code, or
  - Species occurrence data - A column for each species (BKT, BNT, RBT, stocked BKT (optional))
    - Species occurrence data can be represented by an integer >= 1, or by the word 'true'
- **Sample date**
  - MM/DD/YYYY format

Example data file formats

- Species occurrence (True/False) & Coordinates Excel file
- Species occurrence (counts) & Feature IDs CSV file
- EBTJV codes & Coordinates Excel file (multiple worksheets)
- EBTJV codes & Feature IDs CSV file

Additional Info

Extend Upstream: This is an option in both the manual edit and import file update options that uses information from the 2015 catchment classification, specifically the 'Catchment Count' and 'Sample OID' fields, to update any upstream catchments (catchment counts greater than focal catchment) classified by the same sample data (sample OID).

This option is only available to states classified using the 2015 algorithm (northern states) and should be used with caution as data overwriting is possible.

Tool Development Team

- Jason Coombs
- Keith Nislow

Questions or comments should be directed to Jason Coombs at jcoombs@umass.edu.

Optimal Performance Requirements

The tool is currently supported on the latest versions of all major web browsers, however, Google Chrome is highly recommended for the best user experience. The tool is not intended for use on mobile devices, and is a memory-intensive application. Older computers may have difficulty rendering the interface resulting in sluggish performance. If you run into issues, we recommend closing all other programs and browser tabs to increase available memory.

Design and Implementation

The following open-source software libraries were used to create the EBTJV Catchment Updater:

- **PostgreSQL**: Relational database
- **PostGIS**: Spatial database extension for PostgreSQL
- **Node.js**: Web server runtime environment
- **Express**: Web server framework and API
- **Leaflet**: Interactive map framework
- **D3.js**: Data visualization, mapping and interaction
- **Bootstrap**: Front-end framework and styling
- **jQuery.js**: JavaScript library
- **Intro.js**: Guide and feature introduction

Future Work and Contact Info

Development of this tool is currently ongoing. If you have any questions or encounter any errors, please contact Jason Coombs at jason_coombs@fws.gov.

Tool Version

v1.0.0 - 04-20-2022

- Initial release

Datasets

- A list of sources for polygon layers.

Polygon Layers

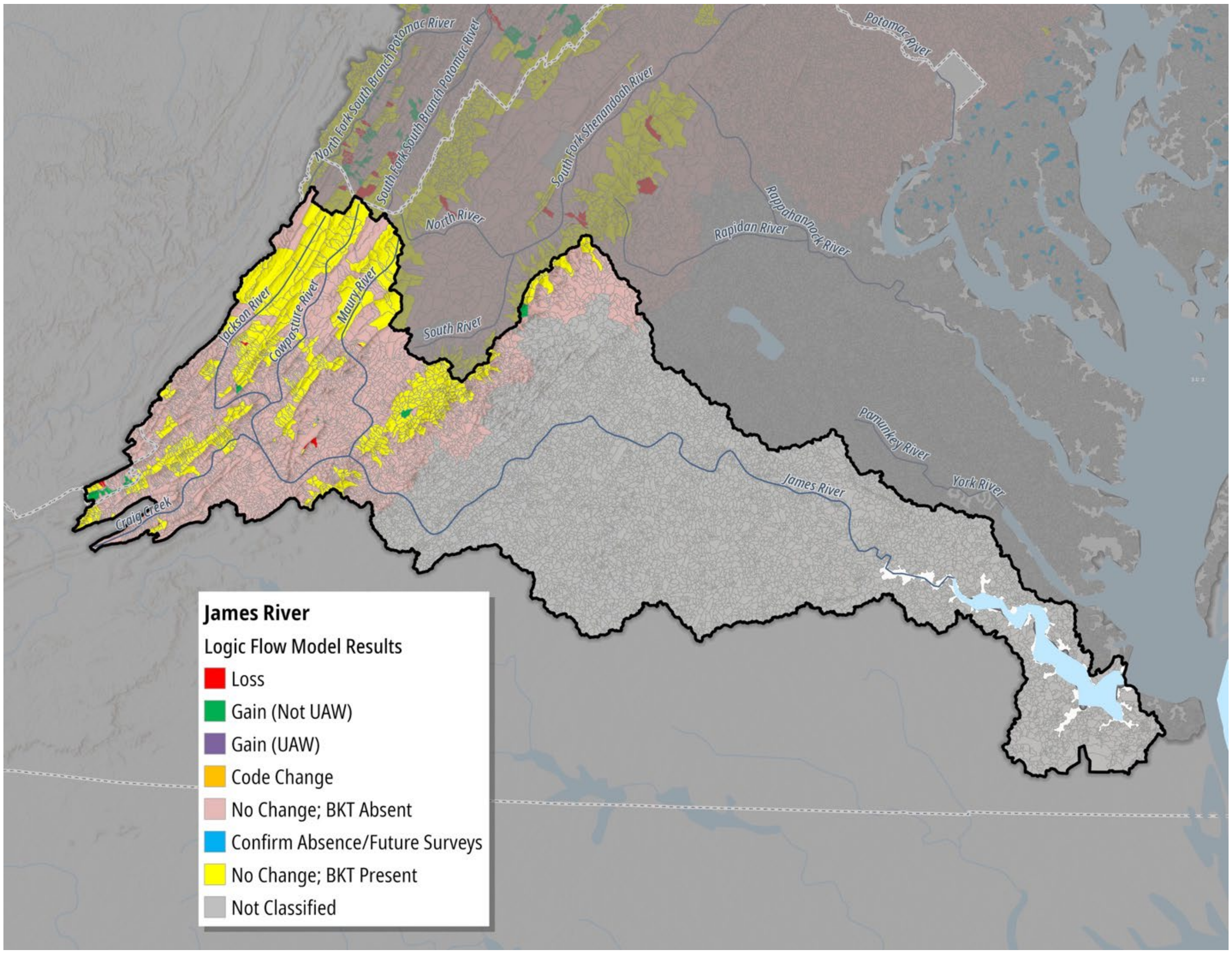
Name	Source	Download
States	United States Census Bureau	
Counties	United States Census Bureau	
HUC-6	USDA Geospatial Data Gateway	
HUC-8	USDA Geospatial Data Gateway	
HUC-10	USDA Geospatial Data Gateway	
HUC-12	USDA Geospatial Data Gateway	
Streams	NHDPlus v2 Streams	

