

## EBEI-2: Observation Systems for Changes in Coastal Areas

### Option Description

The Chesapeake Bay is the largest inner-coastal estuary in the Nation, covering over 166 thousand square kilometers, with more than 150 rivers and streams draining into the watershed, and home to about 15 million people. Most of Maryland's communities and economic activities in this low-lying coastal region are particularly vulnerable to storm surges and flooding, events that will be likely be intensified due to rising sea level associated with climate change. Maryland relies upon its coastal areas along the Chesapeake Bay and its Atlantic coast for healthy fisheries, and reliable transport and navigation. Its dependence on infrastructure networks (roads, power grids, etc) intensifies the potential vulnerability of these areas to impacts from climate change-induced natural disasters.

An enhanced ability to observe sea level rise induced changing along Maryland's coastal areas will provide key benefits to the state. Under climate change, managing resources in these areas is more important than ever and will require accurate information from integrated observation systems to allow for detection and prediction of the causes and consequences of changes in coastal systems, watersheds and infrastructural resources. This option aims to support, enhance and integrate observation systems already in place in Maryland. Specifically, the option aims to strengthen such systems to enable the comprehensive surveillance, monitoring, documentation, and dissemination of rates and locations of sea-level rise in Maryland. This includes the installation of surveillance equipment in coastal sites where current public/private infrastructure is potentially vulnerable to small increases in sea level, the incorporation of long-term coastal monitoring aspects into existing protocols, and the integration of observation activities in regional efforts.

### Option Design

This policy option aims to enhance statewide monitoring programs in natural and urban settings to detect biological, physical and chemical changes and responses due to direct and indirect effects of climate change. This option will be facilitated through the observation, analysis, and interpretation of trends in coastal water levels, elevation (subsidence rates, if any), shoreline change, wetland loss, and tidal influence on estuaries and water supplies. The observation systems will enable the state to assess the responses of coastal landforms to sea level rise as well as the effects of an increase in storm activity. Implementation of the policy option will be coordinated with the policy options for Integrated Geographic Information System Mapping, Modelling and Monitoring and the policy options related to detecting specific impacts of climate change and sea level rise to resources and resource based industries.

The specific objective of this option is to assess how existing observation systems for the Chesapeake Bay region can be enhanced to better understand and address long-term sea level rise and its impacts on the built environment. The overall option design is summarized in the bullets below.

- **Targets:** Observation networks are an essential component of adaptive management in low-lying coastal areas. They are also essential in planning and evaluating the effectiveness of restoration programs in Maryland’s coastal zone. The target for this option is in the form of a detailed assessment regarding the adequacy of MD’s current observation system protocols, systems, technologies, and surveillance strategy to address long-term changes in sea level rise and the associated impacts. The output of the study should be a series of recommendations regarding how current observation networks could be reinforced and/or new component addressed to better address changing conditions regarding sea level rise. Components of the study should include:
  - Enhance federal, state, regional and local level interagency integration and coordination of observations systems that detect trends in coastal water levels, elevation (subsidence rates, if any), shoreline change, wetland loss, and tidal influence on estuaries and water supplies
  - Assess the suitability of vertically-controlled tide gauges;
  - Investigate funding the installation of additional tide gauges in particular locations, including Jug Bay;
  - Assess the adequacy of Surface Elevation Tables to measure whether marsh accretion is keeping pace with erosion/inundation; examine opportunities to add more SET’s with select marsh locations;
  - Integrate findings and study objectives for the Statewide Wetlands Monitory Strategy, currently under development by the Maryland Department of Environment;
  - Observe and record changes for a set of “leading indicators” of specific climate change impacts. This should include indicators that a representative of specific geographic ranges or behaviors or population characteristics of certain species (e.g., plants, birds, mammals, insects) that are known to be hypersensitive to sea level rise and other climatic changes;
  - Enhance the utilization of the *Maryland Geological Survey Groundwater Quality Network* to conducts well water quality assessments in areas where saline intrusion adjacent to tidal waters is known to occur;
  - Evaluate the need to expand the *Maryland Geological Survey Subsidence Studies Program* to assess the risk of elevation declines due to ground water withdrawals, which would exacerbate any impacts of sea level rise. Locations to be assessed could include those with significant current ground water withdrawals and/or those where population and associated groundwater withdrawals are projected to increase significantly in the near future.
  
