Mitigation and Adaptation Strategies of Civil/Coastal Engineers for Sea Level Rise

University/ Academic Views

David R. Basco PhD, PE
Coastal Engineering Centre
Old Dominion University
February 14, 2014

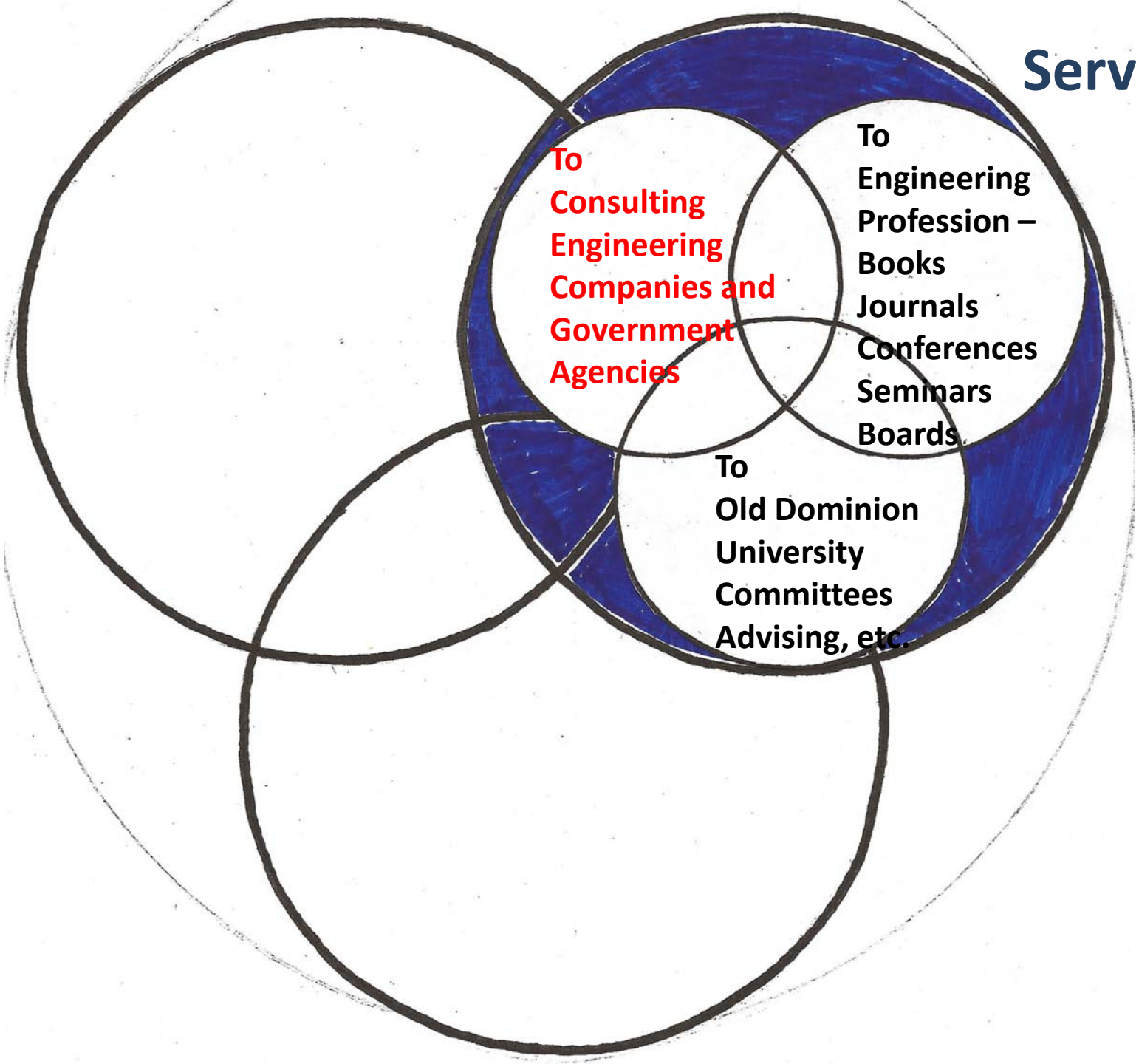
University/Academic Views

- The three traditional areas that university faculty contribute to society (**teaching, research, service**)

Presentation Outline

- **Service** -Mitigation Alternatives, Virginia Examples, What Can Virginia Do? , Federal Government (Corps)
- **Research** - Sea Level Rise For Design, Storm Strength Index (**COSI**) , MARI.
- **Teaching** – The Coastal Engineering Certificate Program **(CECP), Online** to Local, State, National, and the World on the Internet

Service


To
Consulting
Engineering
Companies and
Government
Agencies
To
Engineering
Profession –
Books
Journals
Conferences
Seminars
Boards
To
Old Dominion
University
Committees
Advising, etc.

Service to Consulting Companies, A/E Firms and Federal Government Agencies

- **Mitigation Alternatives**
- Examples in Tidewater Virginia
- What Can Virginia Do ?

  (Individuals, cities, state)
- What Can Federal Government Do?

Mitigation of Coastal Hazards (Flooding, Waves, Erosion)

Structural

- Seawalls, Floodwalls
- Dikes, Revetments
- Breakwaters, Groins,
- Movable Gate Structures
- Beach/Dune Nourishment
- Wetlands Restoration

Non- Structural

- Elevated Structures
- Raise Grade
- Zoning (setbacks, land use, purchase of lands).
- Retreat
- Combinations

Civil/Coastal Engineering **Definitions**

MITIGATION

- to **REDUCE** (**Mitigate**) the damage caused by coastal storms and increased SLR using **both** structural and non-structural alternatives

ADAPTATION

- to **CHANGE** (**Adapt**) our present alternative methods (structural, non-structural) and **decision making methods** as caused by the **predicted levels and uncertainty in SLR**

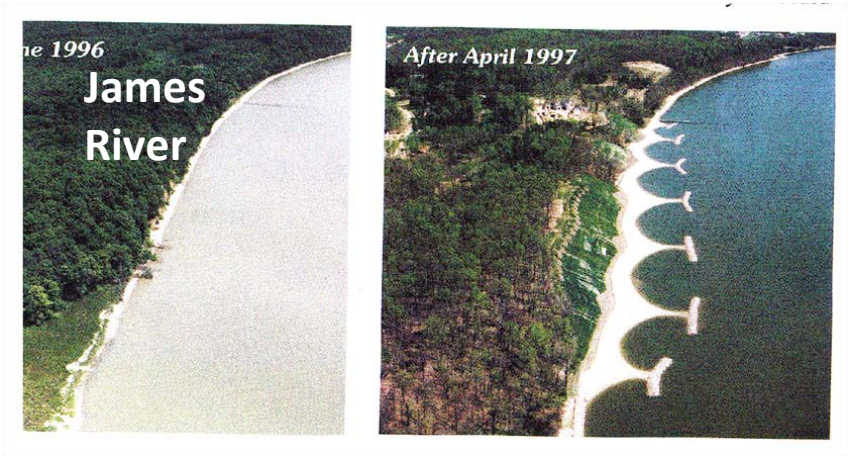
The non-structural alternative is NOT adaptation

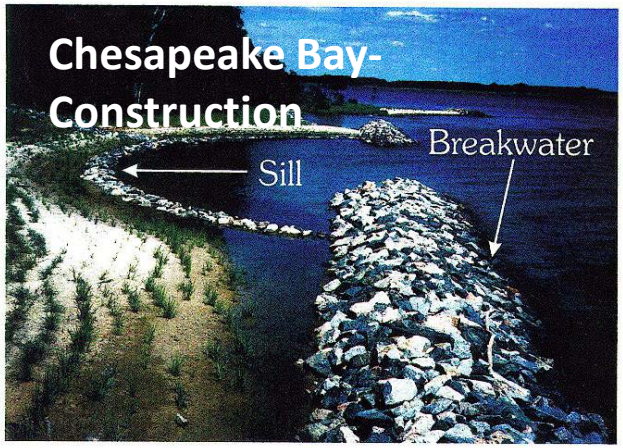
Service to Consulting Companies, A/E Firms and Federal Government Agencies

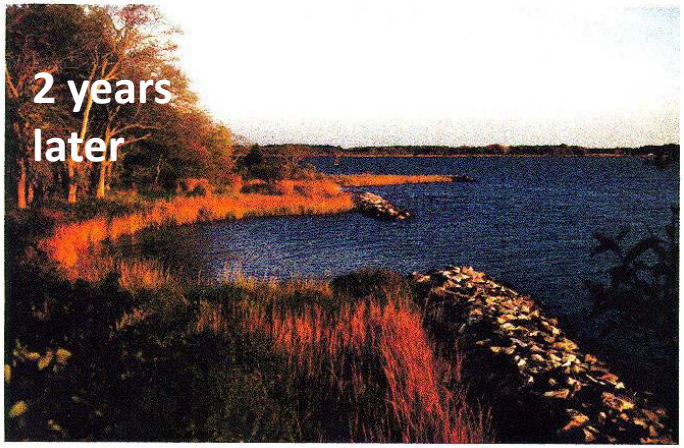
- Mitigation Alternatives
- **Examples in Tidewater Virginia**
- What Can Virginia Do Now ?

  (Individuals, cities, state)
- What Can Federal Government Do Now ?

Near shore Breakwaters and Living Shoreline Systems – **Chesapeake Bay**

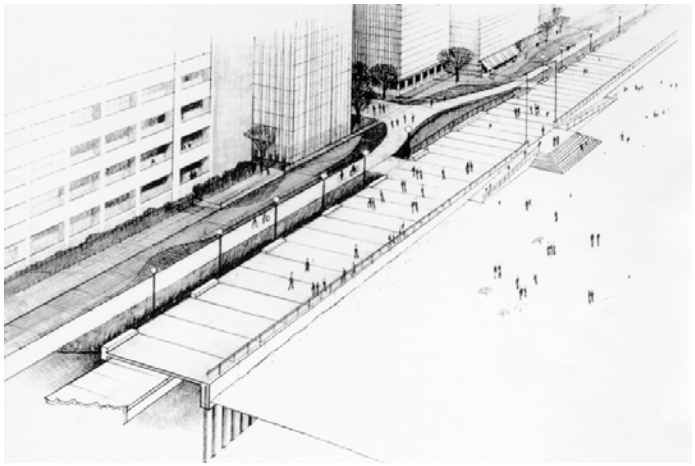


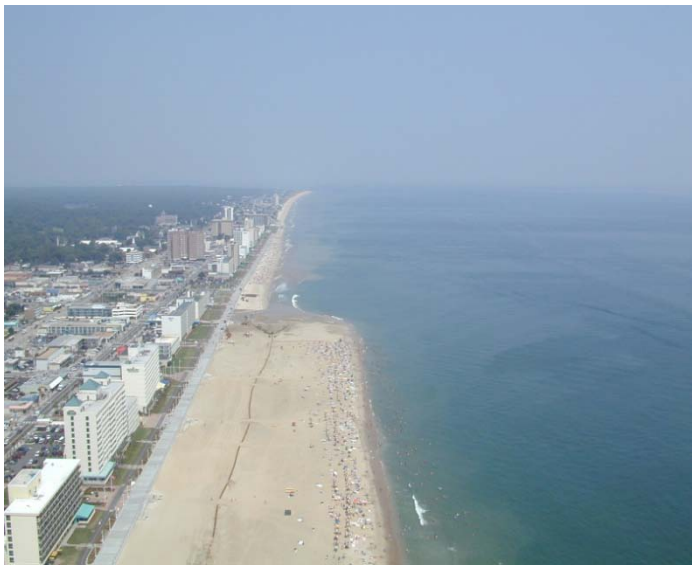




Virginia Beach Hurricane Damage Mitigation Project –Open Ocean

(Seawall and Beach Nourishment)





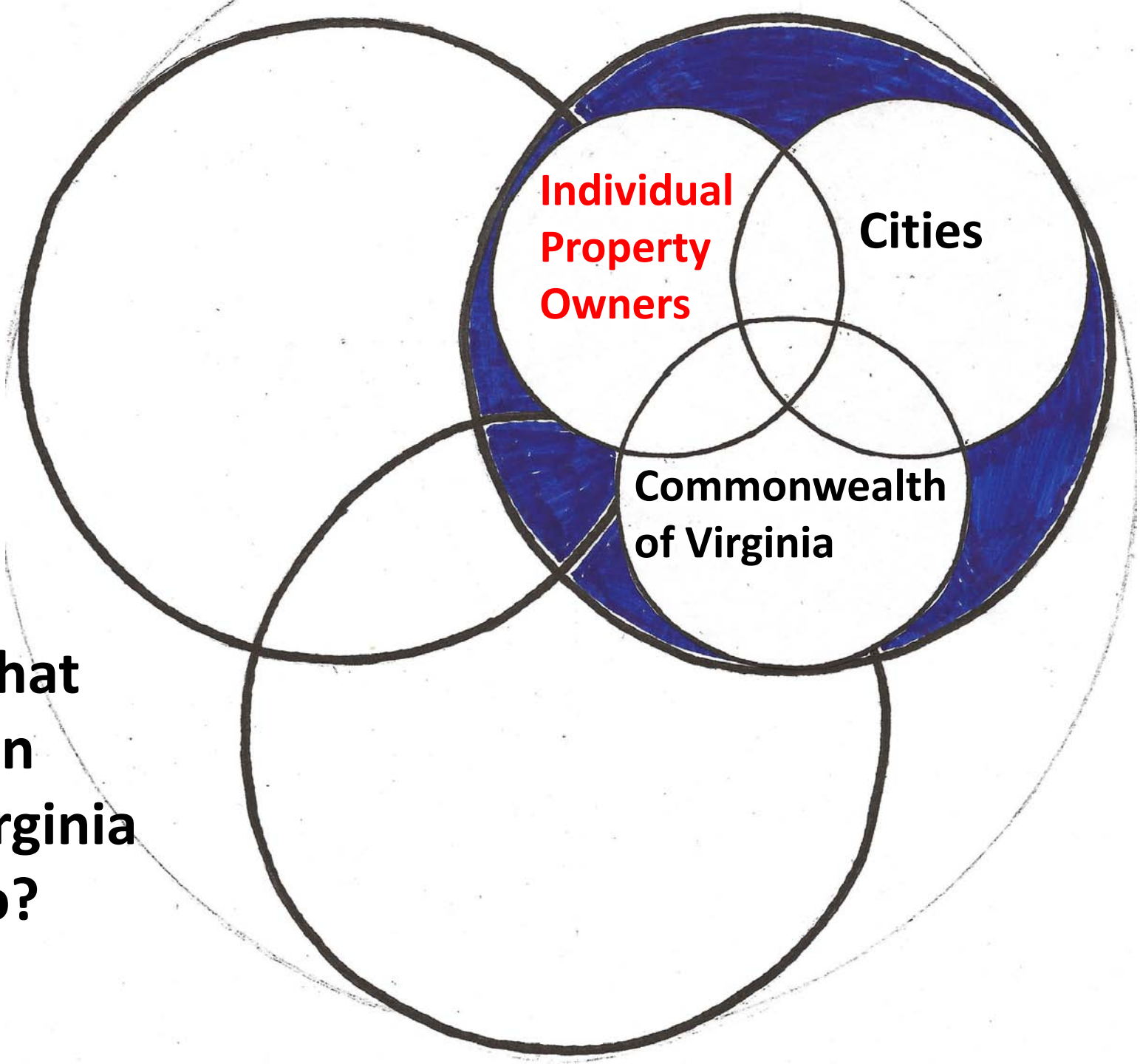
Future Adaptation ?

