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 pristine 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. The function-based definition provides the ability to report and track incremental improvements in stream health achieved from addressing stressors and improving stream function. In addition to reducing erosion and improving habitat for wildlife, fish, and other aquatic species, stream restoration also is a recognized BMP for water quality and will provide a benefit of reducing nutrient and sediment loads to achieve the target load reductions as part of the Chesapeake Bay Total Maximum Daily Load (TMDL) (Table 1).

Table 1: Chesapeake Bay Watershed Implementation Plan (WIP) progress and 2025 targets for stream restoration(units in feet). Source CBP

<table>
<thead>
<tr>
<th></th>
<th>2009 Progress</th>
<th>2011 Progress</th>
<th>2013 Progress</th>
<th>2015 Progress</th>
<th>2017 Progress</th>
<th>2025 WIP Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urban Stream Restoration</strong></td>
<td>32,199</td>
<td>61,812</td>
<td>119,158</td>
<td>142,741</td>
<td>158,140 (6%)</td>
<td>2,608,476</td>
</tr>
<tr>
<td><strong>Non-Urban Stream Restoration</strong></td>
<td>988,575</td>
<td>1,448,109</td>
<td>1,514,798</td>
<td>1,592,186</td>
<td>1,399,642 (65%)</td>
<td>2,152,307</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,020,774</td>
<td>1,509,921</td>
<td>1,633,956</td>
<td>1,734,927</td>
<td>1,557,782 (33%)</td>
<td>4,760,784</td>
</tr>
</tbody>
</table>
Baseline and Current Condition

At a 2018 workshop, the baseline period was defined as the six-year period from 2006 to 2011 by the Interstate Commission on the Potomac River Basin (ICPRB) and an ad-hoc team formed from various area monitoring programs. It was also agreed that results from a watershed model could be combined with monitoring results to fill in gaps in spatial coverage. The model successfully uses landscape features (including upstream imperviousness and canopy cover) to predict Chessie BIBI ratings (Maloney et al. 2018). The combined monitoring and model results, proportionally weighted by catchment area, indicate approximately 60% percent of the Bay watershed area supported streams with fair, good, or excellent (“acceptable”) ratings during the baseline period (Buchanan et al. 2018). This is a preliminary baseline for the Bay Program’s stream health outcome. A final baseline estimate will be produced after a higher resolution stream layer becomes available and an acceptable method is determined to translate the metric as a percent of the basin’s stream miles.

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. 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. Previously, analyses were performed to develop order-, family-, and genus-level metrics and compare their sensitivity to degradation, refine the metric scoring thresholds, and improve procedures for rating the final index (Smith et al. 2017). Future work includes further testing of the index’s sensitivity to various stressors.

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

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 workplan
  - Develops model to predict Chessie BIBI ratings for unsampled streams and assist ICPRB in refining the selection of reference sites in the Chessie BIBI
- 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 approval of 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

Center for Watershed Protection (CWP)
- Chair Stream Health Work Group
- Development and training on stream restoration protocols

Virginia Tech (VT)
- Member of CBP Science and Technical Advisory Committee (STAC), Stream Health Workgroup Drafting Team

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

Chesapeake Bay Trust (CBT)
- Lead effort to organize pooled monitoring approach

National Fish and Wildlife Foundation (NFWF)
- Provides funding for stream restoration projects and BMPs to reduce nutrient and sediment loadings

Local governments
- Responsible for implementation of BMPs to include stream restoration projects as part of the WIPs

Urban Stream Restoration BMP Expert Panel Members
- Development of protocols and nutrient and sediment pollutant load reductions to credit stream restoration projects for water quality improvements

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
- Johns Hopkins University
- Franklin & Marshall University
- Severn Riverkeeper: Manages/Implements Stream Restoration Projects
- American Rivers: Manages/Implements Stream Restoration/Dam Removal Projects
- Maryland Stream Restoration Association (MSRA)
**Likely Participating Jurisdictions:** All listed above in addition to Maryland Water Quality Monitoring Council and Maryland State Water Quality Advisory Committee.

**Local Engagement**
Local governments are responsible for the implementation of BMPs to include stream restoration projects as part of the Phase III Watershed Implementation Plans (WIPs).

