Multi-Metric Stream Health Indicators – Physicochemical Metric Analysis

Chesapeake Bay Program
Science. Restoration. Partnership.

Draft Framework

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Purpose

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This project is conducting interviews with experts, reviewing data, creating a framework, providing a data inventory matrix, and making recommendations that may help develop multi-metric stream health indicators for **physicochemical** parameters. The development of these additional indicators will address the significant science and management need to better understand and communicate how streams respond to management actions.

Technical Advisory Group

Stream Health Work Group

Chesapeake Bay Program

Holistic Approach

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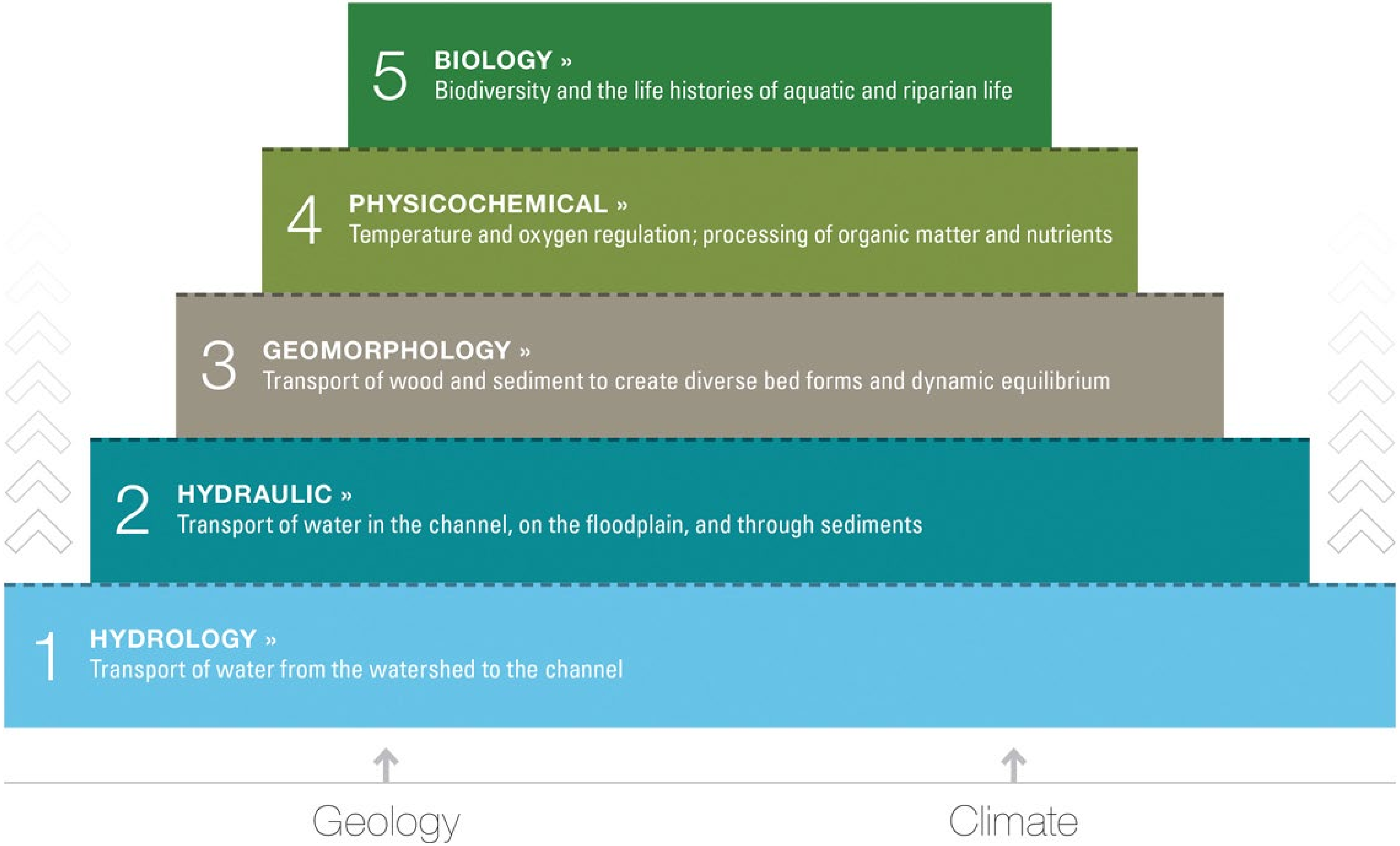
- Stream health is closely aligned with the Clean Water Act goal “to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.“
- Important to recognize that physicochemical elements, and indeed all the components of stream health, interact within the watershed.
- Both EPA and CBP have used a Healthy Watersheds conceptual framework that explicitly includes chemical and physical constituents of water quality as indicators of ecological health

