A Sustainable Chesapeake

BETTER MODELS FOR CONSERVATION

Edited by David G. Burke and Joel E. Dunn

THE CONSERVATION FUND

The case study you have downloaded is highlighted below. Other case studies from this Chapter of *A Sustainable Chesapeake: Better Models for Conservation* can be individually downloaded. The editors encourage readers to explore the entire Chapter to understand the context and sustainability principles involved with this and other featured case studies. The full publication contains 6 Chapters in total: Climate Change Solutions, Stream Restoration, Green Infrastructure, Incentive Driven Conservation, Watershed Protection and Stewardship.

CHAPTER 1 CLIMATE CHANGE SOLUTIONS

A Climate Change Challenge

Focusing Public Attention on Sea Level Rise and Storm Surge Threats in the Chesapeake Bay

The Chesapeake Sea Level Rise and Storm Surge Awareness and Response team was funded by the National Oceanic and Atmospheric Administration to produce visually oriented, active-learning, education tools that use innovative computer modeling techniques to demonstrate how sea level rise and storm surge will affect natural resources and public infrastructure in the Chesapeake Bay.

CASE STUDY SUMMARY

Natural resource professionals and conservationists have done extensive analysis of projected sea level rise impacts on coastal habitats along the Chesapeake Bay. These analyses indicate that the Bay will be dramatically altered by climate change and that sea level rise should be a major consideration in the region's coastal management and ecological restoration plans.[1] These analyses used well respected research tools to model a range of sea level rise scenarios.[2,3,4] The results highlighted the intense challenges posed by sea level rise induced by climate change. Nevertheless, these analyses used a static inundation model that could not consider the effects of storm surge. Storm surge combined with sea level rise and increased storm intensity, can carry floodwaters much farther inland, endangering lives, property and ecosystems. More detailed and accurate models were needed to produce inundation products for students, professionals, businesses and governments to explore the predicted impacts of both sea level rise and storm surge on the Chesapeake Bay.

In 2008, The Conservation Fund assembled and coordinated the interdisciplinary Chesapeake Sea Level Rise and Storm Surge Awareness and Response (CSSPAR) team to develop prototype tools and products that visualize the effects of sea level rise and storm surge inundation in the Chesapeake Bay region. Specifically, the team applied innovative computer modeling techniques to demonstrate how sea level rise and storm surge in the Chesapeake Bay will affect natural resources, such as wetlands and coastal forests, and public infrastructure, such as roads, emergency services, hospitals, schools, and residential structures. These models were then used to produce educational resources including an interactive website and printed map for students, natural resource managers, decision makers, and the general public. The models were also used to design a new course at the National Conservation Training Center for natural resource professionals interested in integrating sea level rise and storm surge into green infrastructure conservation planning and local land use master plans.

The CSSPAR team included the National Oceanic and Atmospheric Administration (NOAA), Chesapeake Research Consortium (CRC), Chesapeake Bay Observing System (CBOS), Maryland Department of Natural Resources (MDNR), Virginia Coastal Zone Management Program (VCZMP), Burke Environmental Associates (BEA), National Geographic Society (National Geographic), Virginia Institute of Marine Science (VIMS), Noblis, Inc. (Noblis), and additional local and regional stakeholders. National Geographic, VIMS and Noblis produced the resulting visually oriented, active-learning, education tools.

RESOURCE MANAGEMENT CHALLENGE

According to the Intergovernmental Panel on Climate Change, an overwhelming number of observations indicate that the world is warming, the climate system is changing and

that these changes will be unstoppable for decades.[5] In the ocean in particular, changes are occurring in global ocean heat content, salinity, sea level, thermal expansion, water mass evolution and biogeochemical parameters.[6] Sea level rise and storm surge pose particularly significant threats to the ecological health of our nation's estuaries, such as Chesapeake Bay, and the economy and safety of the surrounding communities. Although there has been coverage of sea level rise and storm surge in the press, the knowledge has not been available to the general public in a tangible form that allows for exploration of the topic, under various plausible scenarios, to make it more realistic for people.

