The COAST Approach to Climate Change Adaptation Finance

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December 2, 2011

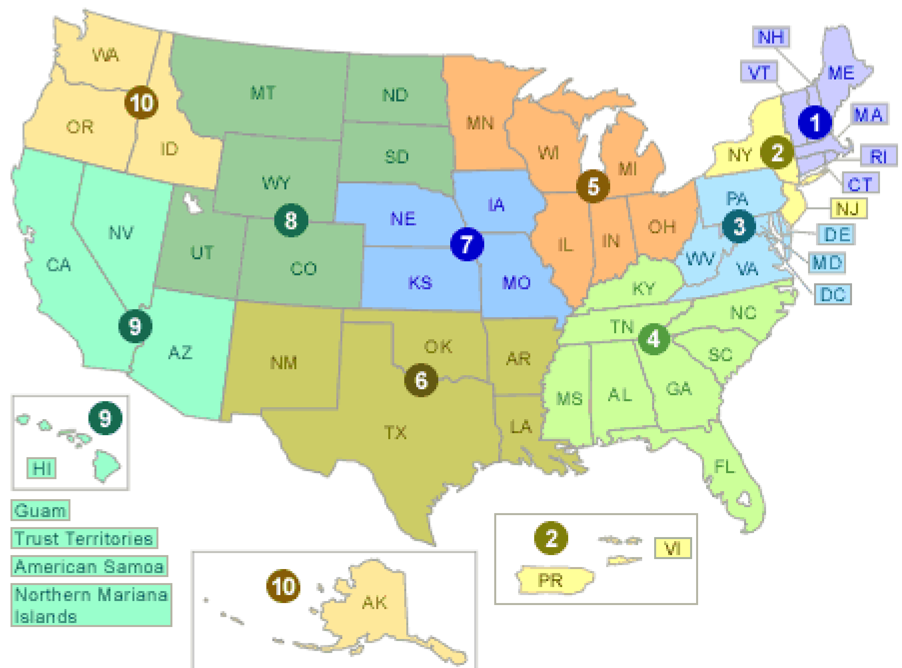
Muskie School of Public Service

University of Southern Maine
Portland, Maine

Environmental Finance Center Network

The EFCN is the only university-based organization creating innovative solutions to managing costs of environmental protection and improvement. It consists of ten EFCs serving states within EPA's ten regions. By sharing and integrating information, tools and techniques, the EFCs work together and with the public and private sectors to promote a sustainable environment, bolstering efforts to address difficult how-to-pay issues.