➢ Our approach will be to focus on the near-term development of physicochemical indicators within **Level 4 of the Stream Functions Pyramid** in the context of the supporting geomorphology, hydraulics, hydrology indicators, and landscape-scale indicators influencing the stream corridor

Stream Functions Pyramid



Interviews

- Interstate Commission on the Potomac River Basin (ICPRB)
- Maryland Department of the Environment (MDE)
- U.S. Geological Survey (USGS)
- U.S. EPA Region 3
- Fairfax County
- Virginia Department of Environmental Quality (VDEQ)

Literature Search

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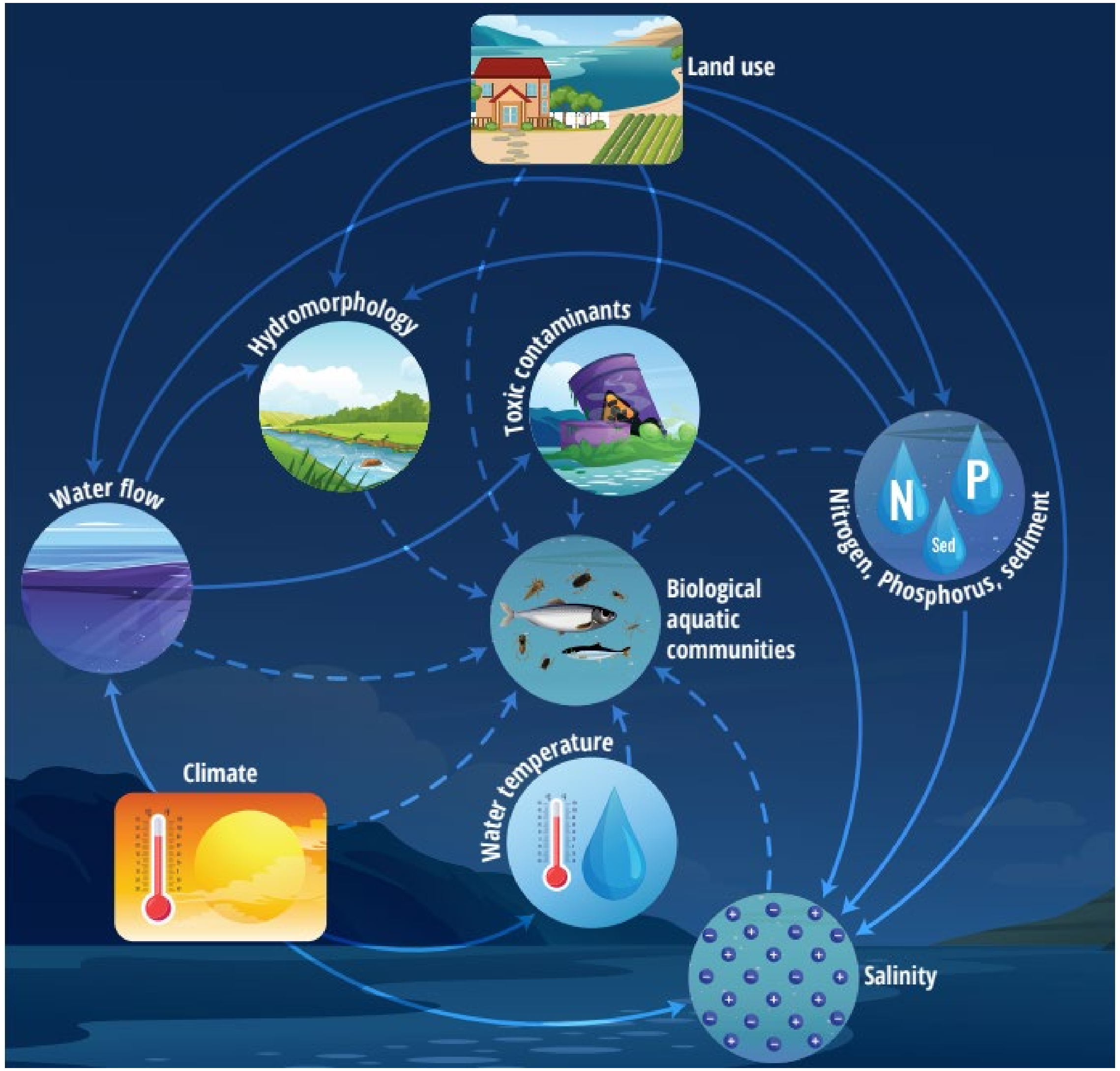
- General literature search to identify journal articles, reports, data, tools, and web information
- Search was conducted at a screening level (i.e., not comprehensive of all literature or resources available)
  - Targeted to capture key approaches and examples
- Information sources provide insights into the current state of the science
  - Assisted in developing the framework