Principal funding for this tool was contributed by the Eastern Brook Trout Joint Venture

Additional support was provided by: US Forest Service: Northern Research Station | University of Massachusetts, Amherst

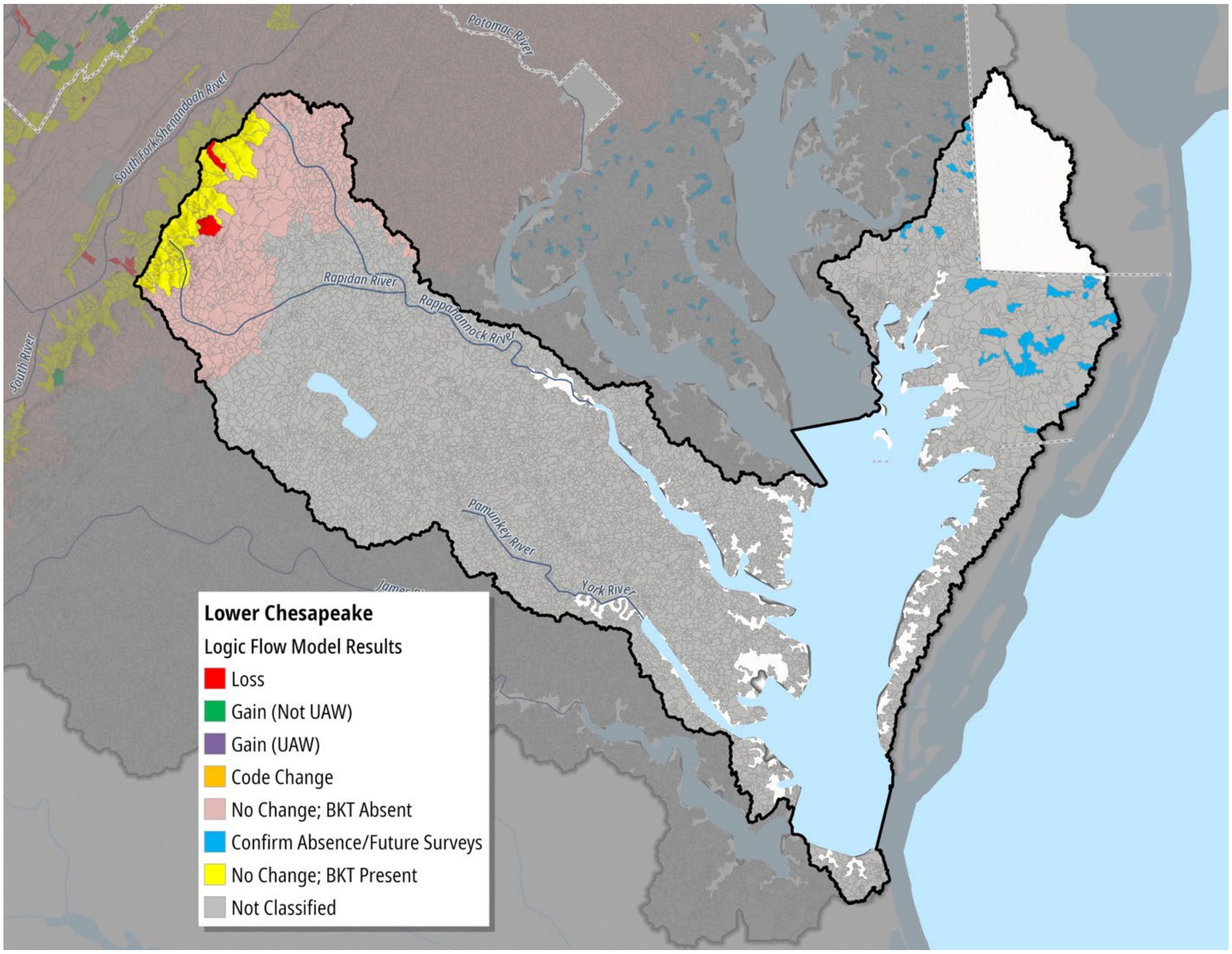
Appendix 6: Results of the Logic Flow Model at the HUC6 level. Maps show catchments which are color-coded based on brook trout population change, the tables show square kilometers for each of the Logic Flow Model categories.