EFCN
environmental finance center network




Jerry and Marcy Monkman


Norbert Psuty

- More frequent flooding
- More coastal erosion
- Wetland inundation and loss

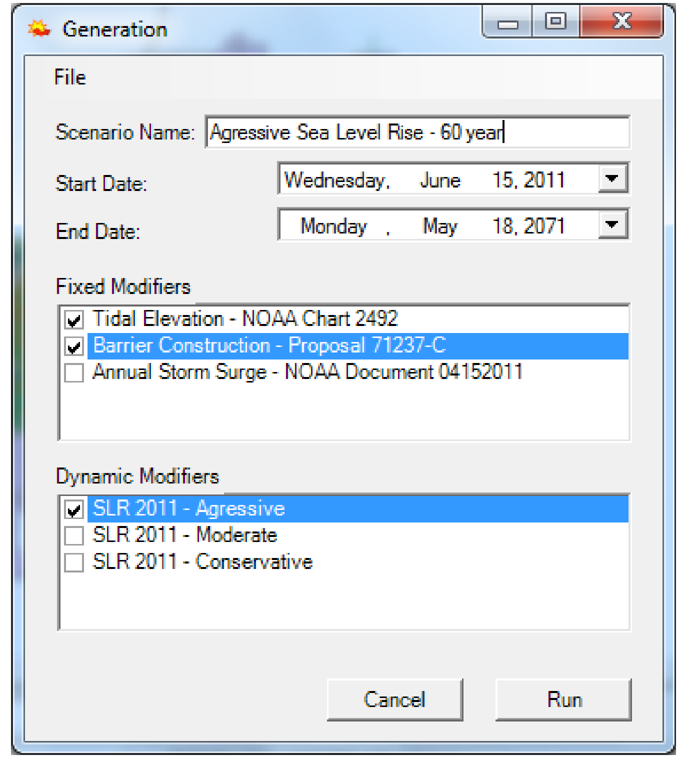

Michael Dwyer

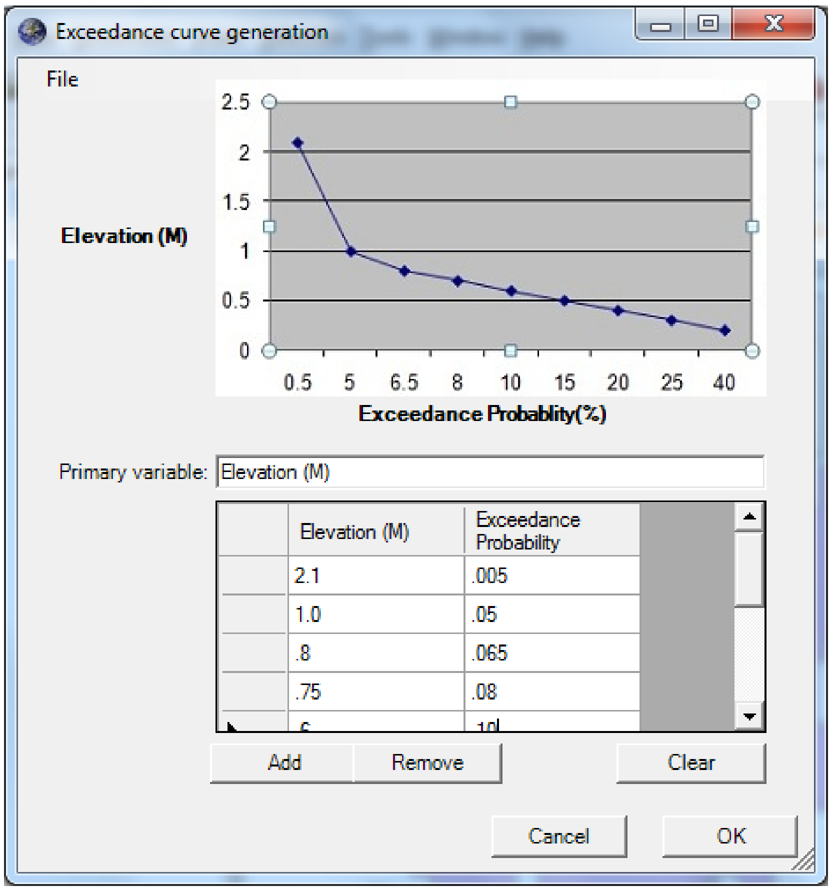
There are only four options:

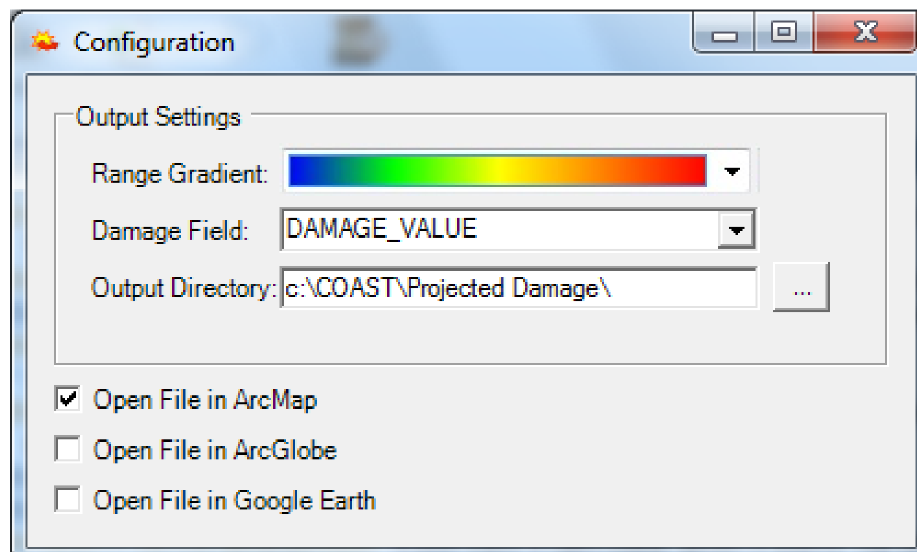
1) Fortify assets
2) Relocate assets
3) Accommodate higher water levels
4) Remain in denial

