# Climate Change, Sea Level Rise, and Changing The Bay's Future

Citizen's Advisory Committee
to the Chesapeake Executive Council

Skip Stiles
Executive Director
Wetlands Watch

May30 , 2013

# CLIMATE CHANGE IMPACTS IN VIRGINIA

**What Do We Know About Climate Change Impact Predictions for Virginia?**

**In 100 years we'll see…..**

- **At Least 2.3 feet of sea level rise (as much as 5.2 feet) in next 100 years (3' current consensus)**
- **3.1 $^{o}$ C increase in average temperature**
- **~11 % increase in rainfall intensity**

**New research out of VIMS and ODU puts minimum sea level rise at 4'**

**Najjar, et al, 2009, Virginia Climate Change Commission, 2008.**

# CLIMATE CHANGE ADAPTATION IN VIRGINIA

**All of this work over 30+ years (and the next 30 years) comes down to changing….**

Chesapeake Bay Program
*A Watershed Partnership*

CHESAPEAKE 2000
The Renewed Agreement

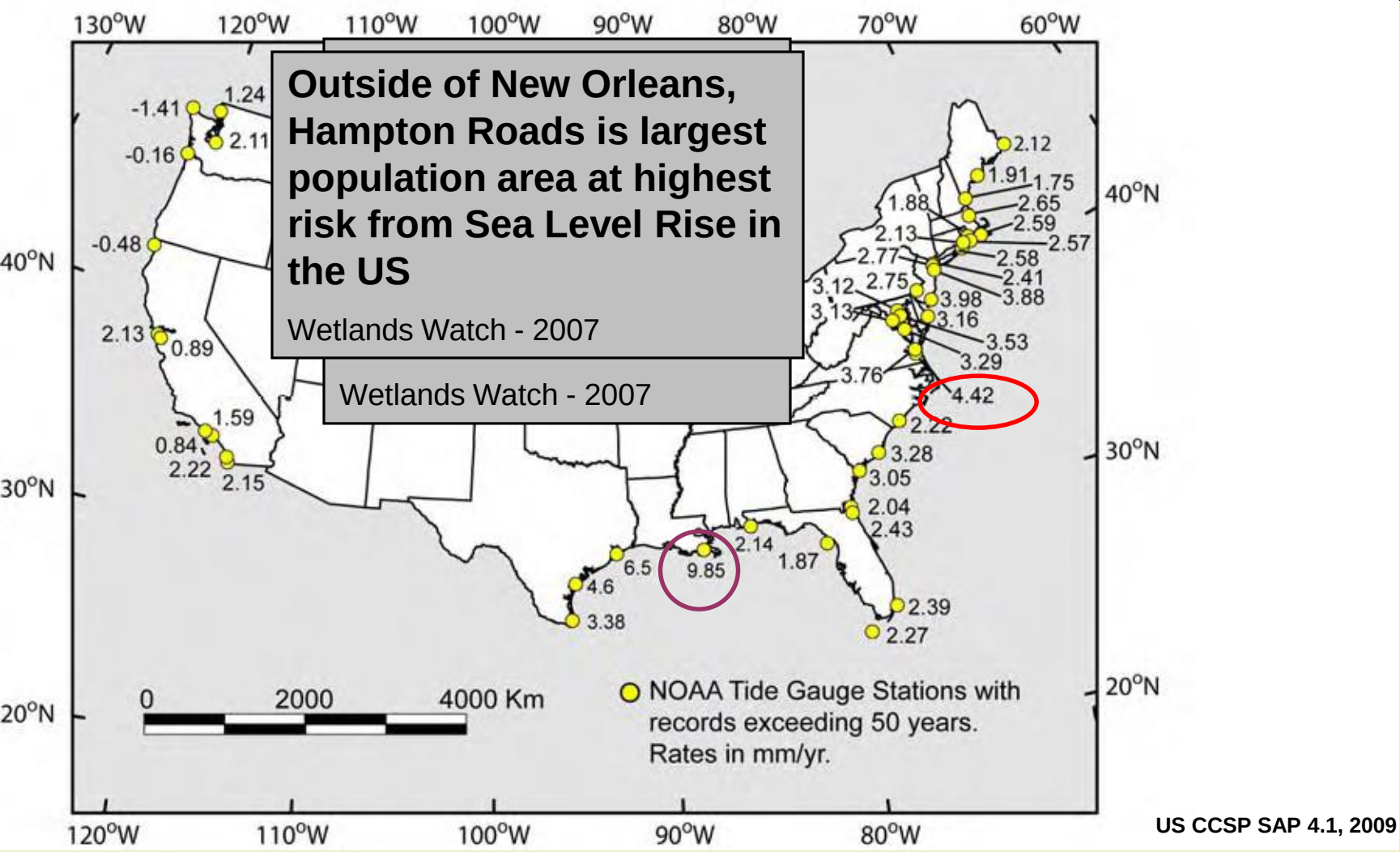
30 YEARS 1983-2013
Chesapeake Bay Program
*Science. Restoration. Partnership.*

# CLIMATE CHANGE ADAPTATION IN VIRGINIA

**This….**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Rates of Sea Level Rise Significantly Threaten the Coastal Ecosystem**