James River HUC6



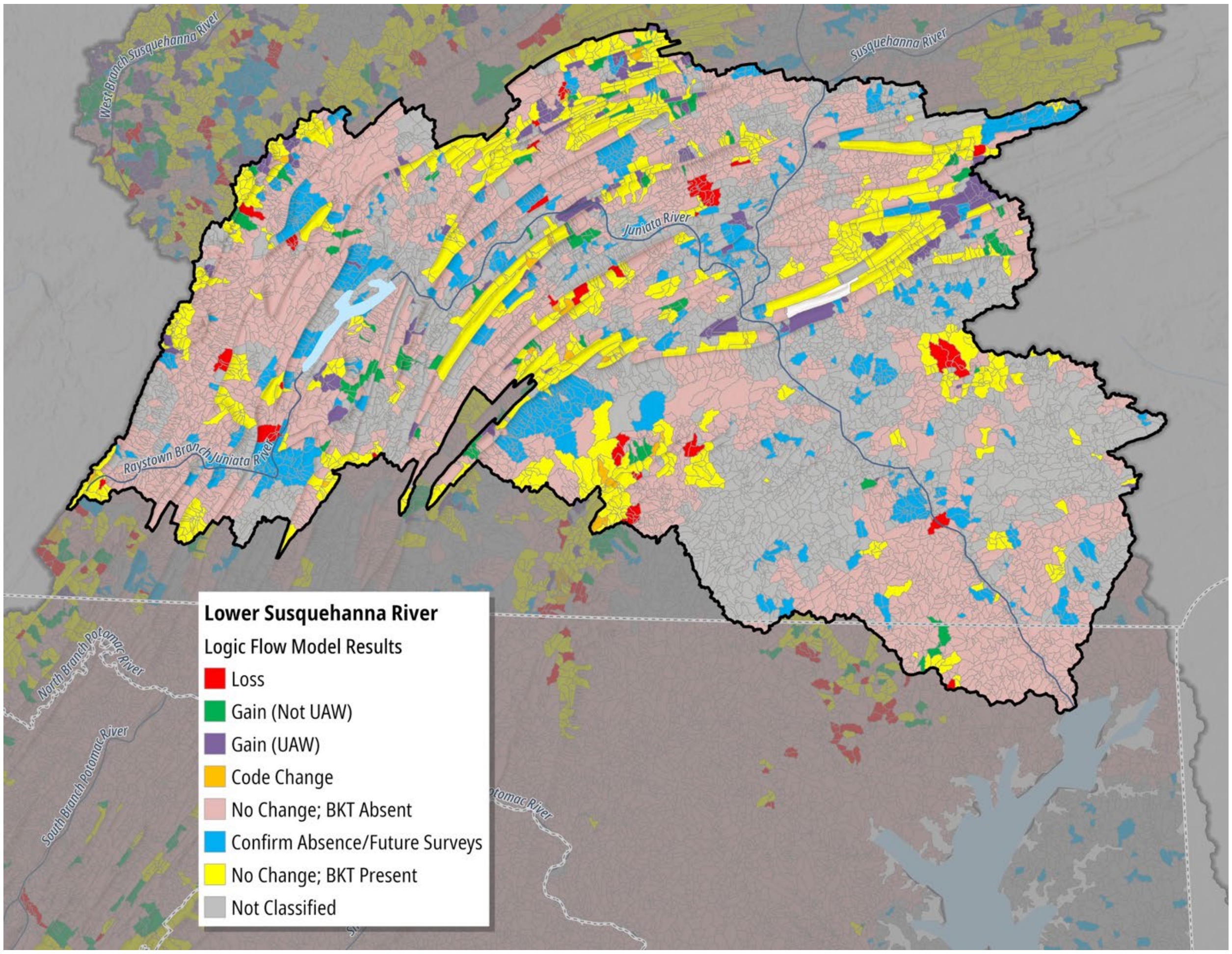
Logic Flow Model Output	Square Kilometers
BKT Loss	18
Total Loss	*18*
Gain Gain - Modeled Gain - Modeled; Biologist Knowledge	63
Total Gain; not UAW	*63*
Gain - Modeled; Biologist Knowledge; UAW Gain - Modeled; UAW Gain - UAW	
Total Gain; UAW	*0*
Code Change; Biologist Knowledge New Sampling; Code Change; BKT Present	
Total Code Change	*0*
No Change; BKT Absent *2016 Code Applied; BKT Absent*	*100* *6,786*
Total No Change; BKT Absent	*6,886*
Confirm Absence/Future Surveys	4,637
Total Confirm Absence/Future Surveys	*4,637*
2016 Code Applied; BKT Present New Sampling; Confirms 2016 Code; BKT Present No Change; Biologist Knowledge; BKT Present No Change; BKT Present No Change; BKT Present, Modeled	2,164 1,100
Total No Change; BKT Present	*3,264*
Not Classified	15,829
Total Not Classified	*15,829*
Grand Total	***76,945***