Chesapeake Bay

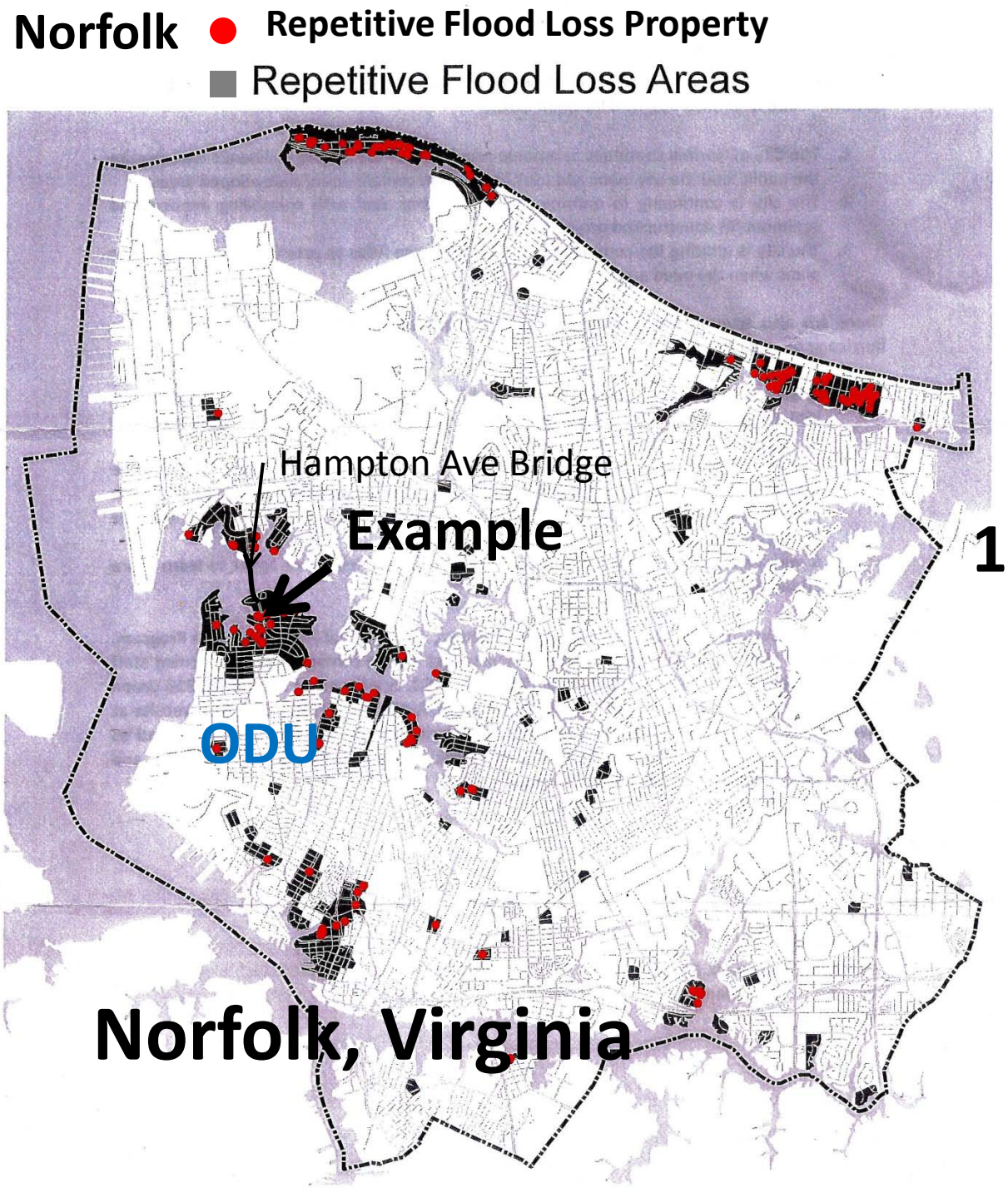
- Combine near shore breakwaters with wave energy conversion systems

Atlantic Ocean

- Permit near shore breakwaters on open Ocean front



What Can Virginia Do?

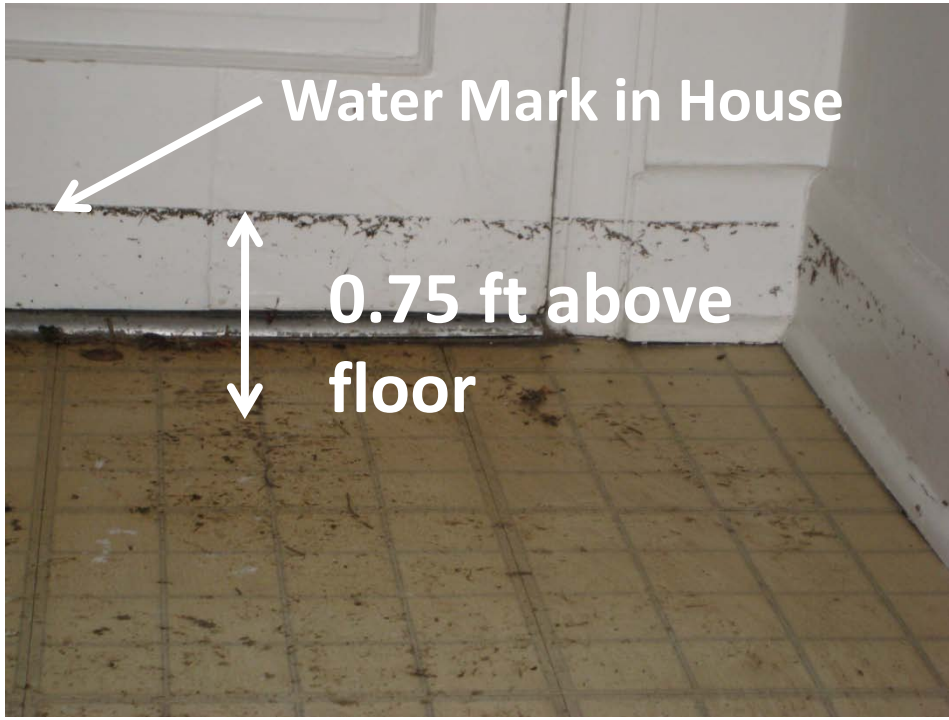


1153 Lexan Ave

Since 1998 NFIP has paid out $ 61,910.12 for damages from 5 flood events.

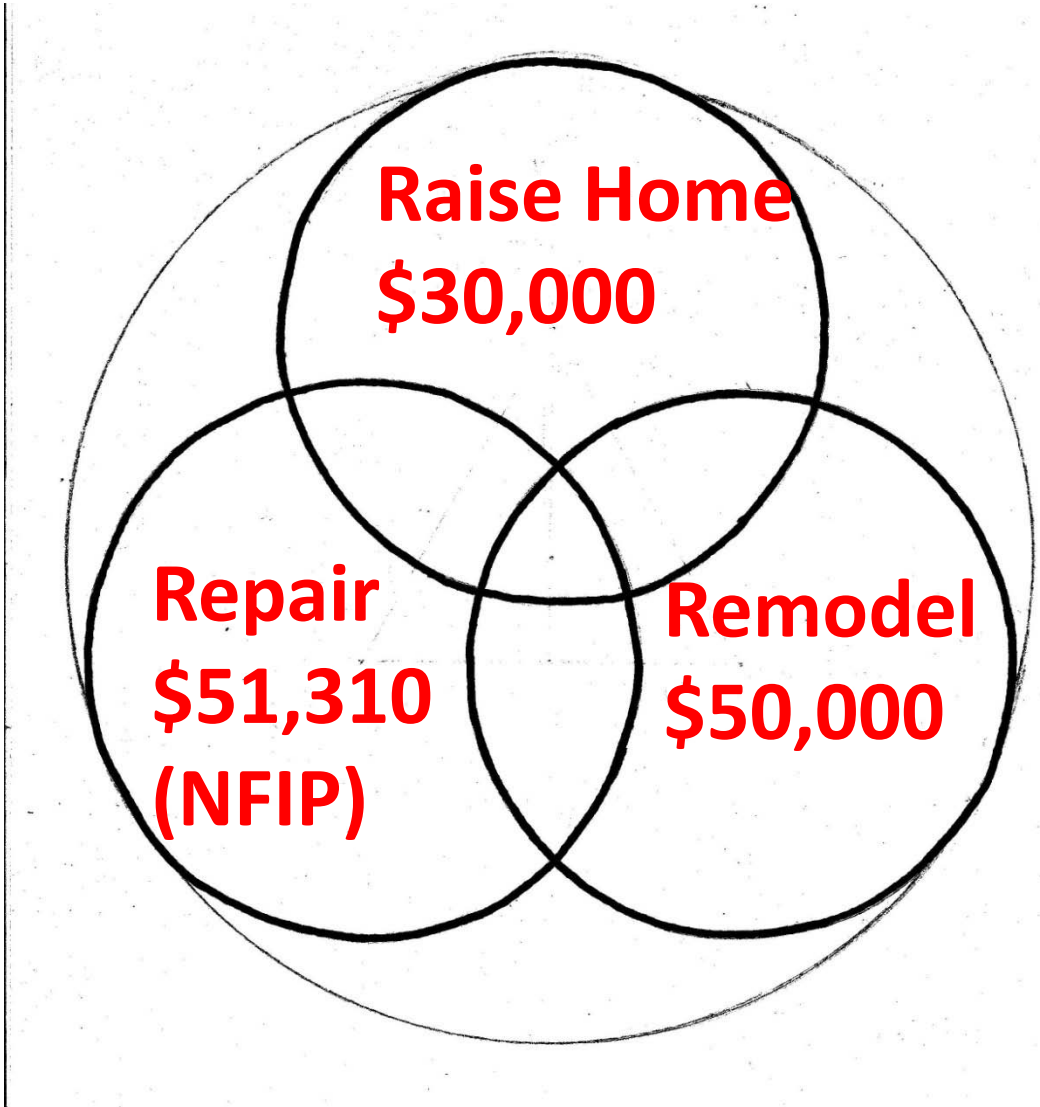
1153 Lexan Ave, Norfolk

(severe damage from NorIDA ,Nov 12, 2009)



NFIP payout our $51,309.34 in damages from NorIDA

1153 Lexan Ave, Homeowner Response to NorIDA Flood Damage-Refinance Mortgage

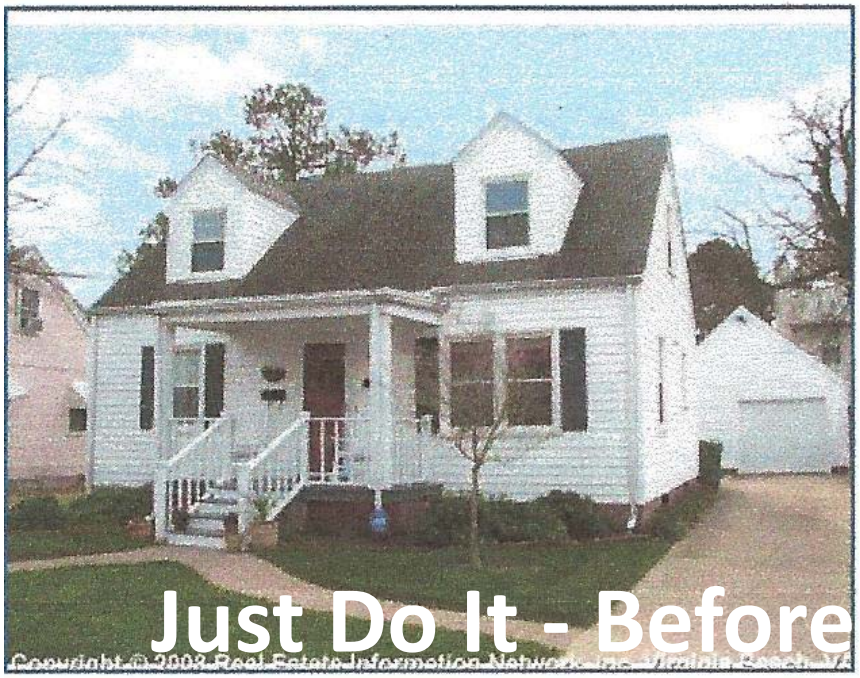



New Bottom Floor
3.67 ft
Old Bottom Floor
Architectural Building Contractors, LLC
Norfolk

1153 Lexan Ave, Norfolk

Before

Flood Insurance
$1374/yr



After

Flood Insurance
$349/yr

Just Do It - Before the Next Flood !

1153 Lexan Avenue, Norfolk

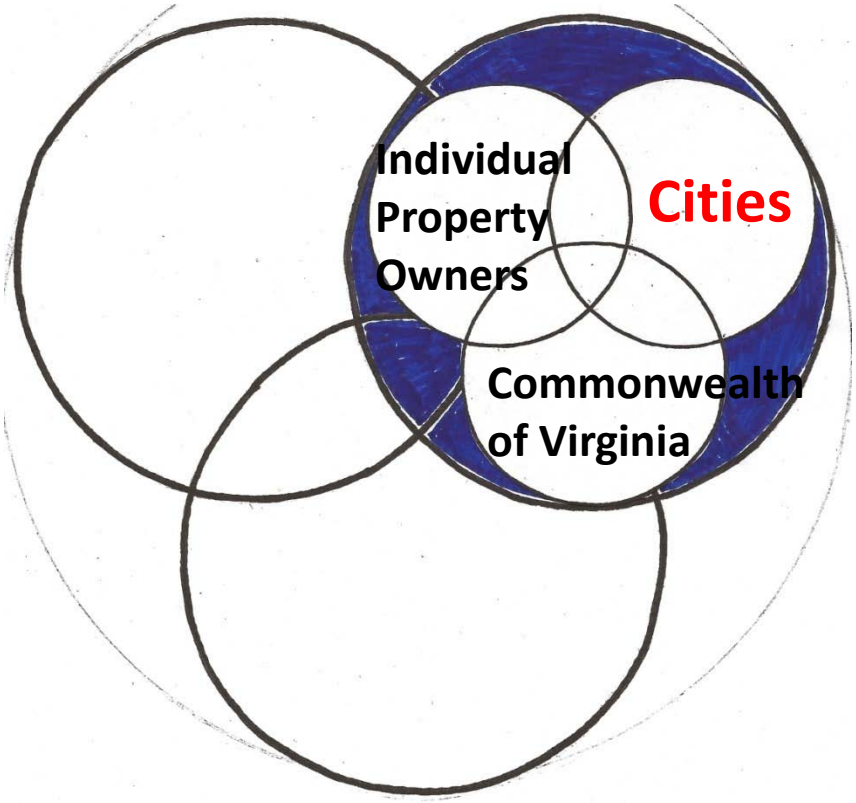
Mitigation

- Elevate structure
- What is the property value and value of piece of mind ?

Adaptation

- **As of Jan 1, 2014** all new construction +3 ft above 100 year flood elevation
- **Future** - Create special tax district (lower) if owner pays to elevate home.