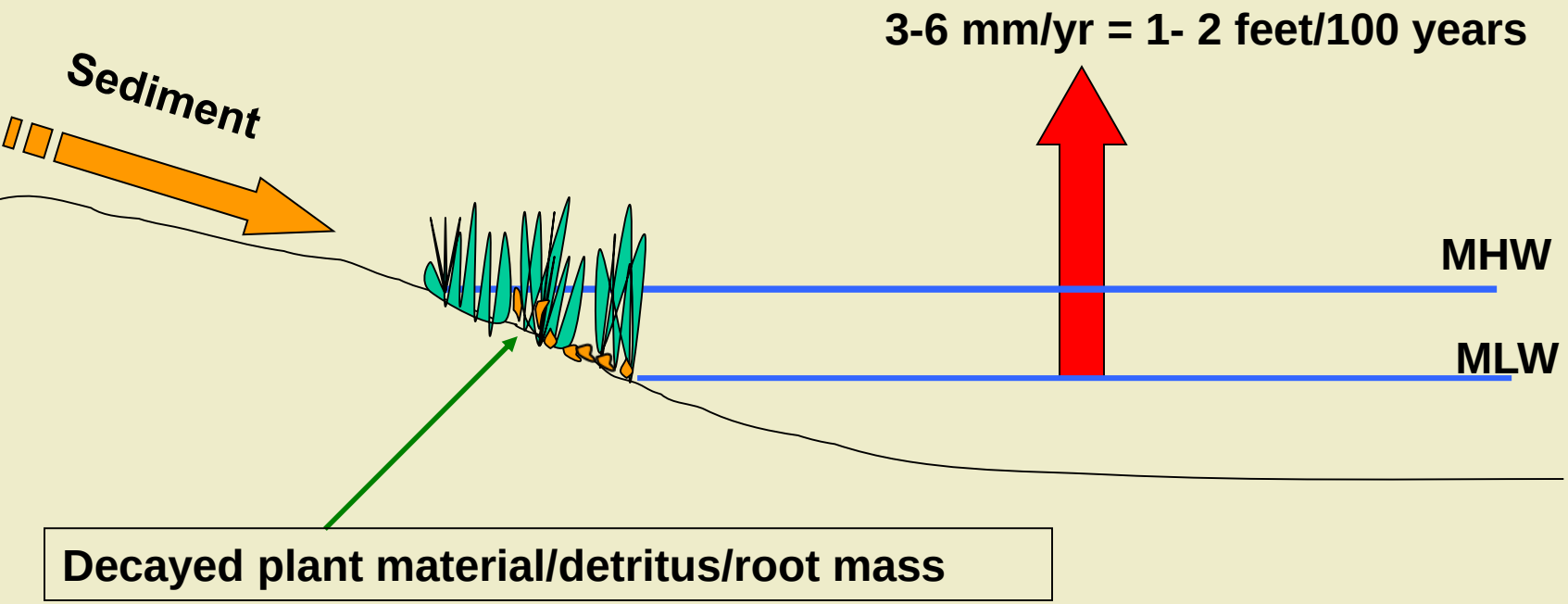

**Outside of New Orleans, Hampton Roads is largest population area at highest risk from Sea Level Rise in the US**

Wetlands Watch - 2007

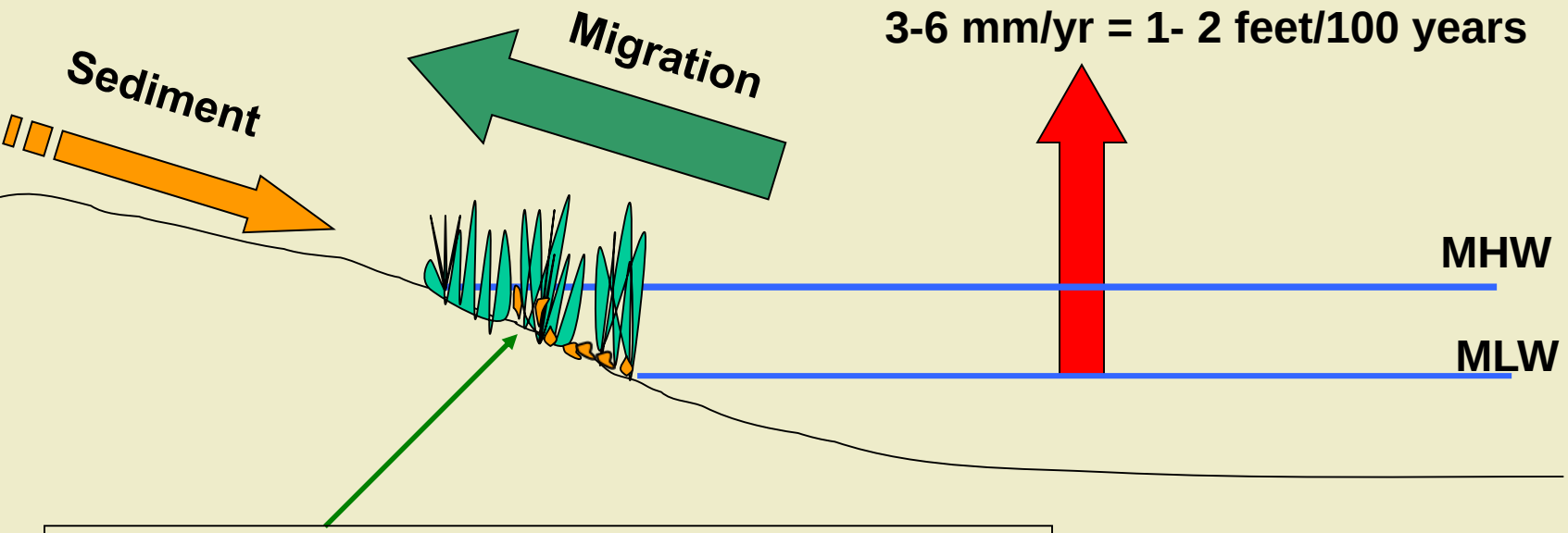
Wetlands Watch - 2007

US CCSP SAP 4.1, 2009

# Wetlands Can Keep Up with Modest Sea Level Rise

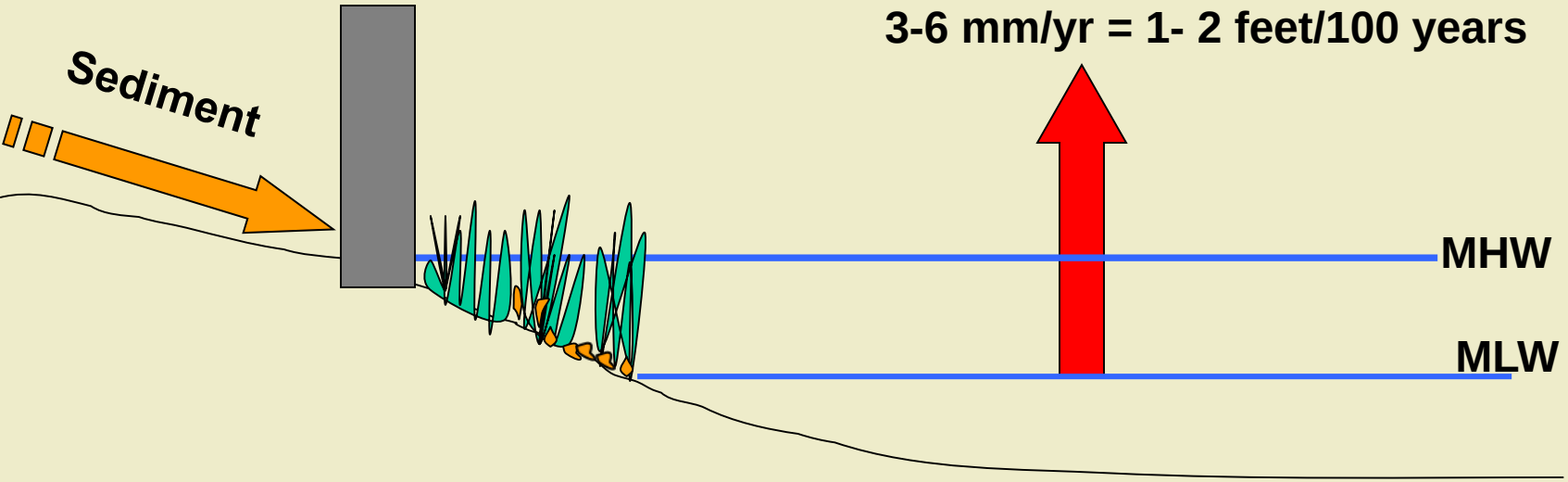


# Rapid Sea Level Rise May Require Landward Migration… *




* Sediment budget problems and/or lower marsh productivity = slower vertical accretion

# …until Barriers are Encountered



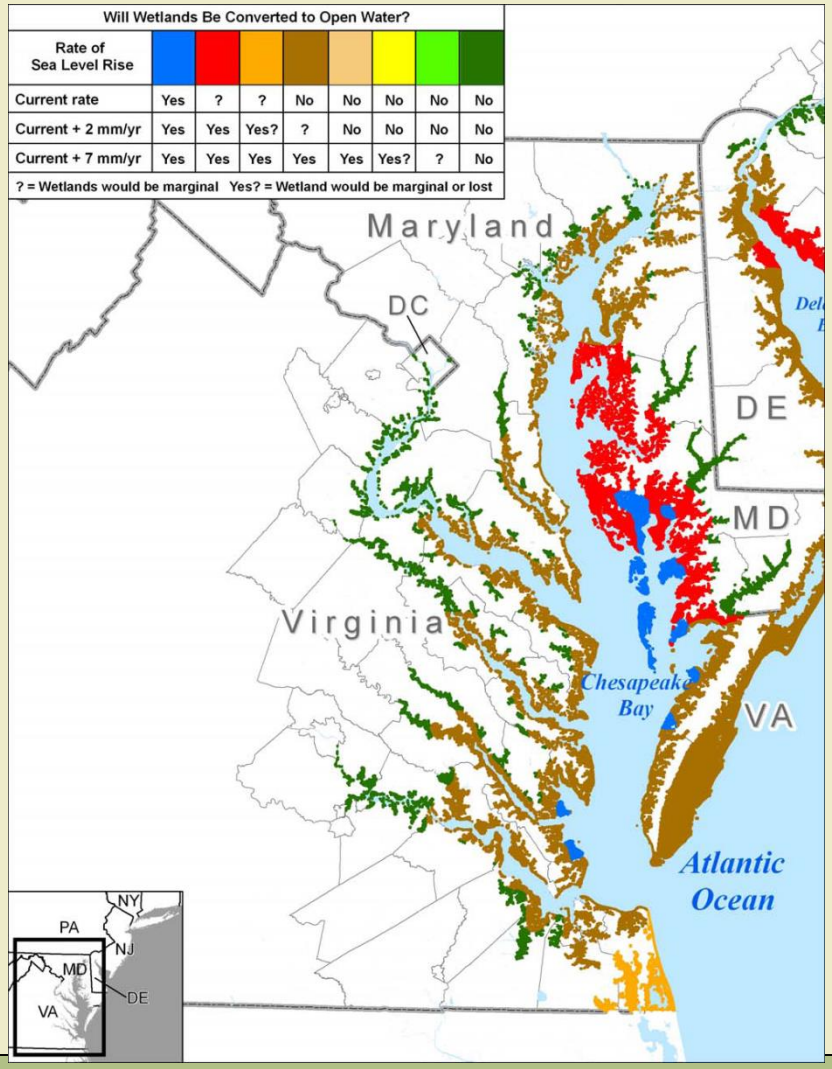
# CLIMATE CHANGE IMPACTS IN VIRGINIA

**Shoreline Hardening + Sea Level Rise = Tidal Wetland Loss**

Past Policy: Move Erosion Control Out of Wetlands, Onto CBPA

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Predicted Rates of Sea Level Rise Will 'Drown' Most of Virginia's Tidal Wetlands**

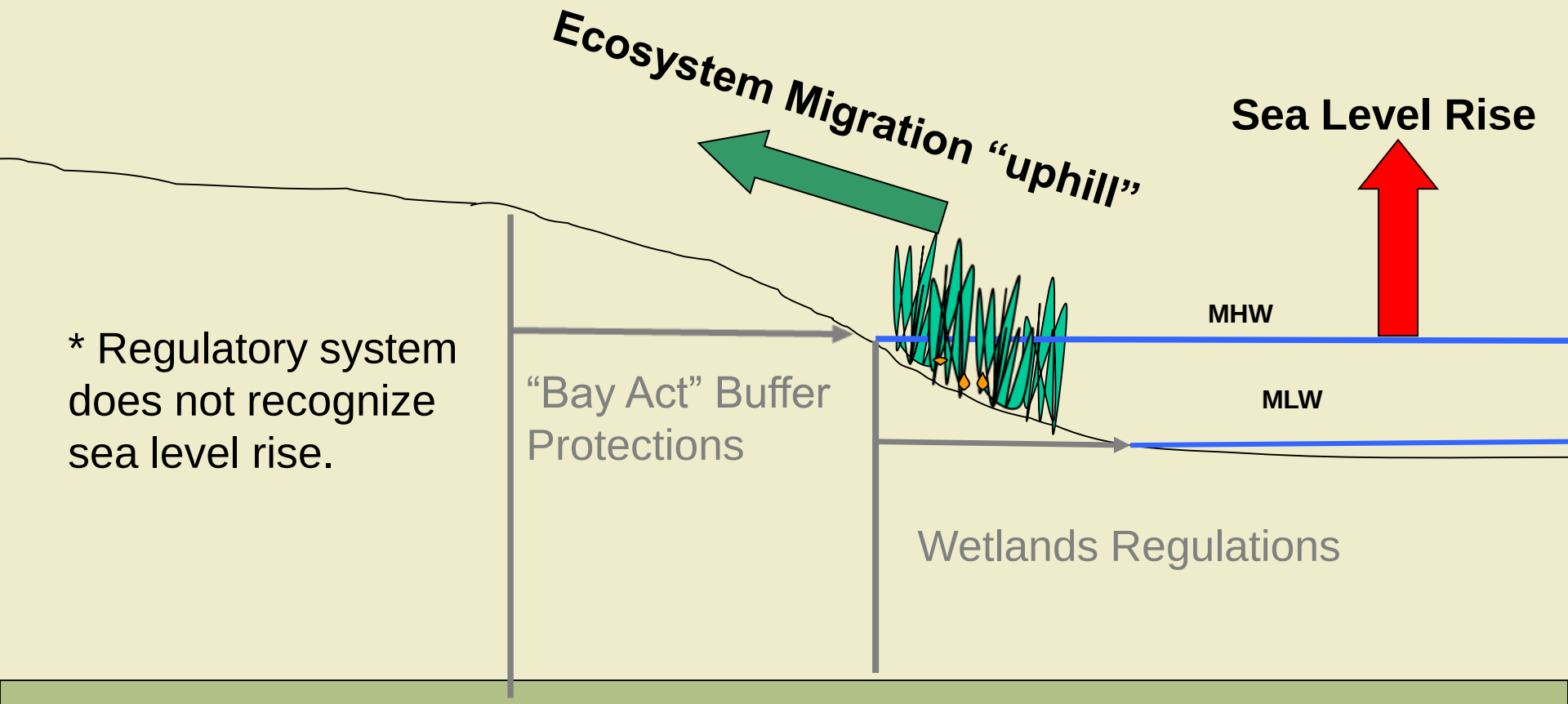



**Blue, Red, Orange, and Brown areas will see wetlands converted to open water at current predicted rates of sea level rise ~ 2-5 feet/100 years**