The Chesapeake Bay region is one of the most vulnerable areas in the nation to sea level rise, trailing only parts of Louisiana, Florida, Texas and North Carolina in national assessments.[7,8,9] Several recent studies have indicated that sea level is predicted to rise steadily along the East coast in the coming decades.[10,11,12,13] Coincidentally, the land of the Chesapeake Bay region is also subsiding due to rebound from the previous glacial period, which increases the relative rate of sea level rise. The effects of sea level rise induced by climate change include shoreline erosion, coastal flooding, salt water intrusion of freshwater resources, and inundation of some coastal areas. The Chesapeake Bay has 11,684 miles of coastline along its main body of water and tidal tributaries, which suggests the Bay has a large area at risk.

Relative sea level in the Bay has risen approximately one foot in the last century, nearly twice the global average.[14] An analysis by the Scientific and Technical Workgroup of the Maryland Commission on Climate Change indicates that sea level could rise from 0.6 to 1.3 feet (0.18 to 0.39 meters) by the middle of this century. The analysis also states that accelerated melting could produce a relative sea level rise at the end of the century from 2.7 feet (0.82 meters), under a lower emissions scenario, to 3.4 feet (1.03 meters) under a higher emissions scenario.[15] Given the current and predicted rates of sea level rise, low-lying areas, such as islands, coastal wetlands and beaches, will be dominated by open water by 2050.[16,17]

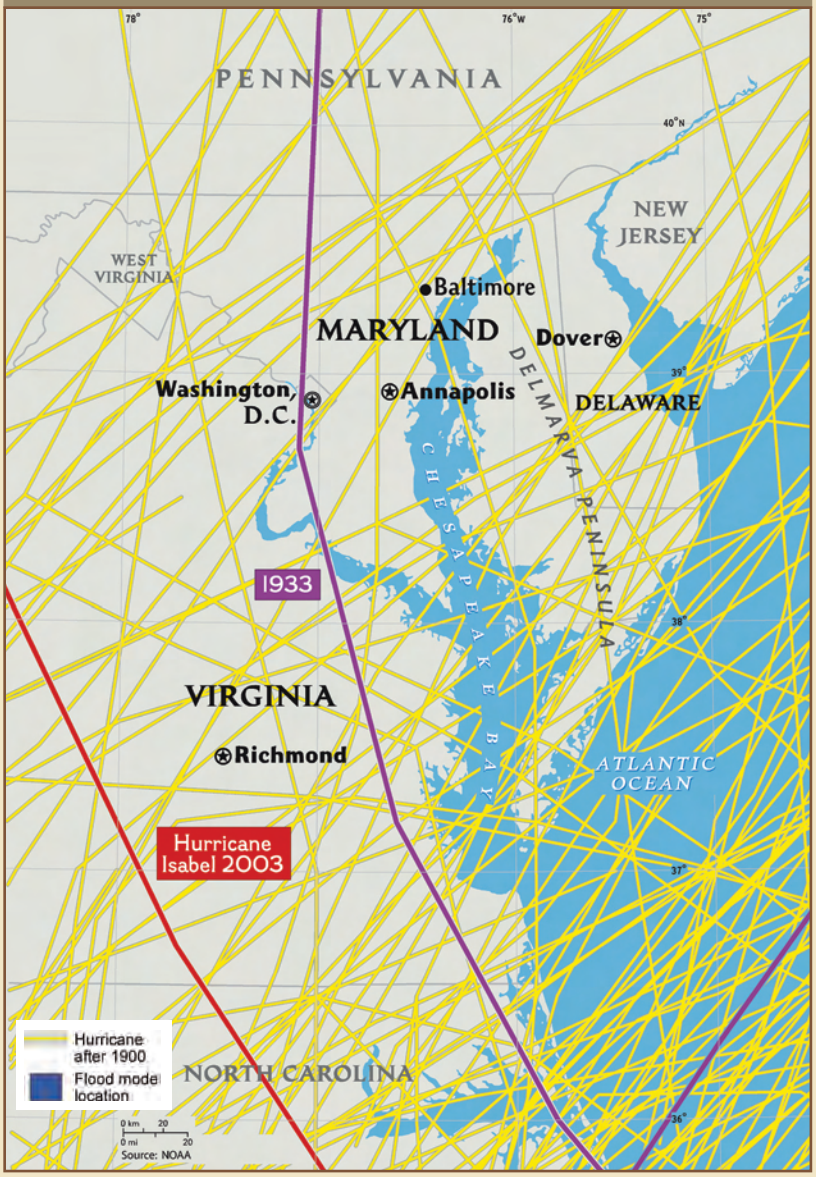
Bayside homes in Bowleys Quarters are surrounded by water the day after Hurricane Isabel. The six-foot storm surge generated by Hurricane Isabel caused extensive damage in this east Baltimore County community.