Lower Chesapeake HUC6



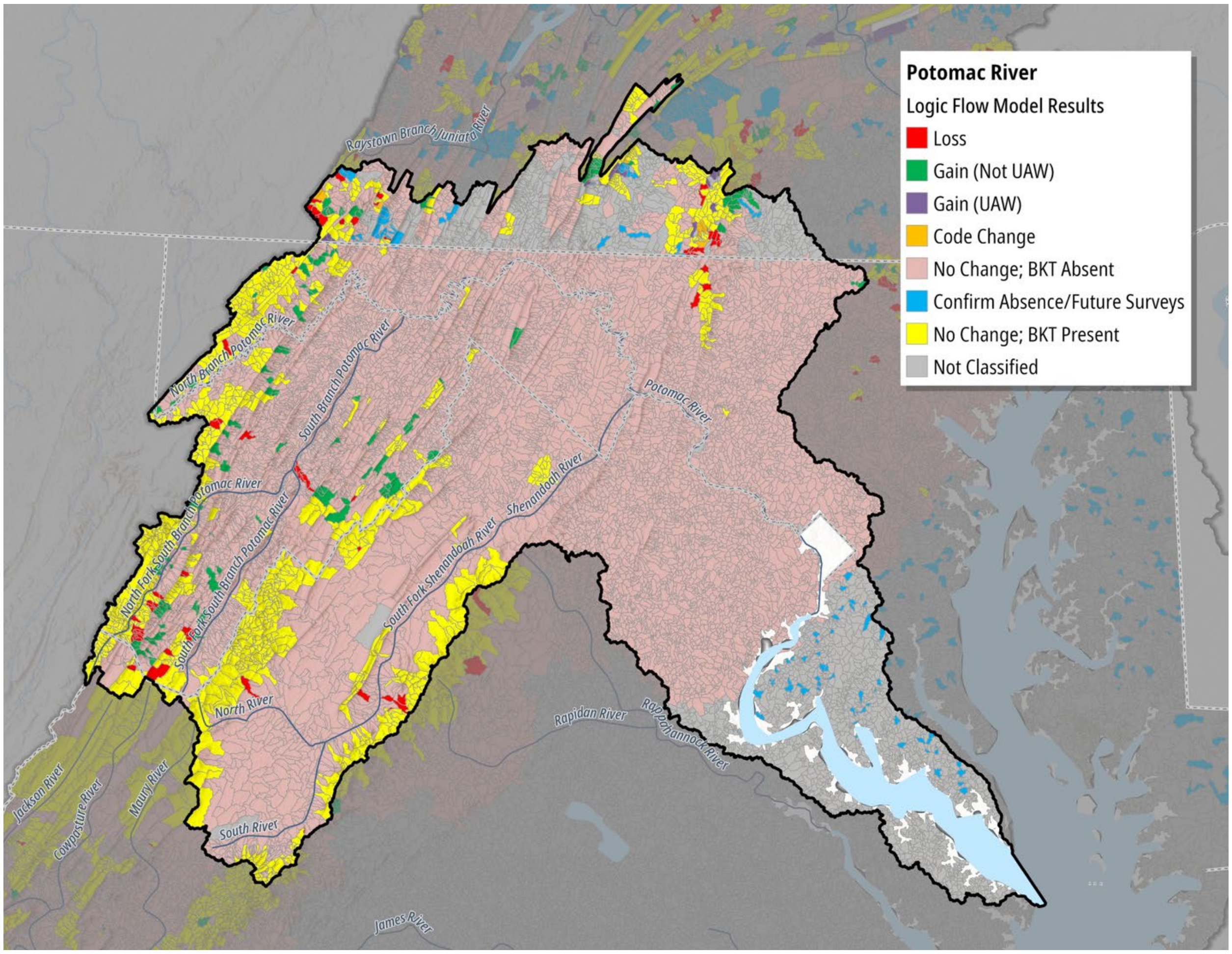
Logic Flow Model Output	Square Kilometers
BKT Loss	51
Total Loss	*51*
Gain Gain - Modeled Gain - Modeled; Biologist Knowledge	
Total Gain; not UAW	*0*
Gain - Modeled; Biologist Knowledge; UAW Gain - Modeled; UAW Gain - UAW	
Total Gain; UAW	*0*
Code Change; Biologist Knowledge New Sampling; Code Change; BKT Present	
Total Code Change	*0*
No Change; BKT Absent *2016 Code Applied; BKT Absent*	 *2,241*
Total No Change; BKT Absent	*2,241*
Confirm Absence/Future Surveys	289
Total Confirm Absence/Future Surveys	*289*
2016 Code Applied; BKT Present New Sampling; Confirms 2016 Code; BKT Present No Change; Biologist Knowledge; BKT Present No Change; BKT Present No Change; BKT Present, Modeled	360 212
Total No Change; BKT Present	*572*
Not Classified	16,200
Total Not Classified	*16,200*
Grand Total	***19,353***