Stream Health Indicators



Landscape Condition
Patterns of natural land cover, natural disturbance regimes, lateral and longitudinal connectivity of the aquatic environment, and continuity of landscape processes.

Geomorphology
Stream channels with natural geomorphic dynamics.

Habitat
Aquatic, wetland, riparian, floodplain, lake, and shoreline habitat. Hydrologic connectivity.

Water Quality
Chemical and physical characteristics of water.

Hydrology
Hydrologic regime: Quantity and timing of flow or water level fluctuation. Highly dependent on the natural flow (disturbance) regime and hydrologic connectivity, including surface-ground water interactions.

Biological Condition
Biological community diversity, composition, relative abundance, trophic structure, condition, and sensitive species.

Select Physicochemical Stream Assessment Literature

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- Surface water quality profiling using the water quality index, pollution index and statistical methods: A critical review
- A review of water quality index models and their use for assessing surface water quality
- Evaluation of the surface water quality using global water quality index (WQI) model perspective of river water pollution
- Water Quality Indices: Challenges and Application Limits in the Literature
- A comprehensive review of water quality indices (WQIs): history, models, attempts and perspectives

Relevant Data Sources

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- Chesapeake Bay Program Data Hub
- SRBC: Water Quality and Biological Indices for the Susquehanna River Basin
- USGS: Data (nutrients, suspended sediment, flow, temperature, conductance, and toxics)
- USGS: Assessments of Stream Health Condition in the Chesapeake Bay Watershed
- EPA: Ecoregion Nutrient Criteria
- EPA: Water Quality Indicator (WQI) Tool
- EPA: Integrated Assessment of Healthy Watersheds
- University of Maryland Center for Environmental Science (UMCES): Eco Health Tool

Example Physicochemical Indicator Approaches

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- SRBC: Water Quality and Biological Indices for the Susquehanna River Basin
- University of Maryland Center for Environmental Science (UMCES): Eco Health Tool
- Oregon Water Quality Index: Background, Analysis and Usage
- A Water Quality Index for Washington Ecology's Stream Monitoring Program
- EPA Water Quality Assessments for Watershed Health

Key Physicochemical Parameters

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- Key **physical** indicators include temperature, turbidity, conductivity, and flow
  - Provide insights into the stream's habitat characteristics and water clarity
- Key **chemical** indicators include pH, dissolved oxygen, and the concentration of nutrients (like nitrogen and phosphorus)
  - Vital for assessing the chemical balance of the water and its potential for supporting diverse biological communities
  - Heavy metals and organic pollutants can significantly impact stream health
- Selection of parameters is the first step – currently no systematic technique to formalize the parameter selection process
  - Expert opinion (Delphi method), ecological importance of the parameter, and data availability have been used

