Stream Health

Management Strategy

2015–2025, v.4

I. Introduction

Restoring health to local rivers and streams not only benefits the fish, wildlife and people using them, but is a necessary step toward meeting water quality standards in the Chesapeake Bay. Over 100,000 stream miles drain from the vast Chesapeake watershed and connect it to its receiving water body—the Bay. Many of these streams are impaired, and management actions are needed to improve the physical, chemical and biological functions of such streams while continuing to maintain the health of less degraded streams. This increases the total number of healthy streams across the watershed. Because stream health is affected by numerous factors, both on the land and in the water and resulting directly or indirectly from human activities, the success of this strategy recognizes an inherent connection to actions under other outcomes, such as wetlands, forest buffers, brook trout, healthy watersheds, toxic contaminants and implementation of water quality best management practices (BMPs).

II. Goal, Outcome and Baseline

This management strategy identifies approaches for achieving the following goal and outcome:

Vital Habitats Goal

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.

Stream Health Outcome

Continually improve stream health and function throughout the watershed. Improve health and function of 10 percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed.

This outcome will be tracked via improvements in the Chesapeake Basin-wide Index of Biotic Integrity (Chessie BIBI). The Chessie BIBI is derived using individual federal, state, county and volunteer benthic macroinvertebrate datasets collected with similar procedures and analyzed with a common method agreed to by the Bay Program's Stream Health Workgroup.

For purposes of this strategy, the goal for stream health and function is to improve 10 percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed. As the Stream Health outcome includes a Basin scale metric to measure the improvement in stream health and function, this Management Strategy offers a complementary function-based approach to stream health addressing watershed level stressors and reach-level stream functions. Function-based metrics provide the ability to report and track incremental changes in stream health resulting from addressing stressors and improving stream function.

Millions of dollars are invested in management actions annually to address the Bay total maximum daily load, yet studies often find limited biological or ecological lift in local streams. Ecological restoration aims to speed up the slow process of environmental healing, working to accomplish in just a few years what might otherwise take decades. Restoration of physicochemical variables can create a template for biotic recovery even though uplift may not occur immediately following restoration. More needs to be done to understand and communicate how streams respond to management actions once priority stressors are mitigated or removed. Currently, the Chessie BIBI (Chesapeake Basin-wide Indicator of Biological Integrity) is the sole indicator of stream health utilized by the Stream Health Workgroup (SHWG). While it is an excellent indicator of the overall biotic community, the data necessary for analyses are collected in 5-year increments throughout the watershed. The Chessie BIBI does not necessarily reflect BMP-driven improvements in hydraulics, geomorphology, and physicochemical qualities because of the timeframe of the data collection and because watershed BMPs generally do not directly affect the benthic macroinvertebrate communities. However, hydraulics, geomorphology and physicochemical parameters are also components of stream health and must be in good condition to support biological communities.

Baseline and Current Condition

CBP uses the Chessie BIBI as a “stream health indicator.” Index results were included in the CBP’s *Bay Barometer* reports between 2008 and 2012, and after 2016. The index is mentioned specifically as a measure of stream restoration progress in the 2009 Executive Order 13508, *Draft Strategy for Protecting and Restoring the Chesapeake Bay*.[1] It is a biological endpoint that will reflect the improvements in stream health and function called for in the 2014 *Chesapeake Bay Watershed Agreement*. The database used to generate index values is currently being updated with the most recent macroinvertebrate data from states and local jurisdictions.

The Interstate Commission on the Potomac River Basin (ICPRB) convened a workshop in April 2018 to identify the "2008 baseline" referred to in the Stream Health Outcome. Participants selected 2006 - 2011 as the baseline period. ICPRB used additional data submitted in a 2019 data call to update the non-tidal macroinvertebrate database and establish the 2008 Baseline for the Chessie BIBI. The baseline is derived solely from monitoring data and indicates that macroinvertebrate populations in about 62% of stream miles in the Chesapeake Bay watershed, or about 89,317 miles, were in Fair, Good, or Excellent condition. Subsequent analysis of the “first interval” period (2012 - 2017) indicates an increase in Fair, Good, or Excellent conditions to approximately 68%, or about 98,049 miles, of streams. Data for a third “pre-baseline” period (2000 - 2005) was also analyzed, with 57.% of streams, approximately 82,576 miles, rated Fair, Good, or Excellent. See ICPRB Report #ICP23-1.[2]

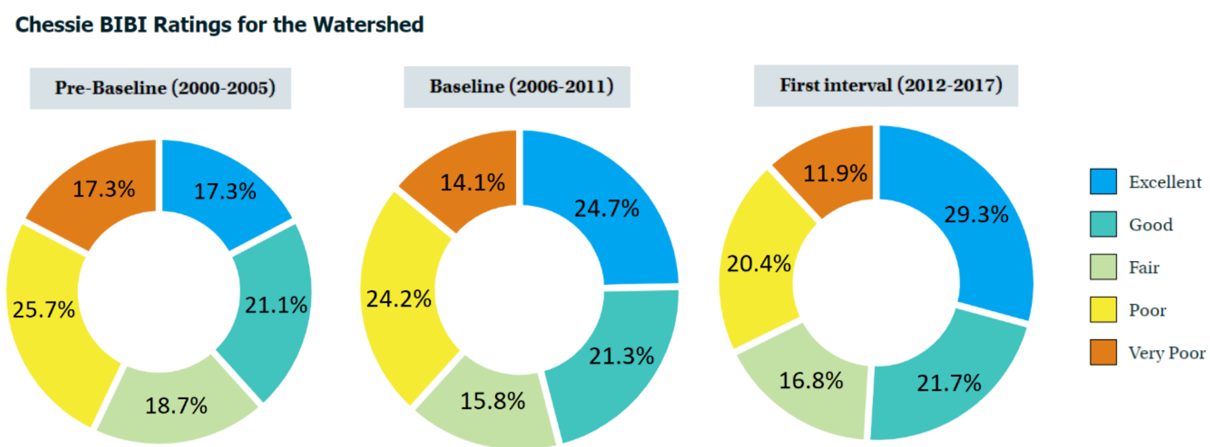

Figure 1. Chessie BIBI Ratings for the Watershed, Chesapeake Progress.[3]