US CCSP SAP 4.1, 2009

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

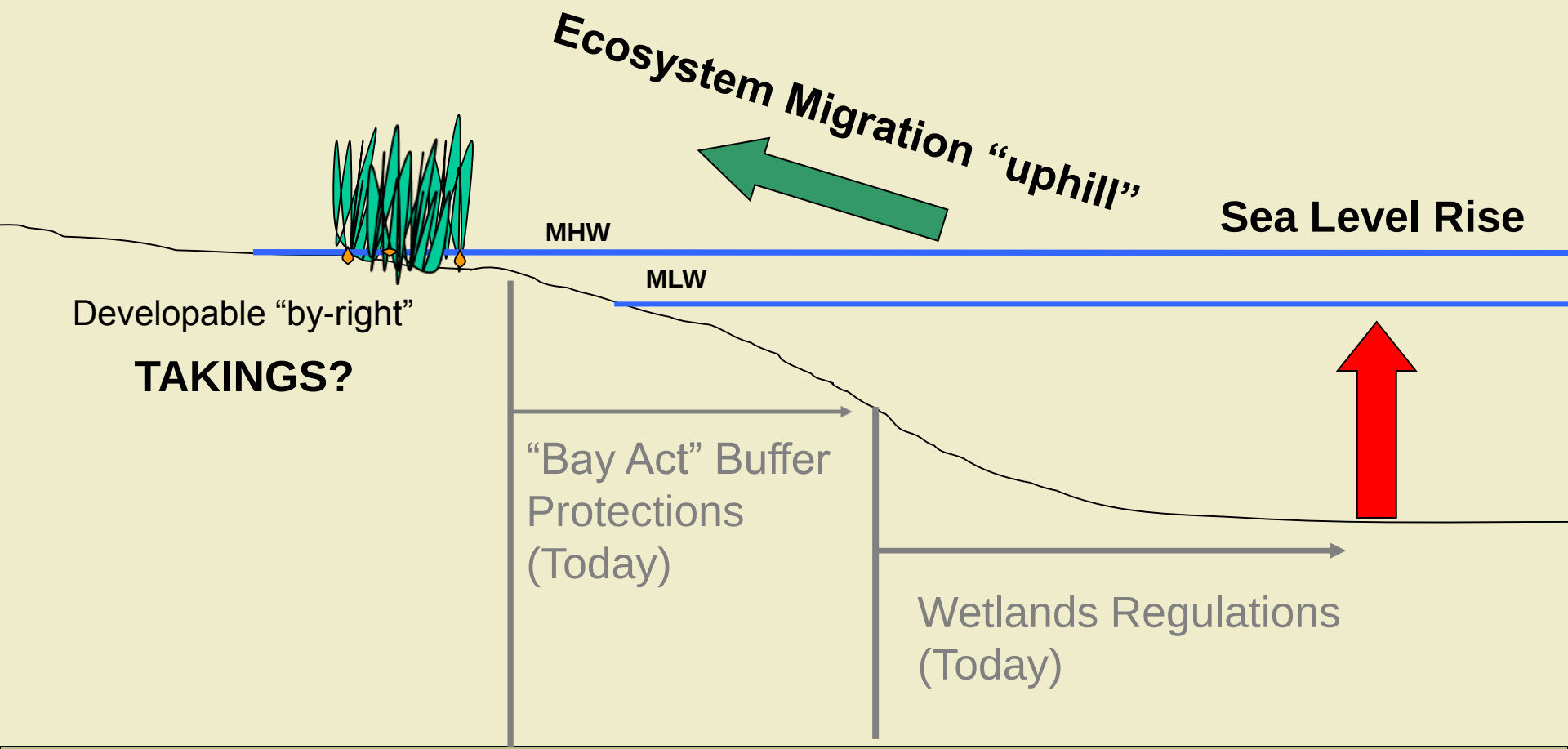
**Sea Level Rise Will Move Shoreline Beyond Today's Environmental Jurisdictions**




* Regulatory system does not recognize sea level rise.

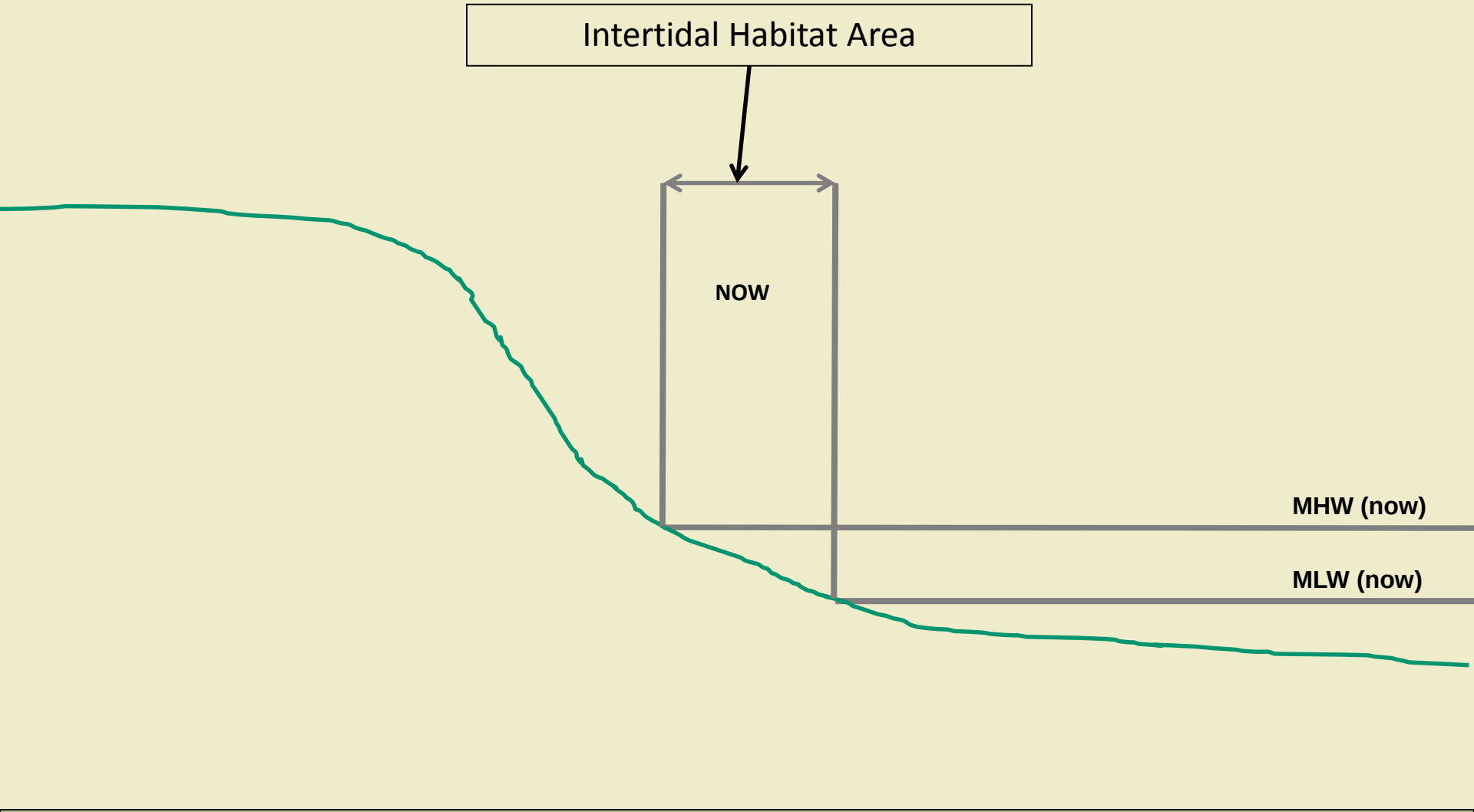
# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Sea Level Rise Will Move Shoreline "Uphill" – Eventually onto "Nonjurisdictional" Land with Development Rights**