Example Physicochemical Parameters

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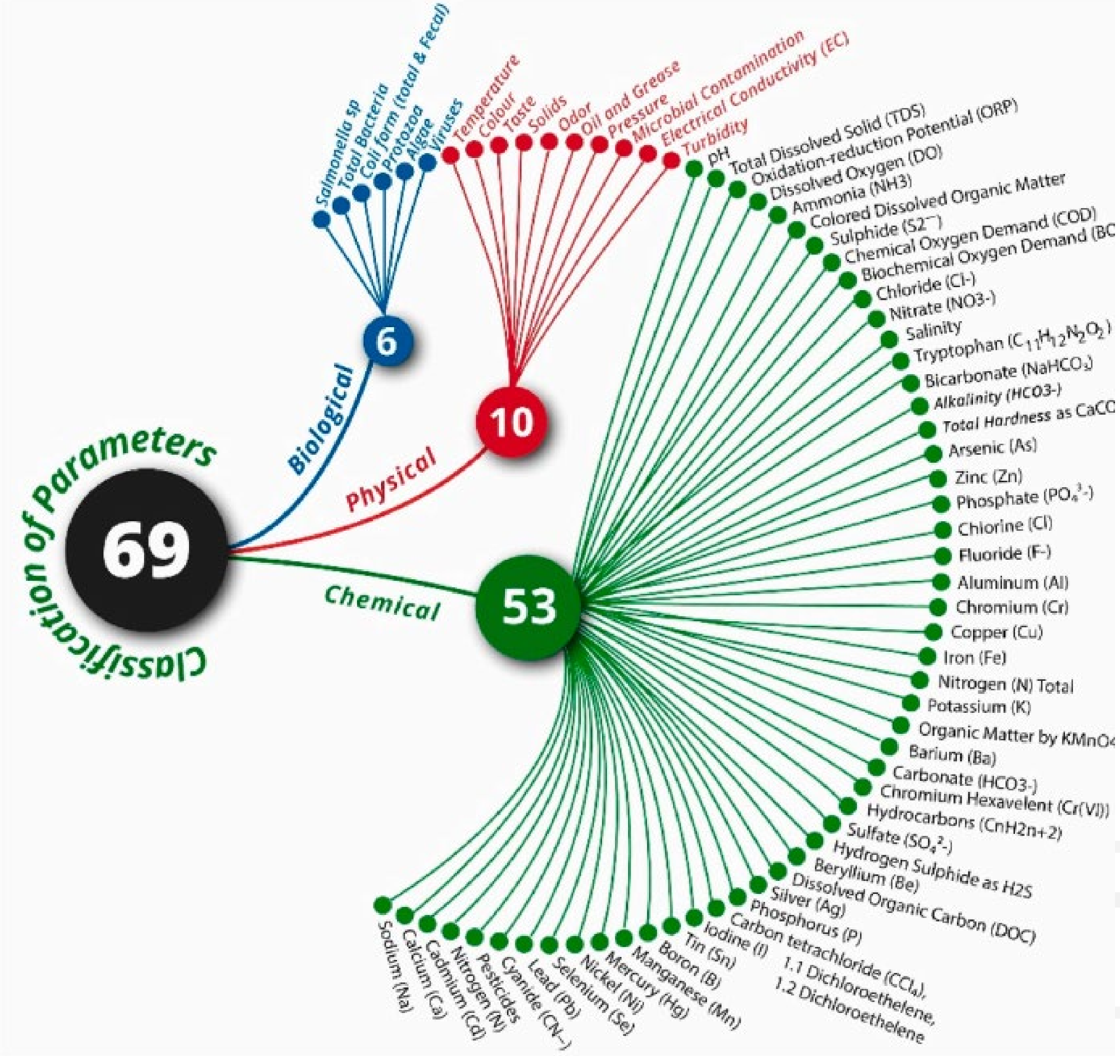
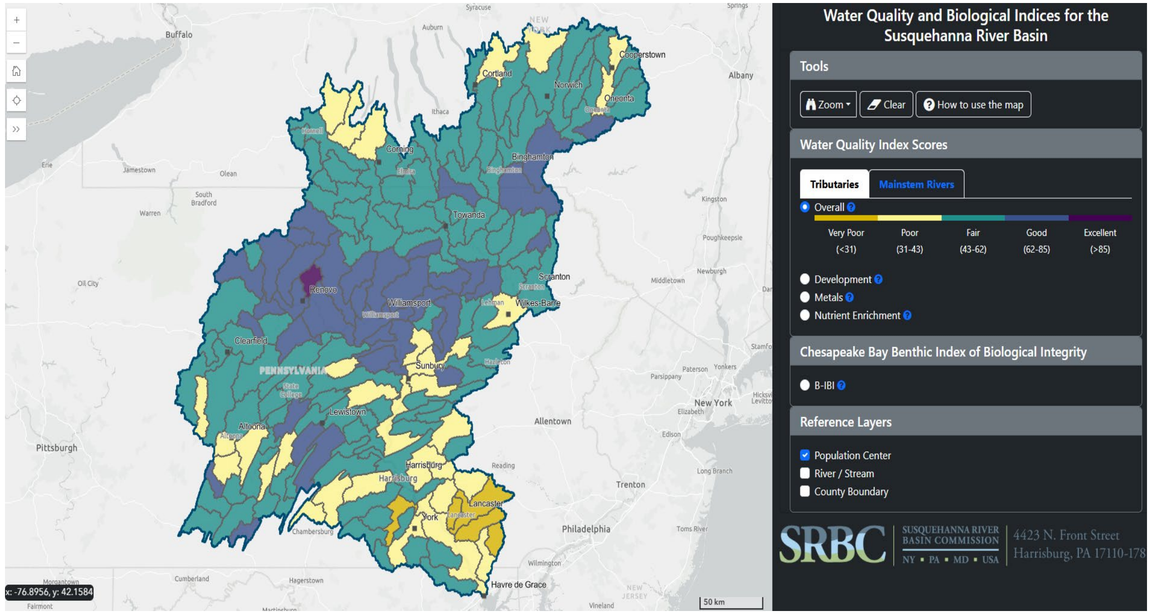
- Scientific literature suggests about 8 to 11 parameters are typically used as indicators, but some studies have analyzed as few as 4 to determine stream health
- Metrics suggested by **USGS**
  - Nitrogen
  - Sediment
  - Phosphorus
  - Water Temperature
  - Salinity
  - Toxic Contaminants
  - Flow



