Outline

Introduction

There are over 100,000 stream miles draining the Chesapeake Bay Watershed that connect the landscape to the Chesapeake Bay. Land activities and water management affects the quantity and how streams transport, store and process nutrients and sediments that eventually affect Bay health. Management actions are needed to improve the physical, chemical and biological integrity of streams as baywide and local stream assessments find many streams are impaired.

In the context of the Chesapeake Bay, streams currently deliver excessive nutrients and sediment to the Bay that impair its health such that in 2010 a TMDL was developed. These streams are also impacted by a combination of stressors that result in a stream not fully supporting its designated uses and reductions in ecological functions, which in turn, impact the health of downstream receiving waters. To improve stream and Bay health, a management strategy needs to focus on actions that address priority stressors to restore stream functions that results in the improvement in local stream health and the Bay.

The following major points are fundamental considerations to meet given the scope of the Stream Health Outcome Management Strategy as part of the Chesapeake Bay Agreement.

- The health and function of streams affects the local stream environment as well as the downstream waters to the Bay.
- Streams are a part a system that include 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 Bay Agreement.
- Stream functions related to nutrient and sediment delivery to the Bay are of fundamental importance because of their explicit inclusion in the Bay Agreement.

Stream Health and Function

Healthy streams support and maintain basic functions associated with either structure or processes (Fischenich 2006). *Stream functions* are the physical, chemical and biological processes that support and sustain a stream's ecology. While there are a number of ways in which stream functions may be defined (see Table 1), there is a synergistic, or hierarchical effect such that the quality and condition of a stream process impact others. Therefore, which processes and function are most critical to improve stream health vary depending on what the stressors are for a stream and which of those stressors must be reduced or removed.

Table 1. A summary and comparison of stream functional categories.

Harman et al 2012	Fischenich 2006[2]	FISRWG[1] 1998 update 2001
Hydrology: Transport of water from the watershed to the channel	**System Dynamics**: ▪ Maintain stream evolution processes ▪ Energy management processes ▪ Provide for riparian succession	**Habitat**: the spatial structure of the environment which allows species to live, reproduce, feed and move
Hydraulics: Transport of water in the channel, on the floodplain, and through sediments	**Hydrologic Balance**: ▪ Surface water storage processes; ▪ Maintain subsurface/subsurface water exchange ▪ General hydrological balance	**Barrier**: the stoppage of materials, energy, and organisms
Geomorphology: Transport and deposition of wood and sediment to create diverse bed forms and dynamic equilibrium	**Sediment processes and character**: ▪ sediment continuity, ▪ Maintain substrate and structural processes ▪ Quality and quantity of sediments	**Conduit**: the ability of the system to transport materials, energy and organisms
Physicochemical: Temperature and oxygen regulation; processing of organic matter and nutrients	**Biological support**: ▪ Support biological communities and processes, ▪ Provide necessary habitats for all life cycles ▪ Maintain tropic structure and processes	**Filter**: the selective penetration or materials, energy and organisms
Biology: Biodiversity and the life histories of aquatic and riparian life	**Chemical processes and pathways**: ▪ Maintain water & soil quality, ▪ Maintain chemical processes and nutrient cycles	**Source**: a setting where the output of materials, energy and organisms exceeds input

	▪ Maintain landscape pathways	
		Sink: a setting where the input of water, energy, organisms and materials exceeds output

A stressor in the context of this strategy is any factor limiting to aquatic life that occurs as a consequence of direct or indirect impacts of current or past human actions. The stressor identification procedures of USEPA (2007,2014) provide a means to identify stressors and prioritize among them based on ecological risk assessment procedures. Priority stressors can include physical, chemical, or even biological conditions. Specific to the Bay TMDL, excessive sediment and nutrients delivery by streams to the Bay are the priority stressors that need to be addressed. Management actions to improve stream functions governing nutrient and sediment export downstream are of greatest interest for Bay Health. However, stressors often act hierarchically such that some are substantially more important than others in determining biological health, and the removal one stressor may cause another unrelated principal stressor to reveal itself. Thus, the biological recovery of stream health requires an understanding of the interrelationship of stream functions and how they respond to, or are impacted by stressors, both within and outside of the stream corridor.