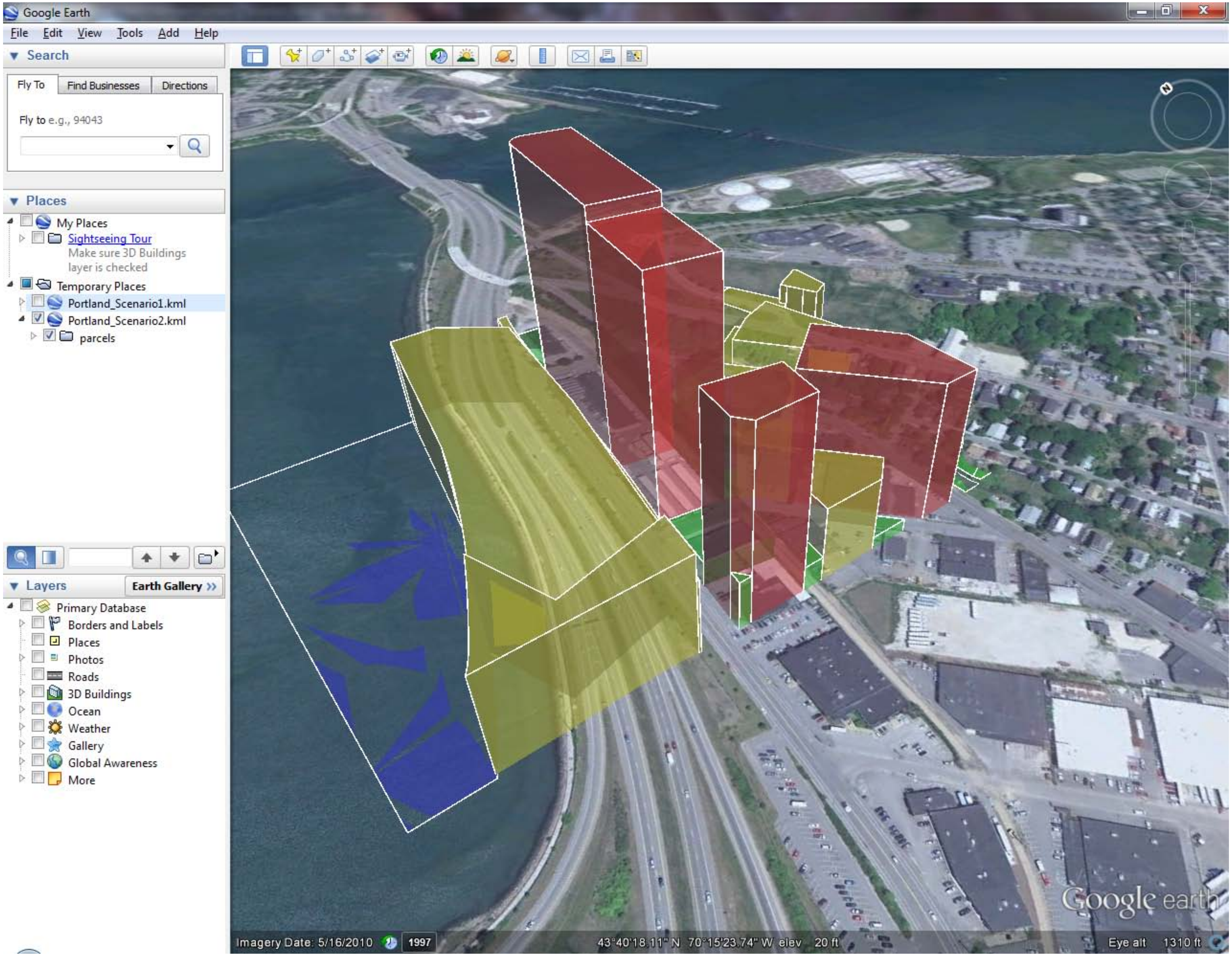
COAST is a tool to help evaluate costs and benefits of these options