Cities in Tidewater Virginia Need to Conduct Coastal Flooding Studies



Example- Fugro Atlantic for City of Norfolk

City of Norfolk
City-wide Coastal Flooding Study
Presentation to
Storm Water Working Group

February 29, 2012

Kevin Smith
Associate Engineering Geologist
Fugro Atlantic

Recommended Alternative –

Movable Storm Surge Barriers

Cities in Tidewater Virginia

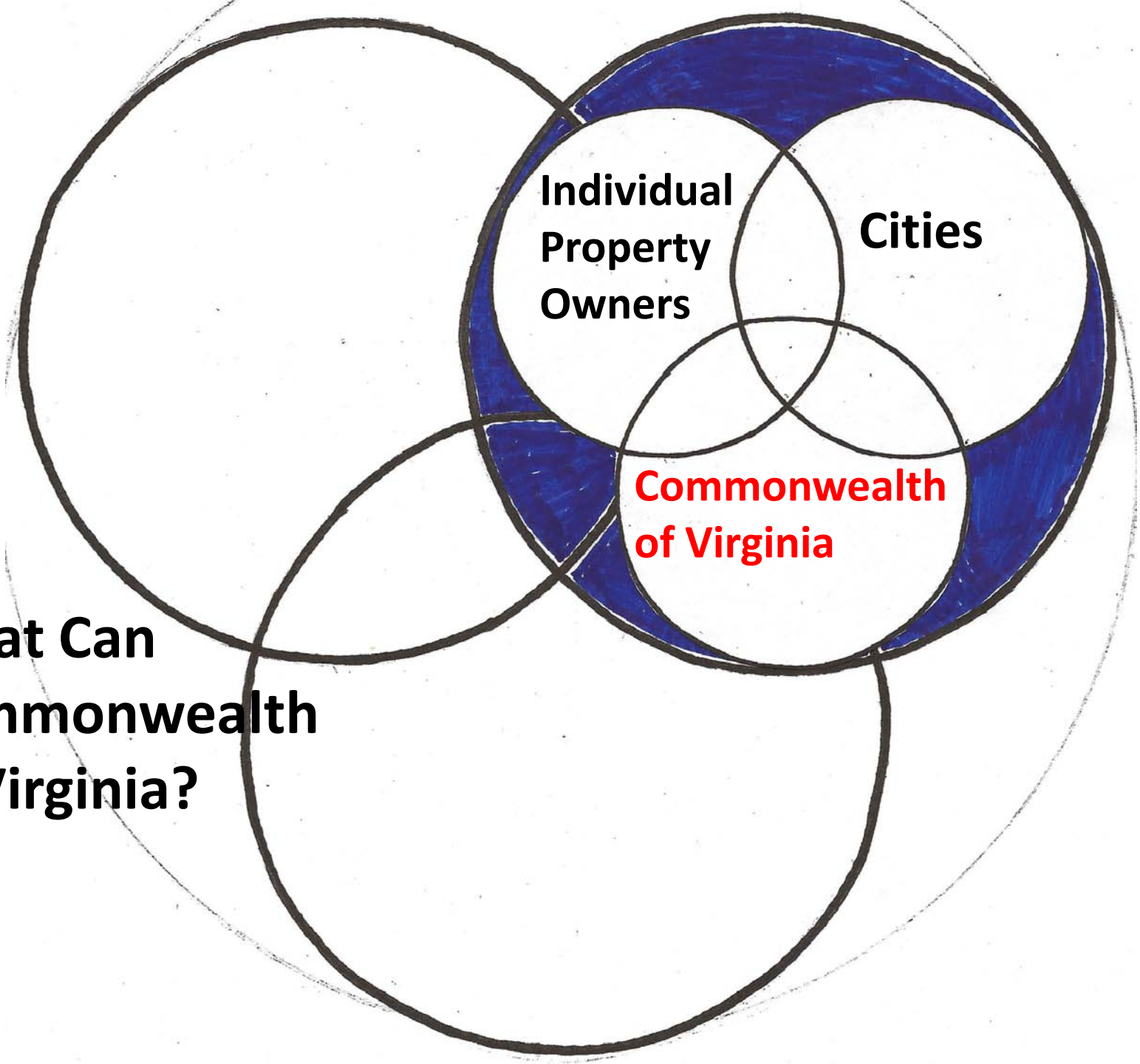
Mitigation

- Studies needed to **prioritize** flooding damage mitigation options for **3 areas**
  - property
  - infrastructure
  - transportation systems

Adaptation

- The **future** adaptation strategy may hinge on which flooding damage **area**
  - property
  - infrastructure
  - transportation systems

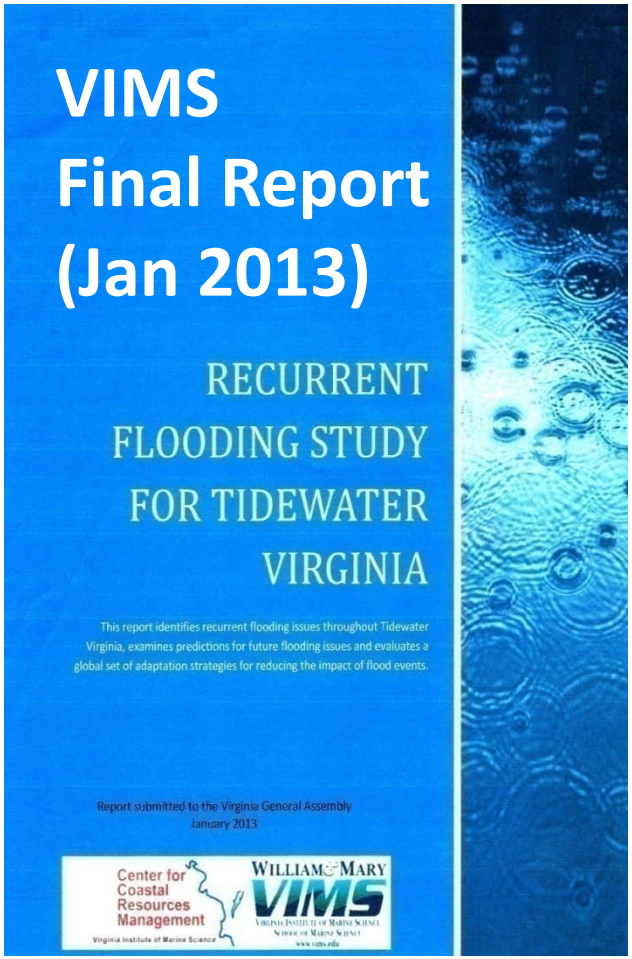
  is **highest priority**.



What Can Commonwealth of Virginia?

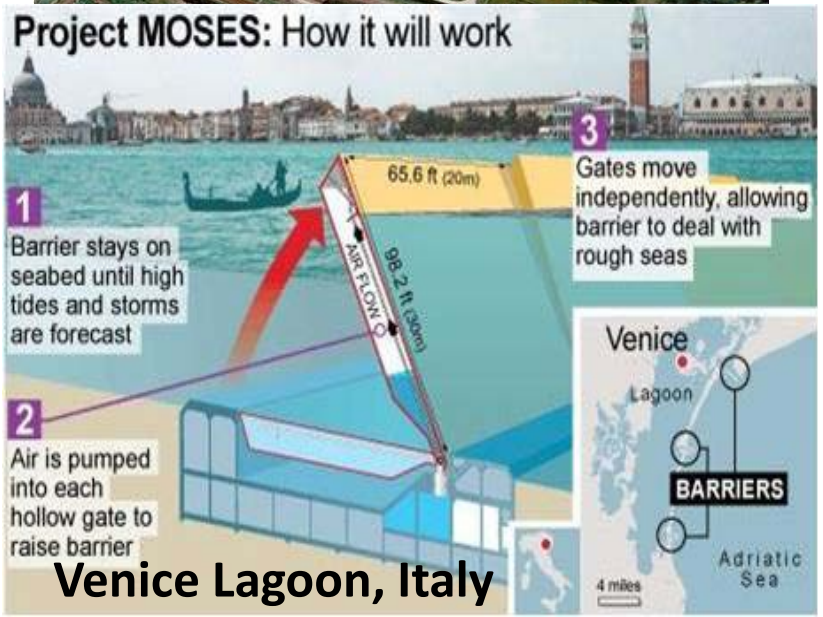
Virginia General Assembly

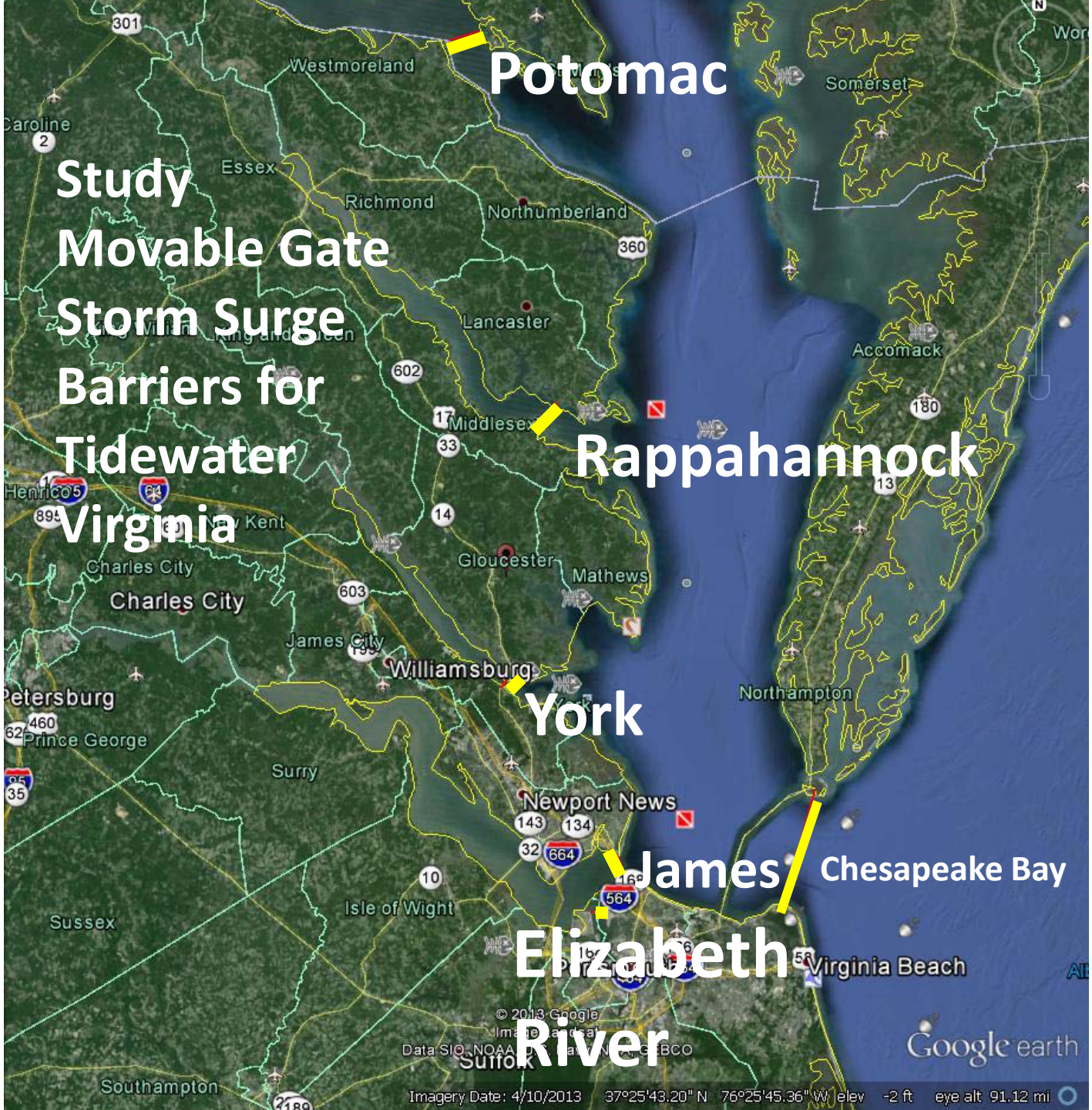
(SJ76ER,Feb24, 28, 2012)



- **Conclusion…**
- **"…tide gates and storm surge barriers are likely to be a more appropriate strategy than levees for most areas" p 49-50**

One Alternative –Movable Gate Storm Surge Barriers

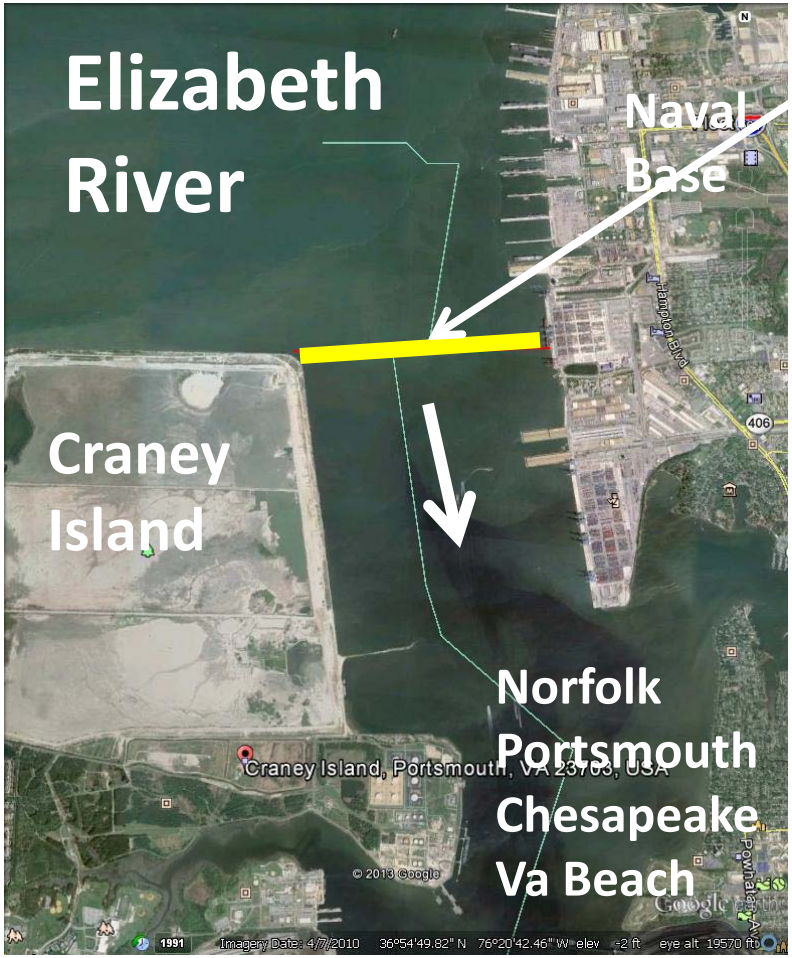



Potomac
Study
Movable Gate
Storm Surge
Barriers for
Tidewater
Virginia
Rappahannock
York
James
Chesapeake Bay
Elizabeth
River
Westmoreland
Somerset
Essex
Richmond
Northumberland
Lancaster
Accomack
Middlesex
Gloucester
Mathews
Charles City
James City
Williamsburg
Northampton
Prince George
Surry
Newport News
Isle of Wight
Sussex
Virginia Beach
Suffolk
Southampton
© 2013 Google
Google earth
Imagery Date: 4/10/2013 37°25'43.20" N 76°25'45.36" W elev -2 ft eye alt 91.12 mi

CEE 403 Senior Civil Engineering **Design** Project – Spring 2014

Design Constraints

1-Science
2-Technology
3-Economics
4-Environment
5-(Institutional, Political, Social)



- **What type of movable gate works best ?**
- **What is the estimated cost ?**

Senate Joint Resolution 3 – **Current Legislature Session (Jan 24, 2014)**

- **Establish a 15-member sub-committee of state legislators and citizens**
- **Committee to "recommend strategies to address challenges" of coastal flooding**
- **Nov 15, 2015 deadline ($20,000/year)**
- **Continuation of SJ76ER (Feb 2012)**

Commonwealth of Virginia

Mitigation

- Movable Gate Storm Surge Barriers

Future - Adaptation

- State **retain engineering consulting firm**
- State be "**Local Sponsor** " with Corps of Engineers for Feasibility Studies for Tidewater Virginia

Virginia Needs to Do More Than Study the Problem (Again) with Another Committee

Service to Consulting Companies, A/E Firms and Federal Government Agencies

- Mitigation Alternatives
- Examples in Tidewater Virginia
- What Can Virginia Do Now ?

  (Individuals, cities, state)
- **What Can Federal Government Do ?**

The **Retreat Alternative** and the US Army **Corps of Engineers-** Example Baytown, Texas

Coastal Engineering Manual (CEM) 2008, Vol V, Section 3, p 82-84
US Army, Corps of Engineers, Wash DC.

