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EBEI-2: Observation System 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 that ever and will require accurate information from an integrated observation system 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.

This policy option aims to enhance statewide monitoring programs to detect biological, physical and chemical 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. The Geographic Information System (GIS) will integrate the current elevation of the built environment with sea level, storm surge scenarios, and changes in coastal buffers that protect the built environment. Such a system will enable the identification of specific structures and infrastructure (roads, ports, etc.) that are most vulnerable to climate change.

Option Design

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:** 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 in the Bay area. 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. 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.

  Ideas to Explore: 1) vertically-controlled tide gauges (there is a gap in the CO-OPS observing system at Jug Bay, and CO-OPS or someone should fund a tide gage there; and 2) Surface Elevation Tables to measure whether marsh accretion is keeping pace with erosion/inundation – there are a bunch of these at Blackwarter, CBNERR-MD has them at Jug Bay and is getting them at Monie Bay

- **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 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

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: General info – http://tidesandcurrents.noaa.gov/index.shtml

National Water Level Observation Network (NWLON):

- 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.
- Routine real-time automated and event-driven data acquisition.
- Data can be used to estimate relative sea level trends (long-term sea level variation, monthly mean sea level).
- Working on the ability to model long-term events (50 to 100 years) and inundation. The exceedance probability product will be available online soon.
- Tie tide gauge stations to Continuously Operating Reference Stations (CORS) in order to tease out local land movements from sea level trends.

➢ More info – http://tidesandcurrents.noaa.gov/nwlon.html

VDatum:

- Software tool designed to transfer between 28 different vertical datums consisting of tidal, orthometric, and ellipsoidal datums.

➢ more info – http://www.nauticalcharts.noaa.gov/csdl/vdatum.htm

Climate Change Science Program (CCSP):

- NOAA is a lead author on Synthesis and Assessment Product 4.1: *Coastal Elevations and Sensitivity to Sea Level Rise*
- Estimated start of 45-day public review of draft report 9/2007.

➢ more info – http://www.climatescience.gov/Library/sap/sap4-1/default.php

National Geodetic Survey (NGS): General info – http://www.ngs.noaa.gov/

National Spatial Reference System

- NGS responsible for National Spatial Reference System. Need land and water levels tied together for local impacts of sea level rise. LIDAR must be tied to good geodetic control for it to be accurate.

Continuously Operating Reference Stations (CORS):

- CORS network – 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.
- NGS 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.

➢ more info – http://www.ngs.noaa.gov/CORS/

Height Modernization Program:

- Provides accurate height information by integrating GPS technology with existing survey techniques.
- Looking at ways to get good elevations in intertidal areas, particularly tidal wetlands.

- This year, for the first time, NGS was funded for a nationwide height modernization program instead of earmarks for individual States. This should allow NGS to focus on areas where heights matter the most (i.e. along the coasts).
  - ➢ more info – http://www.ngs.noaa.gov/heightmod/index.shtml

Remote Sensing Division

- Responsible for collecting national shoreline information, to be fed into nautical charts.
  - ➢ more info – http://www.ngs.noaa.gov/RSD/coastal/index.shtml

(NGS) State Geodetic Advisors

- NGS has agreements with many States to employ geodesists to assist with surveying and geospatial data issues.
  - ➢ more info – http://www.ngs.noaa.gov/ADVISORS/AdvisorsIndex.shtml

Surface Elevation Tables (SETs)

- NGS is 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.
- NGS is also working with USGS to quantify the errors associated with SET devices and to improve the design of the instrument.
  - ➢ more info – http://www.pwrc.usgs.gov/set/

[U.S. Geological Survey – Need to add]

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 consisted 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. In addition, MANTA has developed a Proposed Monitoring Program for Tidal Freshwater Ecosystems

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.

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.

EBEI-3: Adaptation of Vulnerable Public and Private Sector Infrastructure

Option Description

Maryland has thousands of miles of developed waterfront property along the Chesapeake Bay and its tributaries. Much of this area contains public and private sector infrastructure that will be adversely impacted by sea level rise (SLR) and increased climatic severity (storms and wind driven tides) caused by climate change and subsidence. Public sector infrastructure (i.e., roads, bridges, airports, wastewater treatment facilities, municipal water systems, etc.) is essential for community framework. Private sector infrastructure (i.e., residential properties, boating facilities, retail and office buildings, farms, etc.) has historically enjoyed higher market value compared to inland properties because of its proximity to the water especially in more recent times.