Lower Susquehanna River HUC6



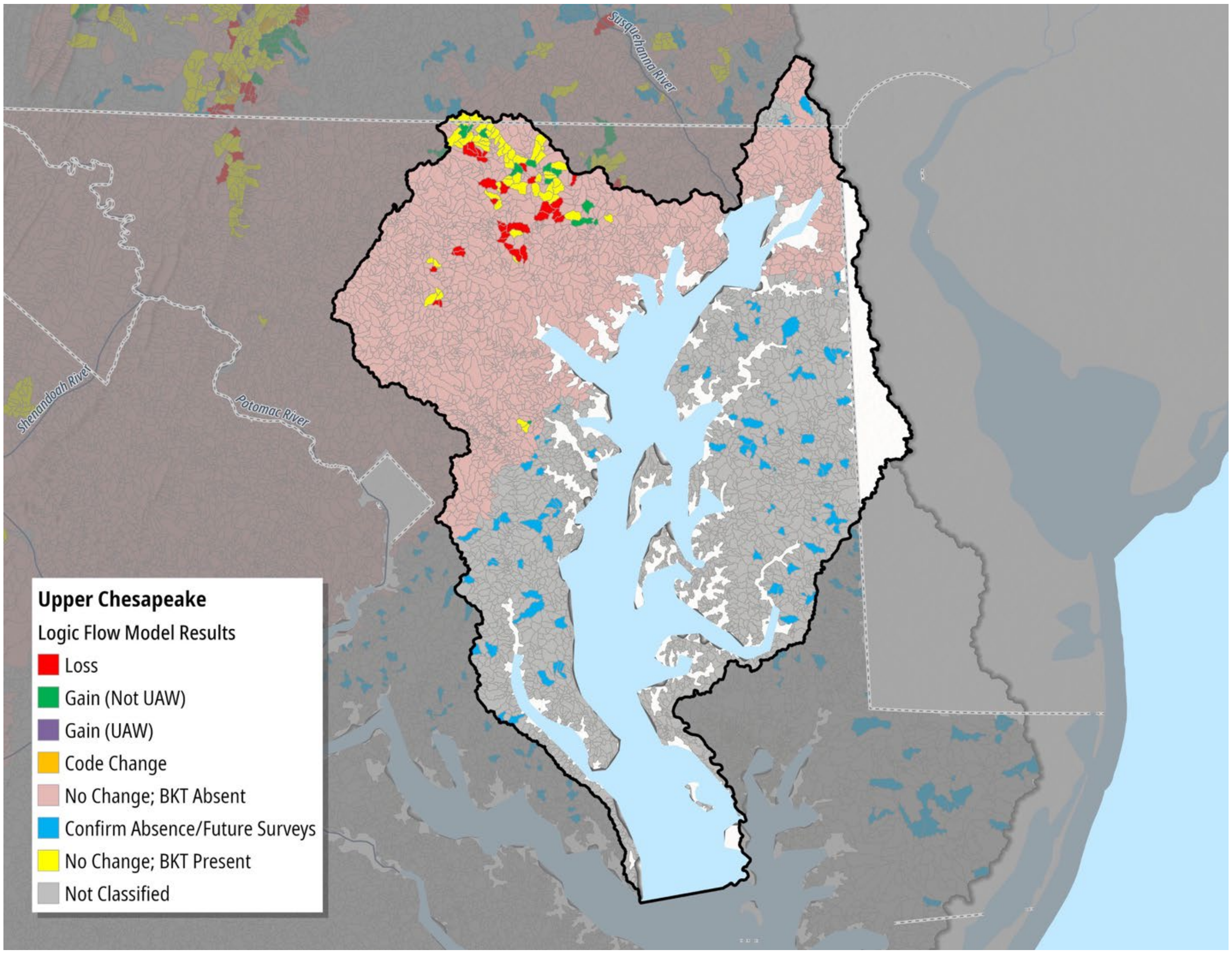
Logic Flow Model Output	Square Kilometers
BKT Loss	275
Total Loss	*275*
Gain	274
Gain - Modeled	84
Gain - Modeled; Biologist Knowledge	
Total Gain; not UAW	*359*
Gain - Modeled; Biologist Knowledge; UAW	
Gain - Modeled; UAW	223
Gain - UAW	288
Total Gain; UAW	*511*
Code Change; Biologist Knowledge	
New Sampling; Code Change; BKT Present	87
Total Code Change	*87*
No Change; BKT Absent	*2,407*
2016 Code Applied; BKT Absent	*7,085*
Total No Change; BKT Absent	*9,492*
Confirm Absence/Future Surveys	1,990
Total Confirm Absence/Future Surveys	*1,990*
2016 Code Applied; BKT Present	2,546
New Sampling; Confirms 2016 Code; BKT Present	101
No Change; Biologist Knowledge; BKT Present	
No Change; BKT Present	560
No Change; BKT Present, Modeled	266
Total No Change; BKT Present	*3,474*
Not Classified	7,635
Total Not Classified	*7,635*
Grand Total	***23,821***

