NASA Langley Research Center

National Aeronautics and Space Administration

Delivering for Today…

Preparing for Tomorrow.

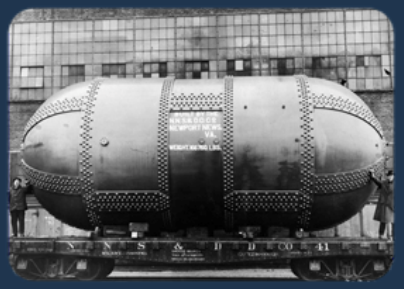
www.nasa.gov

Historical Contributions

FIRST CENTER
Langley Memorial Aeronautical Laboratory

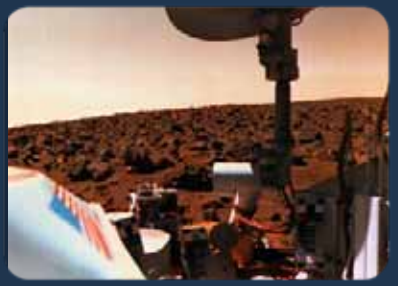
FIRST SOLID ROCKET BOOSTER PAYLOAD-TO-ORBIT
Scout

FIRST PRESSURIZED WIND TUNNEL
Variable Density Tunnel



FIRST SCRAMJET-POWERED MACH 7 and 10 FLIGHT
X-43A

FIRST SPACE GROUP
Space Task Group



FIRST MARS MISSION
Viking

NASA Langley at a Glance (2010)

Founded in 1917
1st civil aeronautical research lab

~$800m Budget
~$685m NASA Langley budget
~$115m External business & 2009 Recovery Act

~3,800 Workforce
~1,900 Civil Servants
~1,900 Contractors (on/near-site)
(~260 students)

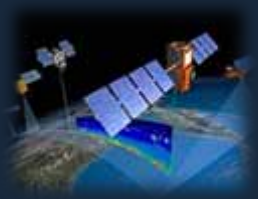
Infrastructure/Facilities
788 acres, 181 Buildings
~$3.3b replacement value

Langley's Economic Impact (2009)
National economic output of ~ $2b and generates over 16,450 high-tech jobs
Virginia economic output of ~ $920m and generates over 8,100 high-tech jobs

Aeronautics $218m

Exploration $94m

Science $95m



Space Operations $6m

Education $16m

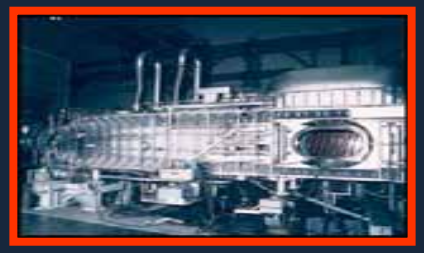
Cross-Agency Support Program & Construction/Environmental Compliance & Restoration
- Center Management & Operations
- Agency Management & Operations
- Construction/Environmental Compliance & Restoration

NASA Langley Facilities

14 x 22 Foot Subsonic Tunnel
Subsonic, Alternate Uses

National Transonic Facility
High Reynolds Number Flow
Nationally Unique

LaRC Unitary Plan Wind Tunnel
Supersonic Speed Range



Aerothermodynamic Complex
Exploration Workhorse

Subsonic → **Transonic** → **Supersonic** → **Hypersonic**

National Assets needed to meet the needs of the Agency, DoD, and Industry

Flight Simulation Facilities

20-Foot Vertical Spin Tunnel
Spin Characteristics & Dynamic Stability
Nationally Unique