Figure 1 depicts that the purpose for this management strategy to improve stream health relies upon the ability to identify the key factors (i.e., stressors) that affect critical stream functions. The factors influencing the Outcome include: ecological stressors and factors , policy/administration and scientific knowledge and application of research. Ecological stressors are the physical, chemical and biological constraints that impair stream health, where the effect of stream health is important at two scales - local and the Bay. Management actions identified to address these factors are directed to remove or reduce the impact of the ecological stressor that is affecting stream function(s). The identification of the ecological stressor, such as excessive sediment, informs the identification of indicator that serves as a surrogate for a specific stream function. That is, the indicator would measure the effect of removing that stressor (e.g. excessive sediment) on stream response (e.g. water quality improvement). The ability to improve steam health and function is not only limited by the ability to identify the ecological stressor(s), it is also affected by policy and administration factors that may limit implementation potential of an action. For example, sufficient monitoring data to demonstrate the effectiveness of stream corridor restoration projects or new design approaches limits permit approval, or the ability to effectively translate the most up-to-date scientific understanding into effective policy and regulatory guidance. The ability to assess progress toward the Outcome will rely upon the collective effect of individual actions as measured by Baywide indices (e.g. Chessie BIBI), while incremental improvements may be assessed by information generated at the site-specific project scale to help inform future assessment at more regional scales.

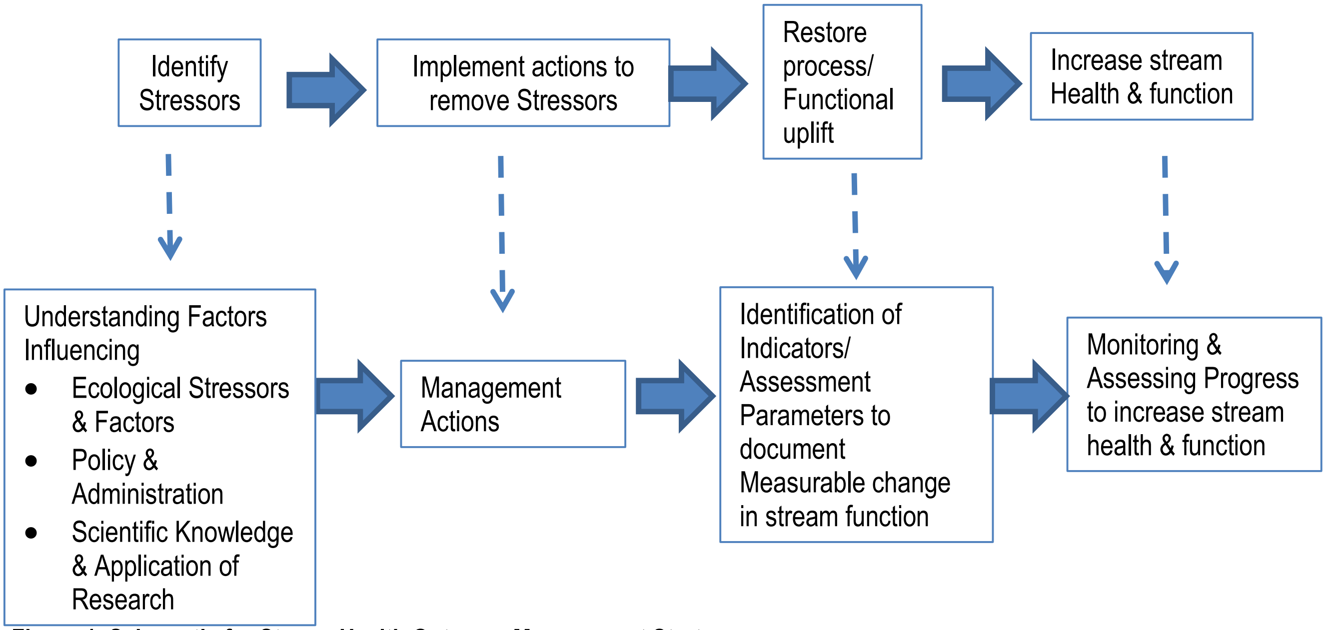

Figure 1. Schematic for Stream Health Outcome Management Strategy

Outcomes and Baselines:

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 ten percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed.