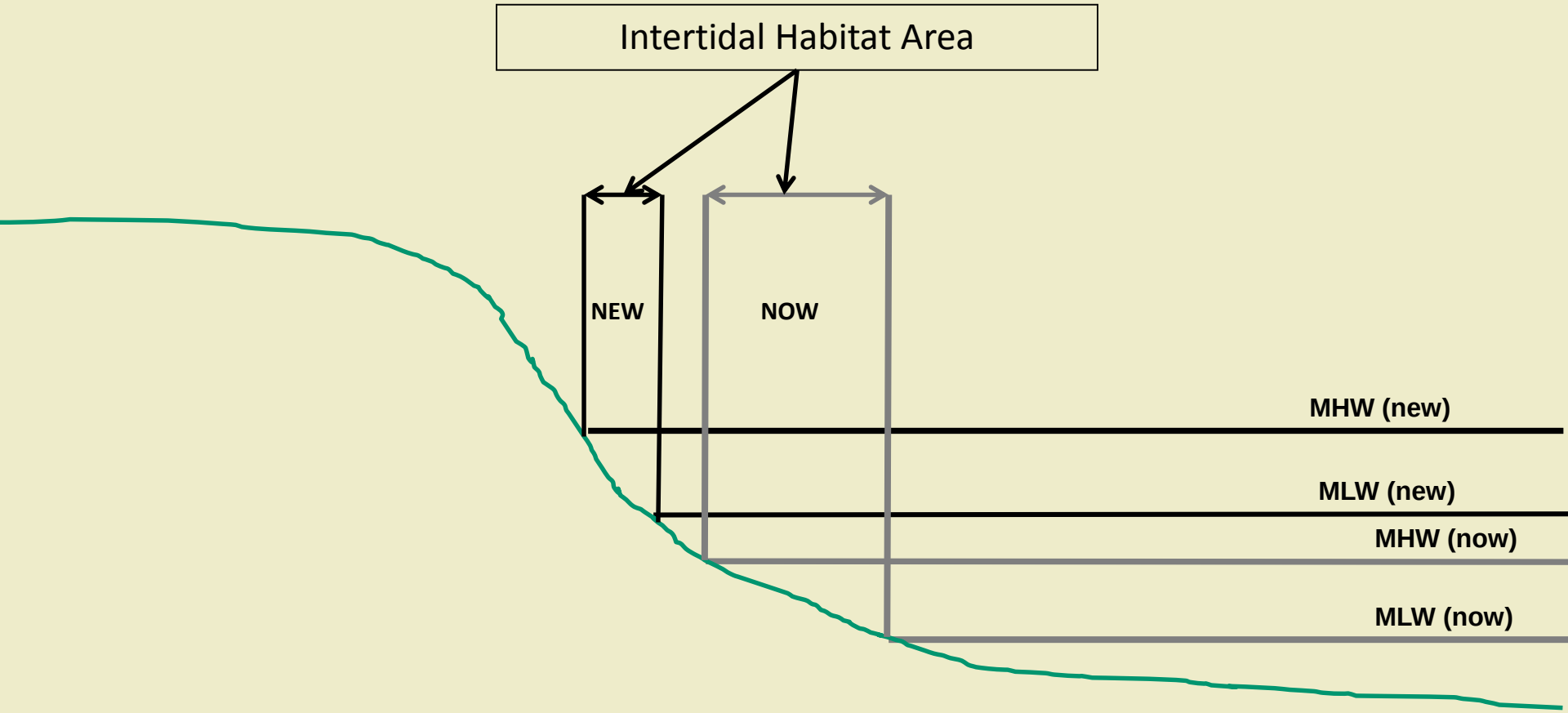
# SEA LEVEL RISE IMPACTS IN VIRGINIA

**Inescapable Reality of the Challenge We Face - Topography**



# SEA LEVEL RISE IMPACTS IN VIRGINIA

**New Tidal Marsh Area Will Decrease, Due to Higher Slope on Adjacent Land – Especially in Tidal Fresh Areas**



# We Can Observe Sea Level Rise Impacts Today

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**FEMA Post-Hazard Mitigation Program**


**~$130,000/house**

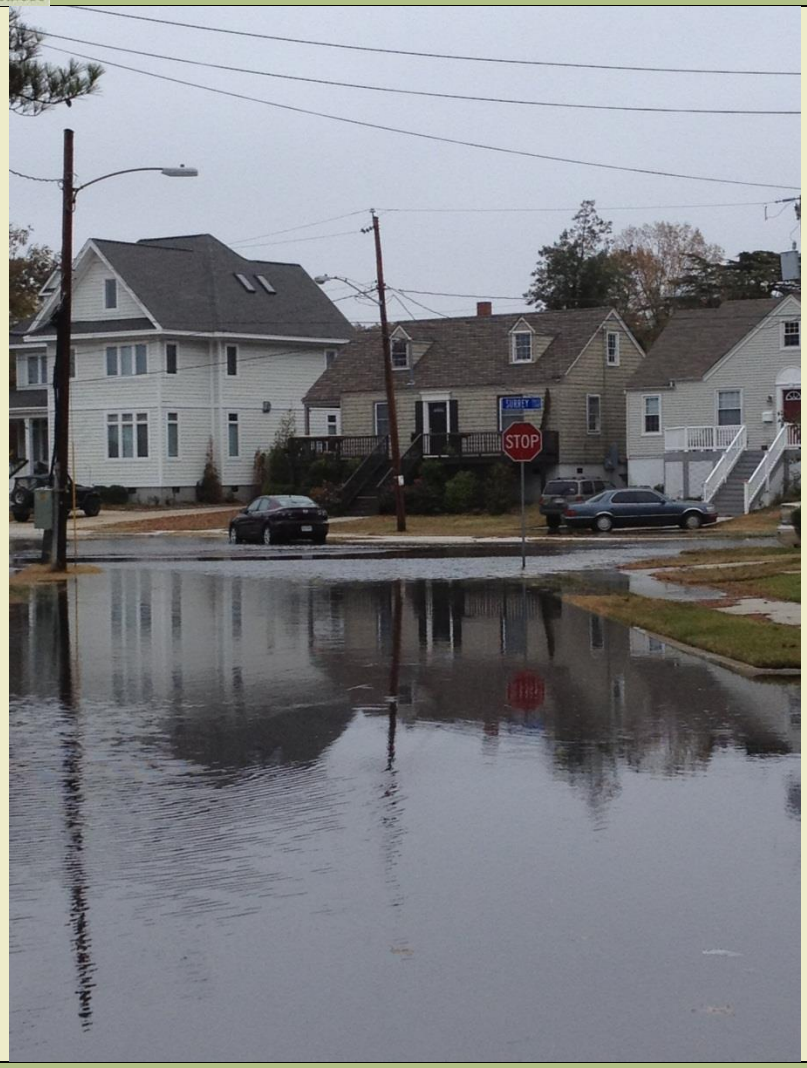
**$4.5 million in FEMA spending to raise houses in Norfolk after Isabel**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**House is Fine…Now About the Street**

**"Business as Usual" = Taxpayer Liability**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA




Even after $1.2 million, the street floods with little more than a “spring tide”

# CLIMATE CHANGE IMPACTS IN VIRGINIA

**Shoreline Moves Onto Forested Wetlands in Mathews County**

# How Do We “Market” Sea Level Rise?

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Challenge Is Not with Natural Science but with Social and Behavioral Science**

97% of scientists concur that humans are causing climate change.

John Cook *et al* 2013 *Environ. Res. Lett.* **8** 024024

Do scientists agree the Earth is getting warmer because of human activity?

| | |
|---|---|
| Yes | 45% |
| No | 43% |
| Don't Know | 12% |

Pew Research Center, Oct. 2012

# CLIMATE CHANGE ADAPTATION IN VIRGINIA

**The person we need to convince**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Storm Surges Over Time in Norfolk**

| DATE | STORM TYPE/NAME | ABOVE MHHW |
|---|---|---|
| August 23, 1933 | Hurricane | 5.26 feet |
| September 18, 2003 | Hurricane Isabel | 5.13 feet |
| November 12, 2009 | Veterans Day Nor'easter | 4.99 feet |
| August 28, 2011 | Hurricane Irene | 4.76 feet |
| March 7, 1962 | Ash Wednesday Storm | 4.46 feet |
| October 29, 2012 | Hurricane Sandy | 4.09 feet |
| September 18, 1936 | Hurricane | 3.96 feet |
| November 22, 2006 | Thanksgiving Nor'easter | 3.87 feet |
| February 5, 1998 | Twin Nor'easter (#2) | 3.82 feet |
| October 6, 2006 | Columbus Day Nor'easter | 3.76 feet |
| April 27, 1978 | Nor'easter | 3.65 feet |
| April 11, 1956 | Nor'easter | 3.56 feet |
| September 16, 1933 | Hurricane | 3.36 feet |
| January 28, 1998 | Twin Nor'easter (#1) | 3.28 feet |
| September 16, 1999 | Hurricane Floyd | 3.21 feet |

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Today's Storms, 100 Years Ago, Would Not Flood as Much**

| DATE | STORM TYPE/NAME | ABOVE MHHW |
|---|---|---|
| August 23, 1933 | Hurricane | 5.26 feet |
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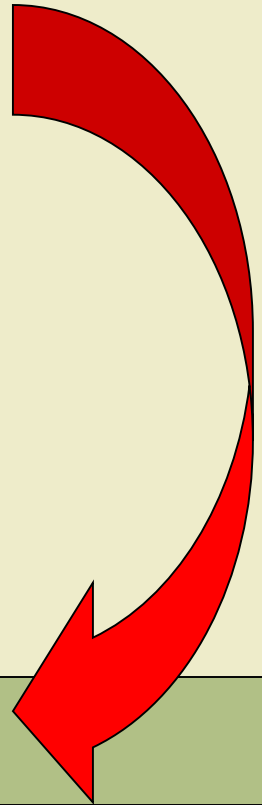
**- 1.45 feet in 1912**



# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Today's Storms, 100 Years From Now, Set Records**