- **Timing:** The timing of the study is immediate. It is anticipated that a 3-year period will be needed to complete the study. By the end of this period, there should be a detailed

recommended program regarding the additional integrated observations required, supplemental data management and distribution systems (if any), and a set of analytical products that respond to user-specific needs (i.e., commercial, management, recreational, educational, scientific, regulatory, safety, hazard protection, and restoration communities).

- **Parties Involved:** There are several parties that would be involved in the design and oversight of the study. At the state level, it would include the MD Department of Natural Resources, Maryland Department of Environment, and local national weather services offices. At the regional/national levels, it would include the National Oceanic and Atmospheric Administration, National Geodetic Survey, Chesapeake Bay Observation System, the United States Geological Survey, and the National Office for Integrated and Sustained Ocean Observations.
- **Other:** NA.

### Implementation Mechanisms

This option would be implemented by first preparing a feasibility study on the scope, issues, challenges, and likely costs associated with upgrading existing observation systems. On the basis of this study, terms of reference for the assessment would be prepared and implemented by a qualified organization/consortium. The recommendations of the study would become the input for changes to existing rules/regulations or new legislation to implement the activities identified as necessary to adequately monitor sea level rise and the effectiveness of Maryland's adaptation responses to climate change.

### Related Policies/Programs in Place

*Chesapeake Bay Observing System (CBOS):* There are important observation systems already in place in Maryland to monitor the Chesapeake Bay. The Chesapeake Bay Observing System (CBOS) is an organization that provides integrated data observation, management, and distribution systems and information for use by Chesapeake Bay and coastal communities. It is part of an evolving sub-regional observing system embedded in the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) and the Congressionally-mandated Integrated Ocean Observing System (IOOS).

*NOAA, Center for Operational Oceanographic Products and Services (CO-OPS): Tides and Currents:* NOAA Tides and Currents, managed by the Center for Operational Oceanographic Products and Services (CO-OPS), is the portal to the National Oceanic and Atmospheric Administration's collection of oceanographic and meteorological data (historical and real-time), predictions, and nowcasts and forecasts. Historic tide gauge data for the Chesapeake Bay can be found on the following website: <http://tidesandcurrents.noaa.gov/index.shtml>

*National Water Level Observation Network (NWLON):* NWLON is a network of 200 long-term, continuously operating water-level stations throughout the U.S., which provide tidal datums and water level observations for the US, as well as long-term sea level trends. They are also the foundation reference stations for NOAA's tide prediction products, and serve as controls in determining tidal datums for all short-term water-level stations.

*VDatum*: VDatum is a software tool administered by NOAA that is designed to transfer between 28 different vertical datums consisting of tidal, orthometric, and ellipsoidal datums. For more info – <http://www.nauticalcharts.noaa.gov/csdl/vdatum.htm>

*Climate Change Science Program (CCSP)*: U.S. Climate Change Science Program Synthesis and Assessment Product, Draft Report 4.1: “Coastal Elevation and Sensitivity to Sea Level Rise.” Available for public comment at <http://www.climate-science.gov/Library/sap/sap4-1/public-review-draft/>

*National Geodetic Survey (NGS)*: NOAA's National Geodetic Survey (NGS) defines and manages a national coordinate system. This network, the National Spatial Reference System (NSRS), provides the foundation for transportation and communication; mapping and charting; and a multitude of scientific and engineering applications. Additional related programs include:

- *Continuously Operating Reference Stations (CORS)*: The CORS network includes over 1,200 Global Positioning System (GPS) stations that run 24/7 and get adjusted daily. CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically. The National Geodetic Survey is working with CO-OPS to co-locate CORS with NWLON stations. This has already been done at several coastal sites, including Charleston, SC and Key West, FL. This enables local land elevation changes to be accounted for within local sea level measurements.
- *Height Modernization Program (HMP)*: The HMP provides accurate height information by integrating GPS technology with existing survey techniques.
- *Remote Sensing Division*: The RSN is responsible for collecting national shoreline information, to be fed into nautical charts.
- *State Geodetic Advisors*: Geodesists are placed within States to assist with surveying and geospatial data issues
- *Surface Elevation Tables (SETs)*. NGS is currently working on guidance documents concerning using GPS to tie SETs to local tidal and geodetic datums to enable measurement of vertical movement of coastal habitats.

*Maryland Dept. of Natural Resources, TEA/MANTA Tidal monitoring*: Maryland's Chesapeake Bay Water Quality Monitoring Program includes an integrated set of components that together provide a comprehensive assessment of water quality conditions. This set of water quality and habitat indicators includes: physical/chemical properties, nutrient limitation of algal growth, ecosystem processes, river inputs of nutrients and sediments, phytoplankton, zooplankton, and benthic organisms. The design, analysis and interpretation of each component of the program address three objectives: Characterize existing conditions; Detect changes and trends in key water quality variables in response to management actions; Determine attainment or non-attainment of water quality criteria; and, Understanding processes of how the Bay ecosystem functions as it relates to anthropogenic and natural stresses, management actions, and

relationships between water quality and living resources. Data is physically collected by scientists 16 times a year at 22 stations located in Maryland's Chesapeake Bay mainstem, 12 to 20 times a year at 55 stations sampled in the Chesapeake Bay tidal tributaries, and 12 times a year at 45 stations in the Coastal Bays.

*MD-DNR, MANTA/TEA Non-tidal monitoring:* Long Term Water Quality Monitoring has occurred at 54 locations on major (4th order and larger) non-tidal portion of Maryland's rivers since 1976. Sampling at these stations provides the data to determine trends in water quality constituents commonly associated with urban and agricultural land -use. Some of the TEA/MANTA monitoring data mentioned above can be access via *Eyes on the Bay*.

*Eyes on the Bay (EOTB):* A website of DNR's Tidewater Ecosystem Assessment (TEA) Division, Eyes on the Bay (EOTB), provides easy access to near real-time, mapped and historical Chesapeake and Coastal Bays water quality information and data. Available data includes water temperature, salinity, dissolved oxygen (the amount of oxygen available for aquatic life), water clarity, chlorophyll (the amount of algae in the water), and pH levels (the acidity/alkalinity of the water). Monthly, Continuous Monitoring and Water Quality Mapping data can be retrieved at EOTB.

*MDNR – MANTA-MD Biological Stream Survey:* Since 1994, Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division (MANTA) has sampled and assessed more than 2,000 freshwater, wadeable streams for biological, habitat, and chemical quality through the Maryland Biological Stream Survey (MBSS). Stream quality indicators have been developed for fish, benthic macroinvertebrates, salamanders, and physical habitat. MBSS results have been used in a variety of ways, including 1) watershed characterizations (i.e., targeting areas in need of both restoration and protection) via the Clean Water Action Plan and the resultant Watershed Restoration Action Strategies, 2) listing impaired streams for MDE's 303d list, 3) evaluation of stressors to aquatic fauna, and 4) determining geographic ranges of rare, threatened, or endangered aquatic species.