Importance: There are over 100,000 miles of streams in the Chesapeake Bay watershed and their health benefits the fish, wildlife and people using them. The health of streams within the Chesapeake Bay watershed requires action to improve the physical, chemical and biological conditions in local rivers and streams. Improving water quality is a necessary step toward meeting water quality standards in the Chesapeake Bay and restore locally-impaired waters. Management actions implemented to reduce nutrient and sediments entering streams and delivered to the Bay are critical to meet the Chesapeake Bay TMDL. These and other actions need to provide conditions necessary to support healthy biological communities.

Approximately 700 miles of stream restoration projects are expected to be implemented to achieve the nutrient and sediment load reductions define by the Chesapeake Bay total maximum daily load (TMDL). Based on the Phase II WIPs and annual progress reports submitted by the jurisdictions, it is reported that 41 percent of planned stream restoration projects were implemented through 2013, with 92 percent of the projects located in areas with non-urban land uses. The data show that urban stream restoration implementation at 17% of the 2025 WIP commitments, while non-urban stream restoration will likely meet its 2025 target based on 2013 and projected 2015 milestone. Projected implementation of stream restoration to meet the 2025 WIP commitments is shown in Table 2.

Table 2. Chesapeake Bay Watershed WIP progress and 2025 targets for stream restoration (units in feet). Source CBP

	2009 Progress	2011 Progress	2013 Progress	2015 Final Milestone	2025 WIP
Urban Stream Restoration	165,375	208,509	385,190	403,293	2,332,664
Non-Urban Stream Restoration	191,638	501,120	1,041,234	1,256,963	1,128,757
Total					41%

Current Conditions: Between 2000 and 2010, more than 14,000 stream sites were sampled and rated for biological integrity. Forty-three percent were in fair, good, or excellent condition. Fifty-seven percent were in very poor or poor condition, or approximately 57,000 stream miles of the 100,000 stream miles in the Bay watershed.

How it was Derived: This outcome was derived using an existing Chesapeake Bay Program indicator that uses an index to measure stream quality; Chesapeake Bay-wide Indicator of Biotic Integrity (Chessie-BIBI). Data are collected and assessed based on methodology agreed to by the Bay Program's Nontidal Monitoring Workgroup.

Baseline: The baseline will be re-evaluated in 2015 by ICPRB and an adhoc team formed from various CBP workgroups.

CBP uses the Chessie BIBI as a "stream health indicator"[1]. Index results were included in CBP *Bay Barometer* reports between 2008 and 2012. 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 Watershed Agreement. At this time, the index needs to be updated with the most recent macroinvertebrate data. It is now possible to develop and test genus-level metrics to incorporate into the index, and further test the index's sensitivity to various stressors (e.g., water quality, physical habitat). Finally, a 2008 baseline needs to be established against which progress can be measured.

While the Chessie BIBI provides a rating of stream health, the data and methods used for its derivation limit annual trend analysis to document changes with time. Further, the Chessie-BIBI provides information about the biological condition of streams, and stream functions which support that condition may only be inferred. Robust statistical analysis of the data has shown significant relationships between watershed stressors and Chessie BIBI. Watershed and stream metrics derived from routinely collected, non-biological monitoring data could be used to detect changes in stream health and function, in addition to biological function, that occur between 2008 (or baseline period) and 2017. These metrics can contribute to a broader understanding of goal attainment for the Stream Health Outcome.

A renewed Stream Health Work Group was formed in October 2013 that serves to coordinate input and make recommendations that advance a holistic approach to stream restoration projects and protection of high quality streams and habitat. The coordination recognizes the nexus between the regulatory framework and the scientific basis to protect and restore streams within the Bay watershed. Click here for more information on the Stream Health Workgroup membership.