Transonic Dynamics Tunnel
Aeroelasticity & Flutter
World Unique

8-Ft High Temperature Tunnel
Large-scale Hypersonics & Propulsion

Specialty Facilities

Revitalization of Langley

2013

2014

2011

2018

2009

2016

Langley's New Town
Repair by Replacement
Revitalization Plan

Storm Surge Prediction and Damage Cost Analysis

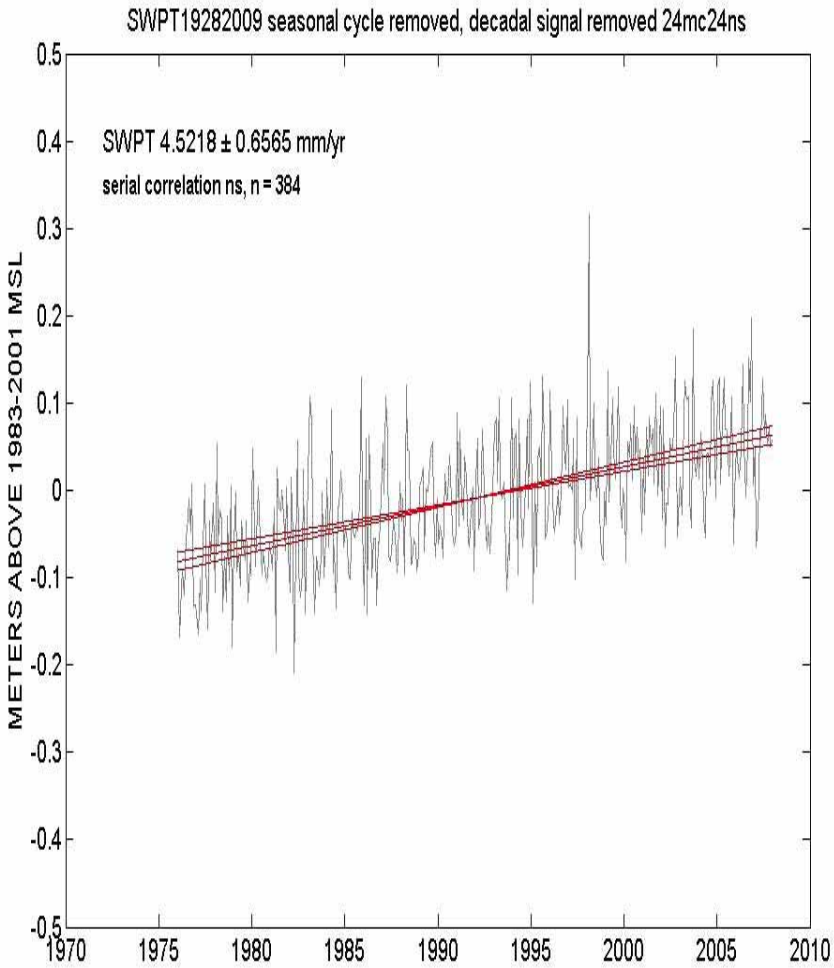
Community Concerns

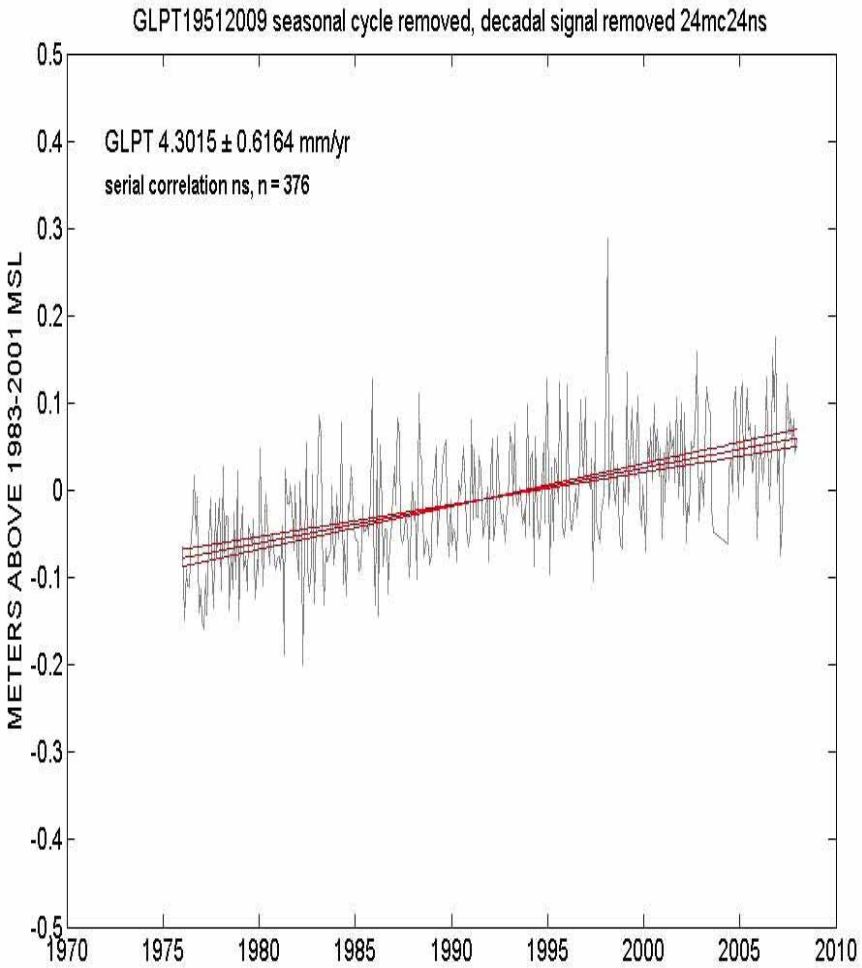
- NASA Langley and Langley Air Force Base susceptibility to storm surge flooding
- High cost of buildings and infrastructure damage repair/replace

Project Partners

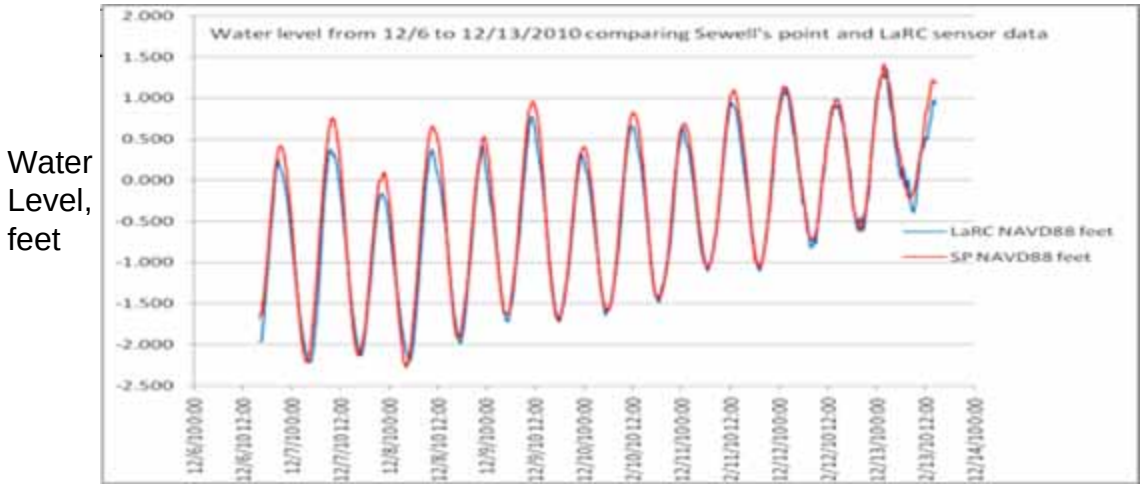
- NASA Langley (LaRC)
- Langley Air Force Base (Langley AFB)
- Virginia Institute of Marine Science (VIMS)
- Langley GIS Team
- DEVELOP

Sewells Point and Gloucester Point Relative Sea Level Measurements

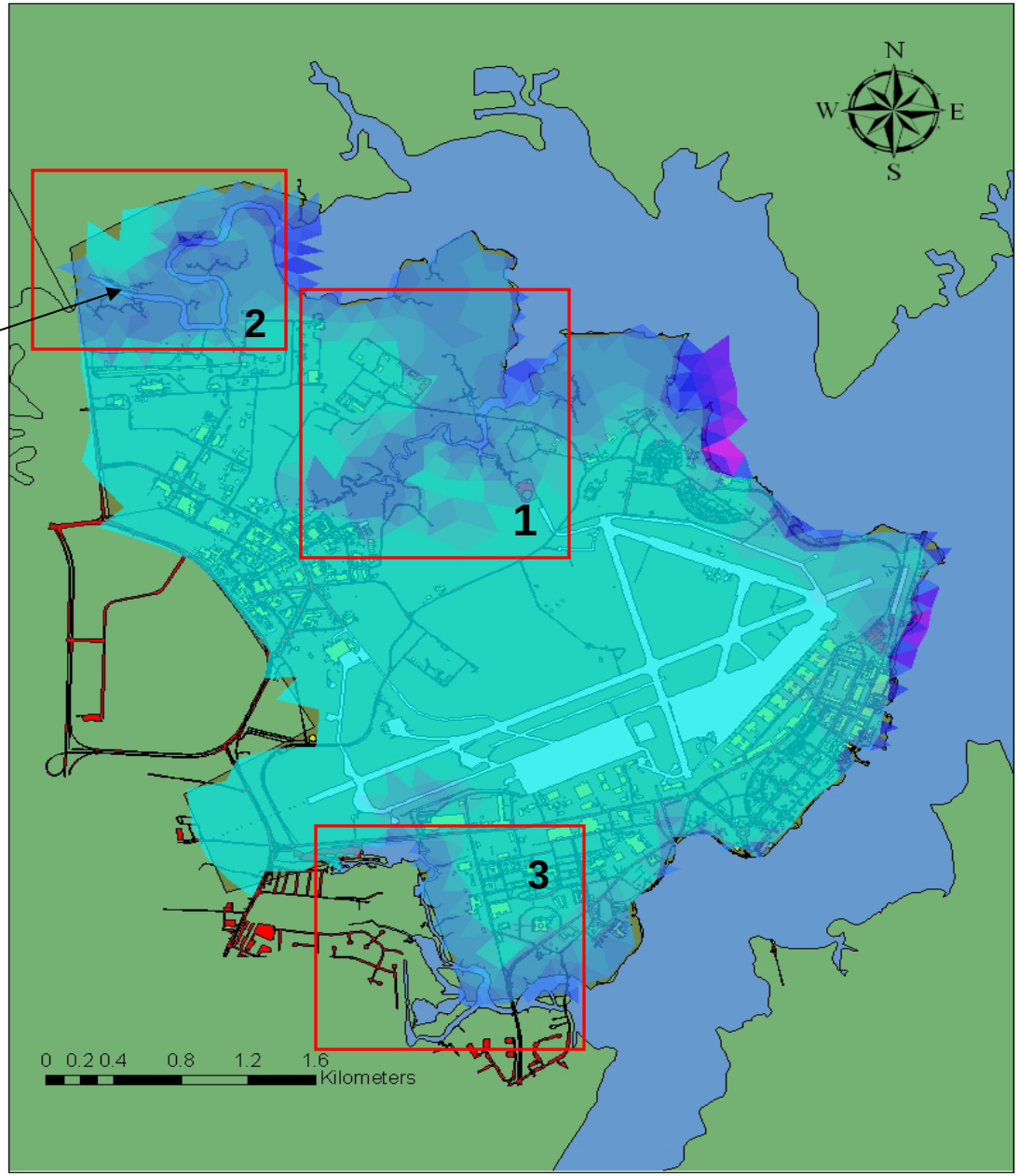




Langley Prototype Water Level Gauge Measurement System



Flood Inundation Maps Made Using VIMS Model For Peak of 2009 November Nor'easter



Tributaries in the Back River prone to flooding:

1. An embayment in the Northwest branch
2. A watershed by the Wythe Creek
3. A watershed located in the southwest branch

Future Hurricane Predictions

Tropical Cyclone Variable	Projected Effect
Frequency	Total numbers decrease by -6% to -34% globally or remain unchanged
Intensity	Increase of cat. 4-5 with wind speed of +2% to +11%, decrease or no change in cat. 1-3
Rainfall	Increase of amount and frequency of heavy rain events with a percentage range of +3% to +37%
Tracks	No predicted change
Duration	No predicted change
Surge Flooding	Increase due to sea level rise and storm intensity

Tropical cyclones and climate change. T.R. Knutson et al. Nature Geoscience, vol 3, p.157. March 2010.