**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 (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/and 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** 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 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. Improvement in local streams overall, not just for nutrient and sediment reductions, is paramount to achieving this outcome. Many of the factors listed are contributing pollutants to Clean Water Act Section 303(d) listed impaired waters for which local TMDLs are established. Ecological stressors and factors influencing the outcome include:

**Within the stream channel and 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.
Stream Health Outcome

- Concentrated flows and reduction in baseflows.
- 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

**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.
- Endocrine disrupting chemicals and other contaminants (e.g. metals, pesticides).

2. **Policy 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. With regard to stream restoration, key among these factors are related to the permit application and approval process. Despite approval of many projects throughout the Chesapeake Bay, there are projects that encounter delays during the permit review process that often may be attributed to the additional information needed to support an application and its interpretation by either the regulatory or practitioner community. Uncovering factors that are common to both the practitioner and regulator need to be overcome to address this barrier 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 loads reductions necessary to improve stream health and consequently the Bay, as well as meeting other requirements. Factors that influence the outcome include:

- Review and approval of stream restoration projects for WIP implementation.
- 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

3. **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* 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.
   - Insufficient data to develop Bay-wide fish-based indicator to complement macroinvertebrate indicator (Chessie BIBI).
   - Lengthy timeframe for adjusting BMP credit or recognizing new BMPs.
   - 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).

4. **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 workplan 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** sources in the watershed are diverse. The current workplan 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.

- Benthic macroinvertebrate data from enough streams with enough frequency to track progress over time. Chessie BIBI provides limited capacity for annual tracking.
- Bay-wide and stream metrics other than 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.
- Sufficiency of data to demonstrate restoration of stream processes following installation of upland watershed BMPs.
- Cumulative effects and interactions between stressors.
- Completion of stressor analysis for additional watersheds.

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.

- Collaboration with the Healthy Watersheds GIT to identify marginal streams and various definitions for stream health (i.e., Chessie BIBI and individual state metrics).
- 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 sediments 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).
- Identification of local and watershed priority stressors that affect local steam health and management actions to result in associated functional improvement or prevention of degradation.
Prioritization
Restoration activity in marginally healthy streams should proceed carefully such that appropriate restoration designs are taken to maintain and enhance natural stream processes. 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 also likely that restoration activity to improve stream health in highly degraded streams may only result in marginal improvements (e.g. Chessie BIBI poor to fair). However, as these streams may be located in ultra-urban environments, marginal improvements may contribute towards broader societal benefits (e.g. environmental justice).

- 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.
- Investments in research to improve the body of knowledge surrounding restoration techniques and net benefit to stream and watershed health.

Current Efforts:

Development of 2008 Baseline for the Chessie BIBI
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 and discussed next steps in developing the CBP stream health indicator. A spatial model was developed to predict the indicator in unsampled catchments to fill in gaps in coverage. A preliminary baseline was calculated in December 2018 from merged monitoring and modeling results. Efforts are currently underway by ICPRB and USGS to update the stream macroinvertebrate database, improve indicator sensitivity, further our understanding of land use and climate change impacts on stream health, and report on progress for the 2012-2017 interval. The Data Center at CBP is also implementing a standardized process for incorporating stream macroinvertebrate data into the Chesapeake Environmental Data Repository (CEDR) and automating calculations of the stream health indicator.

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.
Stream Health Outcome

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 (e.g. see http://www.mde.state.md.us/programs/Water/TMDL/Pages/Programs/WaterPrograms/tmdl/bsid_studies.aspx. Accessed Jan 15, 2015).
- 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 November 2019).
- County monitoring programs
- State monitoring programs not named above

MS4 permits that have incorporated Chesapeake Bay TMDL goals

MS4 permit requirements have started to reflect Chesapeake Bay TMDL goals. This effort is an example of the coordination of BMP implementation and management actions that can address multiple goals.

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.