I. Jurisdictions and agencies participating in the strategy:

Team Lead: Vital Habitats Goal Team
Workgroup Lead: Stream Health Workgroup
Opportunities for Cross-Goal Team Collaboration:

Fisheries Goal Team

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1 http://www.chesapeakebay.net/indicators/indicator/health_of_freshwater_streams_in_the_chesapeake_bay_watershed

Water Quality Goal Team
Healthy Watersheds

Active Current Participation and Role:

Level of Participation: High or Medium

Participating Research, Non-Profit Organizations and others:

Level of Participation: High, or Medium: TBD

Interstate Commission on the Potomac River Basin, ICPRB
Pennsylvania State University, PSU
Virginia Commonwealth University, VCU
University of Maryland, UMD
West Virginia University, WVU
Alliance for the Chesapeake Bay
American Rivers
Trout Unlimited
Maryland Stream Restoration Association
Center for Watershed Protection
Headwaters LLC
Chesapeake Research Consortium, CRC
Biohabitats
McCormick Taylor*
Chesapeake Bay Commission
AquaLaw
Troutman Sanders
Agribusiness – VA
Virginia Grain Producers Association
Altria
Ecosystem Restoration
Land Studies
RKK
Severn River Keeper
Chesapeake Stormwater Network

* Or MESRA representation

Participating Jurisdictions:

New York
Pennsylvania
Maryland
Virginia

West Virginia
Washington, D.C.
Delaware

Participating Federal Partners:
Fish and Wildlife Service
U.S. Geological Survey
U.S. Army Corps of Engineers
Natural Resources Conservation Services
National Park Service
National Fish and Wildlife Foundation
US Fish and Wildlife Service
EPA Region III
EPA CBPO

Local Engagement:
Anne Arundel County
Fairfax County
Arlington County
Northern Virginia Regional Commission

II. Factors influencing ability to meet goal:

Many factors, with wide-ranging levels of importance and management potential, influence the attainment of the stream health outcome. A thorough understanding of ecological, policy/administrative factors and scientific knowledge and application of research affects efforts essential to improve stream health and function at the local and Baywide-scale is needed. See Table in Part VI for a detailed list of factors. A description of the factors are summarized here.

Ecological stressors & factors are the in-stream or watershed-based factors that limit stream function(s) or negatively affect downstream waters. Management actions are needed to reduce or remove these factors to improve stream health to include steam restoration and other upland BMPs that reduce the delivery of excessive pollutants and runoff. While the emphasis of this strategy in the near-term focuses on the Chesapeake Bay TMDL, the improvement in local streams overall is paramount to achieve this Outcome. A list ecological stressors and factors influencing the Outcome include:

- Excessive sediment in-stream from unstable stream banks and legacy sediments
- Excessive nutrient loading to streams from bank erosion, point source sources and groundwater
- Limited nutrient and organic processing-instream
- Alteration in channel form and function resulting in instability and disequilibrium affecting diversity and quality of habitat
- Flow alteration and flashy hydrology
- Concentrated flows and reduction in baseflows

Policy and Administration factors limit the implementation potential of an action. Key amongst these factors is the issuance of permits for stream restoration projects and the regulatory and policy guidance available for stream corridor restoration projects to demonstrate functional lift. The current assessment of jurisdictions to meet their 2017 and 2025 WIP targets heightens to need to address these factors to implement projects that meet the sediment and nutrient loads reductions that improves stream health. A list of policy and administration factors influencing the Outcome include:

- Lack of common stream assessment and restoration guidelines
- Integration of water quality and living resource goals during WIP stream restoration
- 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

Scientific Knowledge & Application of Research are factors 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 into effective policy and regulatory guidance. A list of factors to influencing the Outcome include:

- Stream restoration monitoring to demonstrate functional lift or improvement in stream functions from BMP implementation
- Lag times that affect the ability to evaluate the effect of a BMP on stream health
- Limited ability to define urban reference conditions
- Insufficient data to develop Baywide fish-based indicator