As sea level continues to rise, both state and local governments in Maryland, as well as many other public and private property owners are facing the very real and hard decision about how to adapt and at what expense. Decisions about how to adapt to the impacts of sea level rise will be different for varying land uses, taking into consideration the value of the land (monetary, resource-value, and perceived value), public opinion, public safety and risk assessments, ecosystem survival and replacement, environmental and development opportunities, and others.

There is a range of potential adaptation options such as protection, relocation and retrofitting that can be utilized to respond to sea level rise. Protection of vulnerable coastal infrastructure can be accomplished by use of structural bulkheads, seawalls, or revetments which are the least desireable means. Protection can also be accomplished that will be improve ecosystems and create new opportunities. However, it will not be practical (socially, economically or environmentally) to do so for all areas at risk. Developing a framework for making abandon/modify/move/protect decisions must be done in combination with other comprehensive planning and emergency management decision-making frameworks.

The objectives of this option are to identify and assess Maryland's SLR impacted public and private sector infrastructure (based on various SLR scenarios agreed upon by the STWG which identify vulnerable inundation areas), categorized and assess impacted infrastructure based on research to determine feasible option strategies, and formulate strategies to integrate action plans at the federal, state, and local levels.

In order to plan and ascertain priorities, there needs to be differentiation between properties that can adapt to SLR and those which may need to be abandoned and/or relocated. In the case of public infrastructure, one important factor in this determination can be made by comparing the impact of projected SLR and the projected useful life of the facility. Coordinated plans need to be developed between the private sector, local, state, and federal authorities for how adaptation can best be accomplished. Existing laws and regulations, processes, and practices need to be re-visited and possibly changed, eliminated, and/or supplemented so that they facilitate positive potential results from adaptation in recognition of the changing climate and environment.

It is most important that every effort be made to encourage and facilitate opportunities where appropriate to offset the impact of the losses that are inevitable.

Option Design

Targets: The following are the key targets for this option:

1. Raise the awareness of the impact of SLR in impacted areas. Since SLR is so gradual, one of the obstacles to implementing successful option strategies will be to overcome denial and achieve "buy-in" and participation from stakeholders.
2. Identify vulnerable SLR inundation areas along Maryland's shoreline using newly acquired topographic data.
3. Assess public and private sector infrastructure within these vulnerable areas to gain a statewide sense of the breadth of infrastructure impacted.
4. Categorized and assess impacted infrastructure based on research to determine feasible option strategies. This should be conducted by team of experts considering successes and failures of other actions attempted or contemplated worldwide, potential engineering solutions and technological applications to determine potential applicability to the impacted projected areas. The scope of this study should be to prepare generic adaptation methods descriptions, and the feasibility (costs, impacts, etc.) of implementing various adaptation scenarios (abandon/modify/move/protect).
5. Formulate and prioritize strategies to adapt to climate changes and SLR, along with a plan to integrate plans of action at the state and local levels.

Timing: The following represents some of the key schedule milestones for this option:

1. Raising the awareness level has already begun and is an important part or all options in this effort.
2. Compiling existing data on projected SLR inundation areas and existing infrastructure within those areas could utilize existing tools, programs and resources, and could therefore begin immediately and be targeted for completion by the end of 2009.
3. Categorizing and assessing impacted infrastructure of adaptation options should follow the initial data compilation. This phase of the option should begin in late 2009 and be completed by 2011.
4. Formulate strategies, priorities and implementation action plans (*timing??*)

Parties Involved:

Coordinated involvement will be needed from property owners, local town/city governments, county governments, Maryland agencies including DNR, MDOT, MDE, MDP (Maryland Department of Planning, Maryland Utilities Commission, federal agencies including USDA, US Army Corps of Engineers.

Other: NA

Implementation Mechanisms

Identification and assessment of impacted properties, research, determining strategies, and creating incentives and enabling legislation and/or changes in processes, practices are needed before widespread adaptive measures can be successfully implemented.

Related Policies/Programs in Place

There are several related policies/programs in place in Maryland, as outlined below:

- *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**. The CSI can be used as a state and local planning tool to inventory and assess coastal infrastructure vulnerable to sea level rise inundation or coastal flooding.

- *Strategic Shore Erosion Assessment (SSEA).* From 2000 – 2002, a NOAA Coastal Services Center, Coastal Management Fellow, worked with the Coastal Program to initiate the development of a comprehensive approach to shore erosion planning for Maryland. The Fellow was tasked with developing a protocol to create regional strategies to deal with shoreline erosion issues. The Fellow worked closely with two counties, Dorchester and St. Mary's, to identify an approach to balance the need to address risk from erosion, while also maintaining natural shoreline habitat. The developed protocol became the foundation for the Strategic Shore Erosion Assessment (SSEA), currently under development.