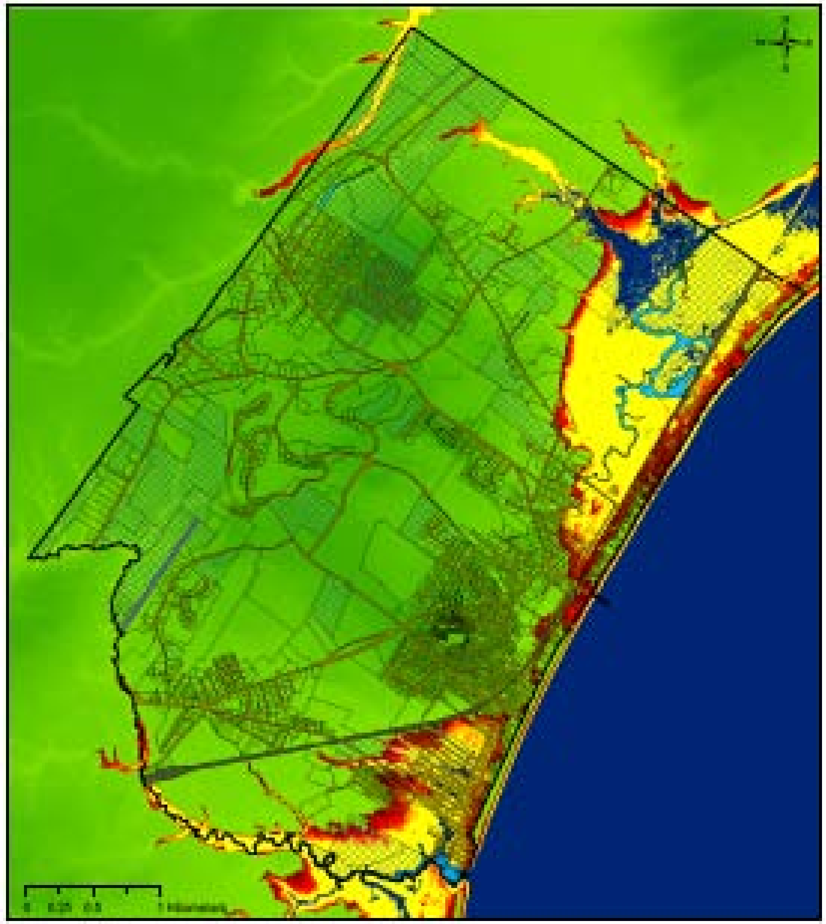

COAST

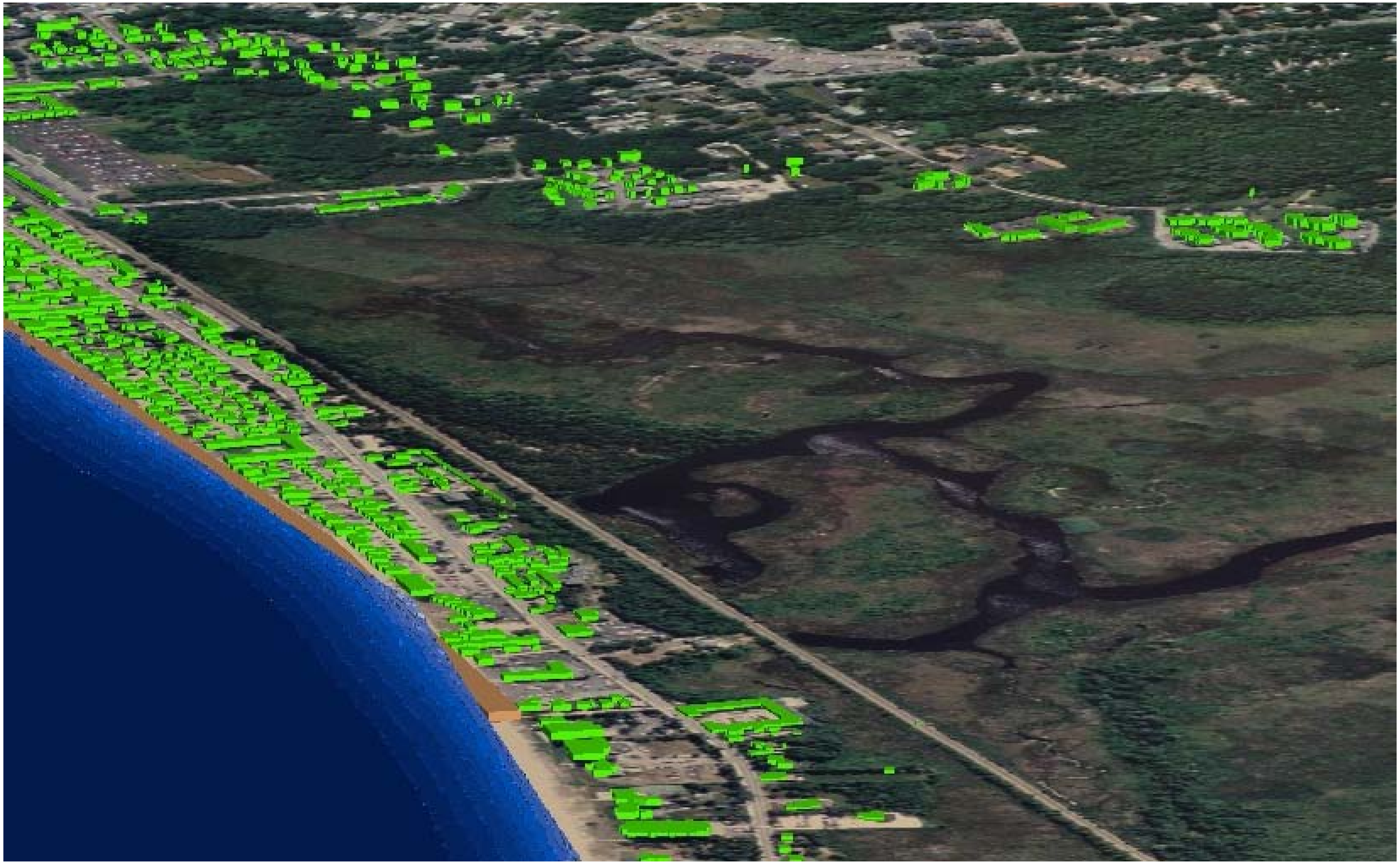

Generation
File
Scenario Name: Agressive Sea Level Rise - 60 year
Start Date: Wednesday, June 15, 2011
End Date: Monday , May 18, 2071
Fixed Modifiers
Tidal Elevation - NOAA Chart 2492
Barrier Construction - Proposal 71237-C
Annual Storm Surge - NOAA Document 04152011
Dynamic Modifiers
SLR 2011 - Agressive
SLR 2011 - Moderate
SLR 2011 - Conservative
Cancel
Run


Exceedance curve generation
File
Elevation (M)
2.5
2
1.5
1
0.5
0
0.5
5
6.5
8
10
15
20
25
40
Exceedance Probablity(%)
Primary variable: Elevation (M)
Elevation (M)
Exceedance Probability
2.1
.005
1.0
.05
.8
.065
.75
.08
Add
Remove
Clear
Cancel
OK


Configuration
Output Settings
Range Gradient:
Damage Field: DAMAGE_VALUE
Output Directory: c:\COAST\Projected Damage\
...
Open File in ArcMap
Open File in ArcGlobe
Open File in Google Earth


Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
Fly to e.g., 94043
Places
My Places
Sightseeing Tour
Make sure 3D Buildings layer is checked
Temporary Places
Portland_Scenario1.kml
Portland_Scenario2.kml
parcels
Layers
Earth Gallery
Primary Database
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
Imagery Date: 5/16/2010
1997
43°40'18.11" N 70°15'23.74" W elev 20 ft
Eye alt 1310 ft
Google earth