Flooding from tropical storms, hurricanes and nor'easters, poses a much more immediate threat to the Bay's human and natural infrastructure, particularly because these storms are often accompanied by a storm surge. Storm surge can devastate entire communities, just as Katrina's storm surge destroyed New Orleans,[18] especially if it occurs at high tide.[19] Storm surge has been a significant concern for the Chesapeake Bay region and was first modeled for Norfolk, Washington, and Baltimore by the United States Army Corps of Engineers in 1959.[20] The size of a storm surge depends on atmospheric forcing, storm path, and an area's bathymetry and water body shape and size.[21] More recent models suggested that a category 4 hurricane could produce storm surges as high as 18 or 20 feet in Baltimore at high tide.[22] In 2003, Hurricane Isabel produced a large and memorable storm surge in the Bay, which significantly raised the public's awareness of the phenomenon. With rising levels of greenhouse gases in the atmosphere and continued warming, the Chesapeake Bay region may face more powerful storms in the future depending upon the storm tracks.[23]

Climate change has become an important topic of discussion throughout our society, and the public, particularly younger generations, want to know how climate change

will affect their lives and the world around them. Although the states of Maryland and Virginia have developed strategies for reducing the region's vulnerability to climate change,[24,25] the general public remains fairly unaware of the significant potential impacts of sea level rise and storm surge on coastal areas. The CSSPAR team identified a need to produce visually oriented, education tools that go beyond simply reading about the phenomenon in a textbook or in the newspaper and includes an opportunity for active learning.

Hurricane Map



Storm tracks of hurricanes and nor'easters after 1900 (yellow) form clots in the Chesapeake region. The great hurricane of 1933 passed right through Washington, D.C. Hurricane Isabel in 2003 veered west, but the hurricane's eastern flank caused great damage throughout the Bay.

CONSERVATION VISION

Communities around the Chesapeake are just beginning the process of determining how to adapt to projected sea level rise increases and more severe storm surge events. The impact of climate change on the Chesapeake Bay is widely recognized to be significant by institutions and government. Members of the CSSPAR team felt there were few reliable and easily accessible educational resources and training opportunities available for students, professionals, businesses and government to explore the phenomena. In response, the CSSPAR project was created to increase public awareness and provide tools for vulnerability assessment that will enhance community resilience to sea level rise, storm surge and inundation, and other biological and physical challenges of climate change in the Chesapeake Bay region.

IMPLEMENTATION RESOURCES

The Conservation Fund received a $298,000 grant from the NOAA Climate Program Office's Sectoral Applications Research Program (SARP) on behalf of the CSSPAR team. SARP is a program designed to support the dissemination and exchange of climate-related research findings critical for understanding and addressing resource management challenges. This funding was used by The Conservation Fund to manage the project and coordinate the work of several partners. Key contractor efforts included the work of VIMS to produce models and land inundation data; Noblis to convert the data into visualizations; and National Geographic to design and produce a map and website. The funding was also used by The Conservation Fund to design and conduct a climate related green infrastructure training course. The Conservation Fund received an $8000 grant from the Bancroft