  In 2002, Coastal Program staff worked with DNR's Shore Erosion Control Program to integrate the protocol developed for the SSEA into the Program's Project Selection Criteria and Financial Assistance Priority Rating System. Environmental and habitat enhancement considerations are now incorporated into the rating system which creates a score for each homeowner's project based on criteria such as infrastructure threat from erosion, and an applicant's financial need.

- *Maryland's 2006 – 2010, CZMA §309 Coastal Hazard Strategy:* The Strategy, approved by NOAA in 2006, sets for the current workplan for development of the SSEA. The project is being implemented in three phases: (1) generation of fetch exposure tool, community risk assessment, and environmental risk assessment; (2) application and validation of GIS tools through development of the Corps Feasibility Study Master Plan; (3) incorporation into the interactive mapping application; and (4) workshop development and training of State and local coastal managers and planners.

- *Chesapeake Bay Shore Erosion Control Master Plan.* Maryland's Coastal Program is currently participating in the development of the *Chesapeake Bay Shore Erosion Control Master Plan* along with the U.S. Army Corps of Engineers (USACE) and MDE. The Plan, being developed as a component of Chesapeake Bay Coastal Management Feasibility Study, will result in outreach material for contractors and homeowners as well as a Master Plan that uses modeling tools to evaluate stretches of shoreline and prioritizes these areas for erosion control activities. The Master Plan will serve as a guide for potential shore erosion management strategies and assist the agencies in being consistent with promoting strategies along tidal shorelines. These strategies will likely include: structural and non-structural erosion control devices, designation of natural erosion areas, land acquisition, and establishment of local erosion-based setback requirements.

- *Draft Report of CCSP Synthesis and Assessment Product **4.1**, **"Coastal elevations and sensitivity to sea level rise:"*** This report is one of 21 synthesis and assessment products being prepared by the U.S. Climate Change Science Program (CCSP). The Draft Report is

posted on the CCSP web site at: www.climatescience.gov/Library/sap/sap4-1/public-review-draft/. The report is currently out for public review. Comments must be received by COB **10 April 2008**. The draft report includes the results of a research project entitled the Likelihood of Shore Protection in Maryland. This project, conducted by the EPA, was based upon interviews with state regulators and county planners to investigate existing and anticipated coastal policies and land uses. The study developed maps that distinguish coastal areas in Maryland that are likely to be protected as sea level rises and areas that will likely retreat because of protection cost or currently land use policy.

- HAZUS-Multi Hazard (MH): HAZUS is a risk assessment software program for analyzing potential losses from floods, hurricane winds and earthquakes. HAZUS-MH estimates damage before, or after, a disaster occurs and takes into account various social and economic impacts of a hazard event. MDE partnered in {insert year} with Salisbury University to complete a statewide analysis of flood vulnerability estimated through the HAZUS-MH flood module. The Level One analysis completed in June 2005, estimates flood damage from a 100-year coastal or riverine flood event to commercial and residential properties. This study takes the next step from identifying flood vulnerability to understanding the risk to the built environment. The final report, "An Assessment of Maryland's Vulnerability to Flood Damage" is now available. [NEED TO UPDATE SEND TO MDE AND MEMA].
- Moreover, the coordination and reinforcement for this option should be with the following other options in this report:
  - Assessment of Coastal Zone Adaptation Options and Evaluation of Shoreline Protection Structures
  - Integrated Planning for SLR and Associated Coastal Hazards
  - State Agency Reporting on Response to CCC Findings
  - Preserve Undeveloped, Vulnerable Lands
  - Integrated geographic information systems, monitoring, and modeling
  - New Criteria for Identifying Priority Protection Areas
  - Forest and Wetland Protection
  - Modify Environmental Protection Regulations to Promote
  - Sustainable Shoreline and Buffer Area Management Practices

Estimation of Adaptation Benefits and Costs

A detailed estimation of the quantitative benefits associated with this option are beyond the scope of this assessment. However, the following qualitative benefits are expected from the ultimate implementation of coastal adaptation measures:

- Environmental and ecological benefits will accrue from creating new marsh and wetlands to replace those that are lost to SLR.
- One for the ecological costs will the fact that currently existing marshes will be eliminated as SLR progresses while there will be a benefit from new marshes to be created both naturally and purposefully.
- Innovative incentives can be made available to the private sector to stimulate opportunities.
- There will be a considerable financial cost to local governments, the state of Maryland, and the federal government because of replacing or relocating impacted public infrastructure that become inundated.