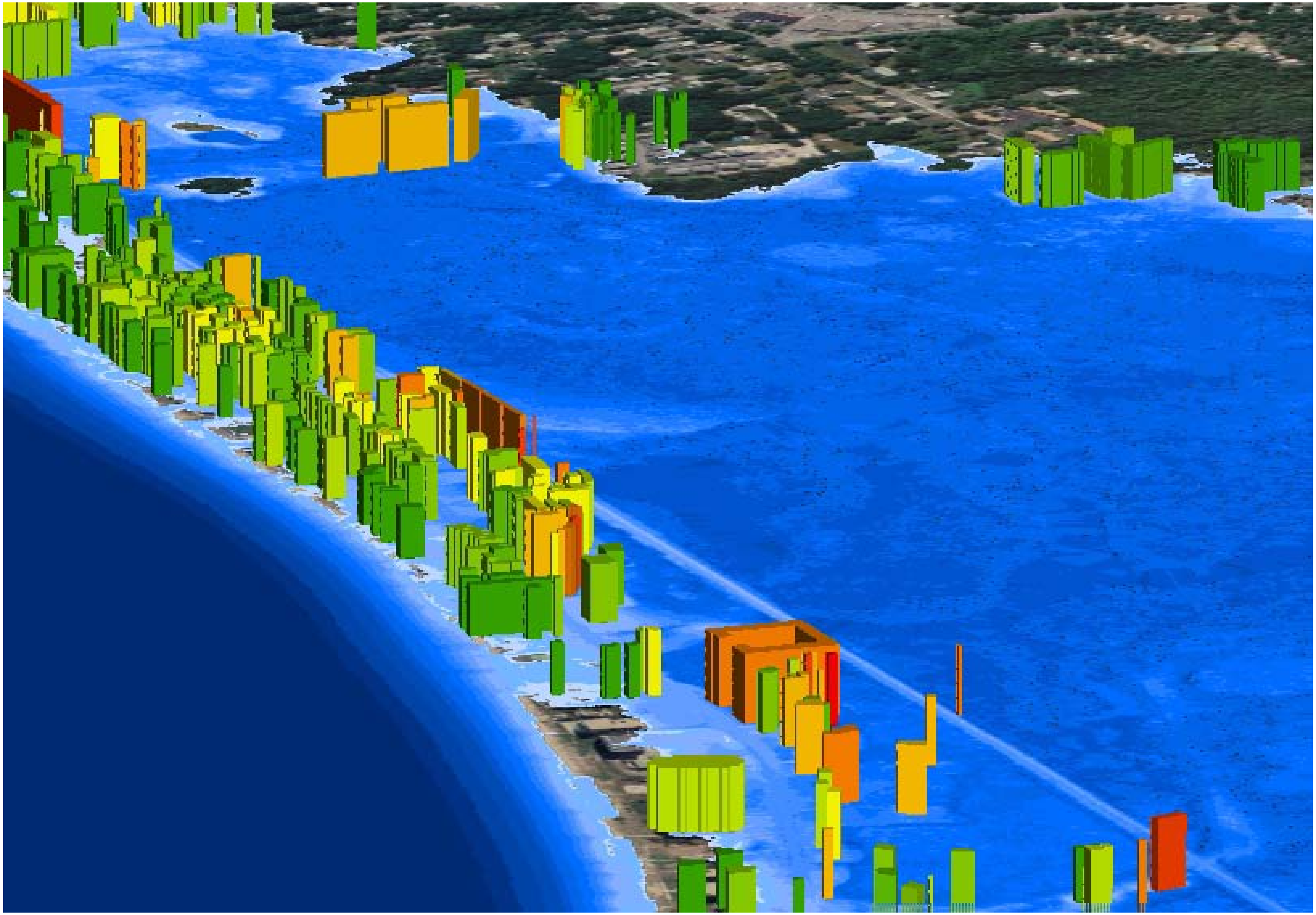




DAMAGE FUNCTIONS
FOR SINGLE FAMILY RESIDENTIAL
STRUCTURES WITH BASEMENTS

Structure Depth-Damage

Table 1 Structure One Story, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0%	0
-7	0.7%	1.34
-6	0.8%	1.06
-5	2.4%	0.94
-4	5.2%	0.91
-3	9.0%	0.88
-2	13.8%	0.85
-1	19.4%	0.83
0	25.5%	0.85
1	32.0%	0.96
2	38.7%	1.14
3	45.5%	1.37
4	52.2%	1.63
5	58.6%	1.89
6	64.5%	2.14
7	69.8%	2.35
8	74.2%	2.52
9	77.7%	2.66
10	80.1%	2.77
11	81.1%	2.88
12	81.1%	2.88
13	81.1%	2.88
14	81.1%	2.88
15	81.1%	2.88
16	81.1%	2.88



Expected costs and damages, 2010 - 2050

SLR Scenario	Adaptation	Residual Damages ($ million)	Adaptation Cost ($ million)	Total Damages and Costs ($ million)
No SLR	No Action	680	0	680
	50 yr flood	3.4	52.4	55.8
	100 yr flood	0	60	60
Low	No Action	899.3	0	899.3
	50 yr flood	28.3	52.4	80.7
	100 yr flood	0	60	60
High	No Action	1016.6	0	1016.6
	50 yr flood	67.8	52.4	120.2
	100 yr flood	37.6	60	97.6

The COAST Process

1. Specify location and vulnerable asset
2. Select time horizons, SLR and SS thresholds
3. Select adaptation action, estimate costs
4. Input Depth Damage Function
5. Input reference data (parcel, LIDAR, etc)
6. Run the model
7. Use maps and tables in public process