Potomac River HUC6



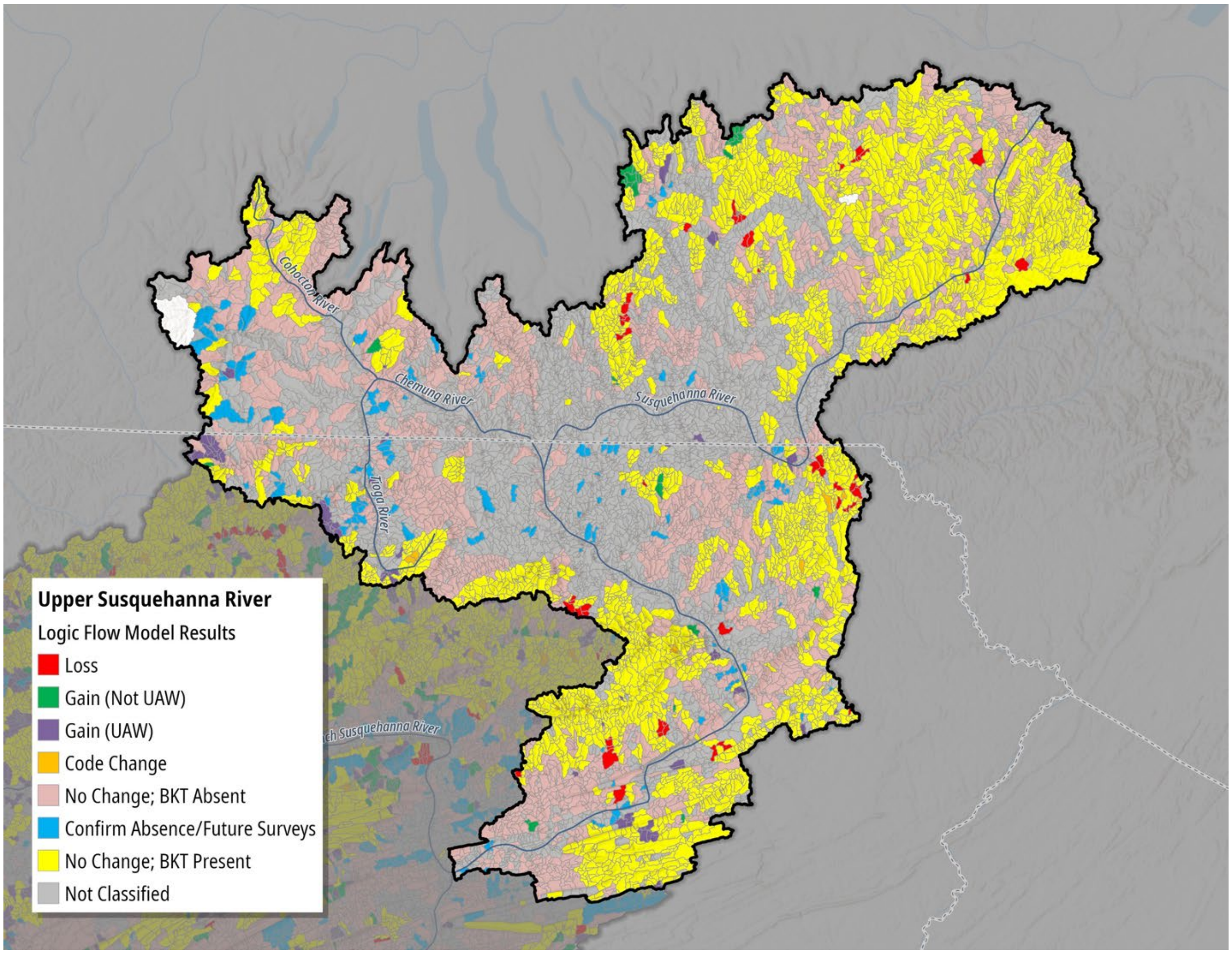
Logic Flow Model Output	Square Kilometers
BKT Loss	295
Total Loss	*295*
Gain	488
Gain - Modeled	70
Gain - Modeled; Biologist Knowledge	
Total Gain; not UAW	*558*
Gain - Modeled; Biologist Knowledge; UAW	
Gain - Modeled; UAW	10
Gain - UAW	36
Total Gain; UAW	*46*
Code Change; Biologist Knowledge	
New Sampling; Code Change; BKT Present	37
Total Code Change	*37*
No Change; BKT Absent	*1,405*
2016 Code Applied; BKT Absent	*23,940*
Total No Change; BKT Absent	*25,345*
Confirm Absence/Future Surveys	289
Total Confirm Absence/Future Surveys	*289*
2016 Code Applied; BKT Present	3,207
New Sampling; Confirms 2016 Code; BKT Present	35
No Change; Biologist Knowledge; BKT Present	
No Change; BKT Present	1,540
No Change; BKT Present, Modeled	26
Total No Change; BKT Present	*4,809*
Not Classified	4,972
Total Not Classified	*4,972*
Grand Total	***36,350***