On the cost side, the cost of adapting, relocating or abandoning & replacing public infrastructure can be estimated after the assessment and identification of impacted properties is complete. Some of these will be able to serve out their useful life before the need to replace them. In the meantime, care should be taken to not site new public sector infrastructure in impacted areas.

Documentation of Adaptation Benefits and Costs

Some data Sources that are relevant to the assessment of costs and benefits of this option are outlined below:

- Town of Oxford, Maryland Flood Insurance Rate Map, Community panel number 240068-001 A, effective September 28 1984
- Earth From Space. http://earthfromspace.photoglobe.info/spc_netherlands_dikes.html
- The Tyee. http://thetyee.ca/News/2007/05/28/FloodControl/
- MSN Encarta. http://encarta.msn.com/encyclopedia_761572410/netherlands_the.html
- Maryland Shorelines Online: http://shorelines.dnr.state.md.us/living.asp
- Chesapeake Bay Funders Network: http://www.campbellfoundation.com/html/related_projects.html
- Coastal defence solutions (approach of ComCoast)
  - **Henk Jan Verhagen** and **Paul J. Visser:** www.citg.tudelft.nl/.../doc/EFRM2007_ComCoast.pdf
- Intergovernmental Panel on Climate Change: http://www.ipcc-wg2.org/index.html

Quantification Methods

- TBD.

Key Assumptions

- The strategies and priorities from research depends on accurate projections of SLR
- funding for strategies developed can be justified and become available because both short term and long term ecological, environmental, and financial benefit

Key Uncertainties

- It is uncertain what the rate and extent of SLR will actually be because of all the complex factors involved.
- The relative impact of subsidence and SLR is uncertain. How much increased inundation is caused by subsidence vs. SLR? What is causing subsidence? Can this be minimized?
- How to achieve continuity of protection between multiple property owners if one or more does not wish to participate thus interrupting protection?
- The failure of our federal government to demonstrate leadership to this country and to the rest of the world by taking immediate and decisive actions to reduce and minimize the man-made causes of climate change must be changed. It is uncertain if this will happen throughout the world thus climate change could continue exceeding projections.

Additional Benefits and Costs

TBD.

Feasibility Issues

TBD.

Status of Group Approval

TBD.

Barriers to Consensus

TBD.

EBEI-8: Building Code Revisions and Infrastructure Design Standards

Option Description

Strengthen existing building codes and construction techniques for new infrastructure and structures in vulnerable coastal areas. This will involve evaluating existing codes and design standards with respect to their proven effectiveness in past storm events, identifying causes of failure, and implementing changes to codes to improve performance in the future. In addition to past performance, codes and standards should be reviewed and strengthened by taking into account future increased hazards caused by sea level rise and the associated possible increase in storm frequency and intensity caused by climate change. All types of development (residential, commercial, institutional, etc.), as well as public infrastucture such as roads and bridges, should be analyzed. Standards for marine-related structures such as piers and wharves should be included in this review.

In addition to the overall evaluation and strengthening of codes, the entire development process must begin to recognize the potential impacts of sea level rise and climate change. Design professionals must look for ways to reduce future impacts, and local governments must increase plan review, inspection and enforcement efforts.

This effort is ongoing at several levels. FEMA regularly publishes a "Summary Report on Building Performance" after major natural disasters (such as Hurricane Andrew and Hurricane Katrina). These reports study the damage resulting from the event, identify areas of strength and weakness in building design and construction, and recommend improvements. The International Code Council also studies code effectiveness and regularly makes improvements to its codes. It is imperative that these reviews begin to consider the effects of climate change and sea levels rise on the long-term sustainability of structures and infrastructure.

Option Design

Targets: All construction-related codes and design standards should be evaluated for their effectiveness in protecting against the future effects of climate change and sea level rise. This will include the following issues:

- Elevation of buildings – FEMA and local governments should mandate freeboard for all construction in coastal flood hazard zones. Freeboard is an elevation above a design high water level (base flood elevation). For example, the bottom of the lowest horizontal structural member should be elevated a minimum of two feet (or more) above the base flood elevation. This is especially pertinent with regard to sea level rise, since base flood elevations will be higher in the future. The required freeboard should relate to the amount of sea level rise expected, potential wave height, and the expected life of the structure. Experience from Hurricane Katrina shows that building elevation is the most effective deterrent to flood damage.
- Foundation design – Certain types of foundations are more effective in flood situations than others. Deep pile or column foundations are desired if significant erosion is possible in oceanfront locations as well as bay locations where the following conditions exist: erodibility of the soil; exposure to "damaging" waves (greater than 1.5 feet high); potential

for velocity flow; potential for flood borne debris; and required resistance to wind forces. These locations include FEMA identified V-zones as well as A-zones