[1] Smith, Zachary M., Claire Buchanan, and Andrea Nagel. 2017. Refinement of the Basin-Wide Benthic Index of Biotic Integrity for Non-Tidal Streams and Wadeable Rivers in the Chesapeake Bay Watershed. ICPRB Report 17-2. Interstate Commission on the Potomac River Basin, Rockville, MD. Accessed September 2024: https://www.potomacriver.org/wp-content/uploads/2017/05/ChessieBIBI_Report_Final_5-25-2017.pdf

[2] C. Buchanan, R. D. Jepsen, and M. E. Mallonee. 2023. Stream Biological Health in the Chesapeake Bay Watershed. ICPRB Report ICP23-1. Report Prepared for the Chesapeake Bay Program Stream Health Workgroup. Accessed September 2024: https://www.potomacriver.org/wp-content/uploads/2023/02/ChesWatershed-Percent-Healthy-Streams_FINAL_02-10-2023-1.pdf

[3] *Stream Health - Chesapeake Progress*. (n.d.). Chesapeake Progress. Accessed September 2024: https://www.chesapeakeprogress.com/abundant-life/stream-health

Stream biological health across each of the categories of fair, good, and excellent showed increases for each of the three time periods, while poor and very poor categories decreased. This trend, showing continual improvement over time, may be due to the long-term efforts to conserve forests, preserve and restore riparian corridors and wetlands, mitigate acid rain and mine drainage, slow stormwater runoff, and reduce nutrients and sediment loads. However, there is significant regional variability and some areas of the watershed, especially urban areas, show degrading trends. The workgroup is exploring additional metrics for a variety of environmental stressors to help future investigations characterize Chesapeake watershed health and assess the reasons for the current trends.

III. Participating Partners

Team Lead: Vital Habitats Goal Team

Workgroup Lead: Stream Health Workgroup

Opportunities for Cross-Goal Team Collaboration: Fisheries Goal Team, Water Quality Goal Team and Healthy Watersheds Goal Team, Wetlands Workgroup, Fish passage, Riparian Forest buffers, Brook Trout Workgroup

Active Current Participation and Role

(Signatory agencies in bold)

Level of Participation: High

- Interstate Commission on the Potomac River Basin (ICPRB)
  - *Develops and refines Chessie BIBI index, compiles and evaluates raw monitoring data*
- U.S. Geological Survey (USGS)
  - *Provides technical support to assist with work plan*
  - *Develops model to predict Chessie BIBI ratings for unsampled streams and assist ICPRB in refining the selection of reference sites in the Chessie BIBI*
  - *Generates and translates science on status and responses of multiple indicators of stream health, and stream stressors, to watershed conditions and implementation of management actions.*
- U.S. Fish & Wildlife Service (USFWS)
  - *Manages and implements stream restoration projects, provides training on stream restoration assessment methods and development of guidance*
- U.S. Army Corps of Engineers (USACE)
  - *Review and approve stream restoration projects*
  - *USACE cost-shares stream and floodplain habitat restoration projects under its ecosystem restoration mission. Under administration policy, USACE does not generally cost-share projects undertaken for principal purpose of water quality improvement*
- **Environmental Protection Agency (EPA) Region III**
  - *Review and approval of stream restoration projects*
- **EPA Chesapeake Bay Program Office (CBPO)**

- *Partnership of federal, state and resource agencies to restore Chesapeake Bay*
- **Chesapeake Bay states (VA, MD, WV, DE, PA, NY) and District of Columbia natural resource, stormwater and permit approval agencies**
  - *Monitor stream conditions and health, implement/manage stream restoration projects and other best management practices (BMPs), provide funding to support project implementation. Provide guidance on stream restoration. Provide permit review and approval of stream restoration projects. Participate in Stream Health Workgroup and other CBP teams.*
- Chesapeake Bay Trust (CBT)
  - *Lead effort to organize pooled monitoring approach - Restoration Research Award Program, described on page 10*
- National Fish and Wildlife Foundation (NFWF)
  - *Provides funding for watershed restoration projects and BMPs to reduce nutrient and sediment loadings and improve habitat*

Level of Participation: Medium

- Natural Resources Conservation Service U.S. Department of Agriculture (USDA)
- University of Maryland, University of Maryland Center for Environmental Science (UMCES)
- Stroud Research Center
- Chesapeake Bay Foundation
- Center for Watershed Protection (CWP)
- Maryland Stream Restoration Association (MSRA)
- United States Forest Service (USFS)

Local Engagement

Local governments are responsible for the implementation of watershed Best Management Practices as part of the Phase III Watershed Implementation Plans (WIPs)[4]. Local governments, non-profit organizations and watershed and community associations are engaged in identifying potential BMP projects and organizing community events related to stream health. These organizations also conduct or support monitoring efforts throughout the watershed.