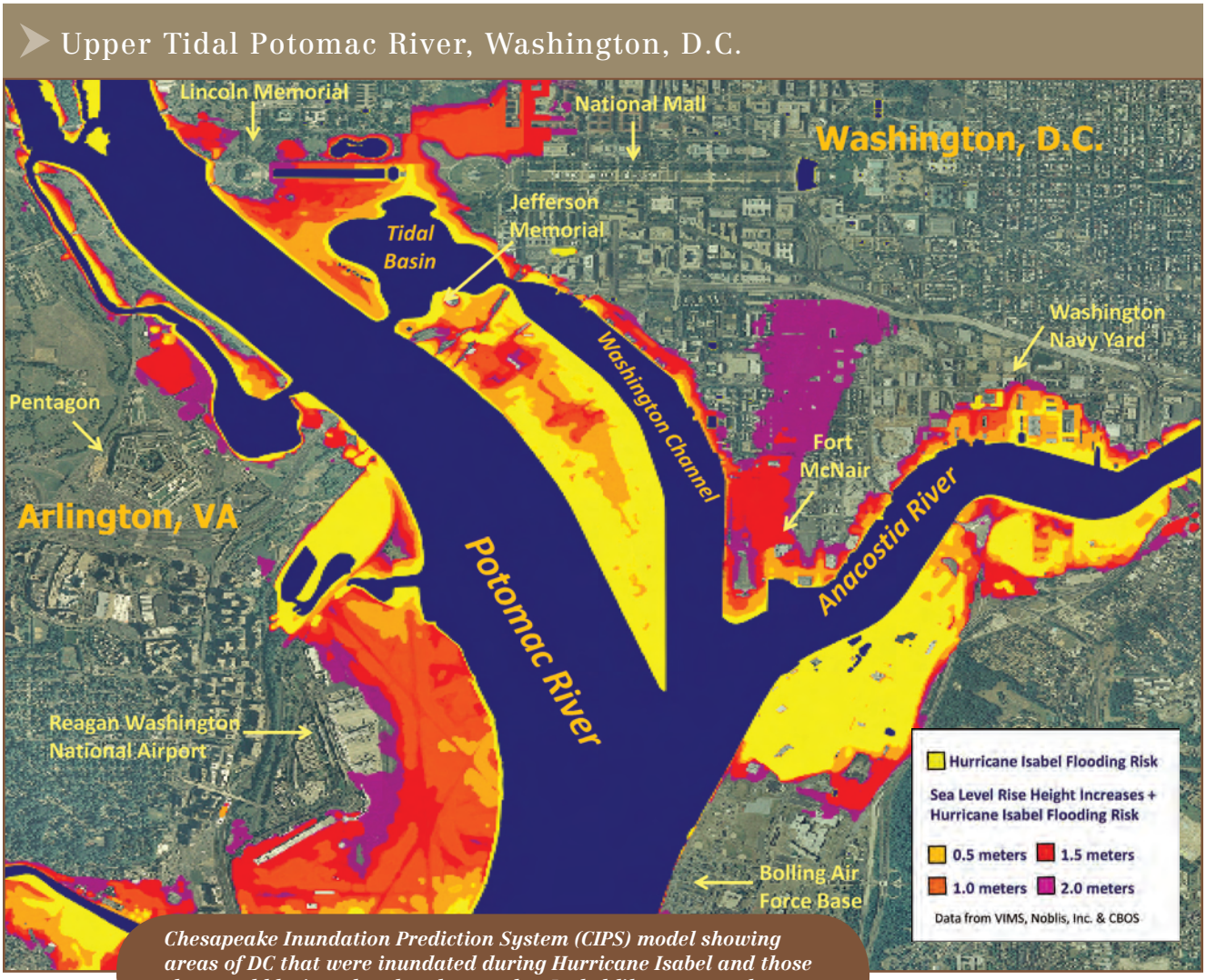
Foundation to print 25,000 copies of the map, which will be distributed to public high schools in Maryland and Virginia.

CONSERVATION STRATEGY

The CSSPAR team felt that an effective way to improve public understanding of sea level rise and storm surge was through visual imagery and information on maps, websites and course material for use by the general public, planners, emergency managers and policy makers. Specific deliverables identified by the team included: a double sided foldout map with Bay-wide sea level rise impacts on one side and area specific storm surge impacts on the other side; an interactive website where the user can control environmental conditions and storm path and intensity; and a course where government managers and planner will be trained how to use accurate spatial information to develop conservation strategies in light of sea level rise and storm surge projections.