Modeled Impact of Anthropogenic Warming on the Frequency of Intense Atlantic Hurricanes. Morris A. Bender et al. Science, vol 327, p. 454. 22 January 2010.

Emergence timescales for detection of anthropogenic climate change in US tropical cyclone loss data, R.P. Crompton el al., Enviro. Res. Lett. Vol. 6, p. 1, 2011.

Storm Surge Prediction and Damage Cost Analysis - Overview

Project Objectives

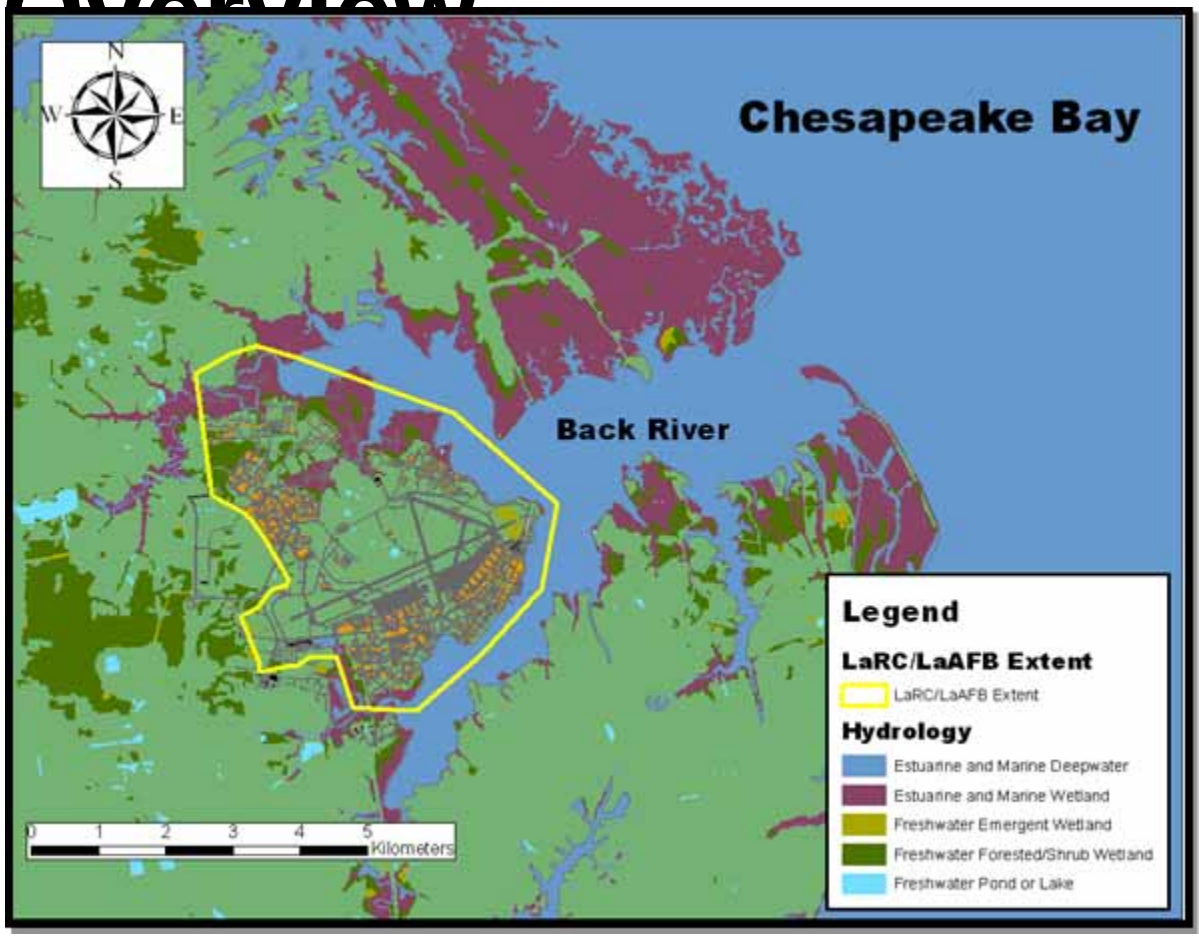
- Estimate future sea level rise magnitudes and projected timeframe, and correlate to VIMS model outputs
- Accurately project VIMS model data onto geographic location of LaRC and Langley AFB
- Determine cost analysis based off storm surge model output

Study Area & Period

- NASA Langley and Langley Air Force Base, Hampton, VA
- Study period: 2003 – 2120

Benefits to Partners

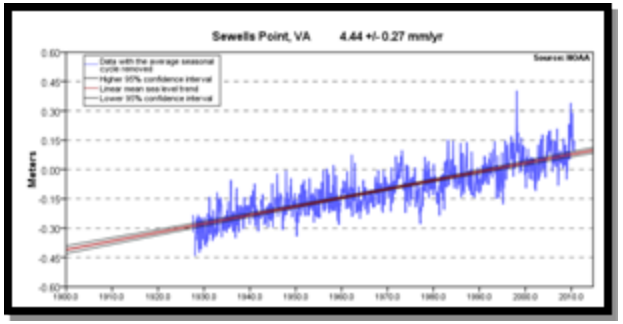
- Accurate storm surge flooding predictions
- Cost analysis for possible damage repair/replace
- Ease of recreation for other storm event with different dynamics