Corps of Engineers, Galveston District Feasibility Study (1975), Final Report (1979)

- Routine flooding from storms and subsidence
- Studied **both** structural (earth dike, floodwall) and non-structural (retreat) alternatives
- **Retreat** alternative **recommended** (1975) and Congress **authorized** project (WRDA, 1978)
- Non-structural alternative- **retreat (B/C = 1.3)**
- Structural alternatives (B/C = 0.1-0.3)
- **Corps projects require local funding**

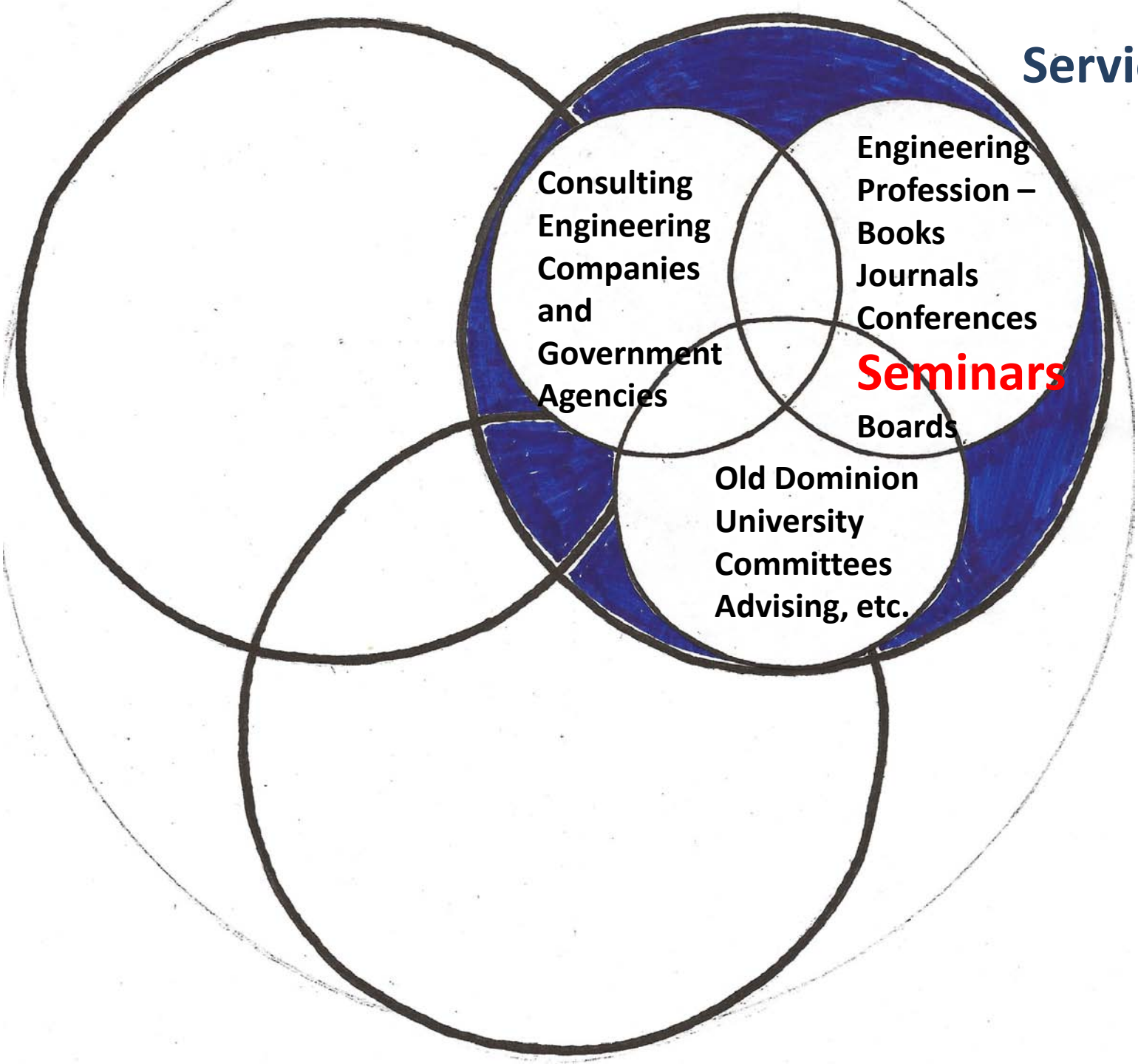
1979 Bond Election for Local Funding (20% in 1979)

- Community divided
- People not living in flood plain asked to help buy out those who did.
- **Bond election,** July 1979 **FAILED** by 60/40 % margin (Pendergrass and Pendergrass, 1990)
- **Congress in 1980 cannot authorize funding**
- Corps placed project in inactive category
- Local citizens decide to stay.

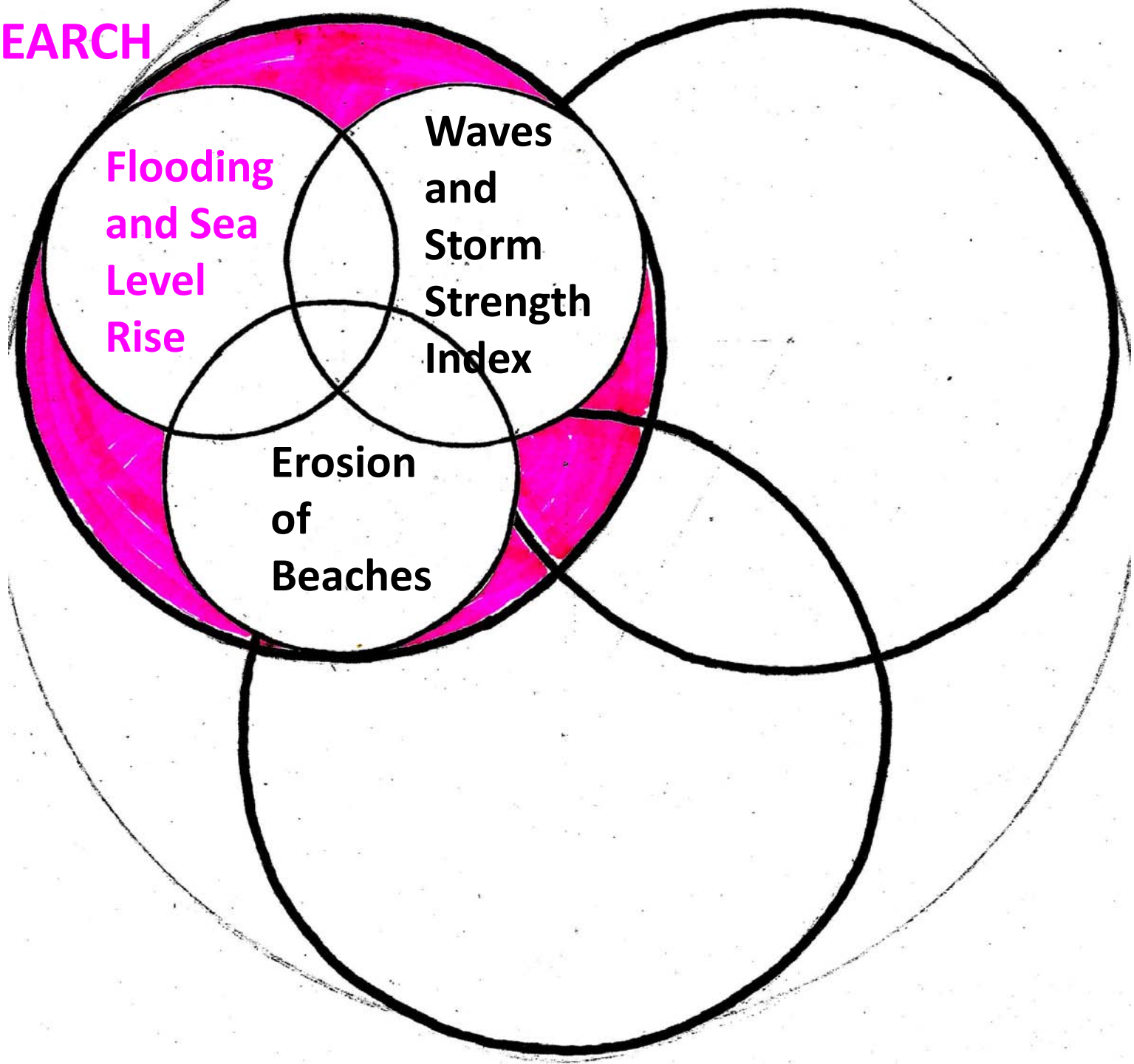
Future -Adaptation Strategy

- Congress **eliminates the cost sharing** part of WRDA projects (20% in 1979, 35% today) when the resulting B/C ratio is large enough (**B/C » 1**) **to cover** the standard **cost share amount** required of local governments.
- **If active in 1980**, the Federal Government would have **saved $$ millions** in flooding related problems in Baytown, Texas over the past 33 yrs.
- How much more saved in future SLR scenarios ?

Service


Consulting Engineering Companies and Government Agencies
Engineering Profession – Books Journals Conferences
Seminars
Boards
Old Dominion University Committees Advising, etc.

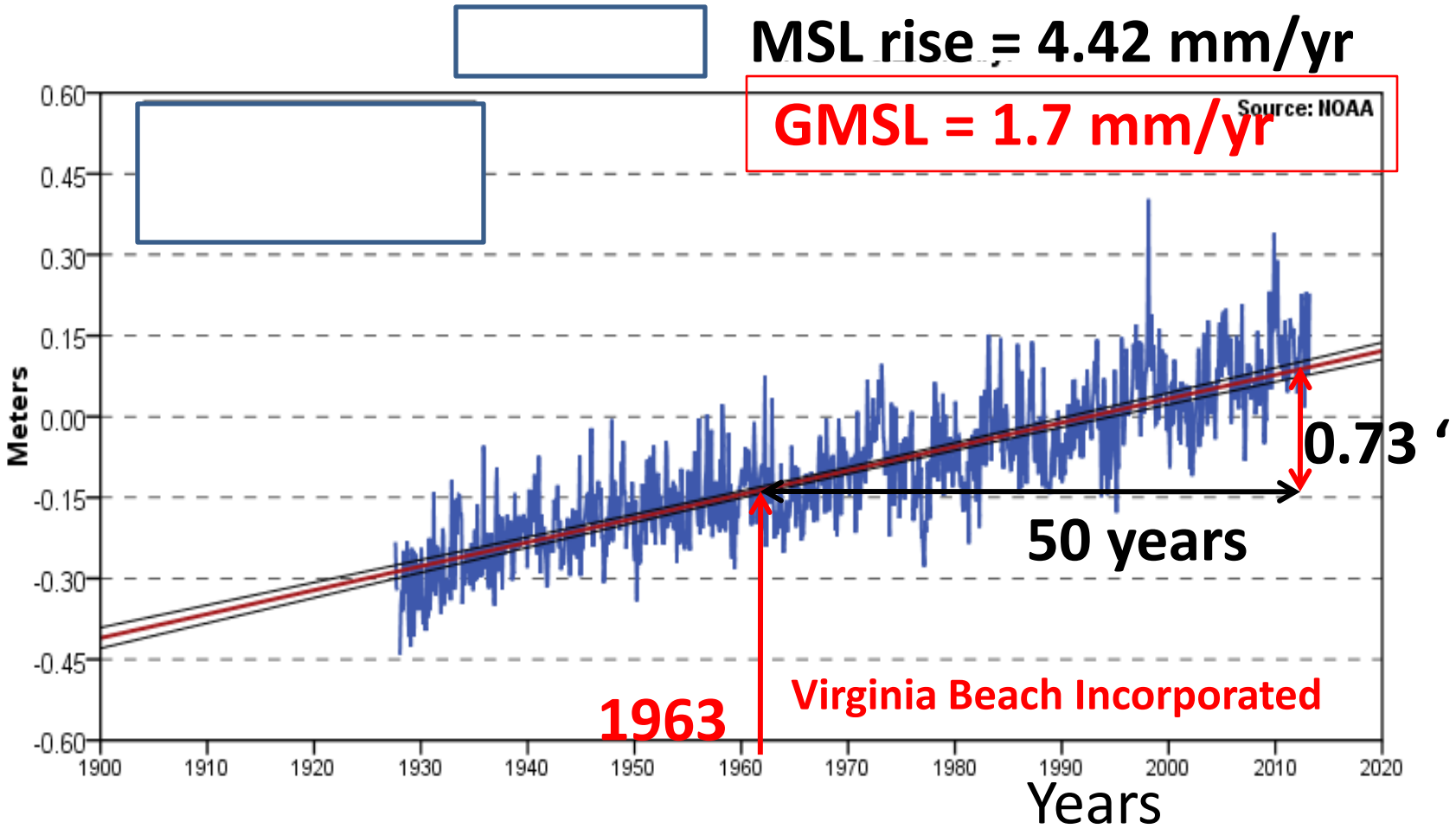
RESEARCH

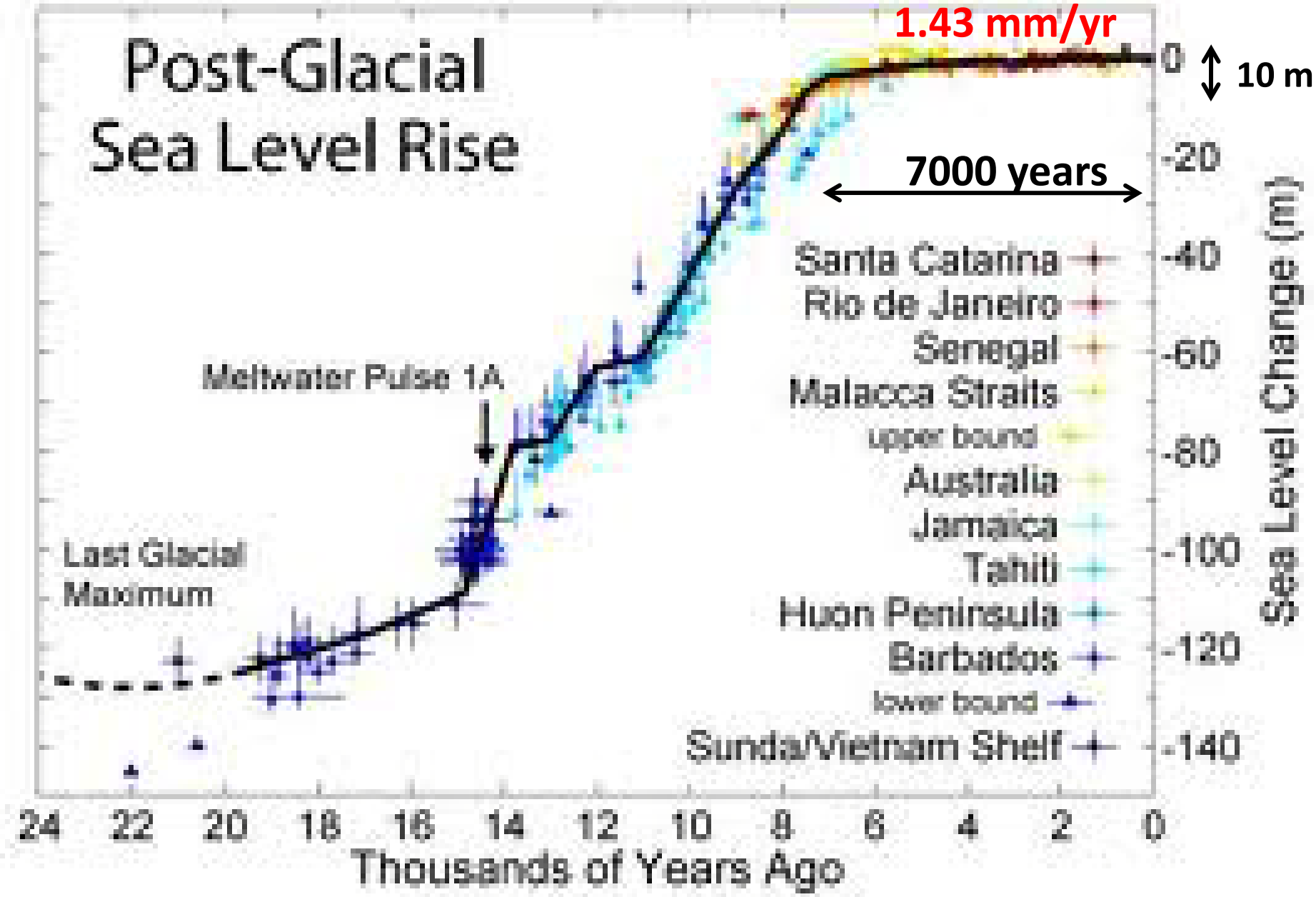

Flooding and Sea Level Rise
Waves and Storm Strength Index
Erosion of Beaches

Research

Sea Level Rise For **Design**

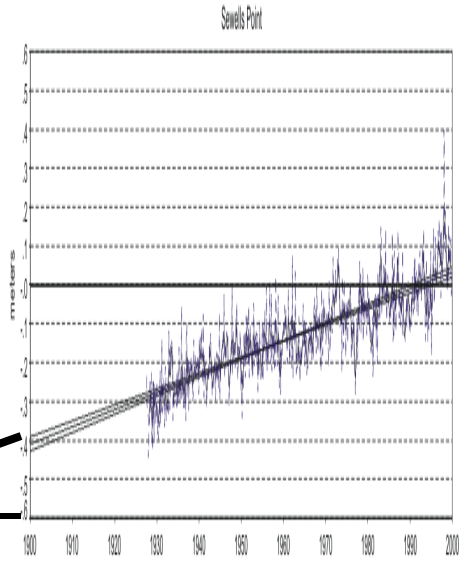
Sewells Point Tide Gage, Norfolk, 1927-2012 (85yrs)





(from Global Warming Art, 2014)