Upper Chesapeake HUC6



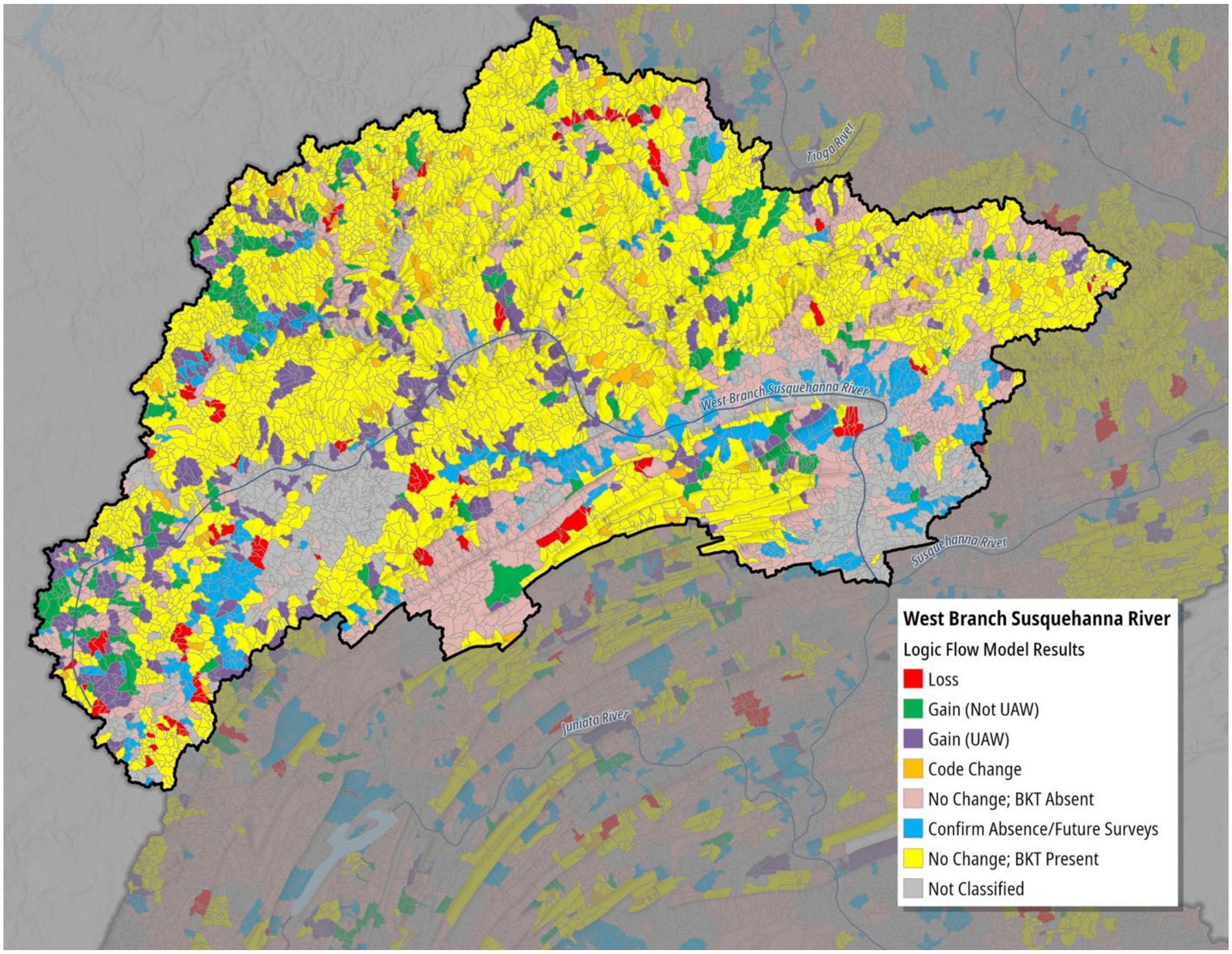
Logic Flow Model Output	**Square Kilometers**
BKT Loss	115
Total Loss	*115*
Gain Gain - Modeled Gain - Modeled; Biologist Knowledge	45
Total Gain; not UAW	*45*
Gain - Modeled; Biologist Knowledge; UAW Gain - Modeled; UAW Gain - UAW	
Total Gain; UAW	*0*
Code Change; Biologist Knowledge New Sampling; Code Change; BKT Present	
Total Code Change	*0*
No Change; BKT Absent	*873*
2016 Code Applied; BKT Absent	*3,848*
Total No Change; BKT Absent	*4,721*
Confirm Absence/Future Surveys	368
Total Confirm Absence/Future Surveys	*368*
2016 Code Applied; BKT Present	78
New Sampling; Confirms 2016 Code; BKT Present	
No Change; Biologist Knowledge; BKT Present	
No Change; BKT Present	138
No Change; BKT Present, Modeled	
Total No Change; BKT Present	*216*
Not Classified	5,000
Total Not Classified	*5,000*
Grand Total	***10,465***