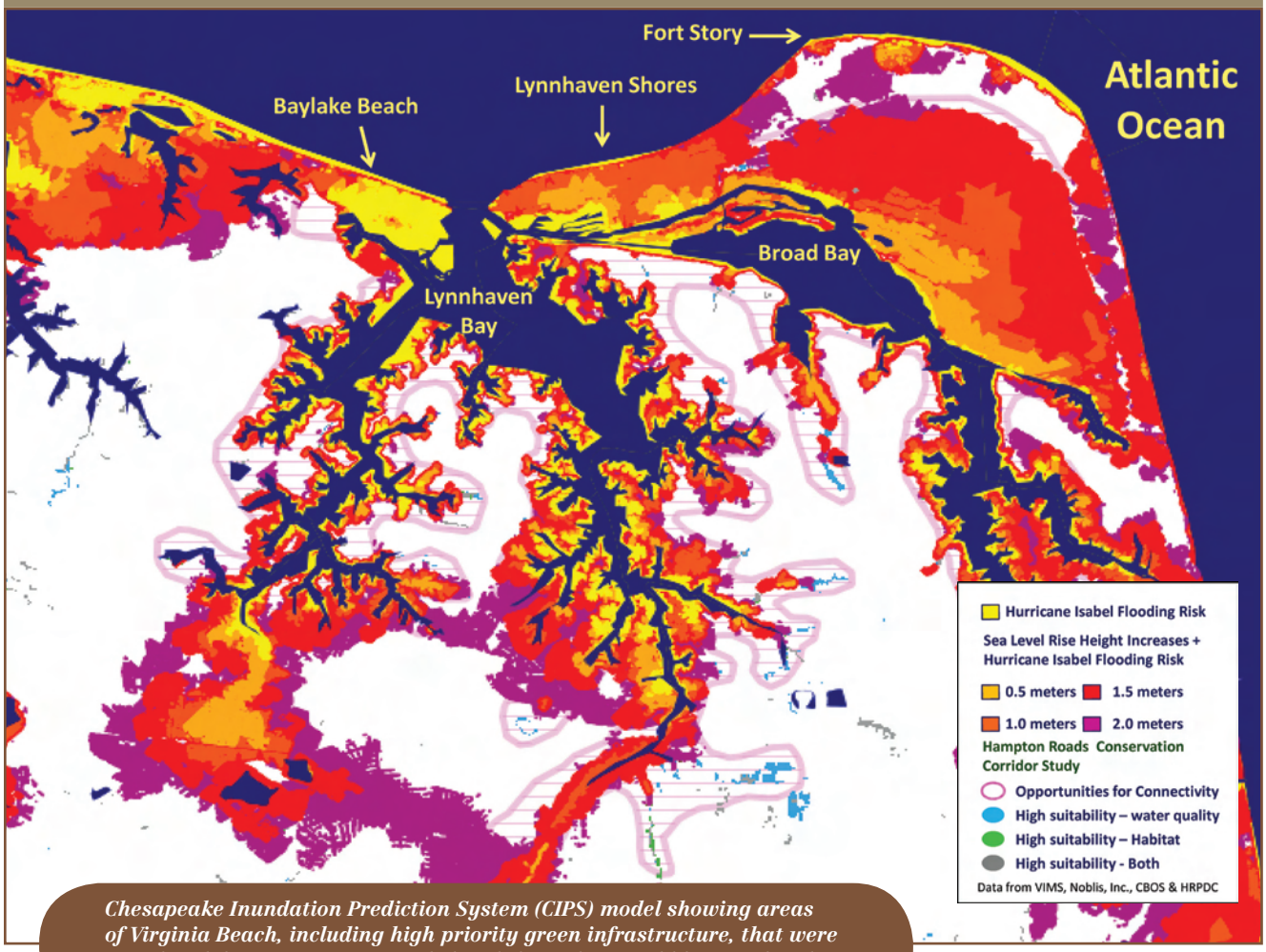
These objectives required scientific models capable of producing visualizations of sea level rise and storm surge that are accurate, reliable, and show flood predictions for hurricanes and nor'easters. Scientists had previously produced ground breaking models, such as the Sea Level Rise Affecting Marshes Model (SLAMM) and the Sea, Lake and Overland Surges from Hurricanes (SLOSH), but the CSSPAR team determined that they needed higher resolution models to produce more visually oriented products capable of animating storm surge and inundation at a spatial scale of less than a city block for the various audiences in need of the information.

The CSSPAR team used the Chesapeake Inundation Prediction System (CIPS) to model the impact of various storm surge and sea level rise scenarios on three distinct areas of the Chesapeake Bay. CIPS is a computer modeling system that uses high resolution atmospheric and hydro-



Chesapeake Inundation Prediction System (CIPS) model showing areas of DC that were inundated during Hurricane Isabel and those that would be inundated under another Isabel-like storm under various sea level rise scenarios.