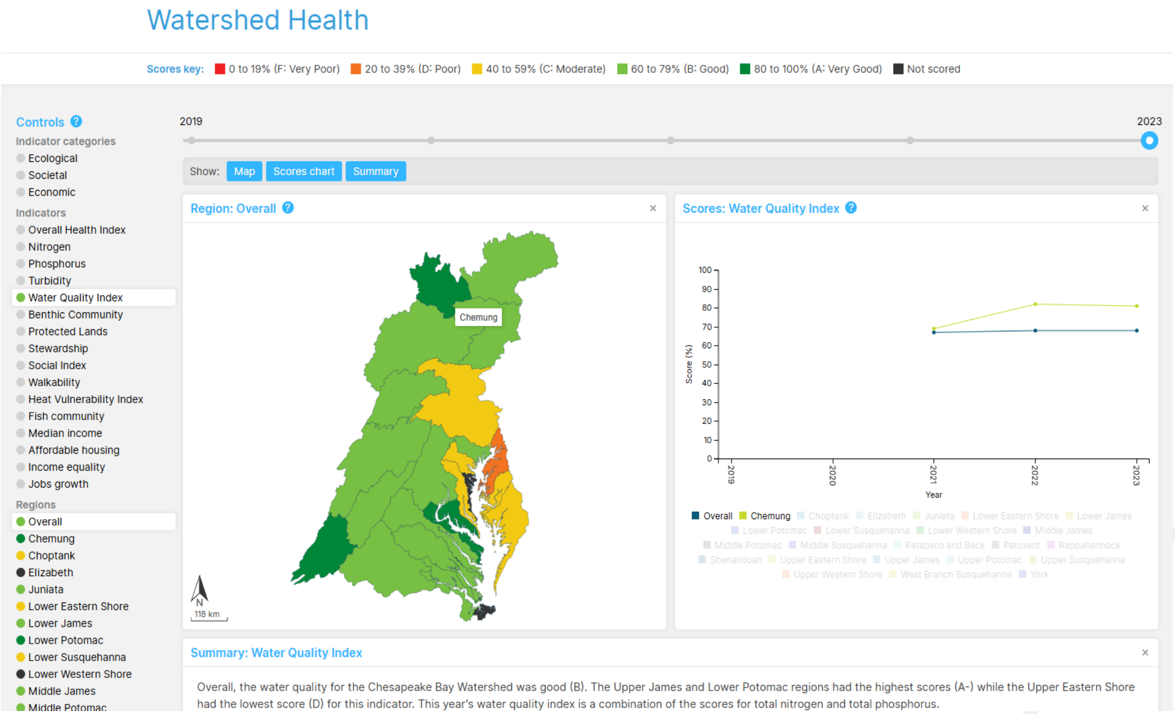
Local Examples of Physicochemical Indicators