Upper Susquehanna River HUC6



Logic Flow Model Output	**Square Kilometers**
BKT Loss	245
Total Loss	*245*
Gain	46
Gain - Modeled	73
Gain - Modeled; Biologist Knowledge	
Total Gain; not UAW	*120*
Gain - Modeled; Biologist Knowledge; UAW	39
Gain - Modeled; UAW	146
Gain - UAW	56
Total Gain; UAW	*241*
Code Change; Biologist Knowledge	
New Sampling; Code Change; BKT Present	39
Total Code Change	*39*
No Change; BKT Absent	*318*
2016 Code Applied; BKT Absent	*7,462*
Total No Change; BKT Absent	*7,780*
Confirm Absence/Future Surveys	627
Total Confirm Absence/Future Surveys	*627*
2016 Code Applied; BKT Present	8,277
New Sampling; Confirms 2016 Code; BKT Present	85
No Change; Biologist Knowledge; BKT Present	
No Change; BKT Present	673
No Change; BKT Present, Modeled	706
Total No Change; BKT Present	*9,742*
Not Classified	10,356
Total Not Classified	*10,356*
Grand Total	***29,148***

West Branch Susquehanna River HUC6



Logic Flow Model Output	Square Kilometers
BKT Loss	375
Total Loss	*375*
Gain	623
Gain - Modeled	340
Gain - Modeled; Biologist Knowledge	8
Total Gain; not UAW	*970*
Gain - Modeled; Biologist Knowledge; UAW	193
Gain - Modeled; UAW	736
Gain - UAW	485
Total Gain; UAW	*1,414*
Code Change; Biologist Knowledge	19
New Sampling; Code Change; BKT Present	293
Total Code Change	*312*
No Change; BKT Absent	*974*
2016 Code Applied; BKT Absent	*1,700*
Total No Change; BKT Absent	*2,673*
Confirm Absence/Future Surveys	1,075
Total Confirm Absence/Future Surveys	*1,075*
2016 Code Applied; BKT Present	5,531
New Sampling; Confirms 2016 Code; BKT Present	329
No Change; Biologist Knowledge; BKT Present	5
No Change; BKT Present	2,029
No Change; BKT Present, Modeled	1,277
Total No Change; BKT Present	*9,171*
Not Classified	2,086
Total Not Classified	*2,086*
Grand Total	***18,075***