Possible Assets to Model

- Lost real estate values
- Lost economic output
- Displaced persons
- Lost natural resources values
- Lost cultural resources values
- Infrastructure (culverts, bridges, roads, utility lines)

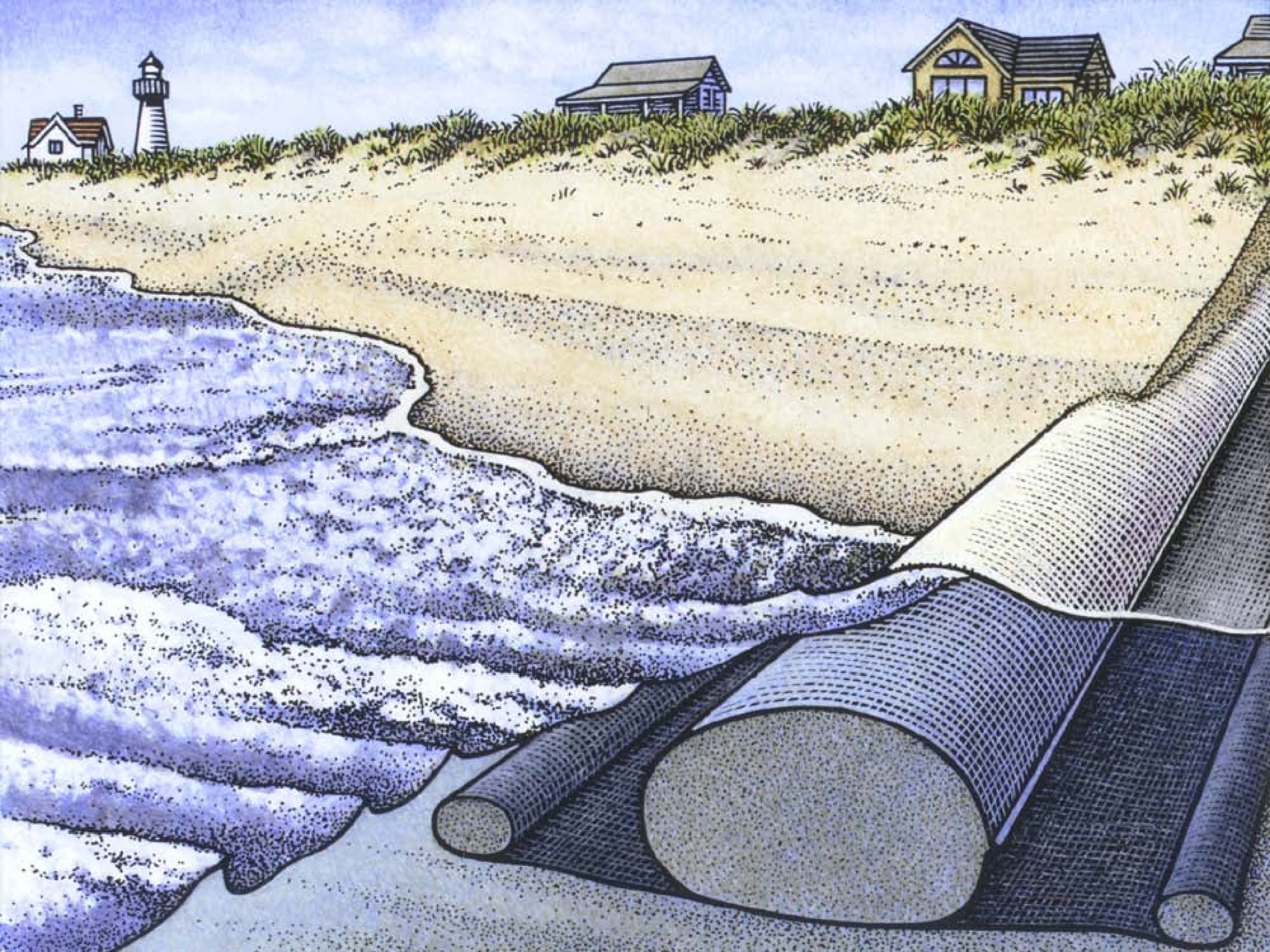
Adaptation Actions: Hard or Soft

- Revetments

Pea Patch Island, DE (Delaware River)