Sewells Point Tide Gauge, Norfolk VA



2007

1600

1700

1800

1900

2000

Year

Sea Level Rise 5.83 ft

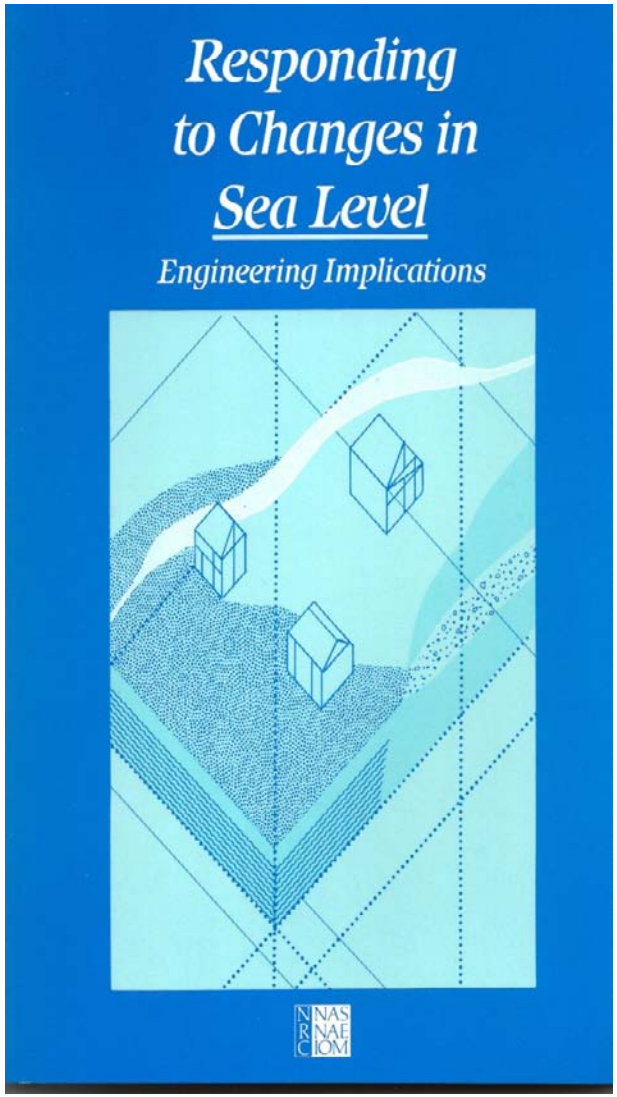
in 400 years

1607

1927- 2013 (85 years) = 1.457 feet/100 years

National Research Council(1987)

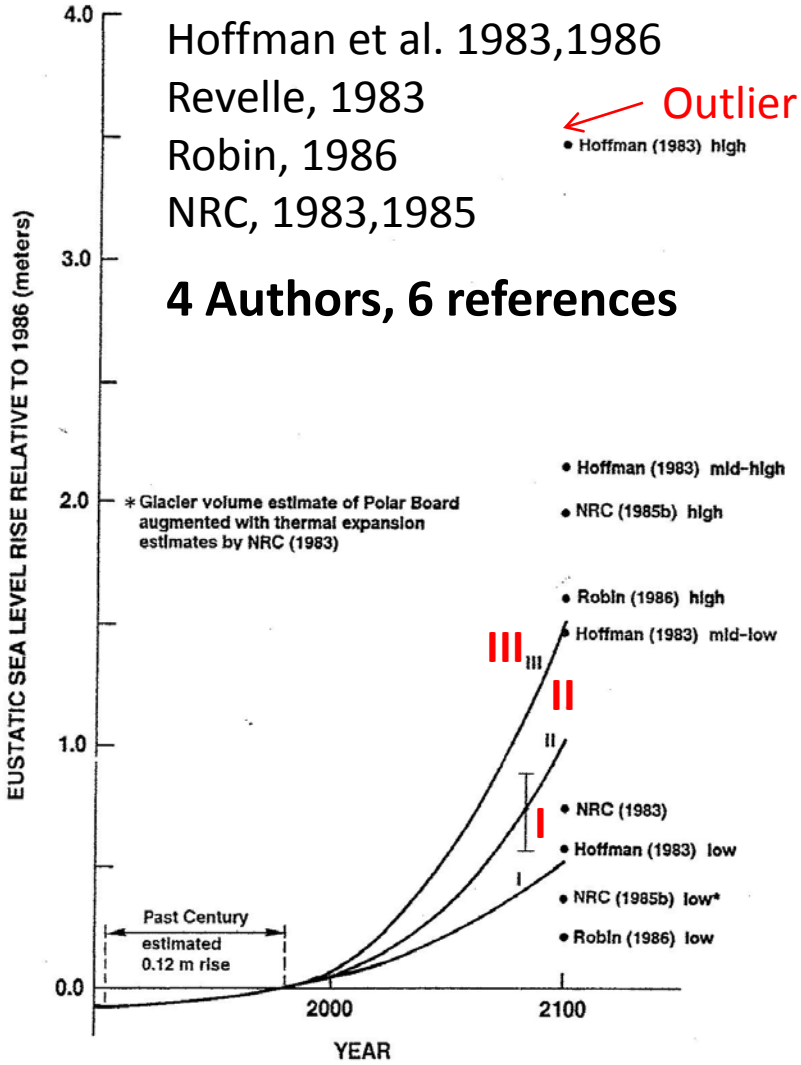
Estimates of Future Sea Level Rise in 2100



Hoffman et al. 1983,1986
Revelle, 1983
Robin, 1986
NRC, 1983,1985

4 Authors, 6 references

Outlier



NRC (1987) Committee Report

- 9 US faculty, 4 gov't agencies, met 3 times (2yrs)
- Chpt 2, Future GMSL changes to 2100 (7 pages)
- Because of uncertainty, postulated 3 scenarios for year 2100.

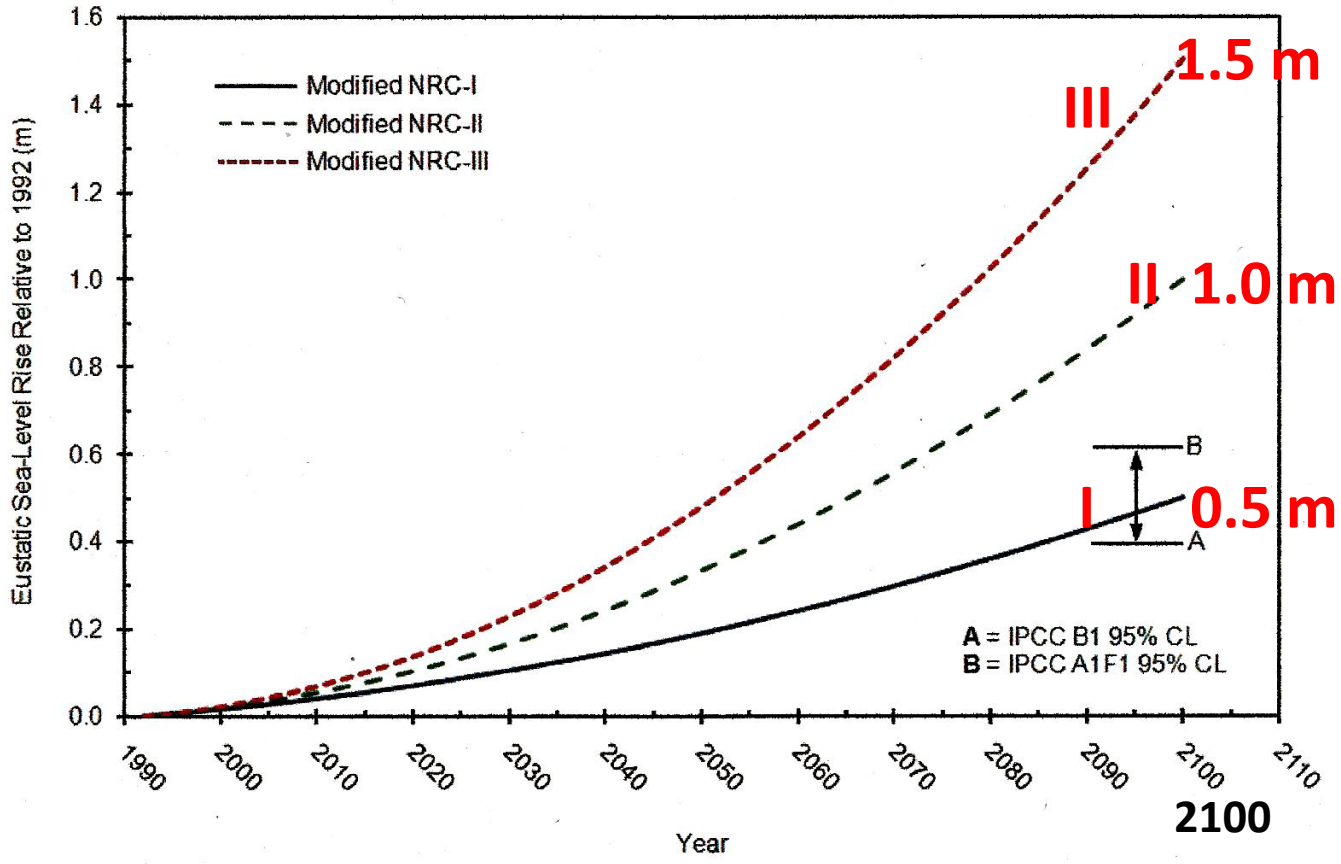
  scenario **I** GMSL rise 0.5 meters

  scenario **II** GMSL rise 1.0 meters

  scenario **III** GMSL rise 1.5 meters
- Corps of Engineers adopts NRC (1987) report

Sea-Level Change Considerations for Civil Works Programs (2011)

Corps of Engineers



EC 1165-2-212 (Oct 2011) Expired Sep 30, 2013

Estimating Future Change in Local MSL Corps of Engineers (2011)

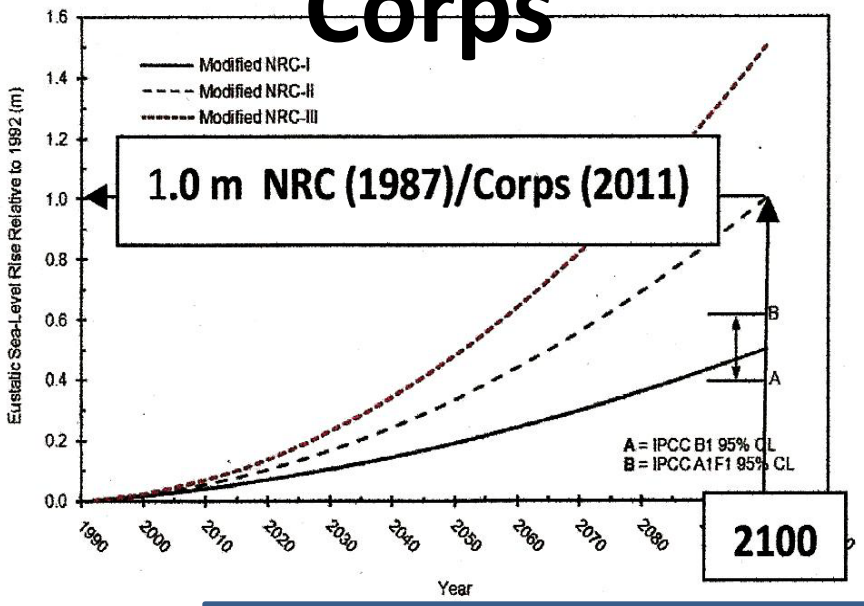
- Uses GMSL rise rate of **1.7mm/yr**
- Uses the **local MSL rate** to estimate the **local subsidence** (or uplift) rate
- **Provides a website** with online Sea Level Rise calculator for any tide gage location

Intergovernmental Panel on Climate Change (IPCC) http://www.ipcc.ch

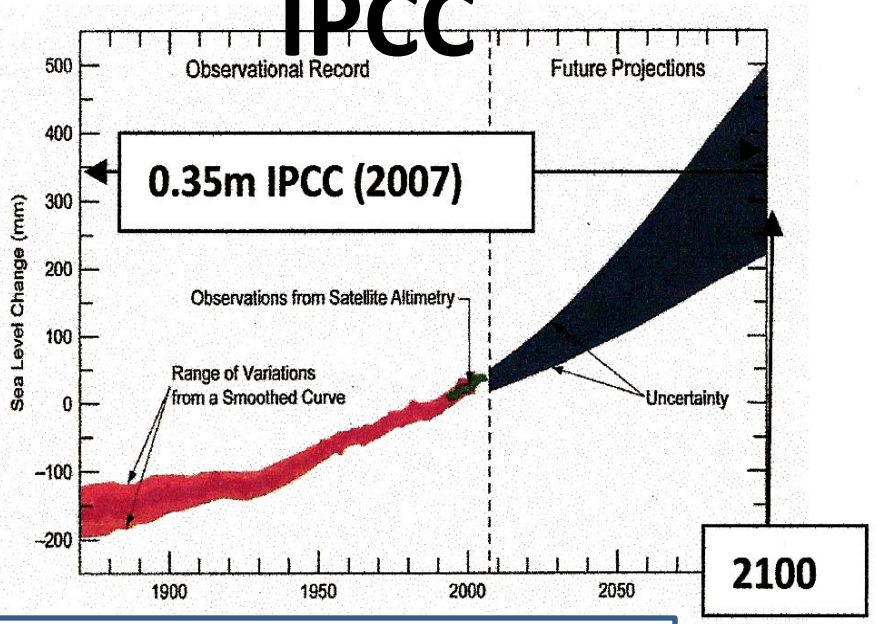
- Established **1988 2500** scientists worldwide
- CC Assessments (1990,1995,2001,2007,2013)
- IPCC 2007 ,GMSL = 1.7±0.5 mm/year (20^{th} C)
- IPCC 2007 did not include polar icecap melting
- Intermediate level **0.19-0.58m in 2100**
- **What does IPCC 2013 say ?**

SLR Seminar Announcement

Corps



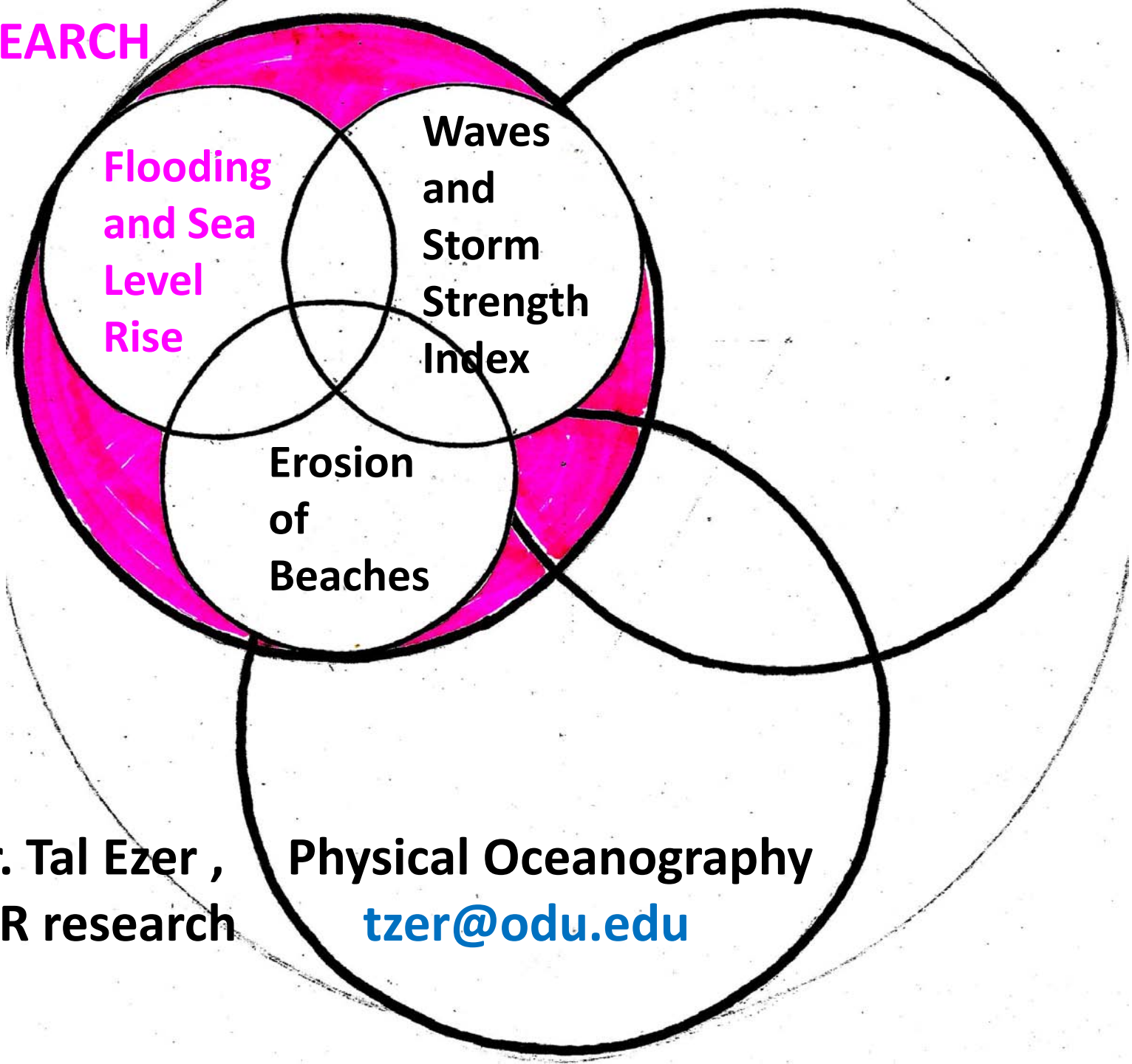
IPCC



What to use for Coastal Engineering Design ? Corps (1.0 m) or IPCC (0.35 m)

Stay tuned for the rest of the SLR Seminar Series.