| DATE | STORM TYPE/NAME | ABOVE MHHW |
|---|---|---|
| August 23, 1933 | Hurricane | 5.26 feet |
| September 18,2003 | Hurricane Isabel | 5.13 feet |
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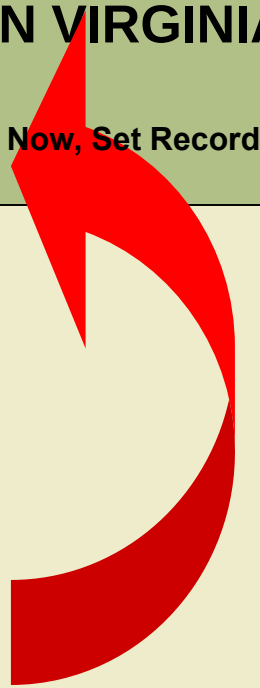
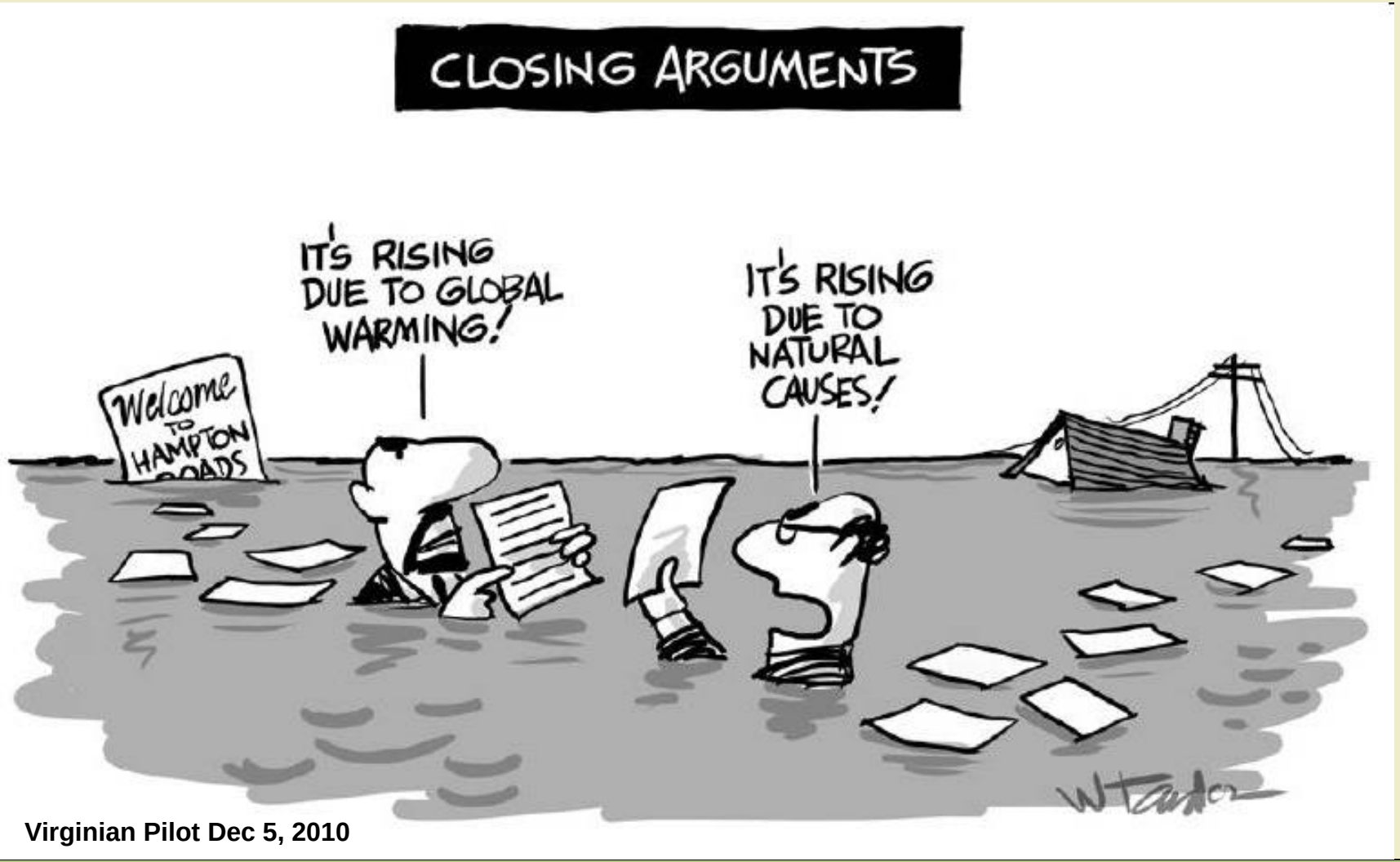


**+3 feet in 2112**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Climate Change Not Needed to Make the Case for Adaptation Here**




**Virginian Pilot Dec 5, 2010**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

## Hampton Roads Impacts – One Meter of Sea Level Rise by 2012

| | TOTAL | LOW ESTIMATE | MIDDLE ESTIMATE | HIGH ESTIMATE |
|---|---|---|---|---|
| GENERAL | | | | |
| Land Area (square miles) | 2,948.20 | 173.1 | 238.5 | 311.4 |
| Population | 1,666,310 | 59,059 | 112,794 | 176,124 |
| Housing Units | 677,549 | 24,436 | 45,791 | 71,548 |
| BUILT ENVIRONMENT | | | | |
| Number of Parcels (intersection) | 605,284 | 39,564 | 61,254 | 84,780 |
| Number of Parcels (centroid) | 605,284 | 16,000 | 35,654 | 58,651 |
| Improvement Value of Parcels (intersection) | $128,305,696,321 | $20,328,915,919 | $26,161,421,399 | $30,833,003,959 |
| Improvement Value of Parcels (centroid) | $128,305,696,321 | $4,142,308,080 | $8,766,633,550 | $13,410,140,979 |
| INFRASTRUCTURE | | | | |
| Roads (total miles) | 11,767.20 | 161.5 | 506.8 | 877.2 |
| Roads (Interstate) | 249.9 | 5.7 | 14 | 17.8 |
| Roads (Primary) | 1,460.40 | 17.1 | 49.6 | 77.3 |
| Roads (Secondary) | 2,216.30 | 24 | 72.2 | 98.2 |
| Roads (Local or Private) | 7,840.70 | 114.7 | 371.1 | 683.9 |
| ECONOMY | | | | |
| Businesses | 57,579 | 575 | 2,026 | 3,659 |
| Employees | 719,835 | 5,237 | 25,088 | 50,869 |
| Total Value of Parcels (intersection) | $215,436,678,988 | $38,892,731,860 | $48,067,888,230 | $56,306,819,672 |
| Total Value of Parcels (centroid) | $215,436,678,988 | $8,513,744,141 | $16,466,833,462 | $25,104,125,807 |
| NATURAL ENVIRONMENT | | | | |
| Protected Lands (acres) | 224,497 | 34,122 | 38,800 | 46,251 |
| VEVA – Outstanding (acres) | 166,276 | 19,257 | 20,454 | 23,566 |
| VEVA – Very High (acres) | 319,728 | 48,947 | 58,707 | 70,994 |
| VEVA – High (acres) | 374,797 | 31,007 | 42,798 | 57,285 |

Economic cost to Hampton Roads runs from $12,656,052,221 to $87,139,823,631 –

just from property losses (no calculation of environmental losses, business losses, cost to maintain infrastructure, etc.)

"Climate Change in Hampton Roads: Phase III Sea Level Rise in Hampton Roads" – HRPDC, 2012

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Economic Drivers for Adaptation Are Emerging - Globally**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Sea Level Rise Increases Frequency of Flooding Events**

| Flood | Flood (Ft) | Historical | Now | +2’ | +3’ |
|---|---|---|---|---|---|
| Record | +8.02 | 80.5 yrs | 26.8 yrs | 7.3 yrs | 1.7 yrs |

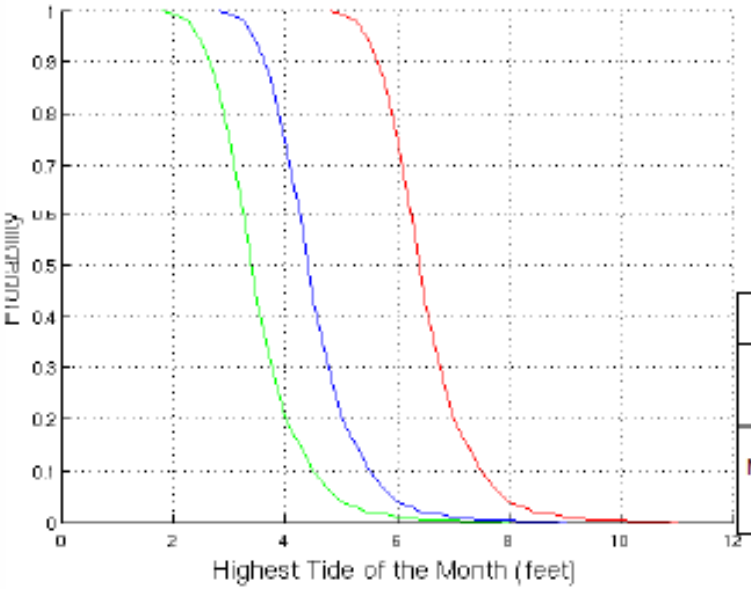
Huntington-Ingalls is Largest Manufacturing Employer in Virginia

Only Shipyard in the US that can build aircraft carriers – Ford Class underway

NORTHROP GRUMMAN

## Sea-Level Rise Notional Scenarios

Probability that Tide at Sewells Pt exceeds:
Historical (Green), Present Day (Blue), Historical + 3’ (Red)




Increasing Sea Level combined with storm surge frequencies alters the risk analysis

Modest levels of rise on the average increase the frequency of extreme events dramatically

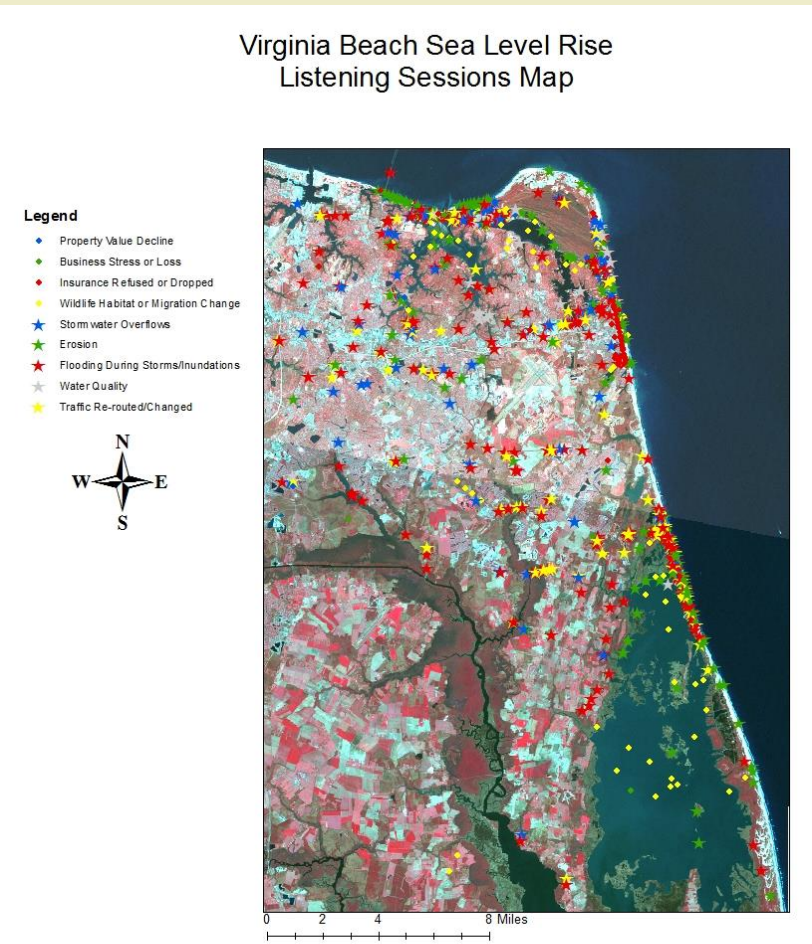
**Average Number of Years Between Inundation Events**

| Event Severity | | Sea Level Rise change (Ft) | | | |
|---|---|---|---|---|---|
| Flood Stage | Gauge Level (ft) | Historical | Present | Hist +2’ | Hist +3’ |
| Flood | 5.00 | 1.71 | 0.33 | 0.10 | 0.08 |
| Moderate | 6.00 | 7.32 | 1.71 | 0.33 | 0.10 |
| Major | 7.00 | 26.83 | 7.32 | 1.71 | 0.33 |
| **Record** | **8.02** | **80.50** | **26.83** | **7.32** | **1.71** |

Sea-level rise reduces the time between (increases the frequency of) record-level inundation events. Colors represent relative risk.