III. Current efforts:

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 at least 60 percent of pollution reductions completed by 2017. WIPs detail how and when the six Bay states and the District of Columbia will meet their pollution load allocations. The progress for WIP implementation is reported annually to Chesapeake Bay Program. BMPs most notably to influence stream health, both upland in the watershed in runoff-reduction urban BMPs and agricultural BMPs to include for example: 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 defined by the Chesapeake Bay total maximum daily load (TMDL)(Table 3. Stream restoration projects identified in the Phase II Watershed Implementation Plans (in feet) for 2025). As a result, the projected implementation rate of stream restoration projects to meet the 2017 and 2025 timelines with the Bay watershed is unprecedented. Based on the planned 2025 Phase II WIPs, the Chesapeake Bay Program reported that approximately 37 percent of planned stream restoration projects were implemented based on the 2013 progress reported by the Chesapeake Bay jurisdictions (NY, PA, MD, WV, VA, DE, DC), with 92 percent of the projects located in areas with non-urban land use (Table 4. Stream restoration project implementation for progress periods (2009-2013).).

Table 3. Stream restoration projects identified in the Phase II Watershed Implementation Plans (in feet) for 2025

Jurisdiction	NY	PA	MD	VA	WV	DE	DC	CBW
Non-urban	337,999	529,435	73,975	104,528	19,618	63,202	0	1,128,757
Urban	26,500	55,000	2,527,626	116,399	0	200	42,240	2,332,664
Total (ft) (mi)	364,499	584,435	2,601,601	220,927	19,618	63,402	42,240	3,896,722 738.02

Table 4. Stream restoration project implementation for progress periods (2009-2013).

CBW 2025 Milestone	2009 Progress	2011 Progress	2013 Progress on 2010	Percent Achieved of 2025 WIP
Non-urban	191,638	501,120	1,041,259	92
Urban	165,375	208,509	385,190	17
Total				41

Development of Chesapeake Bay BMP Verification
In August 2014, the Management Board approved a framework[2] by which the Bay Program partners will develop verification programs to ensure that BMPs implemented continue to work properly and are eligible to receive nutrient and sediment load reduction credits towards the TMDLs. The framework includes BMP verification guidance from the Bay Program's six technical sector and habitat workgroups (e.g., agriculture, forestry, urban, wastewater, wetlands, streams). While the verification guidance recommended 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.

Development of 2008 Baseline for the Chessie BIBI
The Interstate Commission on the Potomac River Basin, ICPRB, received funding to re-evaluate the Chessie BIBI and provide an update to the 2008 baseline.

Guidance to Evaluate Stream Restoration Projects
The US Fish and Wildlife Service and Maryland Department of Environment plan to publish guidance to evaluate stream restoration projects using a function-based assessment process (i.e., Stream Functions Pyramid Framework). Release of the guidance is expected in 2015.

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[2] "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.

STAC Workshop on Designing Sustainable Stream Restoration Projects within the Chesapeake Bay Watershed
The Habitat Goal Implementation Team hosted a workshop in May 2014 to create agreement among practitioners, regulators and scientists on a common language and assessment methods for designing sustainable steam restoration projects that improve the functional elements of stream health.

Pooled Monitoring Approach to Stream Restoration Projects
During the summer and fall of 2014, an ad-hoc committee represented by regulatory agencies (USACE, MDE, FWS), state and resource agencies (MDE, SHA) and stream organizations (MSRA) was coordinated and lead by the Chesapeake Bay Trust to explore and begin development of a pooled monitoring approach. Currently, the data generated from permitted stream restoration projects are insufficient to assess the functional improvement, or uplift, as a result of management actions. While other factors affect the ability to assess the impact of stream restoration projects, the identification of specific monitoring parameters that align with project goals and objectives is needed. A Request for Proposals was released as a result of this work by the CBT to answer research questions that will ultimately lead to an increased confidence in stream restoration project outcomes, clarification of the optimal site conditions in which to apply particular stream restoration techniques, information useful to regulatory agencies in project permitting and information that will help guide monitoring programs.