Storm Surge Prediction and Damage Cost Analysis - Methodology

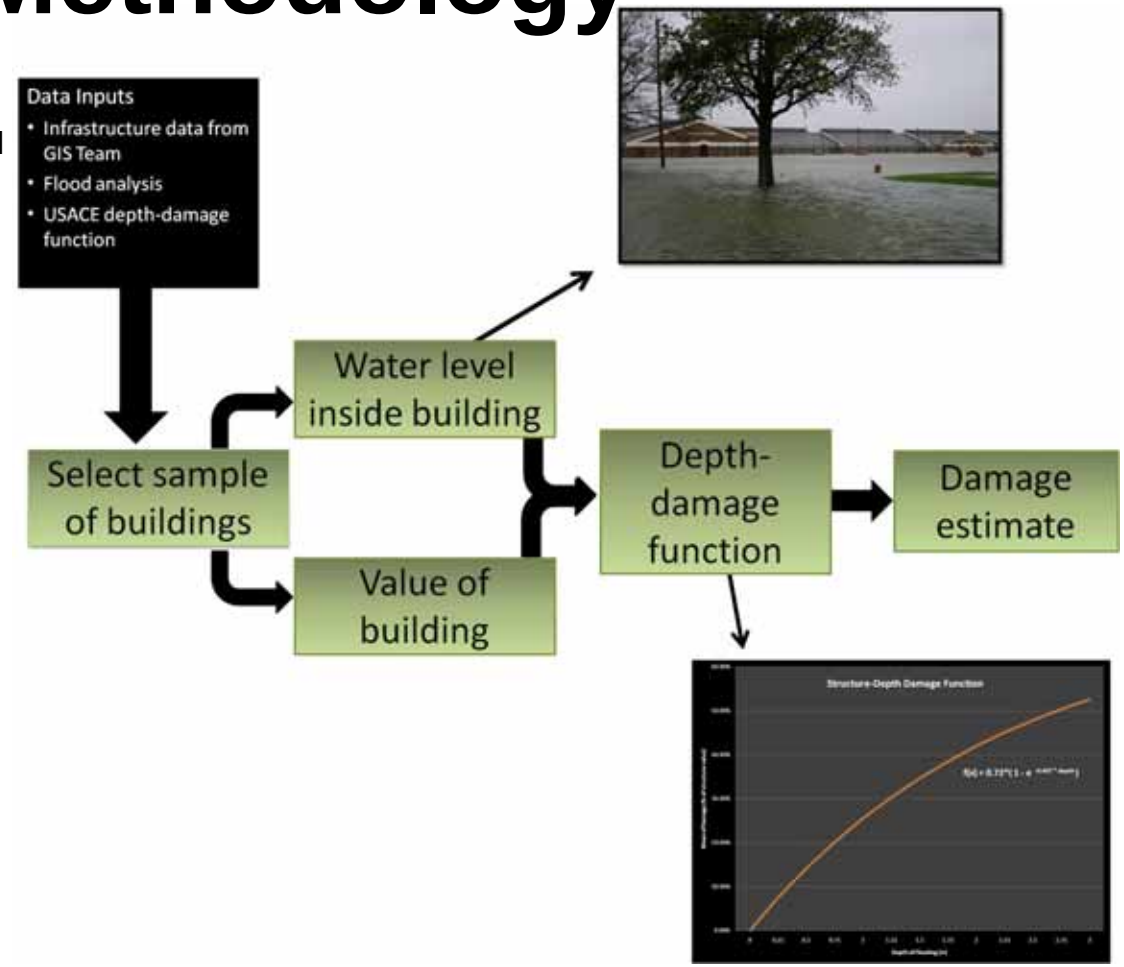
Data Acquisition

- Storm surge model provided by VIMS
- LaRC GIS data
- Hurricane GIS data provided by National Hurricane Center (NHC)
- Sea level rise ~4.5 mm yr^{-1}(NOAA)

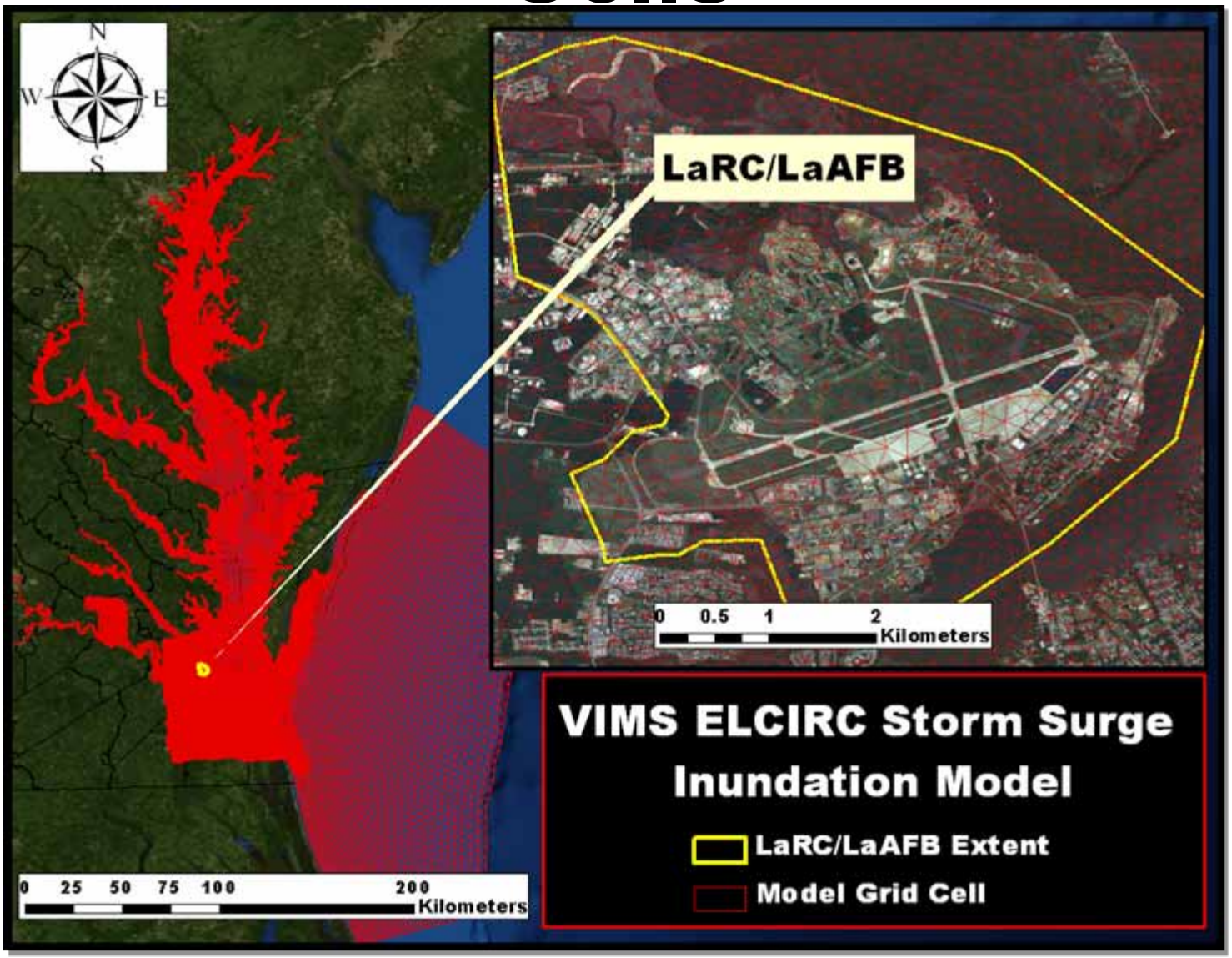


Data Processing & Analysis

- Storm surge model data processed into text files using a C++ program
- All GIS and model data processed in ArcGIS 10
- Statistical analysis of GIS data and cost figures in Excel