Hampton Roads, Virginia Beach, VA



Chesapeake Inundation Prediction System (CIPS) model showing areas of Virginia Beach, including high priority green infrastructure, that were inundated during Hurricane Isabel and those that would be inundated under another Isabel-like storm given various sea level rise scenarios.

dynamic models; highly accurate light detection and ranging (LIDAR) data for fine scale topographic and elevation references; and emerging GIS techniques to produce flooding forecasts for tropical cyclones and nor'easters in the Chesapeake Bay. CIPS was originated by organizations involved with the Chesapeake Bay Observing System (CBOS) to visualize expected on-land storm surge inundation along the Chesapeake Bay and its tributaries.[26] CIPS predicts the combined effect of storm surge, tide, and river flow inundation. The inundation model was developed by scientists at VIMS who build detailed three-dimensional simulations of storm surge and inundation.[27,28,29]

The output from the VIMS model is then used by scientists at Noblis who transform the data into GIS-based visualizations to show water moving onto the land and to produce fine-scale inundation forecasts for the Bay.[30]

While most scientists are confident that sea level will rise over the next century, the rate of relative sea level rise varies geographically and will be significantly affected by current and future global greenhouse gas emissions to the atmosphere. A high emissions scenario, one in which global emissions continue to increase unabated, could result in additional melting of glaciers, further expansion of the ocean, and a change in ocean currents, such as slowing the North Atlantic conveyor belt, all of which influence sea levels. For the purpose of analytical comparison and illustration, the CSSPAR team chose to model four sea level rise scenarios: 0.5, 1.0, 1.5, and 2.0 meters. This allowed for interpretation and consideration of some of the lower and higher emission scenarios.

The Chesapeake region has a long recorded history of being affected by hurricanes and nor'easters.[31] Nevertheless, the unnamed hurricane of 1933 and hurricane Isabel of 2003 really stand out in the minds of scientists. Both of these storms caused

High winds and floodwaters brought by hurricane Isabel caused extensive flooding to numerous classrooms, dormitories, athletic facilities and main roads throughout the U.S. Naval Academy in Annapolis, Maryland. Hurricane Isabel, which cost the Navy nearly $130 million in damage in the Mid-Atlantic region, was a Category 2 storm when it made landfall near Cape Hatteras, North Carolina, several hundred miles south of Annapolis.

substantial damage to the region due to high winds and storm surge. The CSSPAR team used CIPS to model the impact of these storms under the four sea level rise scenarios listed above, so that one can examine the impact of a hurricane to the land in a world where sea level is higher. The results provide important visual insight to the effects of future storm events and a foundation for consideration of mitigation approaches that could be evaluated in future work to minimize these impacts.

VIMS and Noblis used their innovative modeling techniques to develop data and visualizations for scenarios in three distinct areas of the Chesapeake Bay including:

- **Upper Tidal Potomac River:** Home to our Nation's capital, this area is heavily populated and contains significant cultural resources in low elevation areas, such as the National Mall and associated monuments.
- **Hampton Roads:** Hurricane storm surge presents a significant hazard to this highly populated region,[32] which has numerous important military installations and several economically-critical cities for ocean commerce.
- **Lower Eastern Shore of Maryland:** Rich in wildlife, this area has freshwater impoundments, brackish tidal wetlands, open fields, and mixed evergreen and deciduous forests. This area is home to the Blackwater National Wildlife Refuge, sometimes referred to as the "Everglades of the North," and also has the lowest elevation land in the Bay watershed, particularly in Dorchester County.

RESULTS

Interpretive Products and Tools for Education: National Geographic brought together all of the work of the CSSPAR team and produced visually oriented, active-learning, education tools. National Geographic is world-renowned for their commitment to increasing and diffusing geographic knowledge while promoting the conservation of the world's cultural, historical, and natural resources. Their visual products have captured the public imagination for over 100 years – significantly influencing our cultural values and public policies through straightforward and effective, education.

Printed Map: National Geographic and the CSSPAR team produced a visually stunning double-sided printed map highlighting the impacts of rising sea level and storm surge on the Chesapeake Bay and its surrounding lands. The map includes text that details: the evidence of sea level rise and the potential impacts it will have on natural infrastructure, built infrastructure, and wildlife; the impacts of potential storm surge on the three focal areas in the Bay, and; the need for society to prepare for and adapt to the predicted changes. These maps are being distributed to schools and public officials around the Bay.