On-going Monitoring Efforts
There are several state and resource agency monitoring programs to support the assessment of stream health and function at the State level. *Examples of some of these efforts include*:

- EPA National Rivers and Stream Assessment: The EPA NRSA sampled between 90 and 100 randomly-selected sites in the Chesapeake Watershed. These sites have benthic invertebrate, fish, periphyton, water quality, and habitat data. The EPA NRSA surveys are conducted every 5 years, including 2008/2009, 2013/2014, with the next one scheduled for 2018/2019.
- 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,
- National Park Service has 5 inventory and monitoring networks operating within the Chesapeake Bay (provided by Marian Norris);
- Maryland Biological Stream Survey (MBSS): Sampled 252 randomly-selected sites during 2007 – 2009 to characterize Maryland's ecological condition. Round Four is scheduled for 2014-2018….
- County monitoring programs

Chesapeake Bay Regional General Permit for TMDL
The Baltimore District of the U.S. Army Corps of Engineers (Corps) released a draft Regional General Permit for TMDL in July 2014 for activities in waters of the U.S., including jurisdictional wetlands that are part of an overall watershed strategy (e.g., Chesapeake Bay TMDL Watershed Implementation Plan (WIP)) whose purpose is to meet nutrient and sediment load reduction targets under the Chesapeake Bay TMDL mandates. Activities authorized by this TMDL RGP include, but are not limited to, the retrofit of existing stormwater management facilities, the retrofit of existing stormwater management outfalls, and the restoration and enhancement of non-tidal streams and non-tidal wetlands. The purpose of stream and wetland restoration and enhancement projects must be to meet nutrient and sediment load

reduction targets under the Chesapeake Bay TMDL and to restore and/or enhance aquatic resource functions at the project site.

IV. Gaps:

Information & Data

- Benthic macroinvertebrate data are not available from enough streams with enough frequency to track progress over time. Chessie BIBI provides limited capacity for annual tracking, trend analysis less than 5-7 yrs.
- The availability of baywide metrics other than biological indicators, such as the Chessie BIBI, to assess physical and chemical health and functions of streams
- Urban reference conditions or endpoints vs pristine, undisturbed reference conditions

Regulatory & Programmatic

- Design process for stream restoration that can measure change in stream functions and/project success based on a project goals and objectives
- Information needs to support innovative design approaches to identify restoration potential and success for different land uses, stream types, current and future site constraints, causes of impairment/stressors (e.g. legacy sediment vs runoff volume & velocity).
- Identification of priority stressors that affect local steam health and management actions to results in function lift

Prioritization

- Targeting cost-effective restoration actions and design approaches that would achieve both water quality and biological functional improvement
- Investments in research must be made to improve the body of knowledge surrounding restoration techniques and net benefit to stream and watershed health.

V. Management Approach:

The management approach is based on a holistic approach to improve stream health and function that recognizes streams are a part of a watershed (stream, floodplain, upland) such that stream health is controlled by both watershed and in-stream functions, processes, and characteristics. Management actions to restore stream health and function go hand-in hand with protection actions to maintain healthy streams and watersheds. Therefore any restoration action (e.g. BMP) needs to be part of an overall watershed strategy to address the physical, chemical and biological condition of the stream. As stream restoration will have an integral role in reducing nutrient and sediment loads to achieve the target load reductions as part the TMDL, it is equally important to implement actions that positively influence local stream health and focus on critical stream functions. The stream restoration targeted in the WIPs will address 700 miles of streams that will affect an estimated 12%[3] of the effort to achieve this Outcome. The following table identifies a list of management actions that if implemented can address the key factors influencing achievement of this Outcome.

[3] Chessie BIBI finds 57% of streams sampled are rated as poor or very poor. If this can be translated to total stream miles in the Bay, the 57,000 streams would be considered poor or very poor by the Chessie BIBI.