IV. Factors Influencing Success

To fully achieve this outcome, it is critical to address priority stressors to restore and maintain stream functions and improve local stream health, which will ultimately benefit the Bay. A stressor in the context of this strategy is any factor limiting to aquatic life, or stream processes, that occurs as a direct or indirect impact of current or past human actions. Stressors refer to both biological and physical properties. While there are a number of ways in which stream functions may be defined

[4] *Watershed implementation plans*. (n.d.). Chesapeake Bay. Accessed September 2024: https://www.chesapeakebay.net/what/programs/watershed-implementation-plans

(Supplementary Table 1), they are synergistic, or hierarchical in their function such that the quality and condition of each stream process impact others. Therefore, the processes and functions that are most critical to improve stream health will vary depending on what the stressors are for a stream and which of those stressors must be reduced or removed (Supplementary Table 1).

A thorough understanding of ecological stressors and factors, policy/administrative factors, and scientific knowledge and the application of research, is necessary to maintain and improve stream health and function at both the local and Bay-wide scale.

1. Ecological stressors and factors

Ecological stressors and factors are the physical, chemical and biological elements that impair or limit stream health recovery. They may also be watershed-based factors that limit stream function(s) or negatively affect downstream waters. Further, these factors affect stream health at two scales—local and downstream waters to the Bay. Management actions are needed to reduce stressors to improve stream health. Where appropriate and feasible, measures should be implemented outside of the stream and associated riparian (adjacent) area itself to correct or limit the stress to the aquatic ecosystem. A combination of measures may be highly effective as well, with practices put in place close to the source of stressor, as well as actions within the stream corridor. In cases where that is not practical, or where the problem originates physically only in the stream channel or valley itself, stream channel and floodplain restoration work might be optimal management measures. In these cases ecological uplift should be designed for, as this is the approach most likely to result in ecological improvements (stream health outcomes) beyond water quality improvement credits. Improvement in local streams overall, not just for nutrient and sediment reductions, is paramount to achieving this outcome. Many of the factors outlined below contribute a variety of pollutants to impaired waters, as defined and listed by the Clean Water Act Section 303(d), for which local Total Maximum Daily Loads (TMDLs) of specific pollutants are established. Ecological stressors and factors influencing the outcome include:

Within the stream channel and riparian/floodplain factors:

- Excessive sediment and nutrients in-stream from unstable stream banks and legacy sediments in the floodplain.
- Limited nutrient and organic processing-instream.
- Alteration in channel form and function resulting in instability and disequilibrium affecting diversity and quality of habitat.
- Concentrated flows and reduction in baseflows.
- Higher discharges in stream channels.
- Piped and channelized streams; undersized culverts.
- Removal/Loss of forested riparian or wetland areas and the benefits provided by shading and natural biogeochemical processes.
- Degraded soils in riparian area
- Physical loss of streams due to mining activities
- Barriers to connectivity and stream fragmentation

- Other tradeoffs

Watershed-based factors:

- Impervious cover and increases in stormwater runoff.
- Significant changes in watershed hydrology (time of concentration) related to overland flow impacted by road drainage, agricultural land drainage, driveways, stormwater collection systems, etc.
- Flow alteration and flashy hydrology.
- Excessive nutrient loading to streams from excess untreated runoff (agricultural and urban) from the upland areas in the watershed and groundwater.
- Inadequate stormwater management controls (e.g. BMPs).
- Leaky wastewater infrastructure.
- Toxicity of effluent from resource extraction activities (i.e., acid mine drainage, fracking).
- Road de-icing practices (salt).
- Thermal impacts.
- Invasive species.
- Loss of forest and wetlands.
- Endocrine disrupting chemicals and other contaminants (e.g. metals, pesticides).

2. Policy, funding and administrative factors

Policy, funding and administrative factors limit the implementation potential of an action. Stressors degrading streams that originate from watershed land uses or from leaky public and private wastewater infrastructure are often very challenging to address because of the scale of the problem, cost of remediation, difficulty of acquiring space for remediation projects and other challenges. Establishing policies and funding mechanisms to address these stressors would lessen these barriers to implementation. The current assessment of jurisdictions to meet their 2025 WIP targets heightens the need to address these factors to implement projects that meet the sediment and nutrient load reductions necessary to improve Bay health while maintaining and improving local stream health. Factors that influence the outcome include:

- Lack of common watershed, stressor and stream assessment and restoration guidelines.
- Integration of water quality and living resource goals during WIP stream restoration.
- Municipal Separate Storm Sewage System (MS4) permits focus on water quality.
- Adequate financial resources to support local implementation efforts.
- Adequate extension infrastructure to communicate newest research and technical guidance to jurisdictions.
- In very urban areas, the availability of land to retrofit and implement upland BMPs.
- Increases in flooding and potential loss of federal flood insurance coverage

- Current lack of crediting for stream health beyond modeled nutrient and sediment reductions
- Resource tradeoffs
- Failure to design for ecological uplift and maintaining existing high quality resources
- Lack of crediting/incentives for ecosystem improvements beyond nutrient and sediment reduction
- Public perception of stream restoration

3. Scientific knowledge and application of research factors

Scientific knowledge and application of research factors are related to our current understanding of streams and their response to management interventions and the ability to effectively translate the most up-to-date scientific understanding to address *Watershed Agreement*[5] outcomes and regulatory guidance. Factors that influence the outcome include:

- Stressor identification and prioritization procedures.
- Functional metrics that correlate with priority stressors identified for measurement.
- Robust stream restoration monitoring to evaluate the potential functional improvement in stream functions from BMP implementation.
- Possible lag times that affect the ability to evaluate the effect of upland BMP on stream health.
- Research needed to guide the selection of achievable reference conditions/design approaches based on watershed and stream functions to include an urban reference continuum.
- Difficulty in incorporating new metrics into determination of stream health
- Lengthy timeframe for adjusting BMP credit or recognizing new BMPs based on new scientific information.
- Limitations of the applicability of the Chessie BIBI (and other similar ecological data) to streams where restoration work is being conducted on an annual basis.
- Identifiable nutrient hotspots in stream valleys where erodible geologic materials and soils contain excess nutrients.
- Additional research to refine nutrient credits for stream restoration projects as supported by the BMP Expert Panel recommendations on individual stream restoration projects to include (e.g. bioavailability of nutrients).
- Potential failure for stream restoration BMP designs to consider and include science of stream, floodplain, and watershed factors which influence stream health in a comprehensive ecosystem approach for biological uplift to reduce or avoid resource tradeoffs.