Susquehanna River Basin Commission (SRBC) and University of Maryland Center for Environmental Science (UMCES) assess metrics across jurisdictions

- SRBC Water Quality Index
  - Metals: Aluminum, Iron, Manganese
  - Nutrients: Nitrate, Phosphorus, Total Organic Carbon
  - Development: Chloride, Sodium, Sulfate



- UMCES Eco Health tool–Water Quality Index
  - Nitrogen, Phosphorus, Turbidity



Preliminary List of Potential Indicators

- **Water Temperature**
- **Dissolved Oxygen**
- **pH**
- **Specific Conductance**
- **Nitrogen**
- **Phosphorus**
- ***E. coli***
- **Suspended Sediment/Turbidity**
- **Flow/Water Depth/Connectivity**

- Toxics, pesticides, trace metals, and microplastics are not often considered as indicators, but have been suggested in the literature
- Final recommendation of indicators that can feasibly be used will be determined after completing further assessments of ecological importance, data availability, and utility

Proposed Framework to Evaluate Potential Indicators

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Steps to assess data sources and determine their value and practicality for producing indicators and/or a composite water quality index

1. **Categorize available physicochemical parameters based on their importance for stream health (defined as ecological integrity)**
   - Most important
   - Moderately important
   - Least important
2. **Determine the data availability for each important parameter**
   - Spatial coverage across Chesapeake Bay watershed
   - Temporal frequency of sampling relative to natural variability
3. **Identify or develop thresholds of concern**
   - Water quality standards and criteria
   - Reference benchmarks including using Principal Component Analysis
   - Ecologically relevant relationships

Proposed Framework to Evaluate Potential Indicators

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4. **Identify assessment scale and regionalization to capture natural variation**
   - Start with ecoregions
   - Modify with geological subregions if needed and feasible
   - Modify with temperature classifications if needed and feasible
5. **Develop individual metrics or composite indices**
   - Both discrete and continuous concentrations, and how to accommodate variation with natural factors (e.g., DO with temperature and elevation)
   - Indicators of multiple stressors such as conductivity (e.g., for salts, metals, pesticides)
   - Metrics for individual parameters based on benchmarks or departure from expected
   - Composite index using different combinatory methods
   - Transparent composite index with ability to drill down to individual metrics
   - Utility of each indicator method for communication to multiple audiences