VI. Monitoring Progress

Monitoring programs are critical to understanding response of stream 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. Data generated to support development of the Chessie BIBI is key to monitoring progress towards improving 10% of stream health and function. To monitor progress between the Chessie BIBI assessments, the Strategy recommends other data sources to supplement this Baywide indicator to provide annual, State-specific metrics on the achievement towards this Outcome. The Strategy does not advocate for new monitoring programs, rather the development of common stream assessment and restoration guidelines that 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 lift 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 function. The management actions provide examples of the types of indicators that may be used to measure critical stream functions (e.g. lateral stability, bedform diversity, floodplain connectivity, riparian corridor and stream macroinvertebrate) from project specific locations throughout the watershed. While these are example structural parameters other functional parameters more representative of critical stream functions may be used given available measurement methods and resources to generate the data. Data is routinely generated from stream restoration projects as part of permit requirements but the data requirements are not necessarily comparable across projects, nor do they inform functional improvement in stream health. 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 Chesapeake Bay Program verification guidance for stream restoration BMP implementation that recommends site visit and evaluations 2 years after construction and then every 5 years or after catastrophic event. State-specific verification guidance is under development.

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
Ecological Stressors or Factors					
Excessive Sediment (erosion, legacy sediment)	High	High	Stream restoration BMP implementation to reduce local sources of excessive sediment and design elements that provide channel stability[2] Develop common indicators of stream bed and bank stability Watershed: Identify percentage of upland watershed area available for retrofit opportunities to reduce runoff volume and velocities entering streams at non-erosive rates	Water quality:Lbs of prevented sediment (Stream Restoration BMP Protocol 1)[1] Linear feet of stream bank stabilized [2] & stream length benefited Biological:Reduction in biological impaired 303d streams	2017 WIP 2025 WIP
Nutrients Excessive Loading to Streams (erosion, point source discharges, groundwater)	High	High	Stressor identification process to identify the priority factors influencing excessive nutrients Watershed: Identify percentage of upland watershed area available for retrofit opportunities to reduce runoff volume and velocities entering streams at non-erosive rates	Track stream length restored & stream length benefited Water quality: Lbs removed (BMP removal efficiencies)	2017 WIP 2025 WIP

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
Limited Nutrient and organic processing in-stream	High	Moderate	Stream restoration BMP implementation with design features to address major sources of N and enhance biological processing in-stream and/or floodplain wetlands where suitable	Water quality: Lbs removed (Excessive nutrients; Protocol 1) Water quality Lbs removed (stream processing; Protocols 2 and 3) Nutrient and materrial flux to support biota	
Alteration in channel form and function resulting in instability/disequilibrium (diversity and quality of Habitat, Geomorphology)	High	High	Develop common indicators of geomorphic stream health (e.g. lateral stability, bedform diversity, riparian corridor) Stream restoration BMP implementation that provides channel form and in-channel structure	Length of stream corridor which is weighted by overall uplift (e.g., existing low functioning to highly functioning would receive higher credit versus existing moderately functioning to highly functioning) Development of composite index of representative of non-biological data to measure stream health	Wetlands Outcome Forest Buffer Outcome Fish Habitat Outcome Fish Passage Outcome
Flow dynamics			Watershed: Identify percentage of upland watershed area available for		

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
Flow Atleration/Flashy Hydrology Hydraulics (Concentrated flows, reduction in baseflows)	High High	Moderate /Low (available science) High	retrofit opportunities to reduce runoff volume and velocities entering streams at non-erosive rates Develop indicators of floodplain connectivity and complexity	Change in hydrograph Water quality : Floodplain inundation & storage (Protocol 3) Bank Height Ratio	
Policy & Administration					
Lack of common Stream Assessment and Restoration Guidelines	High	High	Development of function-based stream assessment and restoration guidelines Explore development of metrics/composite index from routinely collected, non-biological data to measure changes in stream function	n/a	