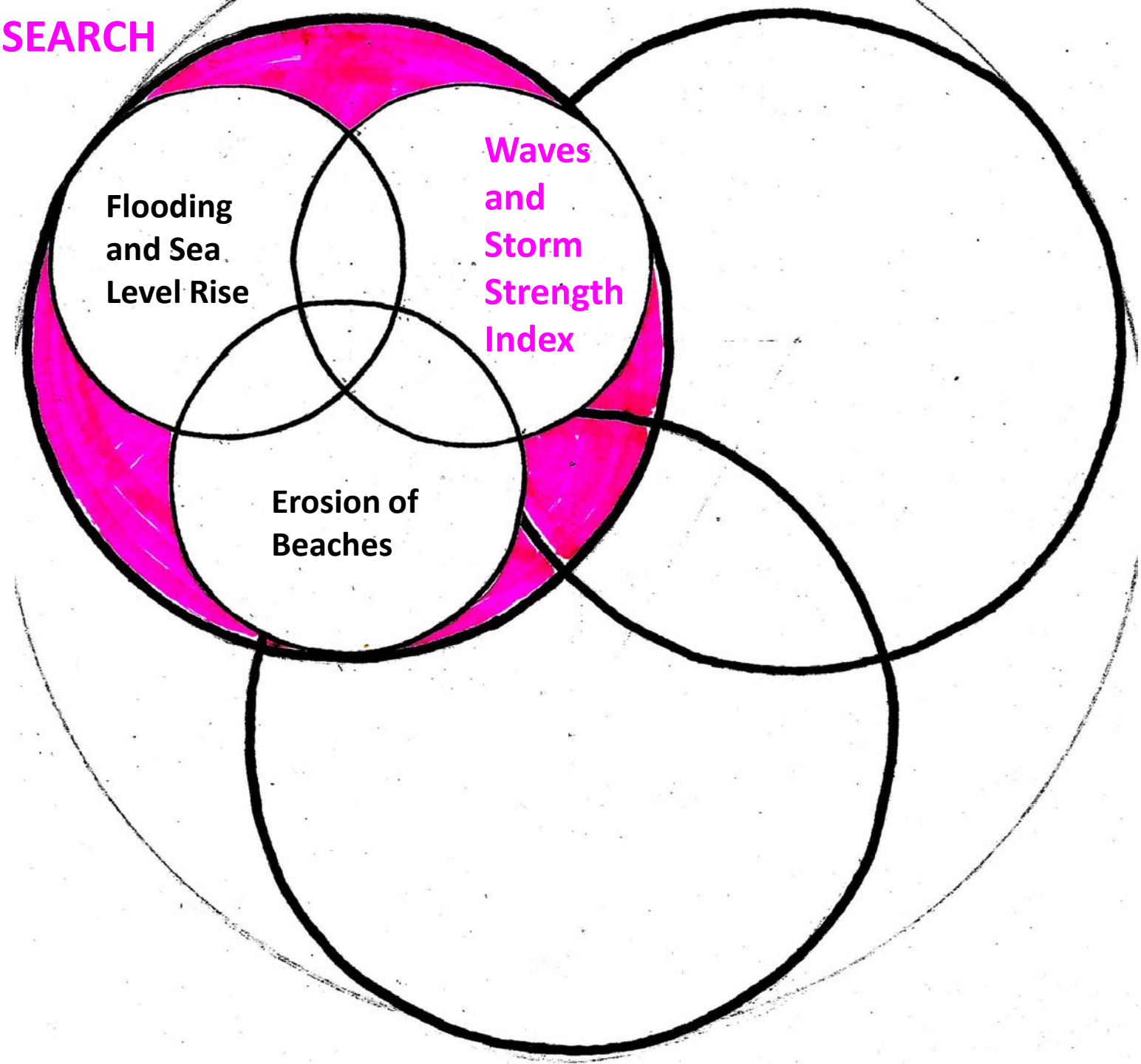
RESEARCH



Dr. Tal Ezer ,
SLR research

Physical Oceanography
tzer@odu.edu

RESEARCH

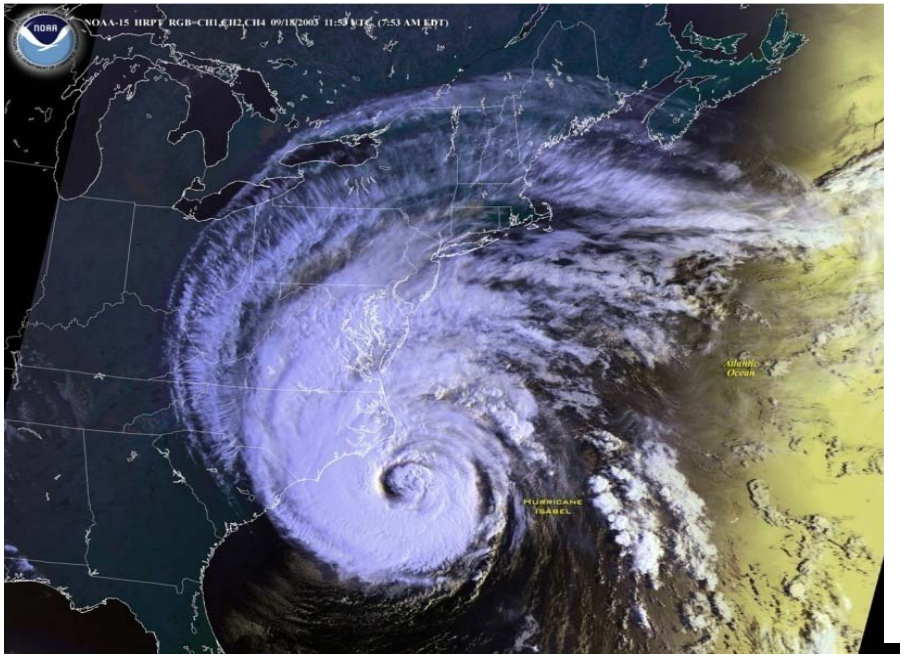

Flooding and Sea Level Rise
Waves and Storm Strength Index
Erosion of Beaches

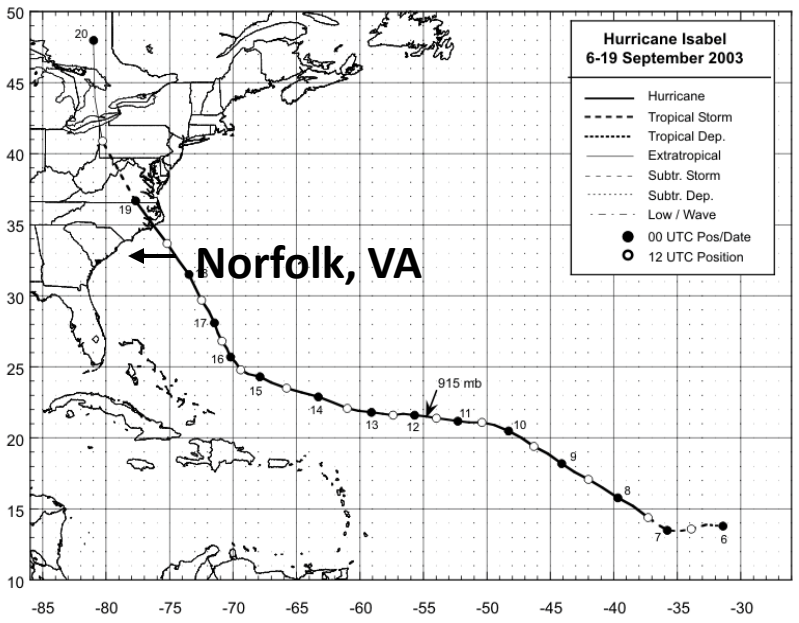
Research

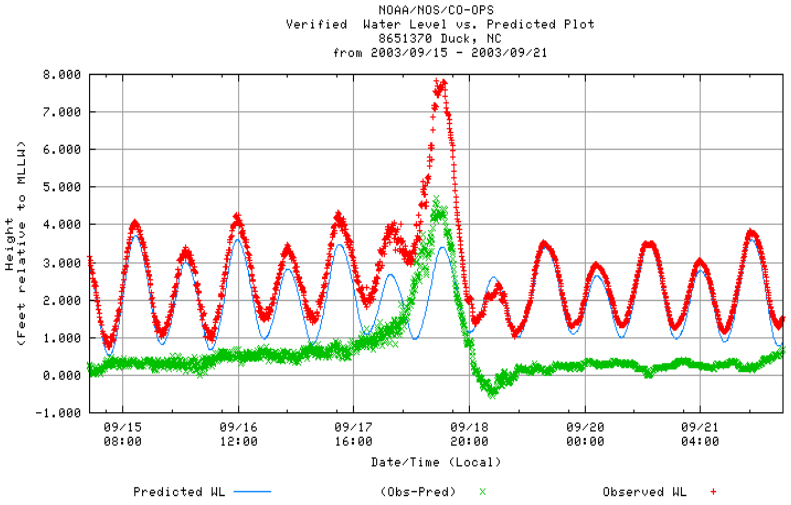
Need Coastal Storm Severity Index

- The Saffir-Simpson (S-S) hurricane scale only considers **hurricane wind speed**
- Coastal storms produce **elevated water levels** and **high waves** over the **duration** of the storm.
- Forecasters, emergency managers and the public need a "**Storm Severity Index**" to supplement the wind-based, S-S scale

An Example- Hurricane Isabel Sep 18, 2003







Category I on S-S Scale

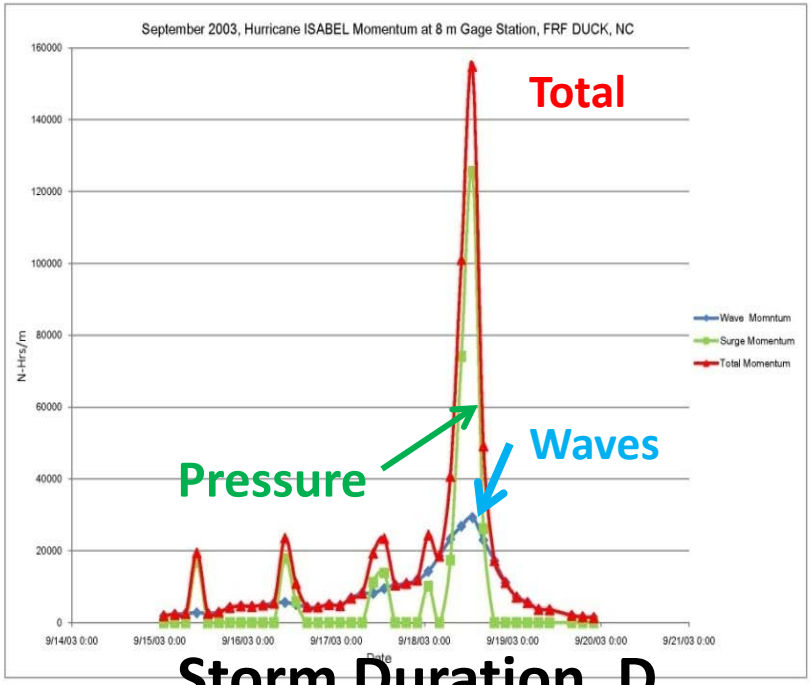
Produced 2nd highest water level recorded at Sewells Point

The COastal Storm Impulse (COSI) Parameter

- Based on Newton's 2nd Law (F = ma) expressed as " **storm impulse = change of momentum**"
- The elevated water level plus mean wave thrust integrated over the storm duration is the **storm Impulse**.
- The coastal land mass impacted by the storm causes the **change in storm momentum**

Total Storm Momentum

Hurricane ISABEL
September 2003



Storm Duration, D

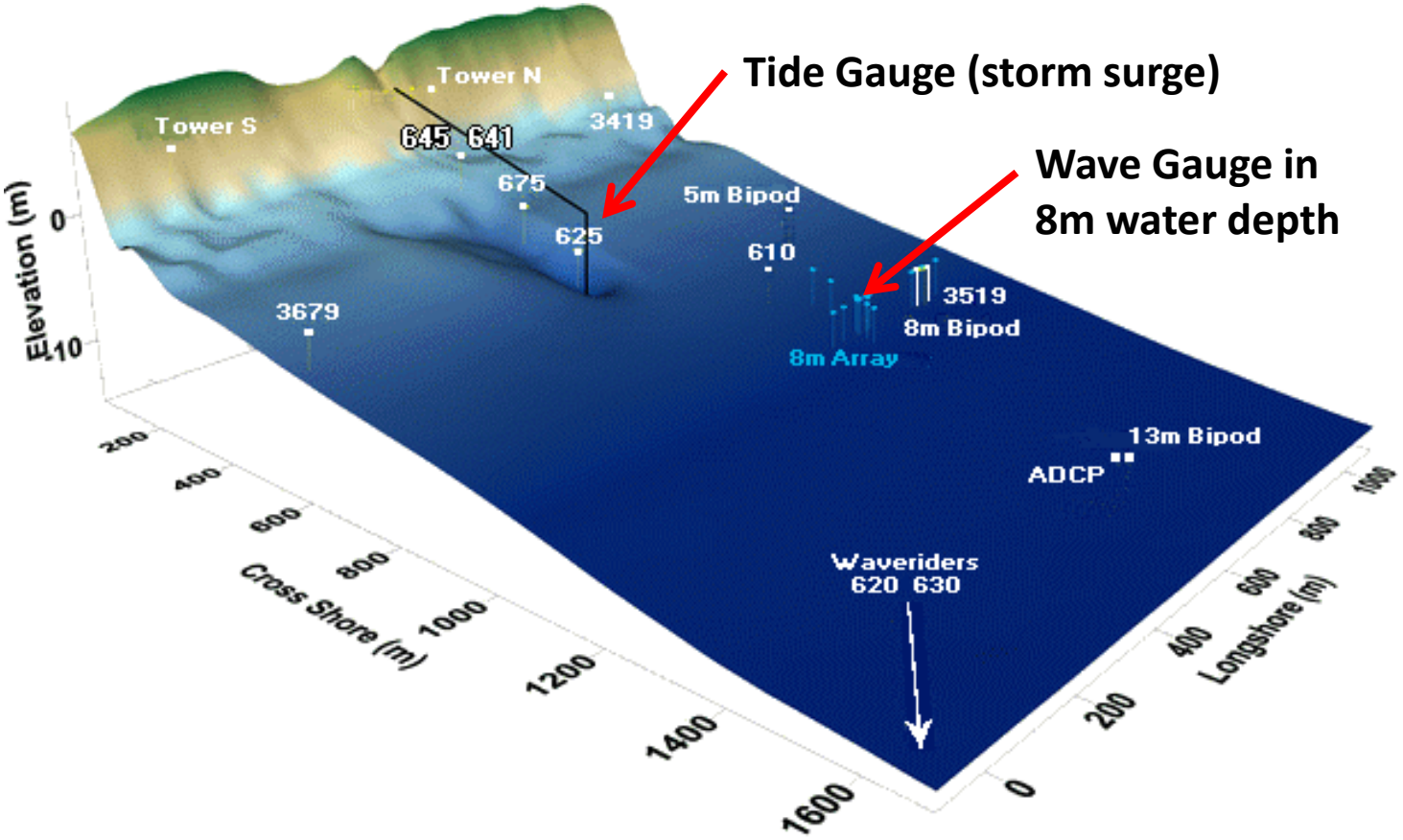
Total storm momentum, I (red)

- $I = \int (fw(t) + fp(t))dt$
- **fw (t)= wave momentum (blue)**
- **fp (t) = pressure momentum (green)**
- **I = 1900 kN-hr/m (area beneath red)**