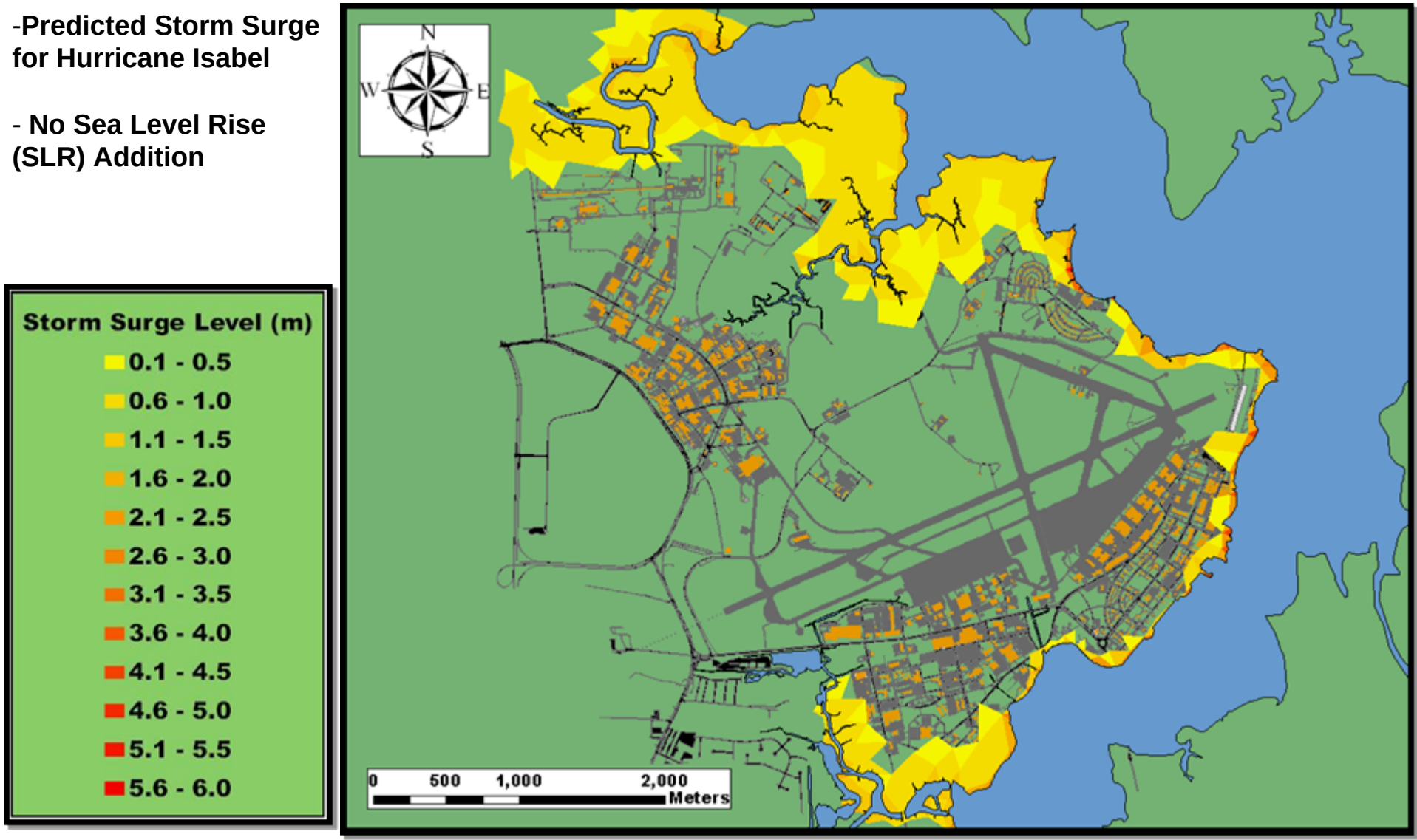
VIMS Storm Surge Model Grid Cells



VIMS Inundation Model of Hurricane Isabel 2003

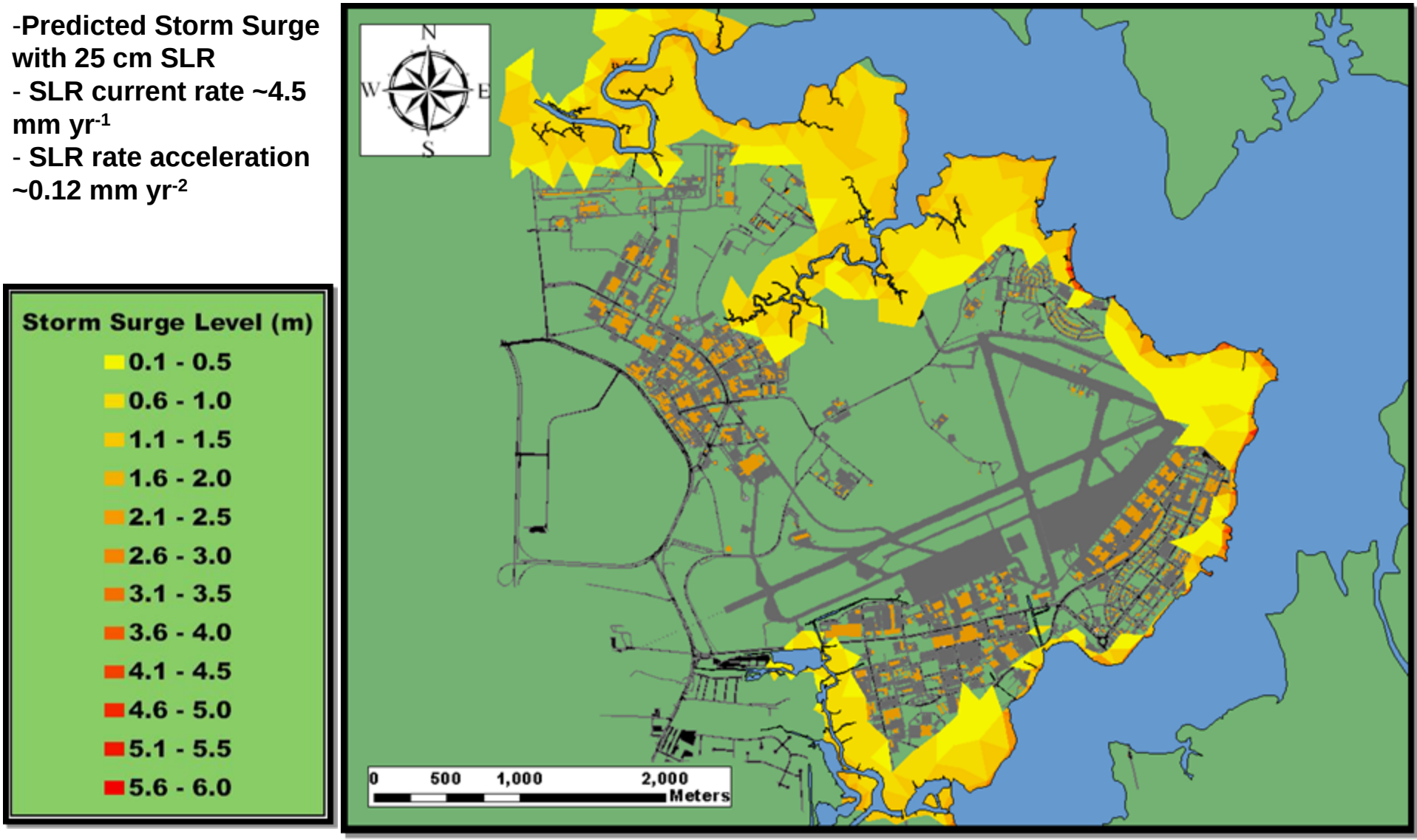
-Predicted Storm Surge for Hurricane Isabel