*MANTA's Sentinel Site Network:* To track natural variability in stream chemical, physical, and biological conditions, the Maryland Biological Stream Survey (MBSS) established a long-term monitoring component, the Sentinel Site Network, in 2000. The Network consists of 26 of the highest quality, minimally disturbed streams in Maryland based on physical, chemical, and biological data collected by the MBSS from 1995-1997. Long-term monitoring of sentinel sites offer the best hope for detecting the effects of climate change on Maryland's non-tidal streams/rivers and will provide important information for the management of stream resources in the face of this threat. In addition, MANTA has developed a Proposed Monitoring Program for Tidal Freshwater Ecosystems – there is currently a paucity of information available on these unique transitional habitats.

*Comprehensive Shoreline Inventory (CSI):* Maryland's Coastal Program contracted with the Virginia Institute of Marine Sciences (VIMS) to prepare a Comprehensive Shoreline Inventory that captures baseline shoreline conditions throughout the tidal portions of Maryland's coastal counties. Shoreline features and conditions were identified through a three-tiered shoreline assessment approach. The Inventory divided the shorezone into three regions: 1) immediate riparian zone (land use), 2) bank (bank characteristics such as height, bank type, etc., and

shoreline buffers), and 3) shoreline features (shoreline attributes including bulkheads, riprap, marinas, boat ramps, docks, etc.). Data from the survey was processed to create three GIS coverages, displayed through reports, summary tables, and maps, which are viewable online at <http://ccrm.vims.edu/gisdatabases.html>. Uses of *CSI*, for changes in shoreline conditions due to climate change and sea level rise impacts are numerous. The *CSI* has already been used by St. Mary's County to conduct a shoreline structure damage assessment following Tropical Storm Isabel. The *CSI* was incorporated into HAZUS-MH to provide shoreline conditions to conduct the level-one analysis of flood vulnerability in Maryland. And, the *CSI* was merged with the Stream Corridor Assessment used in the development of the Watershed Restoration Action Strategy (WRAS) program to provide a watershed view of non-tidal and tidal shoreline conditions. The *CSI* information was used in conjunction with historical shoreline position data by the Maryland Geological Survey to assess the loading of sediments to the Chesapeake Bay from shore erosion. Changes in shore erosion rates and sediment loading that accompany accelerating sea level rise can be assessed from this database.

*Maryland Geological Survey Groundwater Quality Network:* DNR's Maryland Geological Survey routinely conducts well water quality assessments in areas where saline intrusion adjacent to tidal waters is known to occur. Currently, wells on Kent Island and at Ocean City are sampled annually, Annapolis Neck less frequently, and Indian Head on the Potomac River only occasionally. Groundwater is the major source of potable water in the rapidly developing tidewater region of the State, and the combination of increased pumpage and sea-level rise are likely to increase the areas where saline water intrudes into aquifers and the salinity where intrusion is currently known to occur. The methodologies currently utilized and the database in areas already under study can be extended to other areas at risk of saline intrusion.

*Maryland Geological Survey Subsidence Studies:* DNR's Maryland Geological Survey in cooperation with Anne Arundel County and the State Highway Administration, have been conducting elevation surveys at three county water supply wellfields since 1994. These surveys have indicated only minor declines in elevation at the locations of the withdrawals, but ground water levels at these sites have not declined significantly to date. This methodology can be extended to other locations which might be at risk of elevation declines due to ground water withdrawals, which would exacerbate any impacts of sea level rise. Locations to be assessed could include those with significant current ground water withdrawals and/or those where population and associated groundwater withdrawals are projected to increase significantly in the near future.

## Estimation of Adaptation Benefits and Costs

**Estimated Cost:** TBD.

**Flexibility:** TBD.

- **Adaptive capacity:** TBD.
- **Other:** TBD.

### **Documentation of Adaptation Benefits and Costs**

- **Data Sources:** TBD.
- **Quantification Methods:** TBD.
- **Key Assumptions:** TBD
- **Key Uncertainties:** TBD.

### **Additional Benefits and Costs**

TBD.

### **Feasibility Issues**

TBD.

### **Status of Group Approval**

TBD.

### **Barriers to Consensus**

TBD.