Web Resource: National Geographic and the CSSPAR team produced an enhanced Chesapeake Bay web resource, with a map viewer at its heart, summarizing potential impacts of climate change and presenting map layers charting sea level rise and potential storm surge extents for the three focal areas described above (visit www.chesapeakeadaptation.org). The website covers the four major themes presented on the printed maps and provides the user with the means to inspect the broader concepts using two main tools: photo-story galleries and dynamic mapping services.

Each theme includes photo-story galleries, presented as sets of icons on the map, which highlight specific points of interest related to climate change. The dynamic mapping services allow the user to explore the history of hurricanes and tropical storms in the Chesapeake Bay region, and their impact on the natural and built environment. The site provides an expanded comparison of the unnamed 1933 storm and Hurricane Isabel of 2003, and using the sea level rise and storm surge data models and high resolution satellite imagery, visualizes the potential impact of hurricane storm surge on the three focal areas of the Bay under various sea level rise scenarios. The website is the first up close and personal look for the public at the threat to institutions, homes, schools and other infrastructure from projected impacts of climate change in the Bay.

Professional Training: Although the predicted impacts of sea level rise and storm surge pose a severe threat to businesses, homes and natural and cultural landscapes, there isn't a safe environment for individuals from concerned disciplines and government sectors to explore this difficult topic. In April of 2010, The Conservation Fund will conduct a 2.5 day course on green infrastructure and climate change. The course will allow planners and decision makers to examine the projected impacts of sea level rise and storm surge on the Chesapeake Bay region and its green infrastructure. Through hands-on class projects using data layers for two coastal communities, and lectures from cutting edge experts and on-the-ground practitioners, participants will learn and experience first-hand the challenges of deciding what to protect and how to protect it in the face of rising waters and increased storm events.

The National Geographic Society produced a printed map and a website (www.chesapeakeadaptation.org), which are new tools for students, planners and the general public to explore sea level rise and storm surge impacts in the Chesapeake Bay.

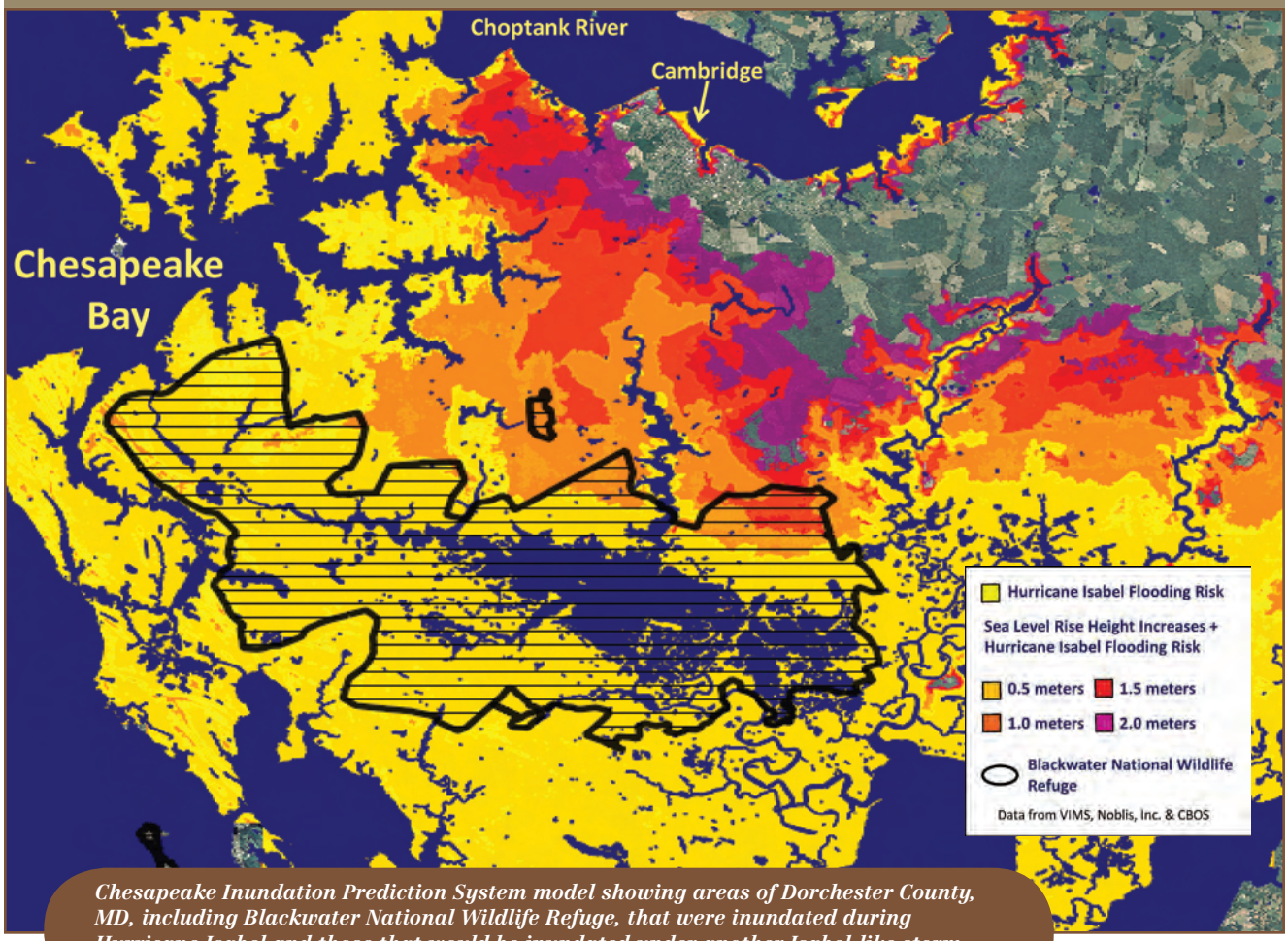
Course Objectives:

- Describe green infrastructure concepts and principles;
- Explore techniques for planning and designing green infrastructure networks at the statewide, regional, and local levels;
- Identify the potential impacts of climate change on coastal communities and effective communication strategies for conveying those impacts; and
- Discover how green infrastructure can be used to facilitate adaptation and mitigation of potential climate change impacts.

The course will be a collaborative learning experience applicable to who are engaged in land use planning and management. The Conservation Fund designed the course with the assistance of several government entities in the Chesapeake Bay that have already begun planning processes to address the implications of sea level rise and storm surge on their jurisdiction, including the State of Maryland, the Northern Virginia Planning District Commission, the Hampton Roads Planning District Commission and NOAA.

The map, website and course will raise awareness of climate change throughout the Chesapeake and provide people with the inspiration and tools needed to begin addressing this major environmental challenge. The overall intent is to expose the public to the intense and complex potential realities of these phenomena, making it more real than theory. Children and

Lower Eastern Shore, Dorchester County, MD



Chesapeake Inundation Prediction System model showing areas of Dorchester County, MD, including Blackwater National Wildlife Refuge, that were inundated during Hurricane Isabel and those that would be inundated under another Isabel-like storm given various sea level rise scenarios.

young adults are perhaps the most important demographic reached by these materials. After all, they will be the ones grappling with the most severe impacts and this may be their first true exploration of the topic, which will give these leaders of tomorrow an advantage when they are faced with the difficult decisions to retreat, adapt or defend our coastal areas.

KEYS TO SUCCESS

- **Effective communication about climate change.** In general, scientists, emergency managers, planners and natural resource professionals agree that sea level rise and storm surge will have a significant impact on the Chesapeake Bay. While some may argue about the extent of sea level rise or the frequency of storms, few professionals deny that the ocean is rising and that storm intensity is increasing. Information about the topic, particularly in low-lying areas like the Chesapeake Bay, needs to be presented in a way that both professionals and the general public can understand.
- **Scientific innovation and partnership.** Scientists at VIMS developed highly advanced models capable of predicting storm surge and inundation throughout the Bay much more accurately than previous models. The scientists partnered with Noblis and National Geographic, who had the special skills and experience needed to make attractive visualizations of the VIMS model data.
- **Strong partner reputation.** All of the organizations and government agencies involved in this project had excellent reputations, but partnership with National Geographic provided a globally recognized and trusted lead brand.
- **State government support and information.** Maryland and Virginia provided valuable data and knowledge on sea level rise and storm surge. Partnership with the states provided the project with strong support and leveraged resources.
- **Funding from the NOAA climate program.** This project was made possible through a grant The Conservation Fund received from NOAA's climate program office.

PHOTOS AND FIGURES

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Endnote

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High resolution products are available for specific climate change and sea level rise planning from Noblis and the Chesapeake Inundation Predictions System partners. Please contact Barry Stamey for more information.