[5] *Chesapeake Bay Watershed Agreement.* Signed June 16, 2014 Accessed September 2024: https://www.epa.gov/sites/default/files/2016-01/documents/attachment1chesapeakebaywatershedagreement.pdf

4. **Partner coordination**

   Partner coordination is an important factor influencing success across state and jurisdictional borders. With streams such an integrated part of the ecosystem, there are many additional CBP outcomes that rely on stream health. Efforts in the current work plan highlight the importance of coordinating, not only within the workgroup, but also across workgroups to achieve functional improvement across the stream habitat. Additionally, the linear nature of streams causes them to cross borders into different states or jurisdictions. It is important to ensure that efforts are coordinated up and downstream.

5. **Funding**

   Funding sources in the watershed are diverse. The current work plan aims to take advantage of several different sources to research support for functional improvement and other stream health cornerstones.

V. Current Efforts and Gaps

Gaps

Information & Data

The Habitat Goal Implementation Team (GIT), recognizes that streams are on a spectrum of health from those that are deemed impaired to those that the states have identified as being outstanding and healthy. However, there is a data gap that needs to be addressed in order to develop a method to track the improvement/degradation of the marginal streams, along with impaired streams. Current gaps in this area include:

- Benthic macroinvertebrates data from enough streams with enough frequency to track progress over time. Chessie BIBI provides limited capacity for annual tracking.
- Watershed-wide and stream metrics other than current biological indices, such as the Chessie BIBI, to assess physical and chemical health and functions of streams.
- Update or review of methods to define reference conditions or endpoints for streams.
- Sufficiency of data to demonstrate effectiveness of stream restoration practices for biological uplift.
- Develop a watershed-wide database of freshwater mussels with a goal to evaluate feasibility and need for an assessment of mussel habitat and their impacts on stream health
- Effects of Climate and Land Use Change and implementation of BMPs on stream health

Regulatory & Programmatic

The Stream Health and Healthy Watersheds outcomes are complementary in that one focuses on improving the health of degraded streams (Stream Health outcome) while the other works to maintain

100 percent of state-identified current healthy waters and watersheds (Healthy Watersheds). Streams that are in the "middle"—or marginally healthy—are at potential risk of becoming the impaired or degraded stream reaches of tomorrow that could offset any progress in neighboring or downstream reaches. Current gaps in this area include:

- Collaboration with the Healthy Watersheds GIT to identify marginal streams and various definitions for stream health.
- Project design process for stream restoration that can measure change in stream functions and project success based on project goals and objectives. Specific to the Chesapeake Bay TMDL, a design process for restoration projects to reduce nutrient and sediment loads delivered downstream while at the same time ensuring optimal habitat conditions are restored.
- Information to support innovative, effective design approaches to identify restoration potential and success for different land uses, stream types and current and future site constraints and causes of impairment/stressors (e.g. legacy sediment, contaminants in water and sediment, runoff volume and velocity, increased discharge from undersized culverts).

Prioritization

Restoration activity in all streams should proceed carefully such that appropriate restoration designs are taken to maintain and enhance the existing stream ecosystem. As streams have degraded over time, further research is needed to understand and predict how the streams will react to anthropogenic and natural pressures. It is likely that peak improvements in stream health in highly degraded streams will be constrained by watershed conditions (e.g. Chessie BIBI will not exceed fair). However, as these streams may be located in ultra-urban environments, limited improvements may contribute towards broader societal benefits (e.g. environmental justice). Current gaps in this area include:

- Targeting procedures for cost-effective restoration actions and design approaches that will achieve both water quality and biological functional improvement. WIPs provide a level of analysis on the type and mix of projects to meet load reductions and associated costs. The process to identify the projects varies by jurisdiction along with cost estimates.
- Prioritizing projects that reduce stressor impacts or principle stressors, if practical.
- Explore targeting and prioritization strategies for underserved and overburdened communities.
- Investments in research to improve the body of knowledge surrounding restoration techniques and net benefit to stream and watershed health.

Current Efforts

Development of Chessie BIBI Second Interval (2018 - 2023) Dataset and Analysis

A data call will be issued in late 2024 by the CBP Data Center Living Resources and Habitat Data Manager for 2018 - 2023 stream data (macroinvertebrates, associated stream habitat and water quality, and documentation). Data received will be QA/QC'ed and merged into the Non-tidal Benthic Database in CEDR (Chesapeake Environmental Data Repository). ICPRB will then calculate the Chessie BIBI index using established R-scripts and lookup tables. The primary and secondary data and related metadata will be made available on-line. ICPRB will prepare a report on CBP progress in attaining the Stream Health Outcome. ICPRB and USGS will further evaluate methods to better synthesize observed and modeled Chessie BIBI results.

Pooled Monitoring Approach to Stream Restoration Projects

The Chesapeake Bay Trust manages the Restoration Research Award Program that began in 2015 with the issuance for the first “request for proposals” to support the pooled monitoring initiative. The Program is a multi-stakeholder effort that includes a partnership with the Maryland Department of Natural Resources, the Maryland Department of Transportation State Highway Administration, Montgomery County Department of Environmental Protection, and the National Fish and Wildlife Foundation through the Environmental Protection Agency’s Chesapeake Bay Program Office. The goal of this research program is to answer several key restoration questions that are a barrier to watershed restoration project implementation. Funding partners hope that answering these questions will ultimately lead to increased confidence in proposed restoration project outcomes, clarification of the optimal site conditions in which to apply particular restoration techniques, information useful to regulatory agencies in project permitting, and information that will help guide monitoring programs. This program supports the Pooled Monitoring Initiative that is designed to connect key stormwater and stream restoration questions posed by the regulatory and practitioner communities with researchers.