Approximately 700 miles of stream restoration projects are expected to be implemented to achieve the nutrient and sediment load reductions required by the Chesapeake Bay TMDL (Table 1). As a result, the projected implementation rate of stream restoration projects to meet the 2025 timeline with the Bay watershed is unprecedented. Based on the planned 2025 Phase III WIPs, the CBP reports that approximately 33 percent of planned stream restoration projects were implemented based on the 2017 progress reported by the Chesapeake Bay jurisdictions, with 90 percent of the projects located in areas with non-urban land use.
Development of Chesapeake Bay BMP Verification

In August 2014, the CBP Management Board approved a framework\(^1\) by which the partnership will develop verification programs to ensure that implemented BMPs continue to work properly and are eligible to receive nutrient and sediment load reduction credits towards the Chesapeake Bay TMDL. The framework includes BMP verification guidance from the CBP’s six technical sector and habitat workgroups (e.g., agriculture, forestry, urban, wastewater, wetlands and streams). While the recommended verification guidance is specific to the source sector BMPs, there are over-arching principles to which the guidance is based: practice reporting, scientific rigor, public confidence, adaptive management and sector equity. The framework was approved by the Urban Stormwater Workgroup on June 18, 2019.

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 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 1 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.

\(^1\)“Strengthening Verification of Best Management Practices Implemented in the Chesapeake Bay Watershed: A Basinwide Framework. Prepared by the Water Quality Goal Implementation Team’s BMP Verification Committee.”
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, 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 affect (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 five approaches are specific to the Stream Health outcome, focusing on a well-developed, broadened application of a function-based approach to stream restoration. A function-based approach is not only central to the permit and review process, but also is recognized by researchers as a sound approach to restoration when implemented using a well-defined project process (e.g. with clearly articulated project goals and objectives).
**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 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 stream function to assess regional improvement.
- 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 demonstrate functional improvement.
- Align metrics of stream functional improvement with stream restoration protocol crediting projects for the Chesapeake Bay TMDL for nutrient and sediment reduction.
- 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.

**Approach 2:**
Provision of adequate funding and technical resources to support stream functional improvement in stream restoration projects, in addition to nutrient and sediment reduction.

- 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 for researchers to inform stream restoration project designs that demonstrate stream functional 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 functional improvement and water quality benefits.
g. Literature synthesis to fully document response of stream ecological conditions from stream restoration management actions 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 functions. Recommendations could be applied to help track estimated stream 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”.

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 restoration stakeholders (e.g., state and federal stream and wetland permitting authorities, natural resource agencies, local governments, non-profit organizations, stream restoration designers, researchers) needs to be improved to identify and remove barriers, providing a clearly defined path to expedite the submittal and review of permit applications, whether the proposed activity is for marginal streams, impaired streams or for credit in the Chesapeake Bay TMDL.

a. A need to conduct a comprehensive review of existing stream restoration permit documentation was identified by certain members of the Stream Health Workgroup. Both permit reviewers and permittees have identified factors related to incomplete permit application submittals, monitoring requirements and inconsistent information requested (or provided) to evaluate projects. Other factors include the need for training and guidance on the information needed to support site selection, and design approaches. Resolution of these issues should facilitate an understanding of the policies and requirements associated with regulatory review of stream restoration projects and result in a more transparent and consistent approval process in accordance with appropriate regulations and policies.

b. 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.
Approach 4:
Develop and promote holistic stream restoration design guidelines that identify the level of degradation and improvement of stream functions and key stressors/factors limiting potential functional improvement.

a. Development of a function-based stream assessment framework. Current work by MDE and USFWS may be used as a template to apply in other Bay jurisdictions.

b. Develop case studies to document functional response in stream with various management interventions.

c. Add language to MS4 permits to recognize stream function improvement as part of nutrient and sediment credits towards meeting the Bay TMDL.

d. Improved stream restoration guidance through work with MDE based on Key Wildlife Habitats.