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
Integration of WQ and living resource goals during WIP stream restoration	High	High	Identify stream corridor restoration designs that provide functional lift (development of case studies) Promote common project design process Identify screening criteria for identifying sites that can achieve both water quality and biological lift Information needs for alternative site analysis Army Corps provide basic information on each project to see how they document functional lift	n/a	
MS4 permits focus on water quality	High	High	Add language to MS4 permits to recognize functional uplift as part of credit for stream corridor restoration projects	n/a	
Adequate financial resources to assist local implementation efforts (administration and incentives)	High	Unknown	Identify opportunities to offer incentives to embrace new technology and attempt new restoration methods and work with permitting agencies to recognize/accept the new technology/methods for stream restoration	n/a	

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
			Incentives for projects to provide functional uplift for water quality and biological uplift Grant funders prioritize stream restoration projects that demonstrate functional lift of critical stream functions		
Adequate extension infrastructure to communicate newest research and technical guidance to jurisdictions (outreach and tech assistance)	High	Moderate	Provide training to jurisdictions on implementation of expert panel report recommendations Support development of verification guidance for stream restoration by State agencies and District Target educational and technical assistance to jurisdictions to broaden impacts of planned WIP stream restoration BMPs Continued coordination of efforts with permitting agencies Promote comprehensive approaches to improving stream health, such as the Upper Susquehanna Coalition Stream team		

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
Scientific Knowledge & Application of Research					
Stream restoration monitoring	High	High	Pooled monitoring – Generate guidance on how to monitor stream restoration projects and collectively generate data to demonstrate functional lift on a project-specific basis. The data would be used to assist the development of case studies to support other management actions. Establishment of an ongoing stream restoration monitoring consortium and data clearinghouse within the CBPO to share project data		
Lag Times	High	Low [4]	Multiple year monitor time frame for selected indicators (of stream processes, structure)		
Limited ability to define urban reference conditions	High	High	Development of urban reference condition		
Ability to demonstrate biological uplift from BMP implementation	High	Moderate	Development of case studies to document functional response in stream with various management interventions	Length (and %) of stream miles meeting respective state biological water quality	

Factors	Influence on Outcome	Ability to manage/change	Management Action	Indicator	Related Outcome(s)
			Convene Expert Panel to quantify biological response in stream health to BMP implementation	criteria (Healthy Watershed Outcome)[3]	
Insufficient data to develop Bay-wide fish-based indicator	High	Moderate/Low	Indicators of species (i.e., aquatic and terrestrial) health	Brook Trout Outcome[3] Fish Passage Outcome[3]	

[1] Schueler. T.R. and B. P. Stack. 2014. *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. U.S. EPA Chesapeake Bay Program.*
[2] Channel stability is defined as a stream channel that can store and transport sediment supply downstream beneficial to aquatic resources and withstands a range of flow events post-restoration.

[3] Management actions to support biological communities would also benefit from these other Outcomes

[4]Acknowledget that lag times, the time elapsed between adoption of management changes and the detection of measurable improvement in water quality, cannot be directly affected by management actions. Rather the management action is to better understand how lag times affect stream response

VII. Assessing Progress

The Chesapeake Bay Program annual progress reports on BMP implementation, specifically BMPs identified to impact critical steam functions (e.g. stream restoration, stream fencing, forest buffers) can be used to estimate the project nutrient and sediment load reductions expected from practice implementation. Assessing progress should also focus on functional uplift and allow for different levels of lift based on project goals and objectives. While we want to encourage biological lift for all stream restoration projects, we cannot require it given site specific constraints and the ability to address 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.

VIII. Adaptively Manage:

For any given restoration project, there are uncertainties in the application of even the best restoration science, both stream corridor restoration and upland BMPs, which includes some level of risk that implementation may not achieve its objectives. As the field of stream restoration science and design continues 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.

IX. Biennial Workplan: (TBD, Development of workplan deferred 6 months post other elements of Management strategy)

Topic	Task	Lead POC	Timeline	Status
Stream Health				

Additional Suggested References

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. *http://el.erdc.usace.army.mil/elpubs/pdf/sr52.pdf*.

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.

U.S. Environmental Protection Agency. 2014. Causal Analysis/Diagnosis Decision Information System, or CADDIS. http://www.epa.gov/caddis/