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

## Putting What They Have Seen on the Map




# Pressure to Adapt is Growing

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Many Federal Agencies Will Force Changes Along the Shoreline**

FEMA

US ARMY
CORPS OF ENGINEERS

NAVY
Task Force
Climate Change

NOAA

NASA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

# Land Use is the Key

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

## Authorities Exist in Virginia Code

**§ 15.2-1200. General powers of counties.**

**Any county may adopt such measures as it deems expedient to secure and promote the health, safety and general welfare of its inhabitants which are not inconsistent with the general laws of the Commonwealth.**

**§ 15.2-2283. Purpose of zoning ordinances.**

**Zoning ordinances shall be for the general purpose of promoting the health, safety or general welfare of the public and of further accomplishing the objectives of § 15.2-2200. (i)…safety from fire, flood, impounding structure failure… (vi) to protect against one or more of the following: … loss of life, health, or property from fire, flood, impounding structure failure**

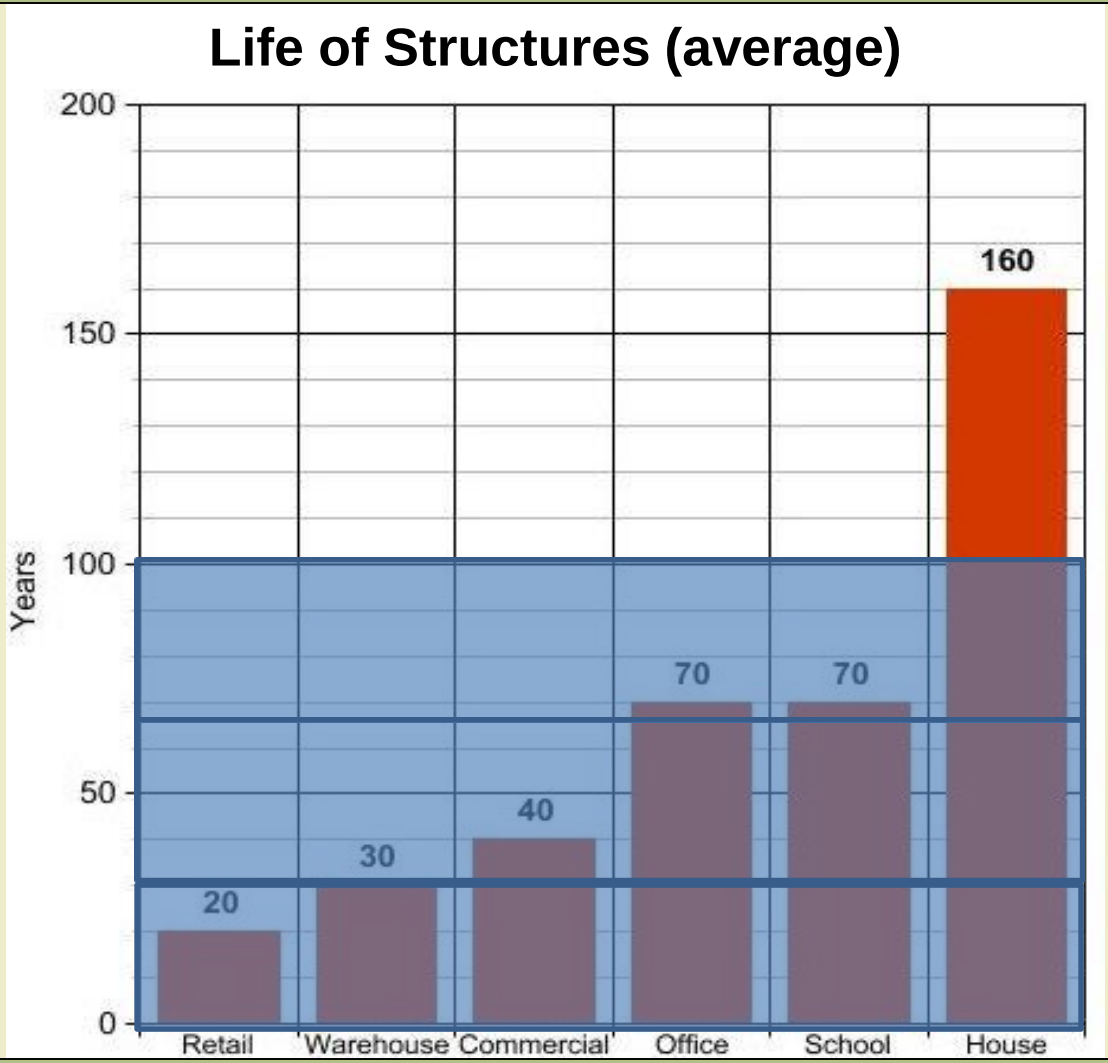
**Coastal Resource Management Guidance -** must be in comprehensive plans, starting in 2013. (Code of Virginia § 15.2-2223.2). To be developed by the Virginia Institute of Marine Science (VIMS), "*The guidance shall identify preferred options for shoreline management and taking into consideration the resource condition, priority planning, and* ***forecasting of the condition of the Commonwealth's shoreline with respect to projected sea-level rise***." (Code of Virginia § 28.2-1100.9)

**SJ 76 Flooding; Institute of Marine Science to study strategies to prevent recurrent flooding.**

**Stolle (House), Northam (Senate)**

# CLIMATE CHANGE IMPACTS IN VIRGINIA

**Land Uses Need to Plan for Sea Level Rise in Different Ranges**




**+ 3 feet**

**+ 2 feet**

**+ 1 foot**

# SEA LEVEL RISE ADAPTATION IN MARYLAND

**Novel Land Use Plan from Crisfield, MD**
**= zoning based on elevation rather than "setbacks" from coast**

**Land Use / Natural Area Compatibility**

| Land Use | Primary Sensitive Area (See Crisfield Elevation Map): 0-2 feet above sea level | 2.1 to 3 feet above sea level | 3.1+ feet above sea level | Remaining Natural Shoreline | Tidal Marsh / Non-Tidal Wetlands | Remaining Intact Woodlands |
|---|---|---|---|---|---|---|
| **Waterfront Planning Area** | | | | | | |
| Conservation of Existing Development | | | | | | |
| Water-dependent uses | ● | ● | ● | - | | - |
| Non-water dependent uses | ○ | ◐ | ● | - | ○ | - |
| New Development / Redevelopment | | | | | | |
| Water-dependent uses | ● | ● | ● | ○ | ○ | - |
| Non-water dependent uses | ○ | ○ | ◐ | ○ | ○ | - |
| Recreation | | | | | | |
| Active (involves some land development) | ◐ | ● | ● | ○ | ○ | - |
| Passive | ● | ● | ● | ● | ● | - |
| Resource Conservation | ● | ● | ● | ● | ● | - |
| **Outside of Waterfront Planning Area** | | | | | | |
| Conservation of Existing Development | | | | | | |
| Neighborhood Conservation | ○ | ◐ | ● | - | - | - |
| Neighborhood Infill (Limited to Vacant Lots) | ○ | ◐ | ● | - | - | - |
| Commercial Revitalization | ○ | ○ | ● | - | - | - |
| New Development / Redevelopment | | | | | | |
| Residential, Neighborhood Redevelopment | ○ | ◐ | ● | ○ | ○ | ○ |
| New Urban Development (non-residential) | ○ | ◐ | ● | ○ | ○ | ○ |
| Recreation | | | | | | |
| Active (involves some land development) | ◐ | ● | ● | ○ | ○ | ○ |
| Passive | ● | ● | ● | ◐ | ◐ | ● |
| Resource Conservation | ● | ● | ● | ● | ● | ● |

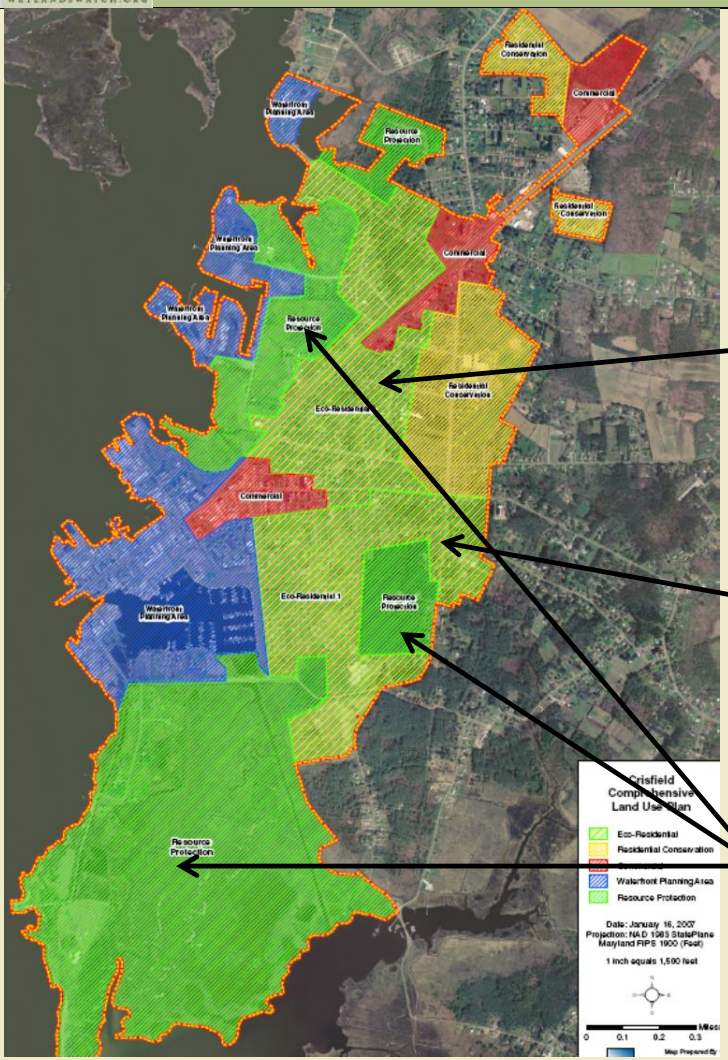
Key: ○ Incompatible; ◐ Limited Compatibility; ● Full Compatibility