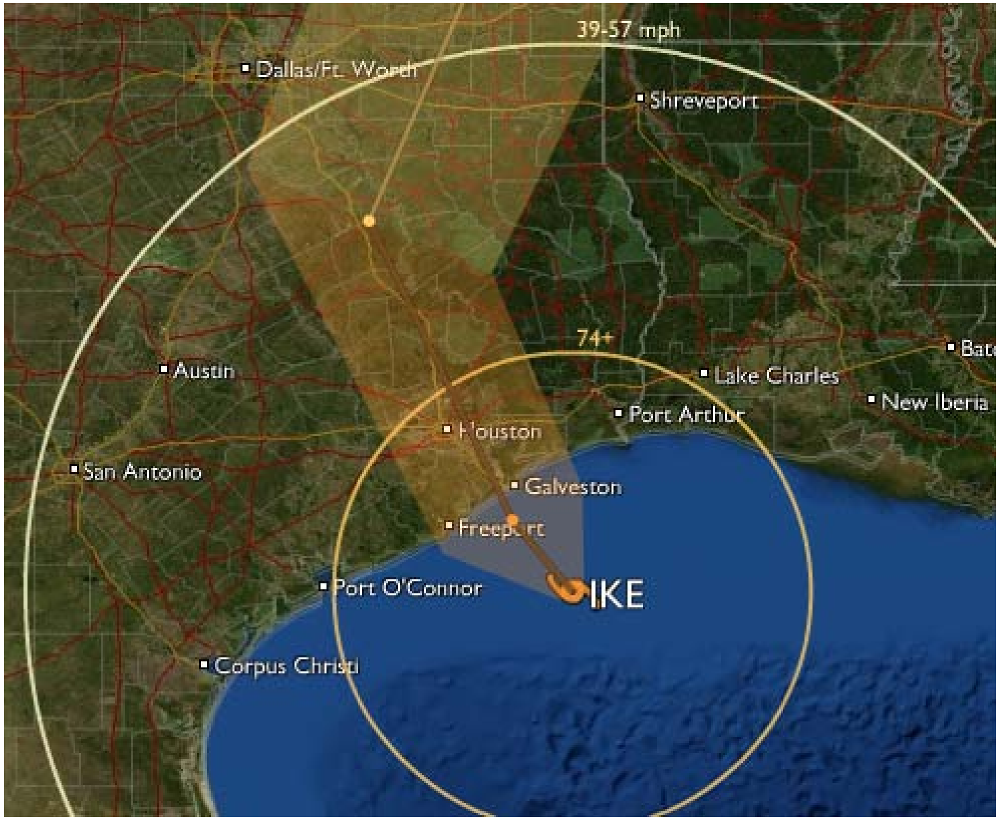
Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes



Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes
- Sea walls


39-57 mph
Dallas/Ft. Worth
Shreveport
74+
Austin
Lake Charles
New Iberia
Port Arthur
Houston
San Antonio
Galveston
Freeport
Port O'Connor
IKE
Corpus Christi