Proposed Framework to Evaluate Potential Indicators

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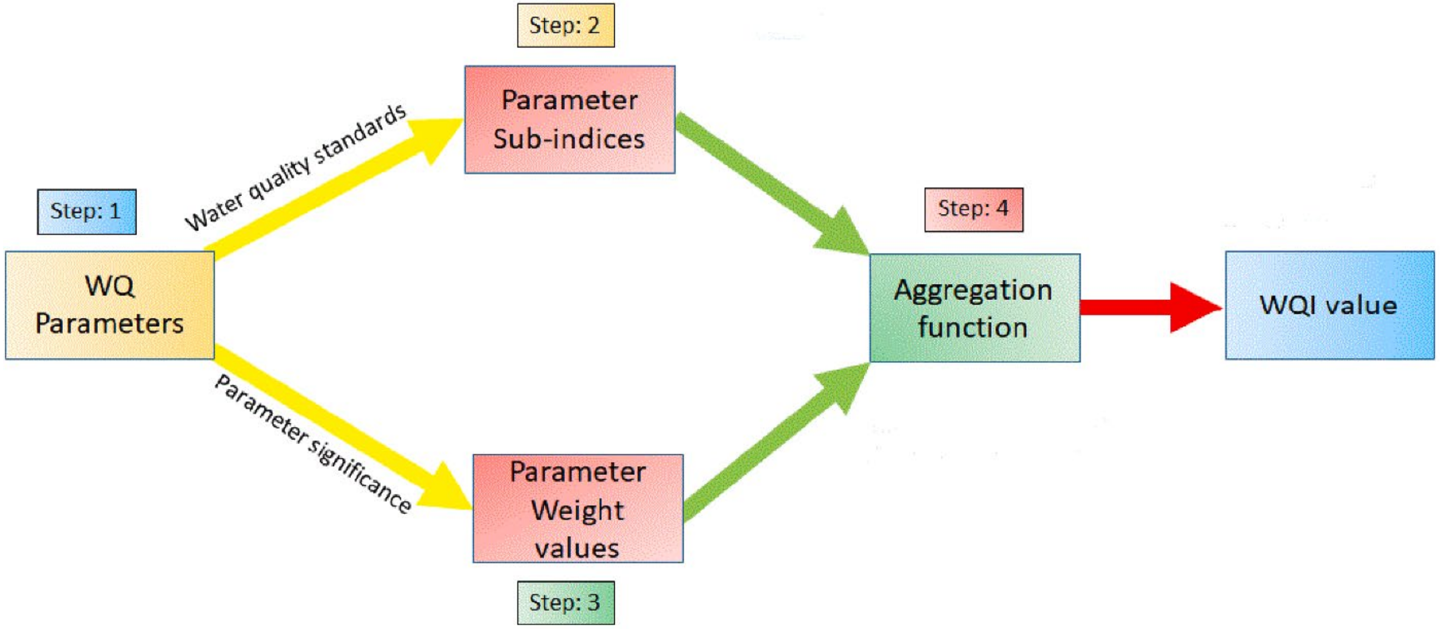
6. Pilot analyses to test feasibility and performance of metrics and indices

- Create simple index with select parameters
- Calculate metrics and indices with MBSS or other data
- Compare metrics with land use, benthic macroinvertebrate IBI, and fish IBI
- Determine feasibility of using biological taxa as stressor surrogates



Feasibility and Challenges of Physicochemical Indicators

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- State-to-state differences in data assessment and reporting, as well as limitations in data availability
- Some indicators can be highly variable because of sensitivity to natural (e.g., seasonality) and/or human-induced factors
- Various water quality index models and approaches have been applied both nationally and internationally, but there are no accepted standard methods
- Single composite water quality index simplifies very complex systems and can potentially lose or distort information (known as "eclipsing")
  - Sub-indexing rules, parameter weightings that do not reflect the true relative influences of parameters, or inappropriate aggregation functions

Discussion and Next Steps

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- Framework and Data Sources comments today
- Further comments due June 27

- Data Inventory Matrix and Recommendations for Further Indicator Evaluation to SHWG on August 6
- Presentation to SHWG on August 15

- Draft Report to SHWG October 31
- Final Report and Factsheet due January 31, 2026