Ongoing Monitoring Efforts

There are several state and resource agency monitoring programs to support the assessment of stream health and function at the state level. These can be used along with the Chessie BIBI to track stream health toward meeting the goal of the Management Strategy. Each of the data sets have unique advantages for use in tracking. Examples of some of these efforts include:

- EPA National Rivers and Stream Assessment (NRSA): The EPA NRSA sampled between 90 and 100 randomly selected sites in the Chesapeake Bay watershed. These sites have benthic invertebrate, fish, periphyton, water quality and habitat data. The EPA NRSA surveys are conducted every five years, with data available for 2008/2009, 2013/2014, and 2018/2019 survey being recently completed.
- State 305b (Integrated Report) Reports
- Tidal network monitoring sites.
- Non-tidal network monitoring sites.
- National Park Service has five inventory and monitoring networks operating within the Chesapeake Bay (https://www.nps.gov/im/ncrn/index.htm, accessed September 2024).
- Maryland Biological Stream Survey continues to monitor the health of Maryland’s streams with annual sampling of randomly selected streams, as well as targeted sampling to evaluate specific activities and/or track natural variability and potential climate change influences. A report of

Round 4 results was recently completed that compares stream health and conditions based on repeat sampling of randomly selected streams sampled 20 and 14 years previously.[6]

- County monitoring programs
- State monitoring programs not named above
- USGS collected partner data and is examining long term data trends of a variety of metrics, including benthic macroinvertebrates, fish, specific conductance, physical habitat, temperature, flow, and nutrients.

WIP Implementation of BMPs

The Chesapeake Bay TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025, with all the identified practices implemented. WIPs detail how and when the Bay jurisdictions will meet their pollution load allocations. Progress in WIP implementation is reported annually to the CBP. BMPs that most notably influence stream health include runoff-reduction urban BMPs and agricultural BMPs such as stream fencing, forest buffers, grass buffers and wetland restoration.

USGS Chesapeake Bay Activities

There are needs to incorporate additional stream health indicators to complement the Chessie BIBI, including key instream stressors such as salinity and physical habitat, to evaluate possible co-benefits or costs and lag times of management practices, and to investigate how land use and climate change may affect overall stream condition. To meet the first need the USGS is developing or updating watershed-wide assessments in 2025 at the 1:24,000 map scale for beyond-BIBI benthic macroinvertebrate indicators (e.g., metrics with more mechanistic inferences), fish, salinity, sediment, and physical habitat. The more mechanistic metrics will be aimed at identifying key components of each assemblage that may be responding to a particular stressor. Additional potential assessments after 2025 may include stream temperature, flow, human dimensions, invasives, and mussels but will depend on need, data availability and funding levels. A final objective is to synthesize outputs from all the modeling efforts into a single web-based platform to ease viewing and data access; input from SHWG members and other users will be essential for successful development of this web-based platform. For the need on management practices the USGS is studying BMP effects and potential lag times that impact stream stressors and health. USGS will summarize the effects of different agricultural and urban BMP practices for multiple stream outcomes (the stressors and the biology). This resource could then be used to prioritize BMPs throughout a watershed that would be more likely to benefit stream health. And for climate and land use change effects the USGS is currently leading a study that is examining how future land use and climate scenarios may alter stream flows and how such changes in flow affect fish populations. Project completion is scheduled for late 2025/early 2026. Interest exists in possibly expanding to examine effects on benthic macroinvertebrates.

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[6] Resource Assessment Service. 2024. Maryland Biological Stream Survey Round Four Results Investigating Potential Changes Over Time in Stream Conditions. Maryland Department of Natural Resources. 580 Taylor Avenue, Annapolis, Maryland 21401. DNR 12-050724-1

VI. Management Approaches

The following major points are fundamental to the Stream Health Management Strategy for which actions are defined. This outcome recognizes:

- The health and function of streams affects the local stream environment as well as the downstream connection and contributions from these waters to the Bay.
- Streams are a part of a system that includes the stream corridor, floodplain, wetlands and watershed, and as such, stream health is affected by both in-stream and watershed functions, processes and characteristics.
- Measures that would improve stream functions may occur in the stream itself, in the floodplain or in the watershed. Some measures could serve to meet more than one outcome of the *Watershed Agreement*.
- Stream functions related to nutrient and sediment delivery to the Bay are of fundamental importance because of their explicit inclusion in the *Watershed Agreement*.

Figure 2 is a conceptual illustration of this management approach showing that improvement to stream health relies upon the ability to identify the key factors that affect critical stream functions. The key factors influencing this outcome are described in Section III and include ecological stressors and factors, policy and administration, scientific knowledge and the application of research, partner coordination and funding.