- No Sea Level Rise (SLR) Addition



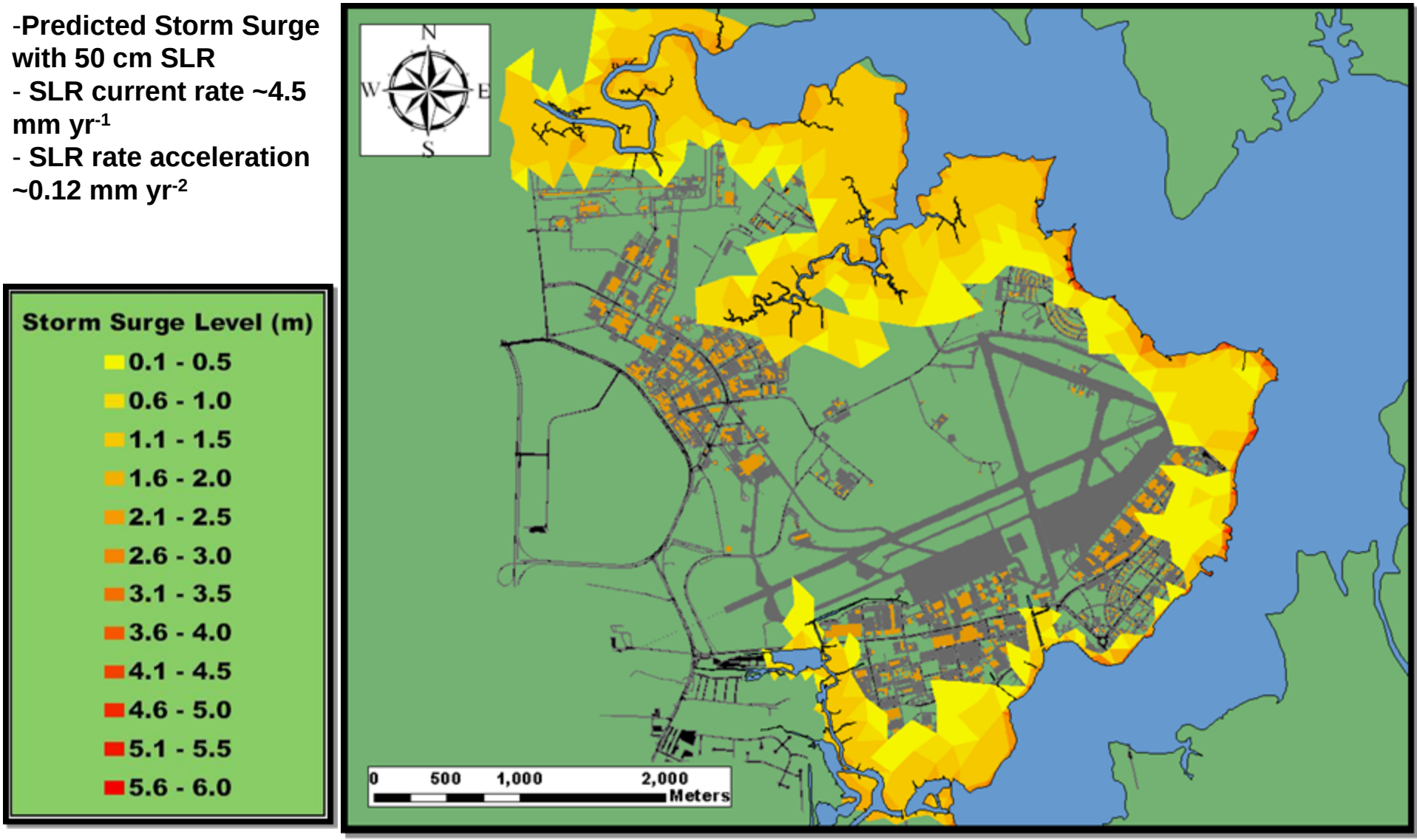
VIMS Inundation Model of Hurricane Isabel for 25 cm SLR Corresponding to 2030-2040

-Predicted Storm Surge with 25 cm SLR
- SLR current rate ~4.5 mm yr^{-1}
- SLR rate acceleration ~0.12 mm yr^{-2}



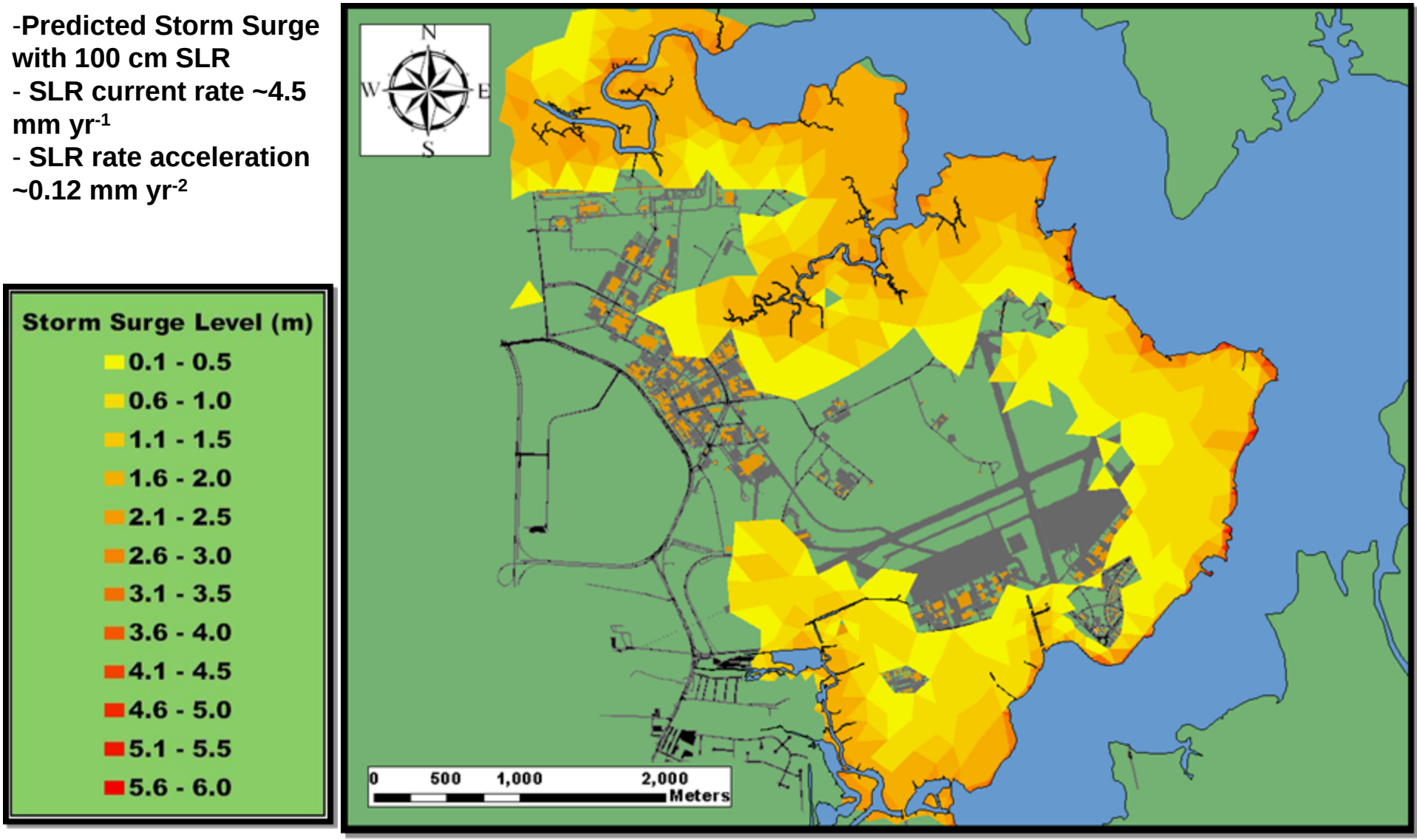
VIMS Inundation Model of Hurricane Isabel with 50 cm SLR Corresponding to 2050-2060

-Predicted Storm Surge with 50 cm SLR
- SLR current rate ~4.5 mm yr^{-1}
- SLR rate acceleration ~0.12 mm yr^{-2}