LAND USE

ELEVATION

# SEA LEVEL RISE ADAPTATION IN MARYLAND

**Novel Land Use Plan from Crisfield, MD**




**Eco-Residential – 2**

**(3+ feet above sea level)**

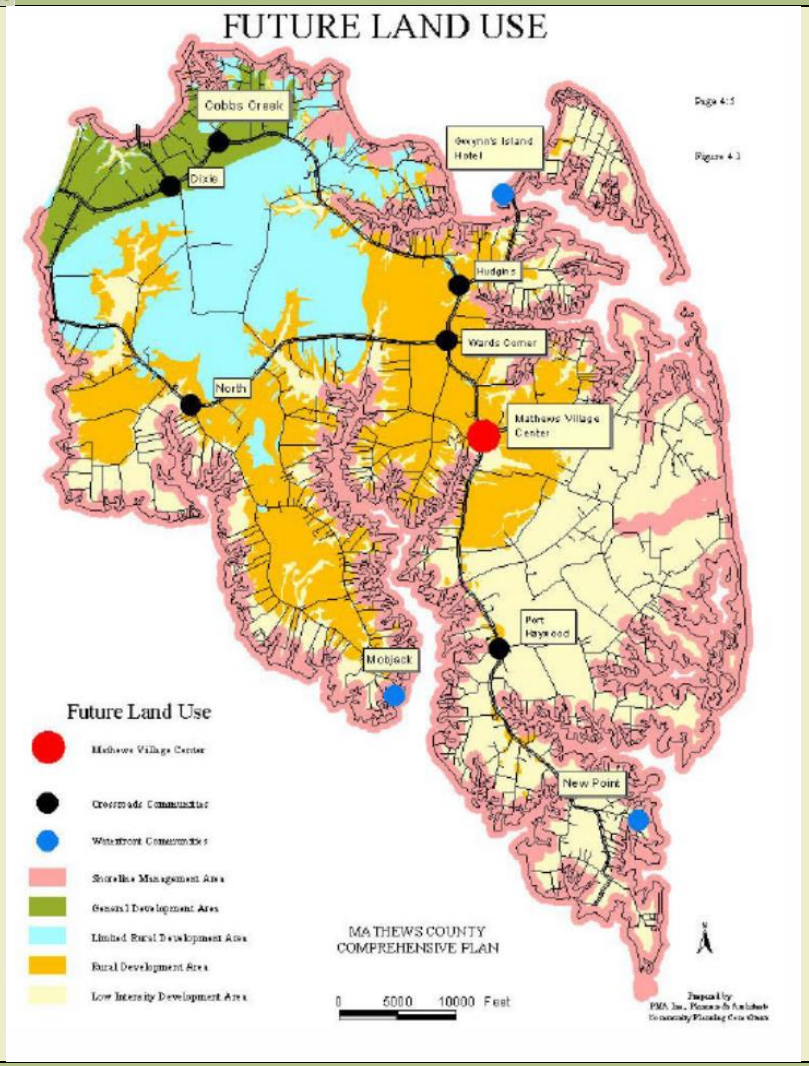
**Eco-Residential – 1**

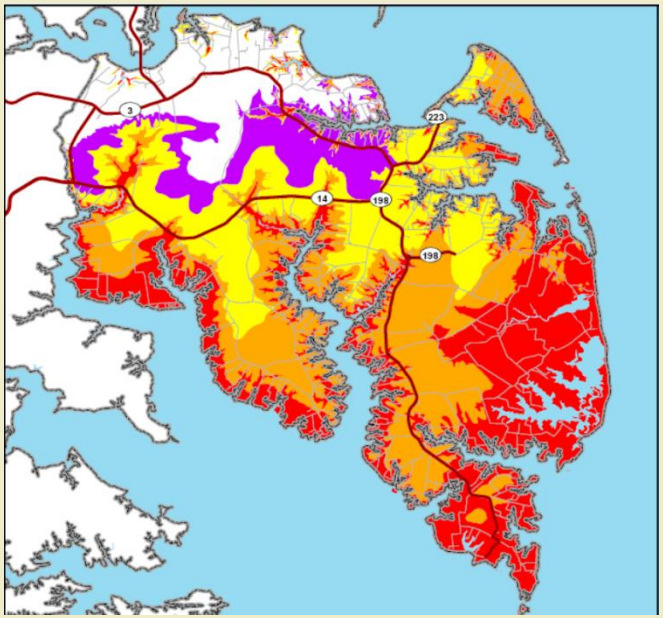
**(1-3 feet above sea level)**

**Resource Protection (lowest land)**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**"Elevation-Based" Zoning in Mathews Virginia - 2008**



Cat 1 Storm Surge Zone (4-6 feet/Red zone)
= "Low-Intensity Development Area"
(0-10 feet above sea level)

# Life in the Real World

# CLIMATE CHANGE ADAPTATION IN VIRGINIA

**The pressure to continue status quo**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

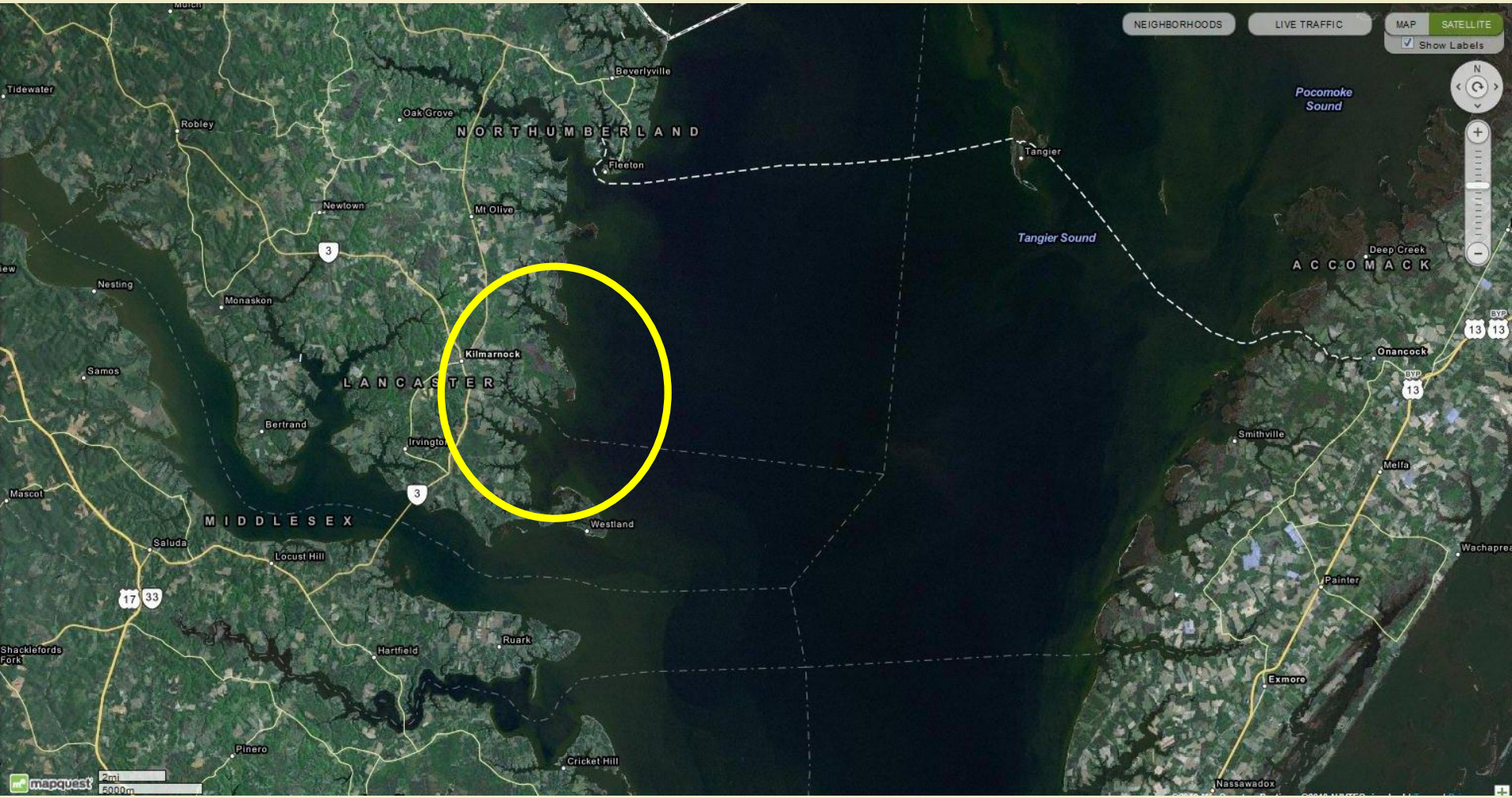
**Technology/New Regulations Allow Septics in Wetlands**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Grandview in Hampton, VA**