- Long-duration flood impacts – Long-duration flooding, which may be a result of sea level rise in the future, can cause extensive damage to interior contents and building materials. Moisture entrapment within walls and floors can impact structural integrity as well as cause biological and chemical contamination. Elevation will avoid this problem, as will the use of flood resistant building materials above the minimum elevation
- Debris impact – Substantial damage can be caused by floating or wind-driven debris in a flood or storm event. Current codes and construction standards should be evaluated with regard to debris resistance
- Building envelope – Building envelope is the entire exterior surface of a building, including walls, windows, doors and roofs. All parts of the building envelope must provide protection from wind, wind pressure, and windborne debris. Building codes are very specific regarding these issues, but they should continually be reviewed and improved as needed
- Design of future public projects, including roads, bridges, tunnels, landfills, water and wastewater treatment plants, etc., should consider the effects of climate change and sea level rise. In addition, standards should be developed for the modification of existing facilities in response to sea level rise
- Abandoned facilities – Provisions should be made to minimize the negative impacts of structures and facilities that may be abandoned due to sea level rise. Such impacts may include navigational and environmental hazards

Timing: This is primarily an ongoing effort. Codes are currently in place, and should be implemented and enforced by everyone involved in the design and construction process. FEMA and the code agencies continually evaluate the effectiveness of the code requirements, especially after a major event such as a hurricane or flood. These events provide essential information regarding the performance of code complaint structures and reveal areas in need of improvement. Training of enforcement personnel should also be an ongoing effort. Codes and design standards should be reviewed periodically in light of new science and evidence of climate change and sea level rise.

Parties involved: All parties involved in the design and construction process should be involved in this effort, including for example the International Code Council, design professionals such as architects and engineers, building materials manufacturers, building trade associations, the Federal government (FEMA, National Weather Service, NOHH, Corps of Engineers), state government (MEMA, DOE, DNR), and local governments. Property owners also need to be aware of potential hazards and know how to evaluate the strengths and weaknesses of their properties.

Other: NA

Implementation Mechanisms

Implementation of this option will initially involve an evaluation of existing codes and regulations with specific regard to the threats associated with climate change and sea level rise. To account for the expected lifespan of newly constructed buildings, this will involve looking many decades into the future and trying to predict these impacts. If deficiencies are found, changes to codes, regulations and laws will be necessary. Enforcement of these codes is usually the responsibility of local governments; funding

assistance is needed to ensure that an adequate number of trained code officials and inspectors are available.

Related Policies/Programs in Place

Codes are currently in place to regulate construction. The International Building Code is the primary building code. FEMA's flood insurance program is the primary source of flood protection regulations. State and local governments often compliment these general programs with more site-specific regulations.

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

EBEI-10: Disclosure

Option Description

This option focuses on the development of operational protocols that specify disclosure requirements for coastal hazards. This includes information related to the purchase/sales of property for residential and commercial properties.

Option Design

The specific objective of this option is to provide a Maryland Sea Level Rise Disclosure and Advisory Statement. A draft of this document has been prepared and is included in Annex A.

- **Targets:** The targets for the disclosure statement are all purchasers of real property in the State of Maryland located in Worcester, Wicomico, Talbot, Dorchester, Caroline, Queen Anne's, Somerset, Kent, Baltimore, Cecil, Harford, Anne Arundel, Charles, St. Mary's, Calvert and Howard counties and Baltimore City.
- **Timing:** The timing for including the statement in real estate transactions is immediate.
- **Parties Involved:** Only those parties directly involved in the transaction (i.e., the buyer and seller, and their agents) are involved in the signing of the statement.
- **Other:** NA.

Implementation Mechanisms

TBD.

Related Policies/Programs in Place

TBD.

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.

Annex A

DRAFT

Addendum number ____ to contract dated _____ ___, 20___

Maryland Sea Level Rise Disclosure and Advisory Statement

*This statement **must** be provided to all purchasers of real property in the*

State of Maryland located in Worcester, Wicomico, Talbot, Dorchester, Caroline, Queen Anne's, Somerset, Kent, Baltimore, Cecil, Harford, Anne Arundel, Charles, St. Mary's, Calvert and Howard counties and Baltimore City.

Buyers are advised that, in the Mid-Atlantic region of North America, tidal and sea levels may be rising relative to the land surface. Such increases are very gradual and take place over very long periods of time. Buyers are encouraged to investigate projections of sea level rise at (website and office to be determined).