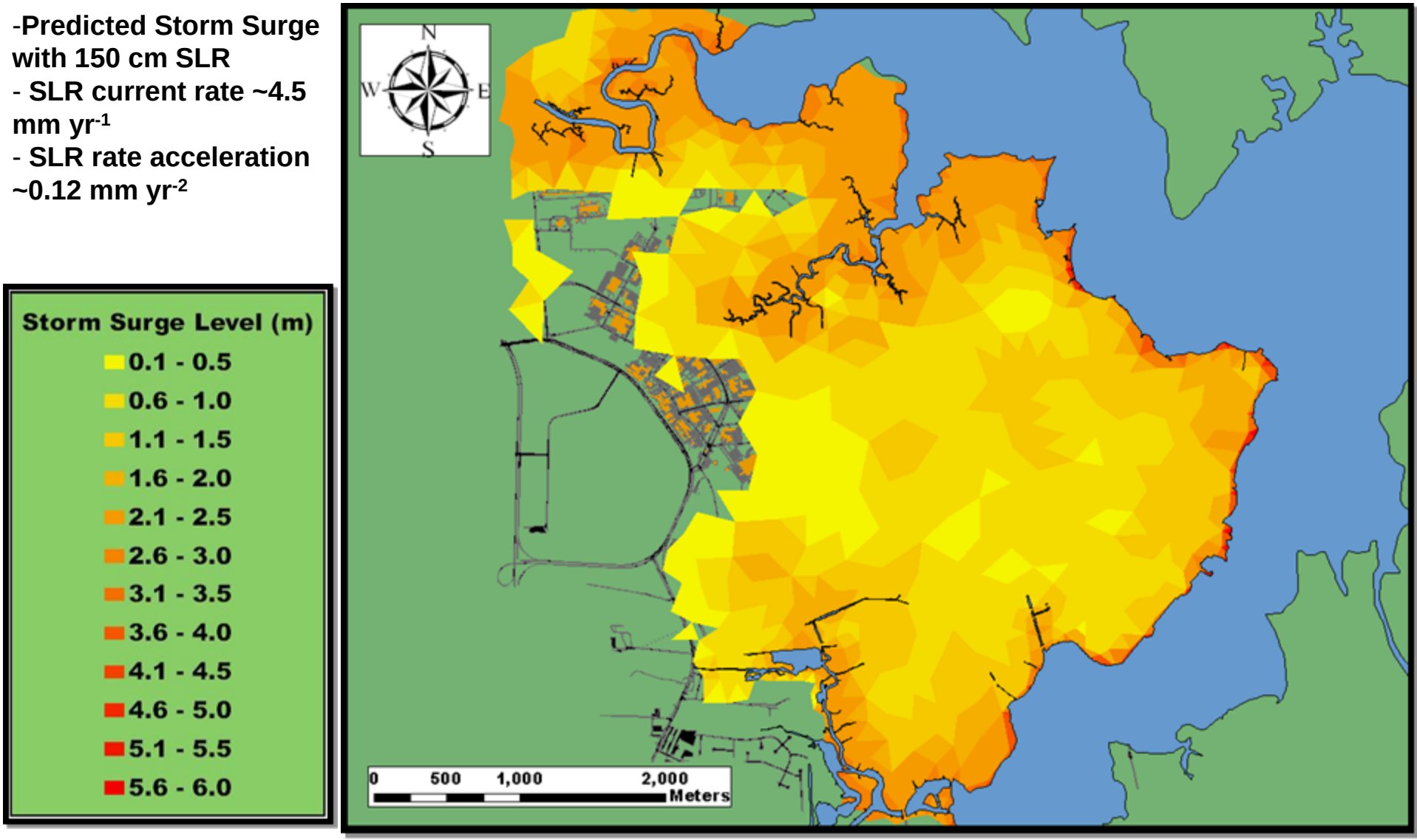
VIMS Inundation Model of Hurricane Isabel with 100 cm SLR Corresponding to 2070-2080

-Predicted Storm Surge with 100 cm SLR
- SLR current rate ~4.5 mm yr^{-1}
- SLR rate acceleration ~0.12 mm yr^{-2}



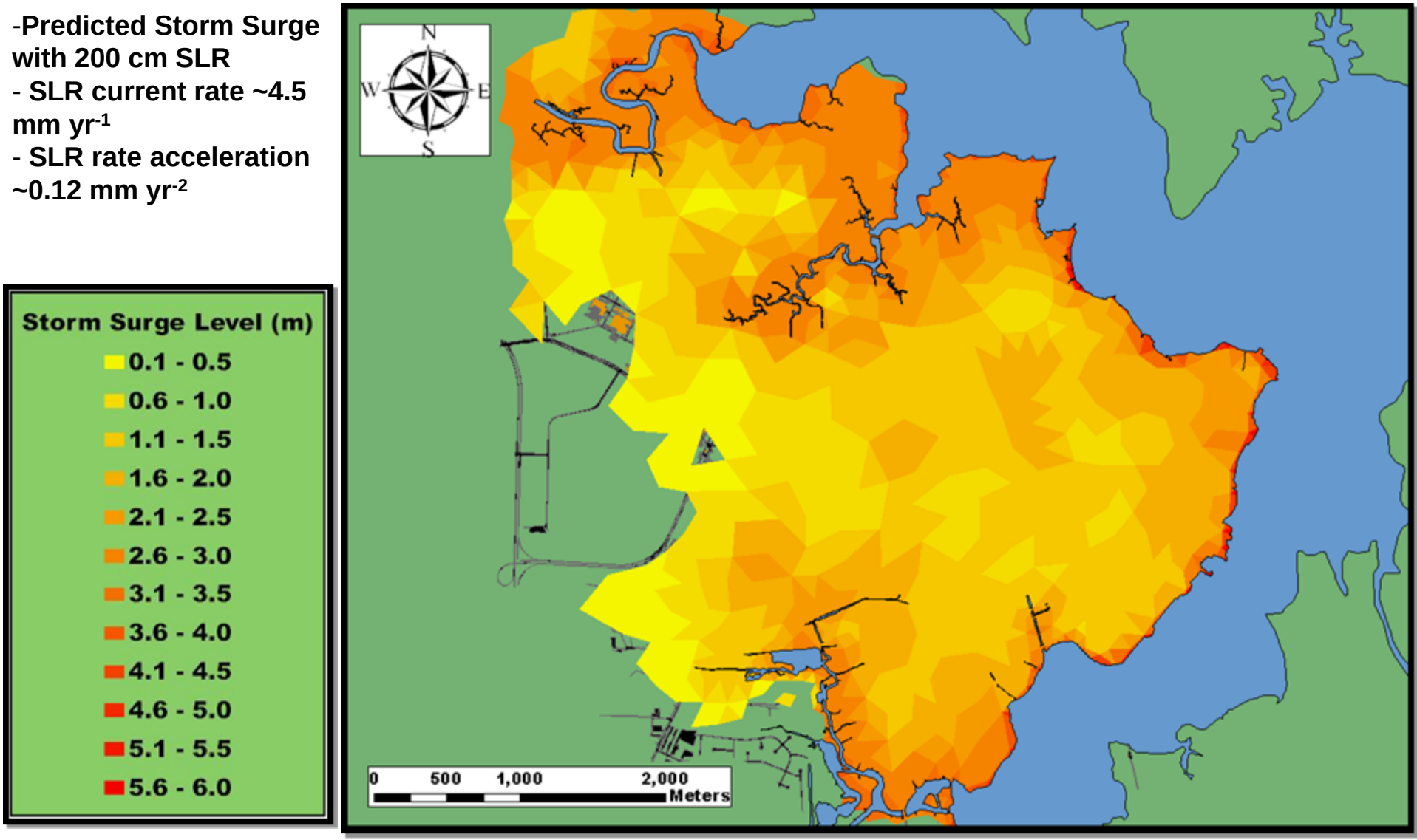
VIMS Inundation Model of Hurricane Isabel with 150 cm SLR Corresponding to 2090-2100

-Predicted Storm Surge with 150 cm SLR
- SLR current rate ~4.5 mm yr^{-1}
- SLR rate acceleration ~0.12 mm yr^{-2}