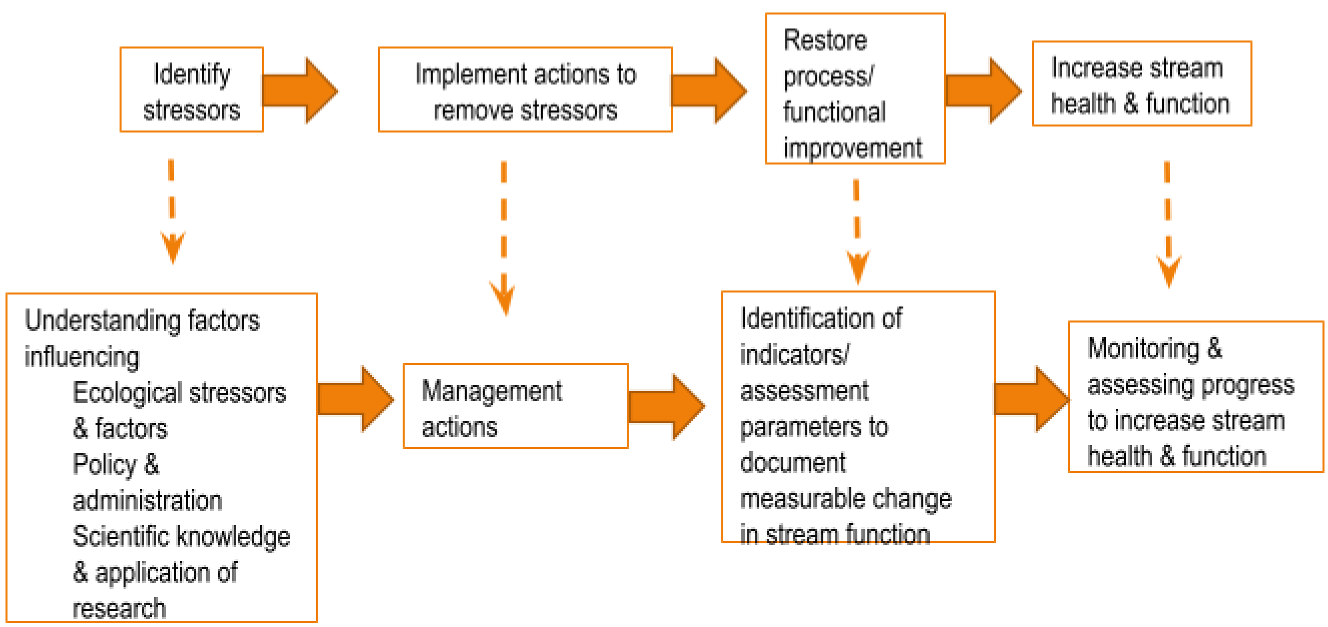

Figure 2. Schematic for Stream Health Outcome Management Strategy

Strategies to attain the outcomes underneath the Water Quality goal (2017 WIP and 2025 WIP, Water Quality Standards and Attainment and Monitoring) complement this outcome as actions to reduce or remove stressors or factors affecting stream health may also be related to watershed activities. As such, implementation of BMPs to reduce nutrient and sediment pollution load reduction necessary to achieve water quality standards would contribute toward improving stream health. Perhaps more important, however, is the implementation of upland BMPs that reduce the volume and rate of stormwater runoff entering streams, assisting in efforts to restore ecologically sustainable flow regimes, and supporting stream functions. Similarly, the practices and controls put into place that reduce and prevent the effects of toxic contaminants below levels that harm aquatic systems and humans, would have a similar effect (Toxic Contaminants outcome). Further, other outcomes that increase the wetland acreage and forested buffers in the watershed would also support improvement in stream health and function as they address the removal or reduction in priority ecological stressors and factors. Overall, this Management Strategy recognizes the need to identify principal stressors affecting stream health if maximum in-stream improvement is going to be achieved, then identify and promote measures to remediate principal stressors through implementation actions (USEPA, 2014).

The following four approaches are specific to the Stream Health outcome, focusing on a well-developed, broadened application of a holistic approach to stream restoration that focuses on ecosystem condition and resilience to allow for sufficient dynamic change to promote stream evolution that optimizes ecological functional uplift while also achieving TMDL goals.

Management Approach 1

The definition of stream health and function for this restoration-based outcome uses a Bay-wide metric, the Chessie BIBI, to measure the improvement in stream health and function. This Management Strategy proposes a function-based definition of stream health that provides a common framework for additional reporting and tracking incremental improvements in stream health at a finer scale.

Identify an appropriate suite of metrics to measure the multiple facets of stream health to complement, but not replace, the Bay-wide Chessie BIBI.

- Develop a definition of stream health, measured as the length (miles) of streams improved that shows the linkage between upland drainages and local stream health, and between local stream health and the health of downstream receiving waters. This effort would work to associate metrics developed for the Chessie BIBI with individual state metrics used to track and report the Healthy Watersheds outcome that states, “100 percent of state-identified currently healthy waters and watersheds remain healthy.”
- Develop metrics/composite indices from routinely collected, non-biological data to measure changes in certain stream functions to assess regional changes and trends.
- Include common indicators of stream functions to include (e.g. lateral stability, bedform diversity, habitat diversity, riparian corridor, nutrient and organic matter processing) as part of monitoring guidance for stream restoration projects to provide more immediate feedback regarding the changing conditions of the stream.
- Collaborate with the Healthy Watersheds GIT to identify marginal streams where restoration activity in-stream or in the watershed may improve stream functions and health. Once identified, work with the partnership and funders to develop incentives to build on existing efforts to target beneficial restoration activity along with guidance for permits to implement the proposed activity.

Management Approach 2

Provision of adequate funding and technical resources to support comprehensive ecosystem improvement in watershed management practices, in addition to nutrient and sediment reductions.