Approach 5:
Work with CBP partners, including the Enhancing Partnering, Leadership and Management GIT, to enhance the capacity of local governments, organizations and landowners of beneficial stream restoration and maintenance practices

a. 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

b. 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.
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 Bay-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 indicators selected to support this Management Strategy is recommended as part of the biennial workplan, and may include these indicators, or others as the work is undertaken. Data are routinely generated from stream restoration projects as part of permit requirements, but the data requirements are not necessarily comparable across projects, nor do

Lessons Learned

The Stream Health Workgroup updated the workplan to reflect lessons learned while trying to implement key actions. The progress made on the workplan reflected the ability to identify a person to lead the implementation of an action. The identification of a lead person was mostly due to an action that aligned with an organization’s mission, work or directive, or funding was provided to allocate staff time to implement an action. For example, MD DNR’s work and available data on stressor identification provided a good fit to lead Action 4.2. Funding made available to ICPRB provided the resources necessary to devote staff time to address Actions 1.1 and 1.2. The CBT is the lead organization for the Pooled Monitoring Approach (Action 2.1).

The ability to leverage existing resources or mutually beneficial actions with other groups also provided an opportunity to advance actions in the work plan. For example, a joint meeting with the Urban Stormwater Workgroup was held in June 2018 to address cross cutting issues related to stream restoration, while an opportunity to provide training in Pennsylvania was led by the Center for Watershed Protection was possible due to existing grant funding (external funding source).

The annual review of the workplan also provided an opportunity to better define (refine) actions and performance targets. For example, previously defined actions were either eliminated as they were too loosely defined, did not have an individual or organization to lead its implementation or was redundant with work underway.

Lastly, changes to the workplan occurred as it was more appropriate to define an action as a performance target of another action.
they necessarily inform functional improvement related to nutrient and sediment delivery downstream, or for stream health, in general. The ability to adopt a pooled-monitoring approach using commonly accepted stream assessment and restoration guidelines could then demonstrate the effect of design approaches and stream functional response from case studies analyses. Post-construction monitoring would also be supported by data generated and reported from the CBP verification guidance for stream restoration BMP implementation that recommends site visits and evaluations two years after construction, and then every five years or after the catastrophic event. Jurisdiction-specific verification guidance is under development.

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 will 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 Workplan**

Biennial workplans for each management strategy were developed in November of 2019 for 2020-2021. 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.

<table>
<thead>
<tr>
<th>Stressor Categories</th>
<th>Hydrologic Factors</th>
<th>Geomorphology and Energetics</th>
<th>Physical and Chemical Factors</th>
<th>Biotic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hydrology: Transport of water from the watershed to the channel</td>
<td>Geomorphology: Transport and deposition of wood and sediment to create diverse bed forms and dynamic equilibrium</td>
<td>Physicochemical: Temperature and oxygen regulation; processing of organic matter and nutrients</td>
<td>Biology: Biodiversity and the life histories of aquatic and riparian life</td>
</tr>
<tr>
<td></td>
<td>Hydrologic Balance: • Surface water storage processes; • Maintain surface/subsurface water exchange • General hydrological balance</td>
<td>System Dynamics: • Maintain stream evolution processes • Energy management processes • Provide for riparian succession</td>
<td>Chemical processes and pathways: • Maintain water &amp; soil quality, • Maintain chemical processes and nutrient cycles • Maintain landscape pathways</td>
<td>Biological support: • Support biological communities and processes, • Provide necessary habitats for all life cycles • Maintain trophic structure and processes</td>
</tr>
<tr>
<td></td>
<td>Conduit: the ability of the system to transport materials, energy and organisms</td>
<td>Sediment processes and character: • Sediment continuity, • Maintain substrate and structural processes • Quality and quantity of sediments</td>
<td>Filter: the selective penetration or materials, energy and organisms</td>
<td>Habitat: the spatial structure of the environment which allows species to live, reproduce, feed and move</td>
</tr>
<tr>
<td></td>
<td>Source: a setting where the output of materials, energy and organisms exceeds input</td>
<td>Sink: a setting where the input of water, energy, organisms and materials exceeds output</td>
<td>Barrier: the stoppage of materials, energy, and organisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Land use land cover (urban, impervious cover, mine land use)</td>
<td></td>
<td>• Water chemistry (dissolved oxygen, various pollutant parameters)</td>
<td>• Biotic interactions</td>
</tr>
<tr>
<td></td>
<td>• Flow regime</td>
<td></td>
<td>• Energy source</td>
<td></td>
</tr>
</tbody>
</table>