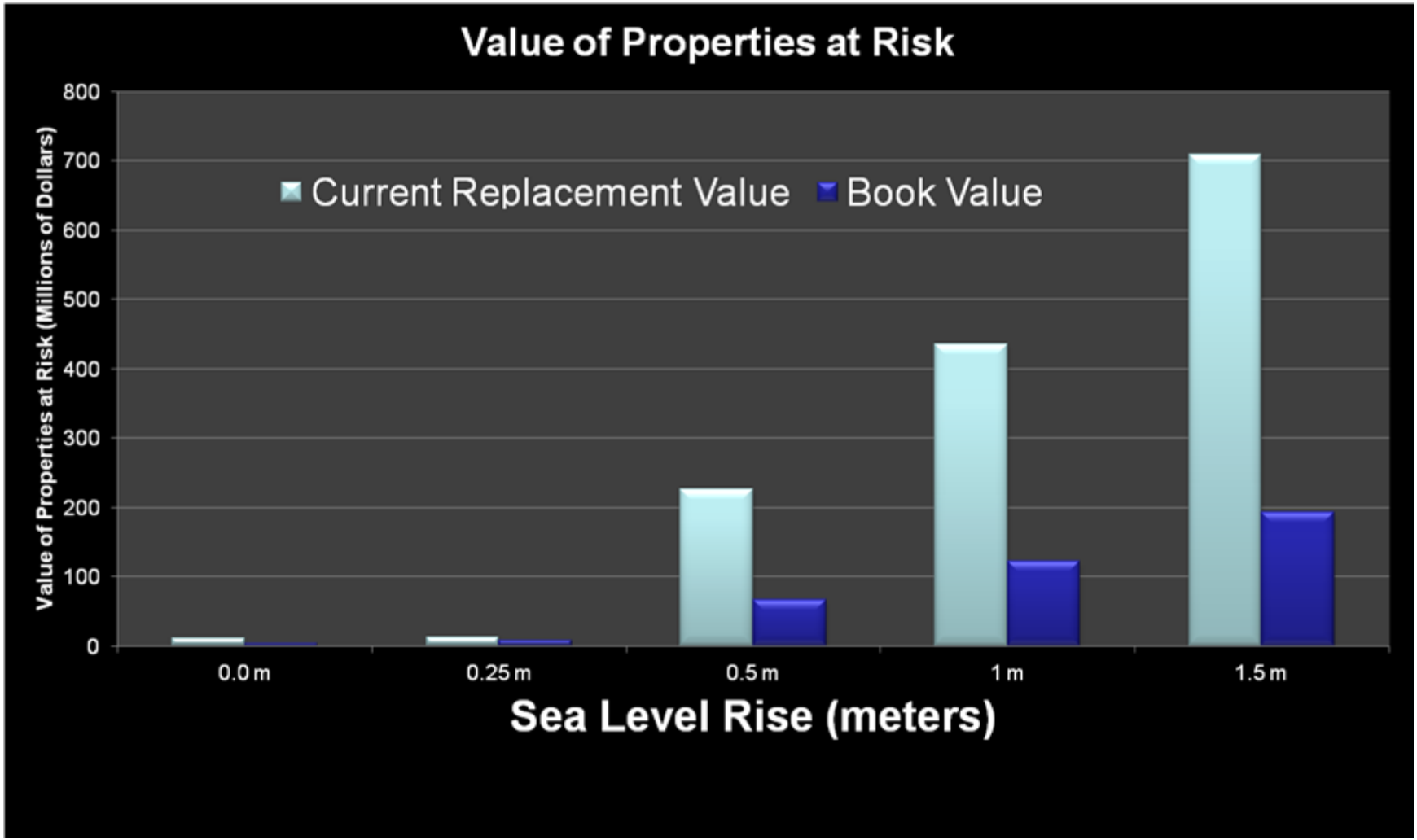


VIMS Inundation Model of Hurricane Isabel with 200 cm SLR Corresponding to 2110-2120

-Predicted Storm Surge with 200 cm SLR
- SLR current rate ~4.5 mm yr^{-1}
- SLR rate acceleration ~0.12 mm yr^{-2}



Hurricane Isabel with added Sea Level Rise: Langley Impact



Environmental Management Branch

Resilience and Adaptation to Climate Risks Workshop

Natural System - Proposed Actions Post Workshop

•Decrease Center Imperviousness – Focus on eliminating unneeded impervious surfaces and utilize pervious surfaces when possible (pervious pavers, green roofs, gravel parking, etc.). Include the demolition of impervious surfaces as part of the project when demolishing a building.

•Revaluate management of open green spaces. Create more no-mow zones, especially in underutilized areas, to slow sheet flows and absorb more water. Possibly transition unused green space to native forested habitat that no longer needs mowing maintenance

•Implement tree planting/maintenance program. Prevent losing existing trees. Focus on increasing planting efforts, especially reforesting areas of sloped green spaces that sheet flow to ditches or storm inlets (absorb more water) with native trees species. Also, focus on increasing and maximizing natural riparian buffers. Review and recommend policy changes requiring planting or replanting native trees or shrubs if they are removed from Center during demolition, construction, etc.

•Conserve wetlands to ensure their ongoing beneficial natural resource functions: (capture of Sediment, Nitrogen, Phosphorus, stormwater; Storm surge buffer; Migratory bird habitat)

Environmental Management Branch

Resilience and Adaptation to Climate Risks Workshop

Natural System - Proposed Actions Post Workshop (cont'd)

•Conduct data gathering effort - mapping/ photo/ contours/ vegetation/ soil

•Integrate data into GIS for Master Planning

•Identify/prioritize areas to allow wetlands to develop and act as buffer zone

•Include potential future wetland areas within COF Stormwater Improvement Project for FY14 or FY15

•Identify any key areas to berm (e.g. cultural sites). Explore possibility of shoreline stabilization in area of Chesterville foundations and cemetery. Use rip-rap from demolition

•Collaborate w. LAFB on shoreline restoration activities along the banks of the Back River as a result of the Shoreline Restoration study

•Implement Invasive Species compliance/ control program

•Space Act Agreement with local schools to pursue research activities in North 40 area

Environmental Management Branch

Resilience and Adaptation to Climate Risks Workshop

Natural System - Proposed Actions Post Workshop (cont'd)

CoF Stormwater PER

•Evaluate where we care about flooding on Center. Which of LaRC's ten main drainage basins should we focus funds/improvements? Do we need more flow data? What pollutant loads would increase with more flows? What areas on Center are acceptable for stormwater storage (Bioretention, detention ponds, cisterns, rainwater harvesting), etc.?

•Reexamine/review the design/purpose of the storm drain system as it will be affected by increased water levels due to climate changes

•Capital Improvements – Implement low impact development upgrades to the current system., widen ditches and slow ditch flows with engineered rock check dams to allow more infiltration in the ditch, utilize more plantings in and around ditches (this could also be part of the maximizing system functionality), utilize ponds/detention areas, harvest stormwater, green roofs, etc. Separate industrial discharges from stormwater discharges (allows for more treatment of stormwater options when the pollution stream is separated). Add new system capacity – pipes, ditches, etc. Create capture points at high risk flood prone areas within the main campus area and pump captured stormwater/flood waters to the North Forty

•Investigate designs for capture and distribution of roof storm water runoff

•Review the current stormwater system maintenance program, especially catch basin and ditch maintenance

Environmental Management Branch

Resilience and Adaptation to Climate Risks Workshop

Natural System - Proposed Actions Post Workshop (cont'd)

Built System Recommendations

•Harden or elevate vulnerable elements (for example, HVAC components, transformers) in conjunction w/scheduled rehab/repair/maintenance projects.

•Ensure new construction incorporates future sea level impacts in the design phase.

•Maximize System Functionality – Improve/increase maintenance of the current system to maximize its potential. Increase efforts in catch basin and pipe maintenance. Remove sediment and leafy debris to carry more flows efficiently without back-ups (floods).

•Channel summer AC water drainage to planted areas on and around New Town buildings, and position outdoor AC units on the north/protected sides of buildings, if reasonable.

•Consider designing for and pre-plumbing future New Town buildings for grey-water reuse, so that they can operate both in the standard manner yet switch to the water-conserving reuse operating model. NASA-ARC can provide design guidance.

NASA Langley Research Center