- Subwatershed monitoring studies that could explore how much upland retrofit implementation is needed to optimize stream functional improvement when stream restoration and stormwater retrofits are installed as part of an integrated restoration plan.
- Provide training to jurisdictions to implement BMP expert panel report recommendations.
- Work with funding agencies to provide multi-year funding to monitor effects of stream restoration.
- Adopt a pooled monitoring approach, and to partner with other organizations, for researchers to inform watershed best management practices that demonstrate stream and riparian ecosystem improvement.
- Establishment of an on-going stream restoration monitoring consortium and data clearinghouse within the CBP to share project data.
- Recommend incentives for projects that provide both stream biological improvement and water quality benefits.
- Literature synthesis to fully document response of stream ecological conditions from stream restoration management actions or, in the case of less degraded systems, how existing conditions support nutrient and sediment reductions, and that may be used to support a BMP expert panel similar to those available for expected nutrient and sediment reductions. Part of the BMP expert panel would address the applicability of Chessie BIBI (and other similar ecological data) to where restoration work is being conducted to improve stream ecology and functions. Recommendations could be applied to help track estimated stream ecological improvements similarly to the way nutrient and sediment trends are already tracked by CBP. This panel could also develop guidance on how the restoration/enhancement of stream functions translates to nitrogen, phosphorus and sediment "credit" as recommended by the STAC report on "Designing Sustainable Stream Restoration Projects within the Chesapeake Bay Watershed".
- Investigate the effects and implications of climate change, population growth and continued landscape development on stream health, including various metrics associated with healthy streams and future potential.

Management Approach 3

Active and engaged participation by local communities with federal and state partners is central to Bay restoration. Improvements to stream health and function will rely upon significant investments by local communities, municipal, county governments and watershed groups, to implement restoration and conservation actions. While, Executive Order 13508 states the Federal Leadership Committee shall closely coordinate actions by state and local agencies and consult with stakeholders and members of the public in the development of annual action plans and reporting progress, actions to clearly define a process for local input to advance project implementation is needed. Therefore, state and federal agencies shall ensure the participation of local communities in support of activities that advance project implementation. Ongoing coordination with stream health stakeholders (e.g., state and federal stream and wetland regulatory authorities, natural resource agencies, local governments, non-profit organizations, watershed BMP practitioners, researchers and local communities) needs to be improved to identify and remove barriers to improving stream health.

The SHWG should work with CBP partners, including the Enhancing Partnering, Leadership and Management GIT, to enhance the information available for local governments, organizations and landowners to support beneficial watershed best management practices, stream restoration and maintenance needs.

- Review and identify opportunities to improve stream health and function, while meeting other regulatory requirements through the coordination of multiple regulatory programs that have identified principal stressors impairing streams. For instance, states might use a biological stressor identification analysis (BSID) to identify sources of stream impairment yet resulting TMDLs might only focus on one stressor (e.g., sediment). Restoration opportunities to address this stressor are often singularly focused, missing opportunities to improve other stressors identified through the BSID analysis.
- Engage with local governments to inform landowners, as well as the general public, of beneficial stream restoration and maintenance practices. This includes individual homeowner practices (e.g. rain barrels, lawn care) and their impact on the community, the streams in their own backyards and public places. A programmatic approach similar to the Upper Susquehanna Coalition Emergency Stream Intervention initiative that provides outreach and technical training and assistance through a network of conservation specialists are good practices to follow
- Provide research or documentation that identifies the nexus between improving stream functions and health, and broader societal issues such as environmental justice, in support of the Diversity outcome.

Management Approach 4

Develop and promote holistic stream restoration design guidelines that identify the level of degradation and improvement of stream biology and key stressors/factors limiting potential biological improvement.

- Develop case studies to document biological response in stream with various management interventions.
- Add language to MS4 permits to recognize stream biological function improvement as part of nutrient and sediment credits towards meeting the Bay TMDL.
- Improved stream restoration guidance for biological improvements or maintenance of higher quality systems.
- Develop design guidelines to include greater consideration of resource tradeoffs and other Chesapeake Bay Agreements goals and outcomes.

VII. Monitoring Progress

Monitoring programs are critical to understanding the response of streams to restoration activities—in-stream or upland areas. Federal, state, local and natural resource agency monitoring programs generate data on the physical, chemical and biological conditions of streams. These data are used to generate the Chessie BIBI. The Chessie BIBI is key to monitoring progress toward improving 10 percent of stream health and function. This Management Strategy does not advocate for new monitoring programs, but rather, to monitor annual progress. To do so, the Management Strategy recommends using other existing data sources to supplement this watershed-wide indicator (e.g. jurisdiction-specific metrics). While minor differences in stream biological, physical habitat and water quality monitoring methods exist, jurisdiction assessments may also be useful in tracking stream health and function over time at individual sites. Further, the development of common stream assessment and restoration guidelines would generate comparable datasets across stream restoration projects. This would provide data to characterize stream health across all stream functions so that incremental changes in stream functional improvement can be reported, and support data needs for the Chessie BIBI.

The monitoring data would be based on routinely collected data to measure changes in stream functions for instream and floodplain conditions. The management approaches provide examples of the types of indicators that may be used to measure critical stream functions (e.g., lateral stability, bedform diversity, habitat diversity, floodplain connectivity, riparian corridor condition, water quality and benthic macroinvertebrates and fish) from project specific locations throughout the watershed and streams in general. The task to identify the

Lessons Learned

The SHWG sponsored the 2023 STAC workshop on reviewing the state of the science and practice of stream restoration in the Chesapeake watershed. The key findings of the workshop (the draft report is currently in USGS review) is that often the primary goal of stream restoration projects is to improve geomorphic stability in the restored reach and downstream water quality, and not to improve local ecological conditions through 'uplift', and therefore these projects often do not improve aquatic macroinvertebrate or fish communities. Specifically:

1. The outcome of stream restoration monitoring has revealed that while geomorphic and hydrodynamic functions of stream restoration projects may be achieved, biotic stream function improvements remain elusive.
2. As such, restoration projects that may risk resources in higher-quality streams and riparian corridors should be avoided to ensure uplift.
3. It is likely that current understanding of stressors and drivers of stream ecosystem health is insufficient, and that reach-scale restoration focused on geomorphic restoration is not removing the actual sources of stream health impairment that may arise in the upstream watershed.
4. It is recommend that if a desired outcome of stream restoration includes ecological uplift, then projects should prioritize efforts to focus toward that goal.

indicators selected to support this Management Strategy is recommended as part of the biennial work plan, and may include these indicators, or others as the work is undertaken.