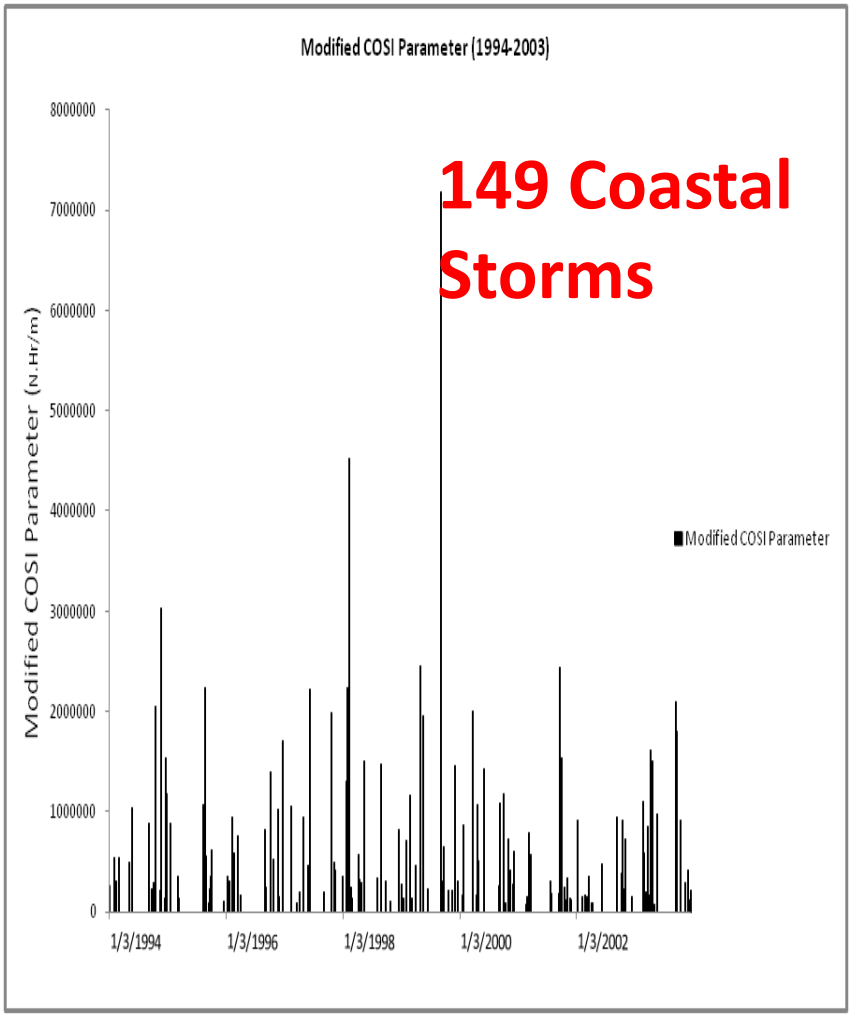
Location of Data for Analysis

US Army, Corps of Engineers, Field Research Facility (FRF) at Duck, NC

Data set for year 1994-2003



Chronological Display
The COSI Parameter for the years 1994 to 2003



Wave momentum 60% of total momentum

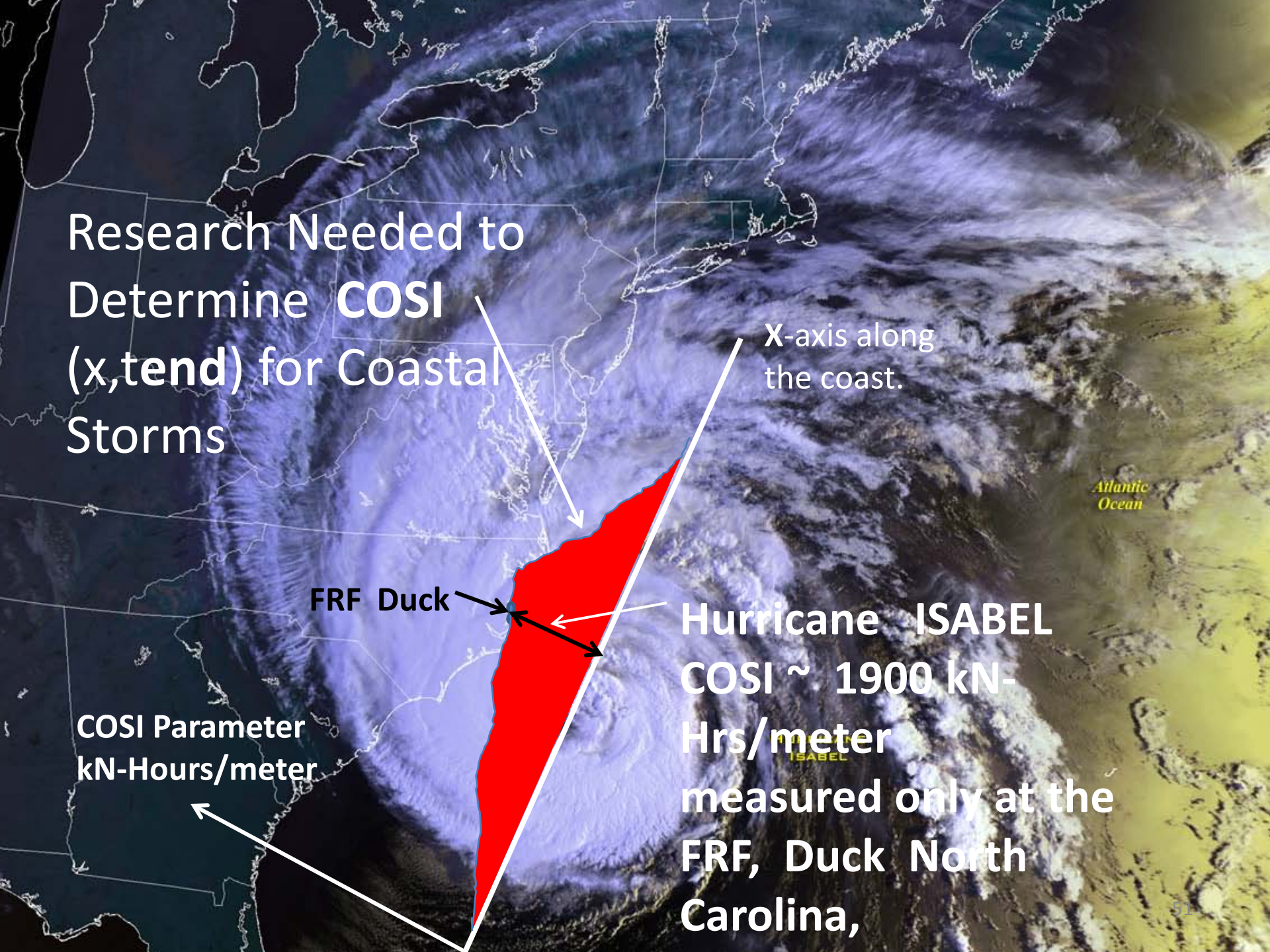
What happened from

1984 – 1993 ?

1994- 2003 (149storms)

2004 - 2013 ?

What will be the future trend with Climate Change/ SLR/ Storms ?


Research Needed to Determine **COSI** (x,t**end**) for Coastal Storms
X-axis along the coast.
Atlantic Ocean
FRF Duck
COSI Parameter kN-Hours/meter
Hurricane ISABEL COSI ~ 1900 kN-Hrs/meter measured only at the FRF, Duck North Carolina,

References

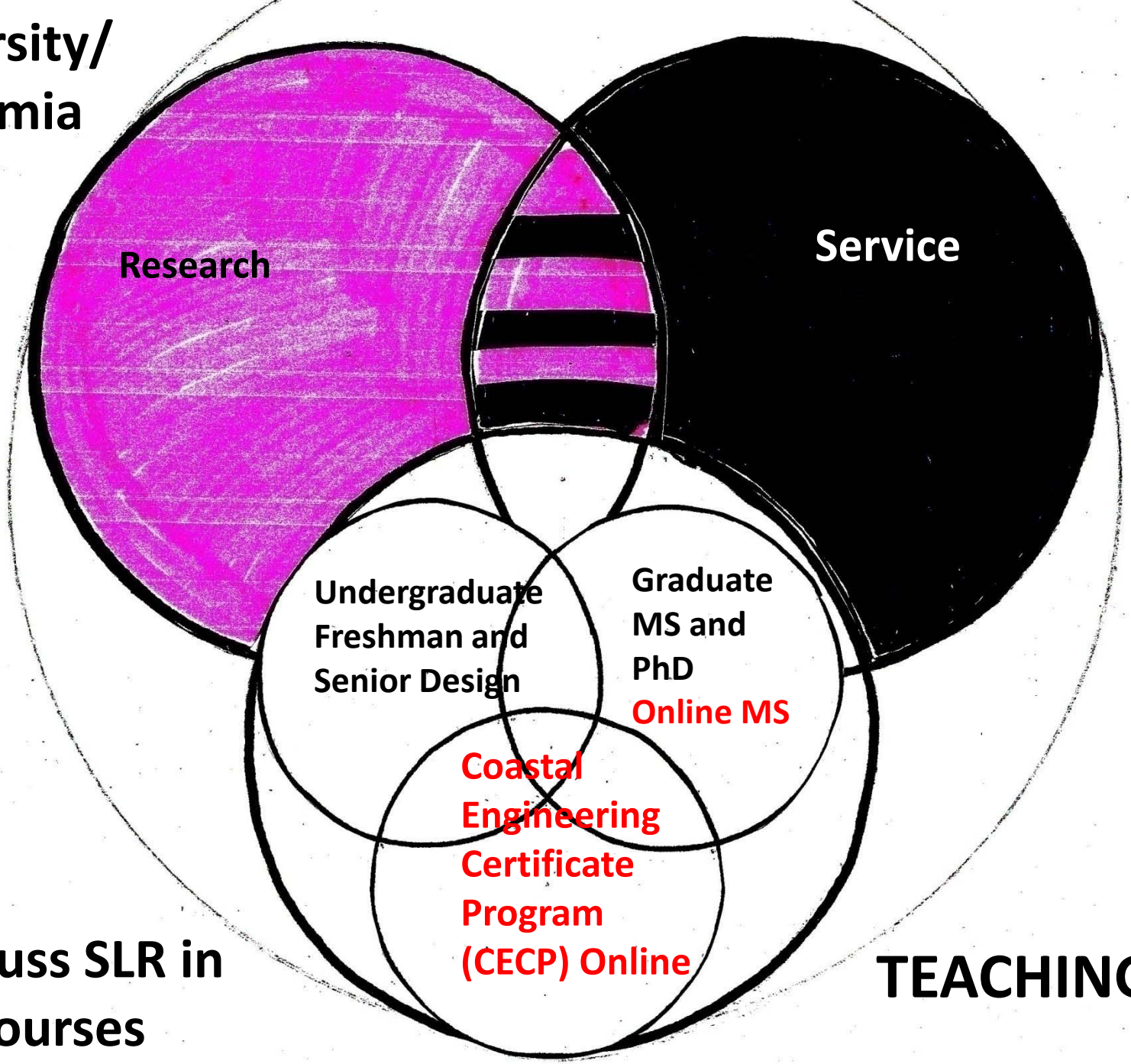
- **Mahmoudpour, N** (2012) “The Modified Coastal Storm Impulse Parameter”, unpublished, ***PhD Dissertation*****,** Civil Engineering Department, Old Dominion University, Norfolk, VA , May.
- **Basco, D.R. and N. Mahmoudpour** (2014) “On the Hydrodynamic Strength of a Coastal Storm”, ***Coastal Engineering***, (in review) Elsevier, Holland.
- **The National Academies**, Ocean Studies Board, “Storm Severity Index”, COSI presentation , ***Board Meeting***, Mar 22, 2013, Wash DC.

Proposal for MARI presented to Board of Visitors (Feb 11, 2014). Awaits approval of ODU Budget

Other Topics

- Prioritizing Flooding Mitigation Projects
- The B/C Ratio and net (B-C) amount.
- Quantifying Risk
- Quantifying Resilience
- Mitigation Economics
- **The Media - When things go RIGHT ?**