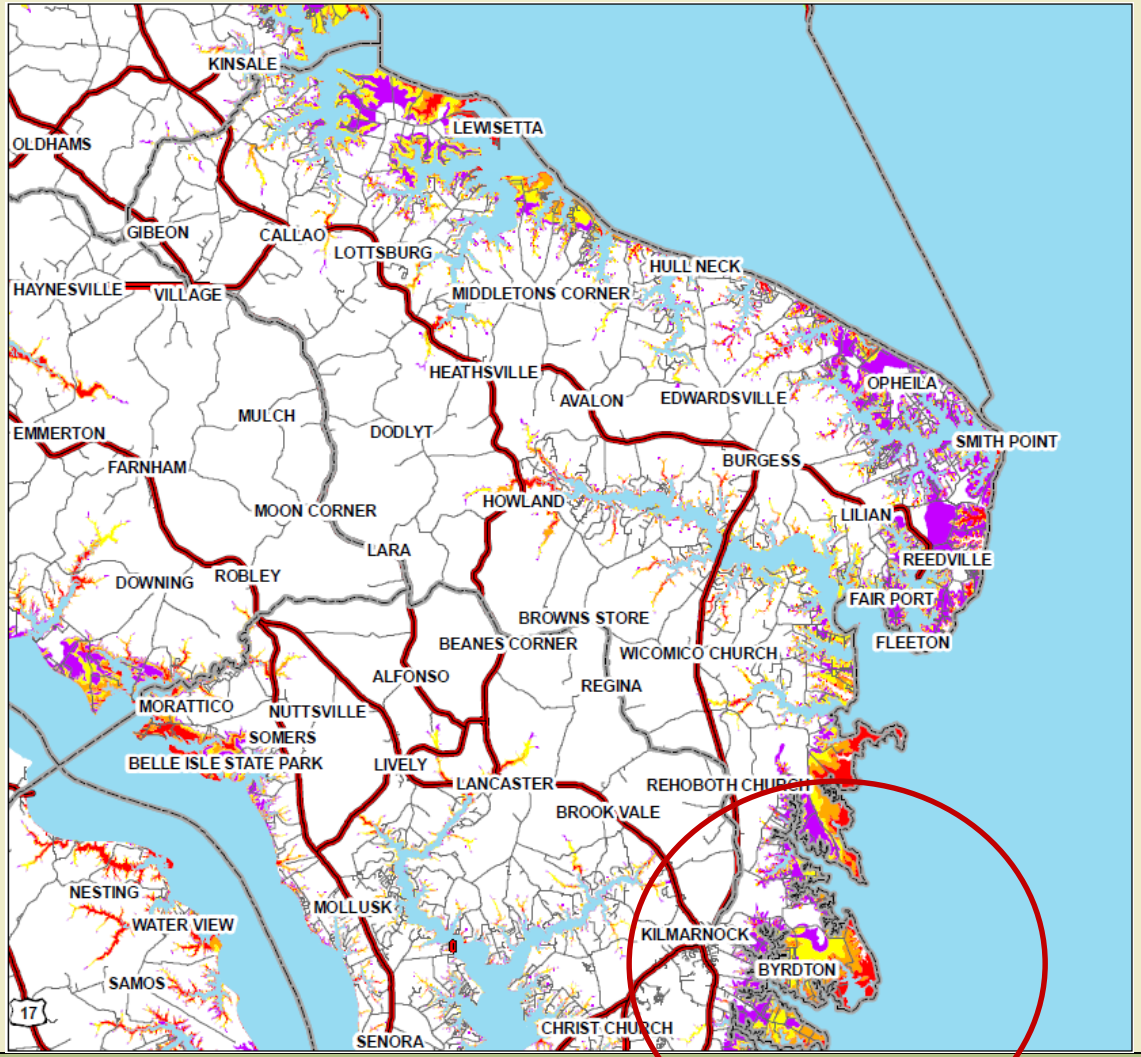
# SEA LEVEL RISE ADAPTATION IN VIRGINIA

## Cash-Starved Rural, Coastal Counties Look for Development



# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Development Proposed in Areas That Get Wet *TODAY***



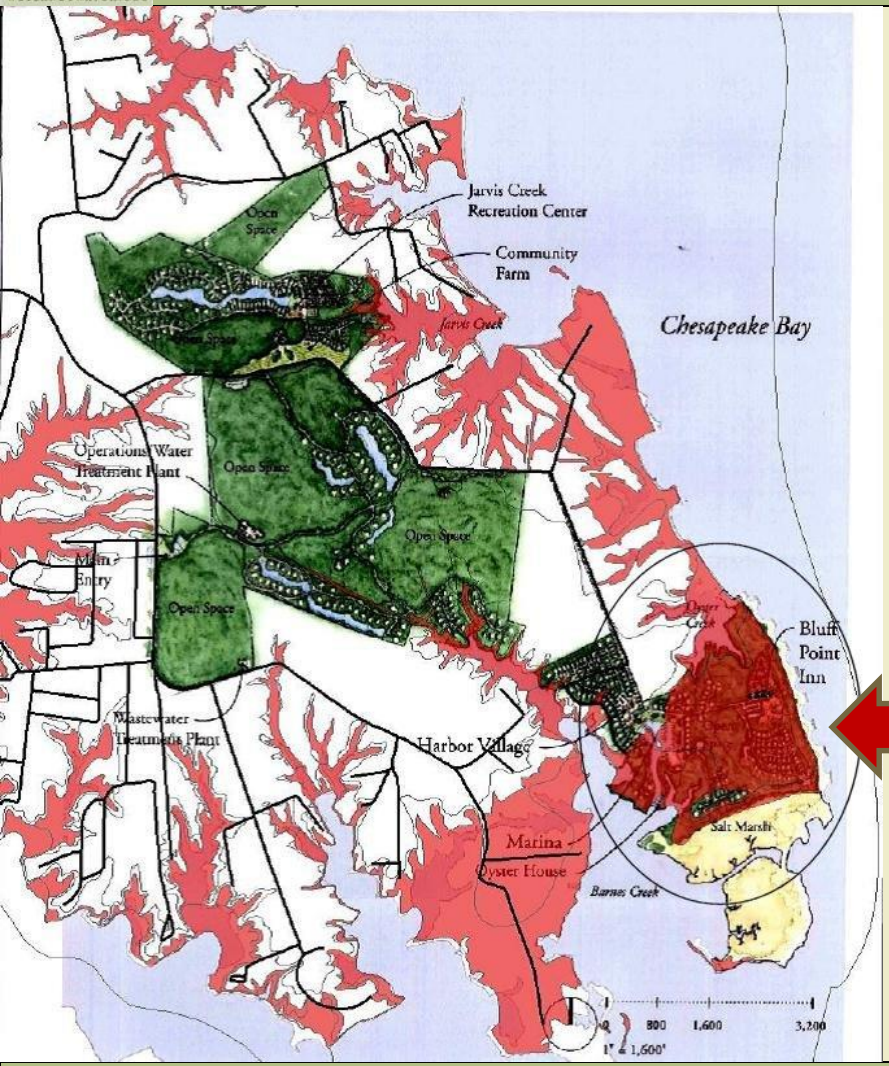

Red = Category 1 surge zone, 4-6 feet above MLW

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**By-Right Development on Higher Land, but Coastal Land Still Has Appeal**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Bluff Point Development Proposal**

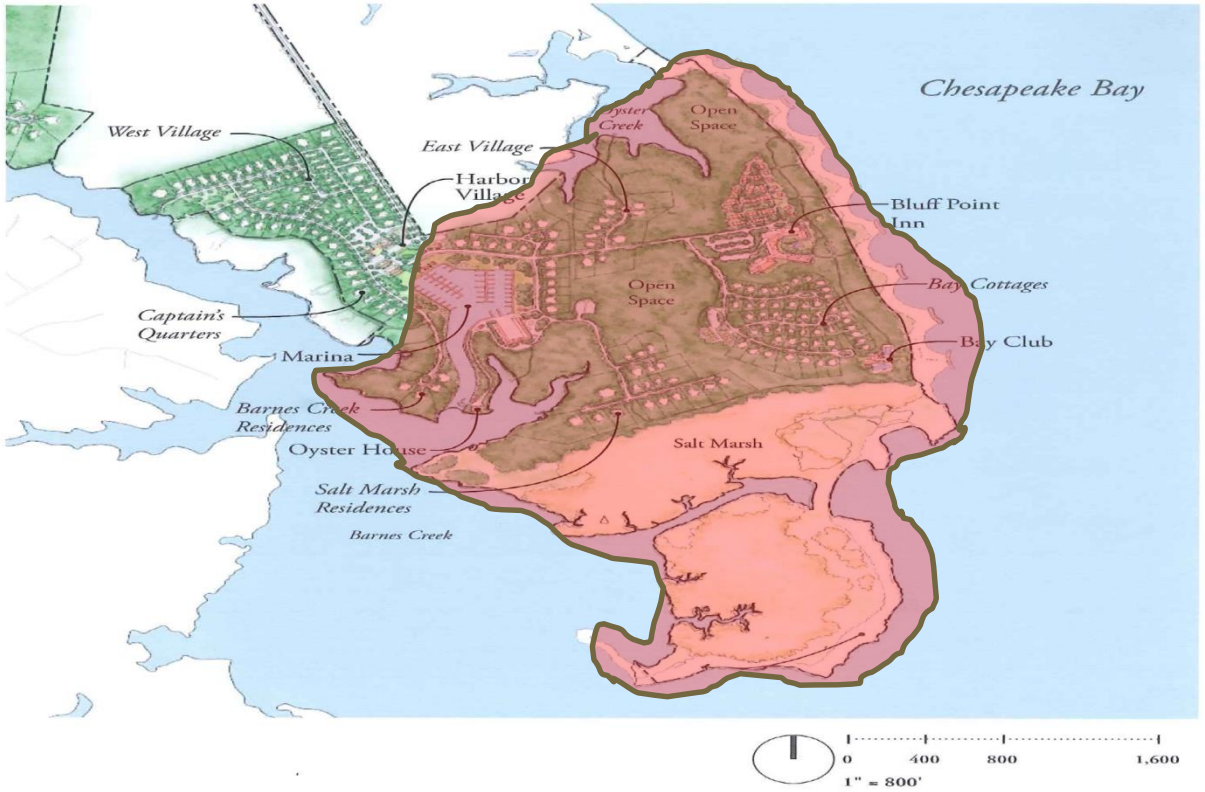



**Use narrow connector to unify property, create a "planned unit development," and flip the development from the excising subdivision onto the conservation land (red overlay = 100 year flood zone)**

- **168 single-family homes**
- **$40 million hotel/spa, marina**
- **34,000 square feet of retail space**

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

**Flood Zone Overlay**




Bay and Harbor Master Plan, Exhibit B

Project Approved for Rezoning – 5-1

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

## Next Steps???

- Better maps, better models to predict inundation, better planning, more community conversations
- Life-cycle costing of investments, infrastructure, and developments
- “Do No Harm” = slow development and redevelopment in tidal floodplains
- Invest in solutions = business opportunity
- Get Virginia’s government to step up and seek federal government involvement
- Partner with “fact-based” advocacy groups

# SEA LEVEL RISE ADAPTATION IN VIRGINIA

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