VIII. Assessing Progress

The CBP annual progress reports on BMP implementation, specifically BMPs identified to impact critical steam functions (e.g., stream restoration, stream fencing and forest buffers) can be used to estimate the project nutrient and sediment load reductions expected from practice implementation. Assessing progress should also focus on remediation of principal stressors and stream reach functional improvement based on stream restoration project goals and objectives. While projects may be undertaken for the purpose of nutrient and sediment reductions under the Chesapeake Bay TMDL, information available from completed stressor identification analysis should also be considered to improve stream health, as well as instream and floodplain habitats. While CBP wants to encourage the remediation of priority stressors to improve stream health, or maximize functional improvement for all stream restoration projects, it cannot be required given site-specific constraints and the ability to address watershed stressors affecting the health of the stream. It is important that a progress reporting process be developed that can be used to assess progress up through biology but allow for lower levels (i.e., stability) of report only.

IX. Adaptively Managing

For any given restoration project, there are uncertainties in the application of even the best restoration science, both in stream corridor restoration and upland BMPs, which includes some level of risk that implementation may not achieve its objectives. At the scale of the Chesapeake Bay watershed this uncertainty is compounded by the extent of BMP implementation required to meet the Chesapeake Bay TMDL. The adaptive management approach to address the urban, agricultural and wastewater management measures that may improve stream health undertaken outside of the steam corridor and floodplain are addressed in the management strategies for the outcomes underneath the Water Quality goal.

As the field of watershed management, stream restoration and BMP science continue to evolve, the desired ecological endpoint for any given project may also evolve throughout the project life and through feedback from monitoring of the relevant function-based parameters. Further, understanding the response in stream health to a management action is affected by nature itself to include lag times but also the interactions amongst many stream functions. For example, the improvement in biological stream function may take a longer time period compared to improved flow regimes. In short, the understanding of stream process functions and the interrelationship with the watershed will continue to advance with implementation in the field. A process that communicates the current state of the science on the influence of efforts to improve stream health now, with periodic updates, would help ensure the most successful practices are implemented and the most benefits possible for stream health are achieved.

X. Biennial Work plan

Biennial work plans for each management strategy were developed in September of 2024 for 2024-2026. They included the following information:

- Each key action.
- Timeline for the action.
- Expected outcome.
- Partners responsible for each action.
- Estimated resources.

Supplementary Table 1. A summary and comparison of watershed stressors and stream functional categories.

	Harman et al 2012[1]	Fischenich 2006[2]	FISRWG 1998 (updated 2001)[3]	Stressor Categories (from MDE 2015[4] and MD DNR 2005[5])
Hydrologic Factors	**Hydrology:** Transport of water from the watershed to the channel **Hydraulics:** Transport of water in the channel, on the floodplain, and through sediments	**Hydrologic Balance:** ● Surface water storage processes; ● Maintain surface/subsurface water exchange ● General hydrological balance	**Conduit:** the ability of the system to transport materials, energy and organisms	● Land use land cover (urban, impervious cover, mine land use) ● Flow regime
Geomorphology and Energetics	**Geomorphology:** Transport and deposition of wood and sediment to create diverse bed forms and dynamic equilibrium	**System Dynamics:** ● Maintain stream evolution processes ● Energy management processes ● Provide for riparian succession **Sediment processes and character:** ● sediment continuity, ● Maintain substrate and structural processes ● Quality and quantity of sediments	**Source:** a setting where the output of materials, energy and organisms exceeds input **Sink:** a setting where the input of water, energy, organisms and materials exceeds output	● Instream and riparian habitat ● Habitat structure ● Sediment/stream flow
Physical and Chemical Factors	**Physicochemical:** Temperature and oxygen regulation; processing of organic matter and nutrients	**Chemical processes and pathways:** ● Maintain water & soil quality, ● Maintain chemical processes and nutrient cycles ● Maintain landscape pathways	**Filter:** the selective penetration or materials, energy and organisms **Barrier:** the stoppage of materials, energy, and organisms	● Water chemistry (dissolved oxygen, various pollutant parameters) ● Energy source
Biotic Factors	**Biology**: Biodiversity and the life histories of aquatic and riparian life	**Biological support:** ● Support biological communities and processes, ● Provide necessary habitats for all life cycles ● Maintain trophic structure and processes	**Habitat:** the spatial structure of the environment which allows species to live, reproduce, feed and move	● Biotic interactions

[1] Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. *A Function-Based Framework for Stream Assessment and Restoration Projects*. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

[2] Fischenich, J.C., 2006. Functional Objectives for Stream Restoration, EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-52), US Army Engineer Research and Development Center, Vicksburg, Mississippi.

[3] FISRWG (10/1998). Stream Corridor Restoration: Principles, Processes and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN3/PT.653.

[4] Maryland Department of the Environment. 2015. Biological stressor identification studies. Accessed September 2024: https://mde.maryland.gov/programs/water/tmdl/pages/bsid_studies.aspx

[5] Maryland Department of Natural Resources. 2005. Maryland Biological Stream Survey 2000-2004, Volume XIV: Stressors Affecting Maryland Streams. Accessed September 2024: https://dnr.maryland.gov/streams/Publications/ea-05-13_new_ibi.pdf