University/
Academia

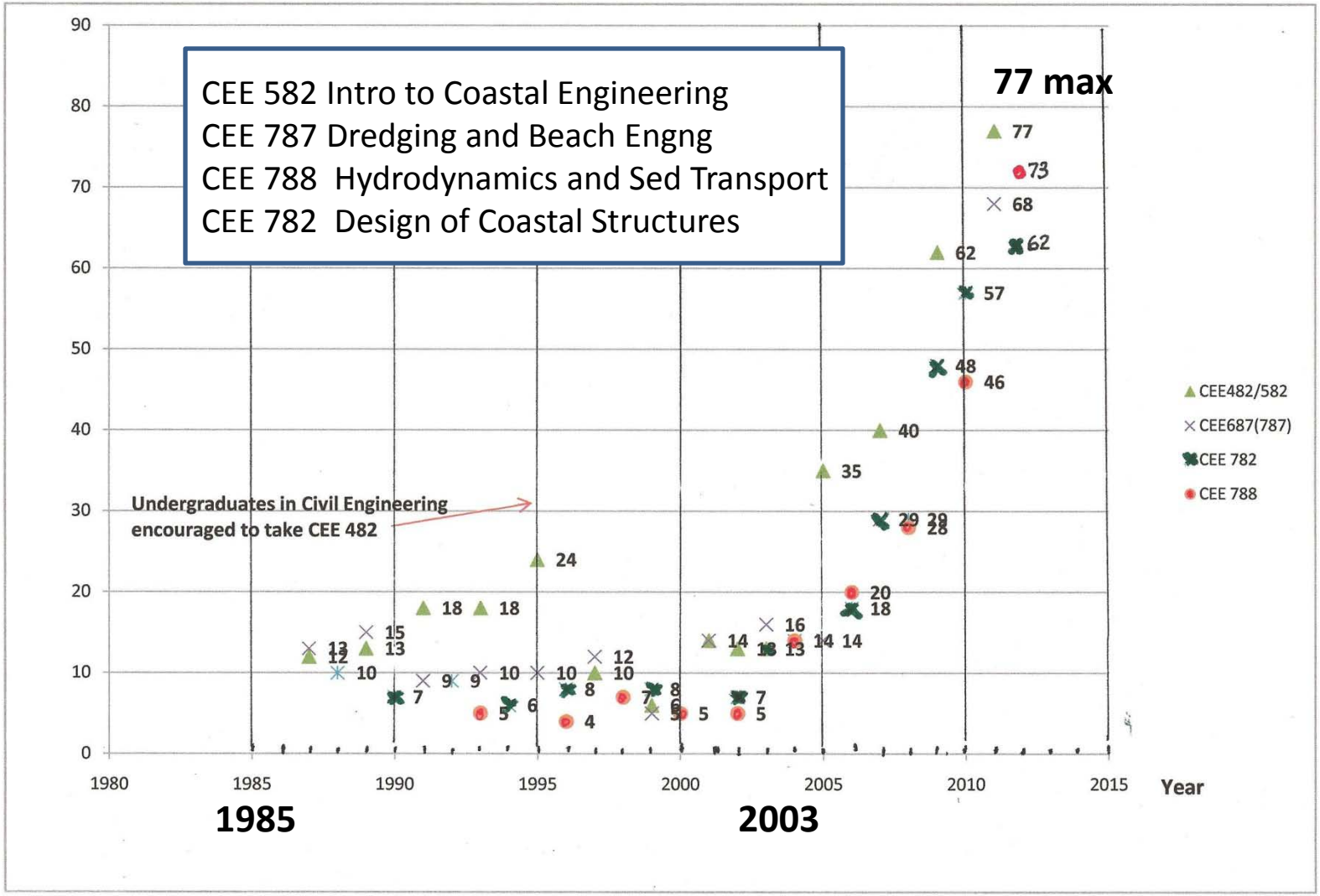


Discuss SLR in
all courses

TEACHING

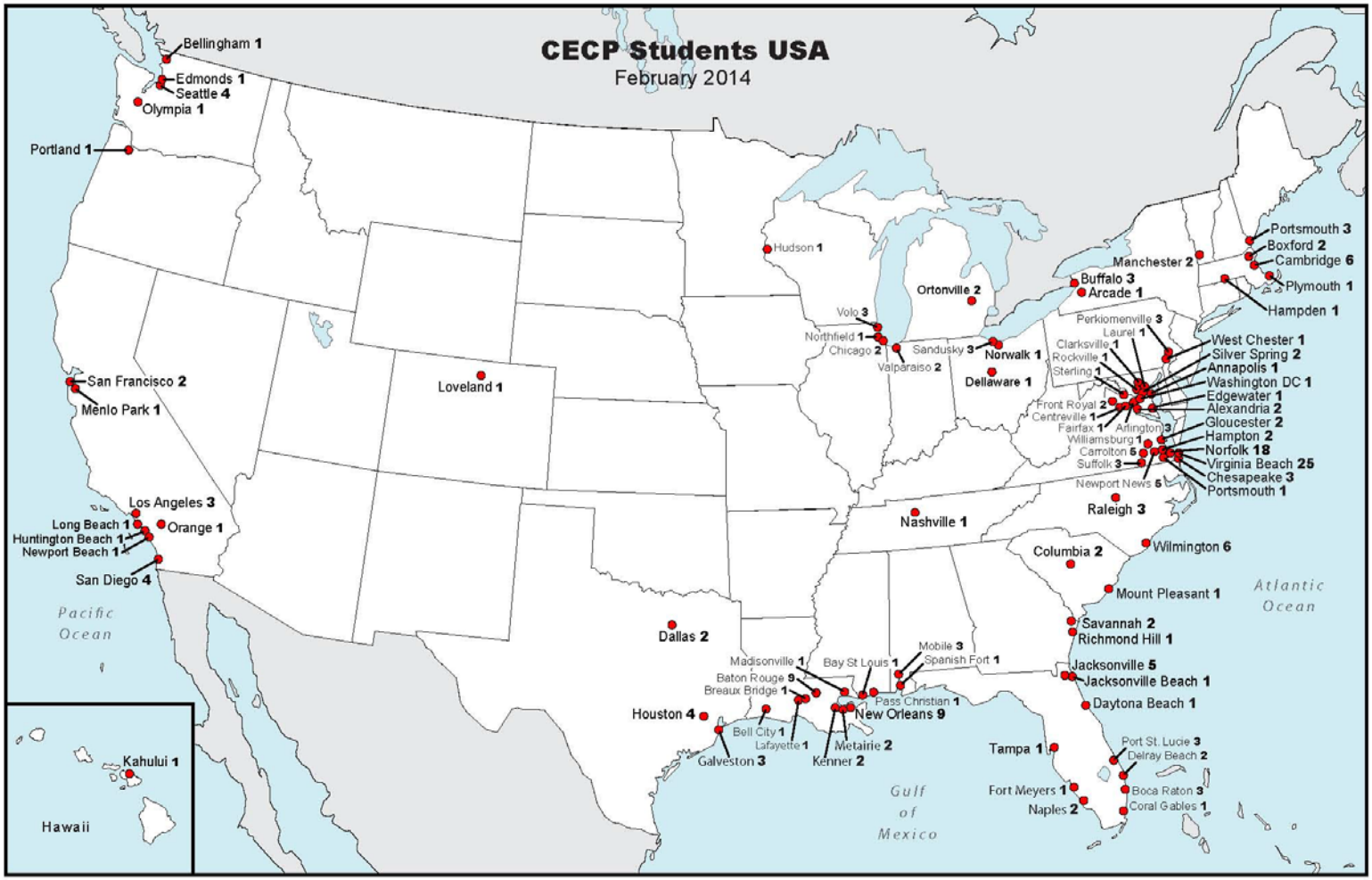
Student Enrollment 1986-2014

CECP and Online Courses Introduced in 2003



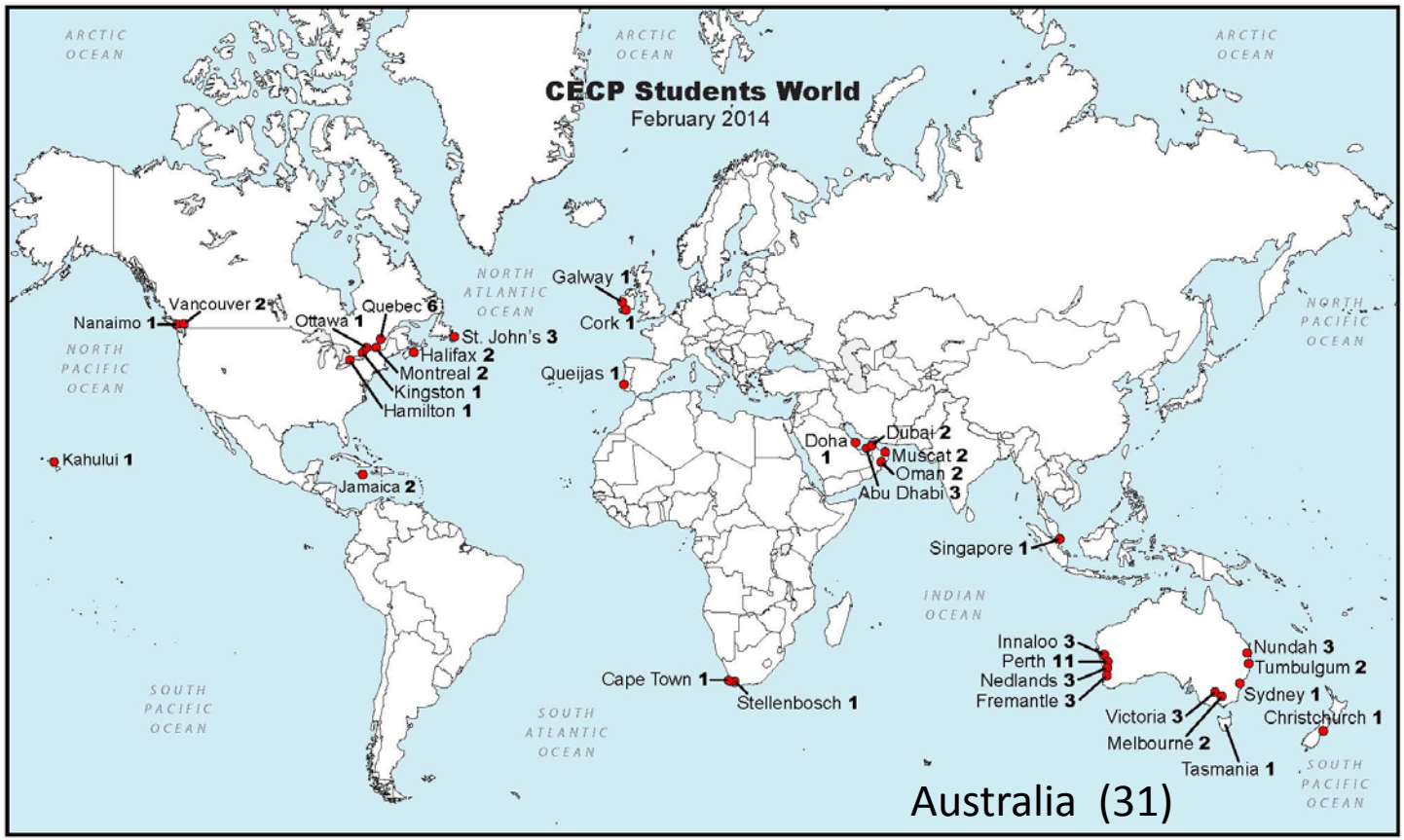
Location of CECP Students in US

226 Students from 31 States



Location of CECP Students Around World

67 (23%) Students from 14 Countries (Australia, Brazil, Canada, Dubai (UAE) France, Ireland , Jamaica, Malaysia, New Zealand, Oman, Portugal, Qutar, South Africa, United Kingdom

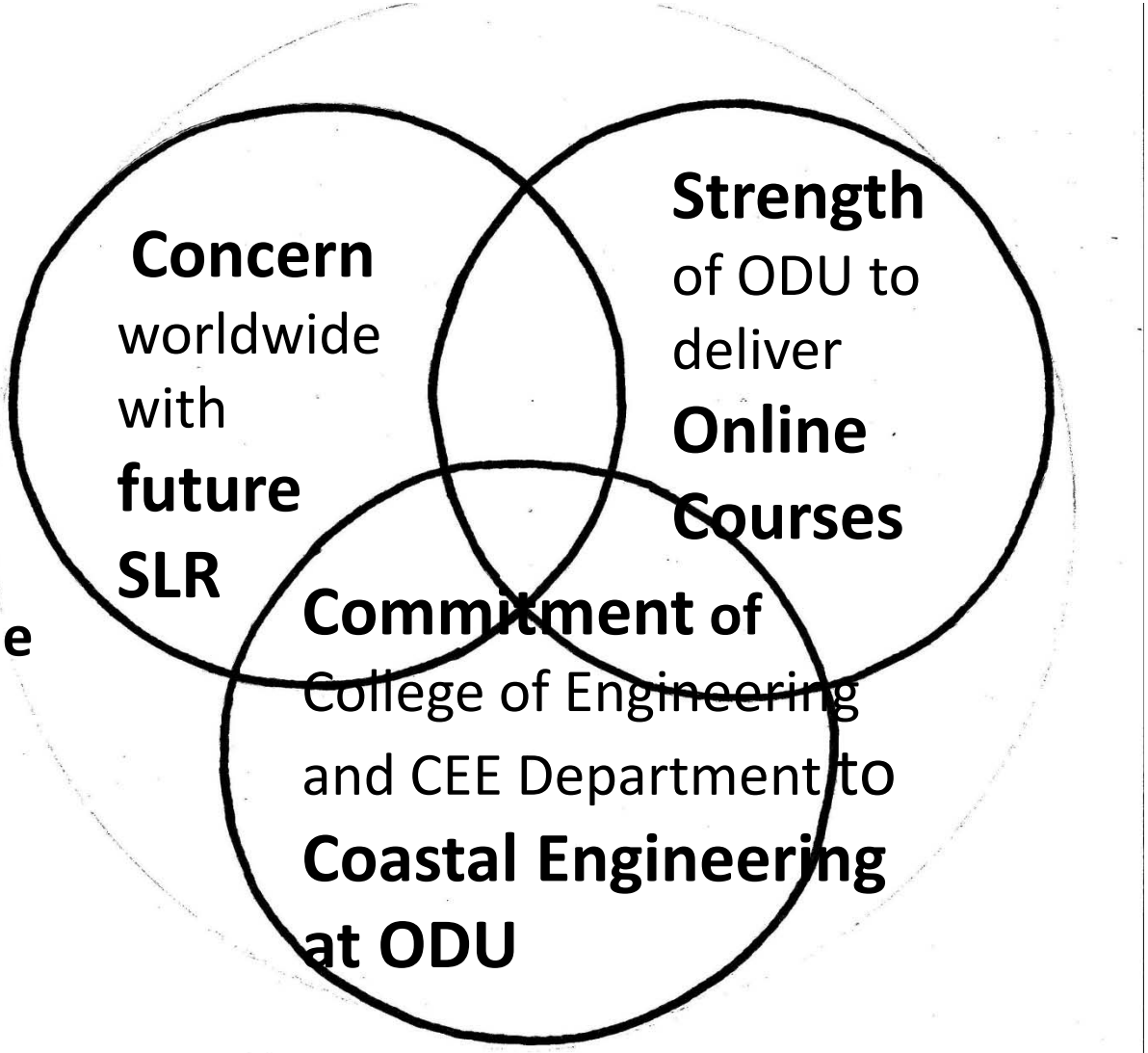


Reasons for Student Numbers (293) and Student Locations for CECP Courses

Corps of Engineers Certificate Program

CECECP online

- **ODU**
- **LSU**
- **TAMU**
- **Miss St**



SLR Education at ODU

Traditional

Undergraduate and Graduate **Courses and Students on ODU campus** in Norfolk

Adaptation

Online, Certificate Programs in all Colleges and Departments with **responsibilities in SLR education** locally, state, US and around the world

Summary

- **Mitigation -** Structural and non-structural alternatives known (combine with other CZ uses).
- **Adaptation -** Many potential changes needed by institutions, political bodies, the public and the media.
- **Recommendations -** Some adaptation strategies presented for individuals, cities, the Commonwealth of Virginia and the Federal Government (Corps).
- **Predicted SLR in 2100 -** What to use for **design**? Stay tuned for remaining lectures in series.

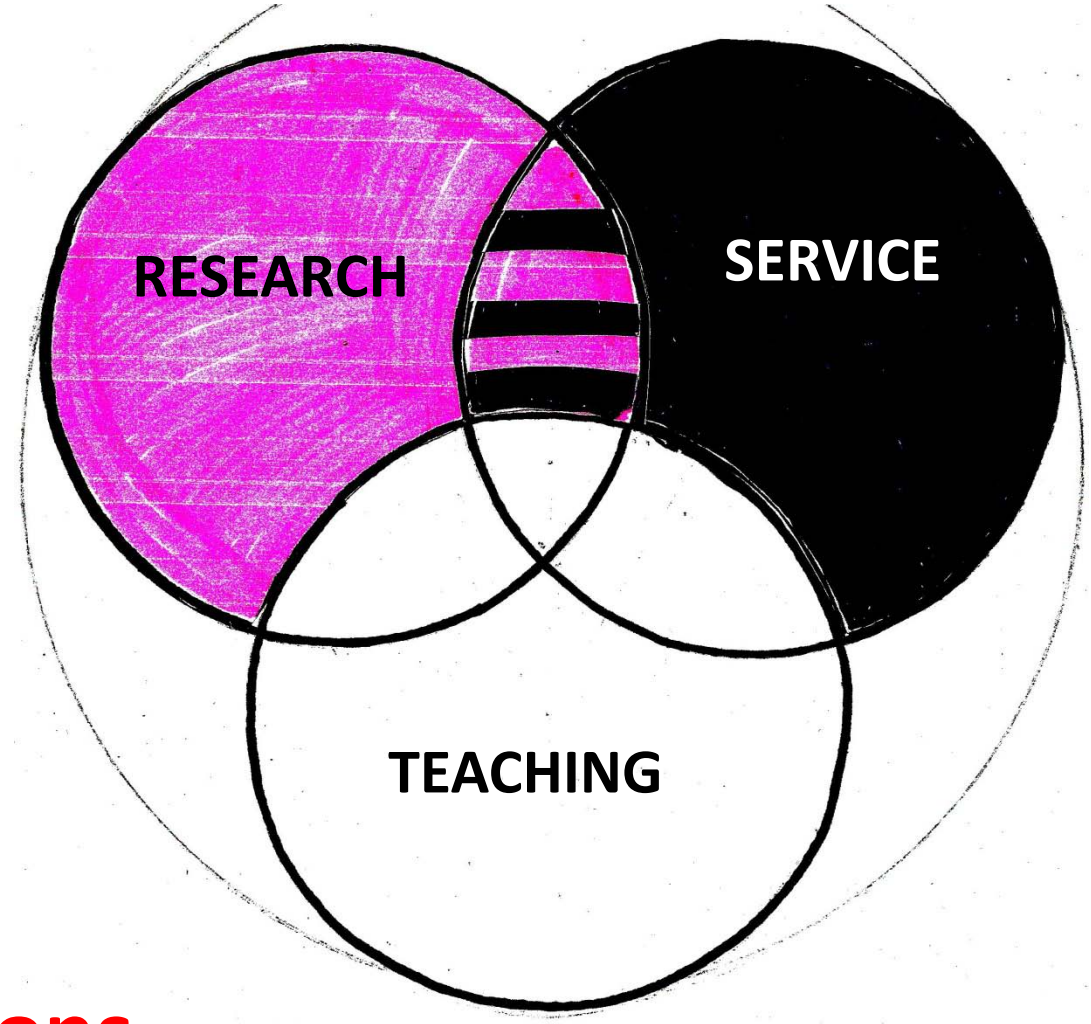
Seminar Series - Spring 2014
Mitigation and Adaptation Strategies of Civil/Coastal Engineers for Future Sea Level Rise

- **March 7, 2014:** **Corps of Engineers Role in SLR – Post Superstorm SANDY**
- **1:00 – 2:00** PM Dr. Charlie Chesnutt, Chiefs Office, Washington, DC

- **April 4, 2014:** **Adaptive Management Strategies for SLR: Ports, Beaches,**
- 2:00 – 3:00 PM **Coastal Structures and Marsh Restoration Projects**
- John Headland, Moffatt & Nichol Engineers, New York City

- **April 25, 2014** **European Union Perspective on Adaptation and**
- 2:00 – 3:00 PM **Mitigating SLR Impacts**
- Professor Marcel Stive, Coastal Engineering,
- Delft Technical University, The Netherlands

University/ Academia



Questions