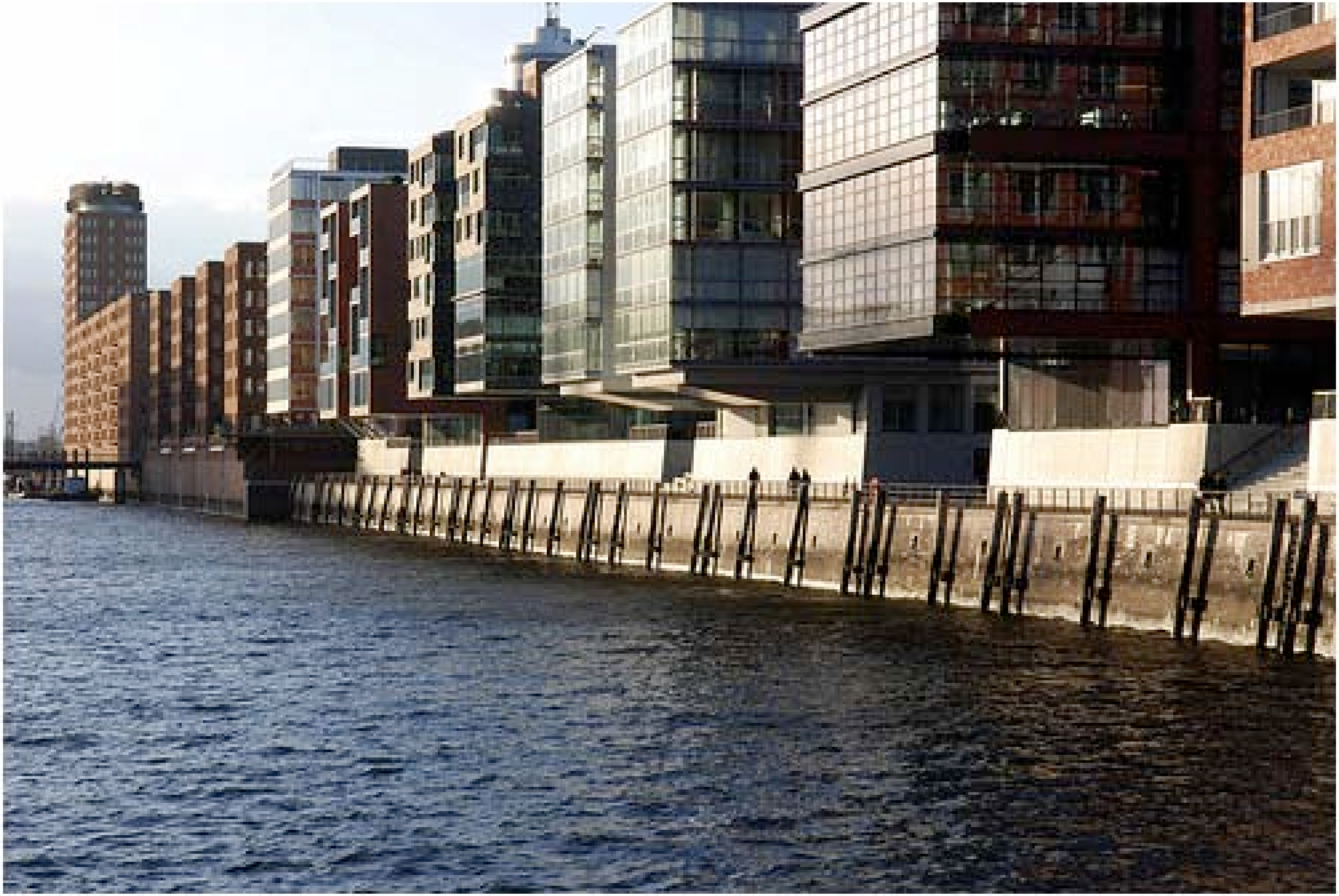
Input: a range of adaptation options

- Revetments
- Geotextile tubes
- Sea walls
- Jetties

Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes
- Sea walls
- Jetties
- Other creative approaches

Floodwalls with removable aluminum or steel gates. Cologne, Germany (Rhine).



Buildings have a “hardened” 1st story along a wide pedestrian walkway.

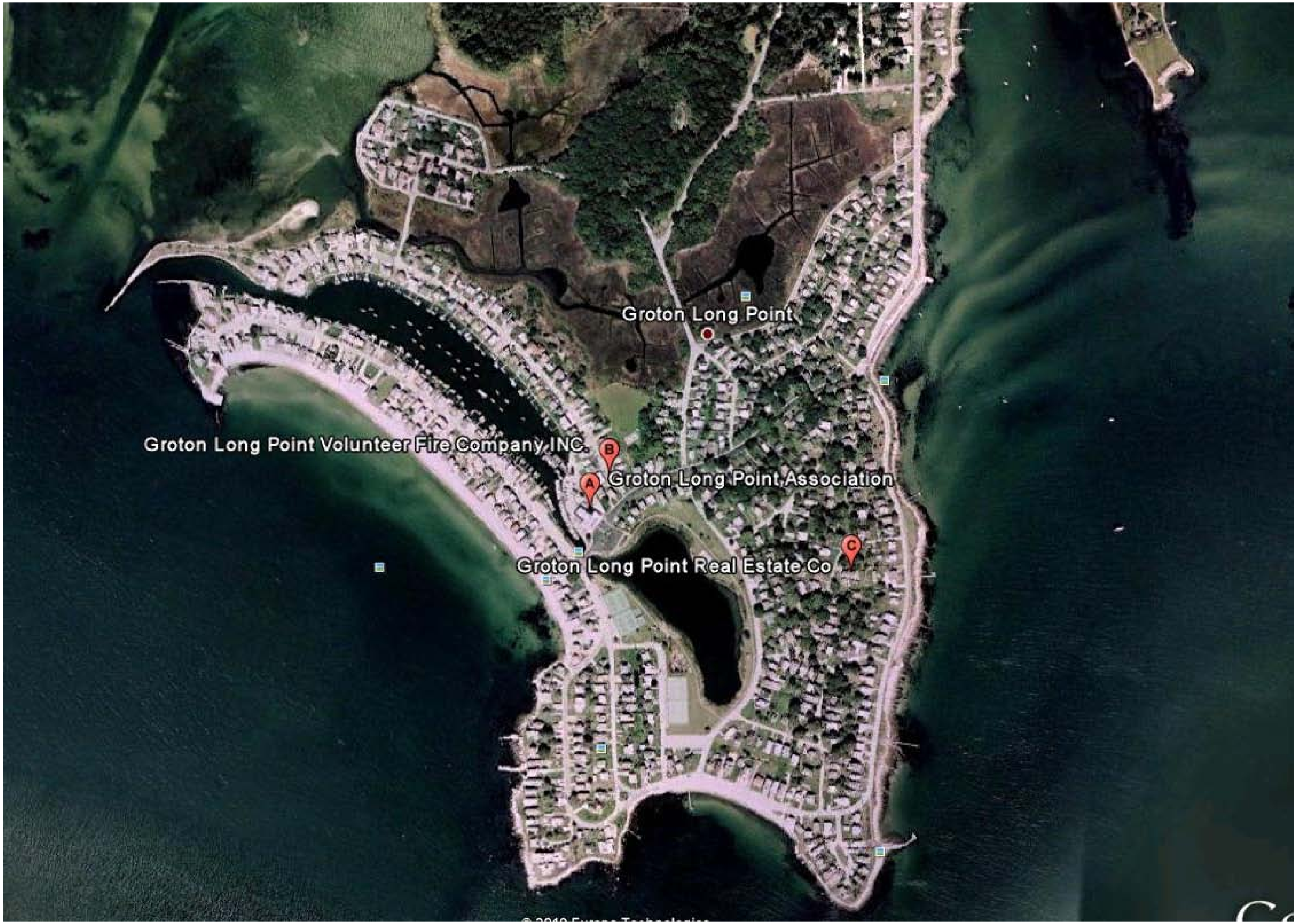
Urban design strategy: Hamburg, city on the water

Adaptation Actions: Hard or Soft

- Revetments
- Geotextile tubes
- Sea walls
- Jetties
- Other creative approaches

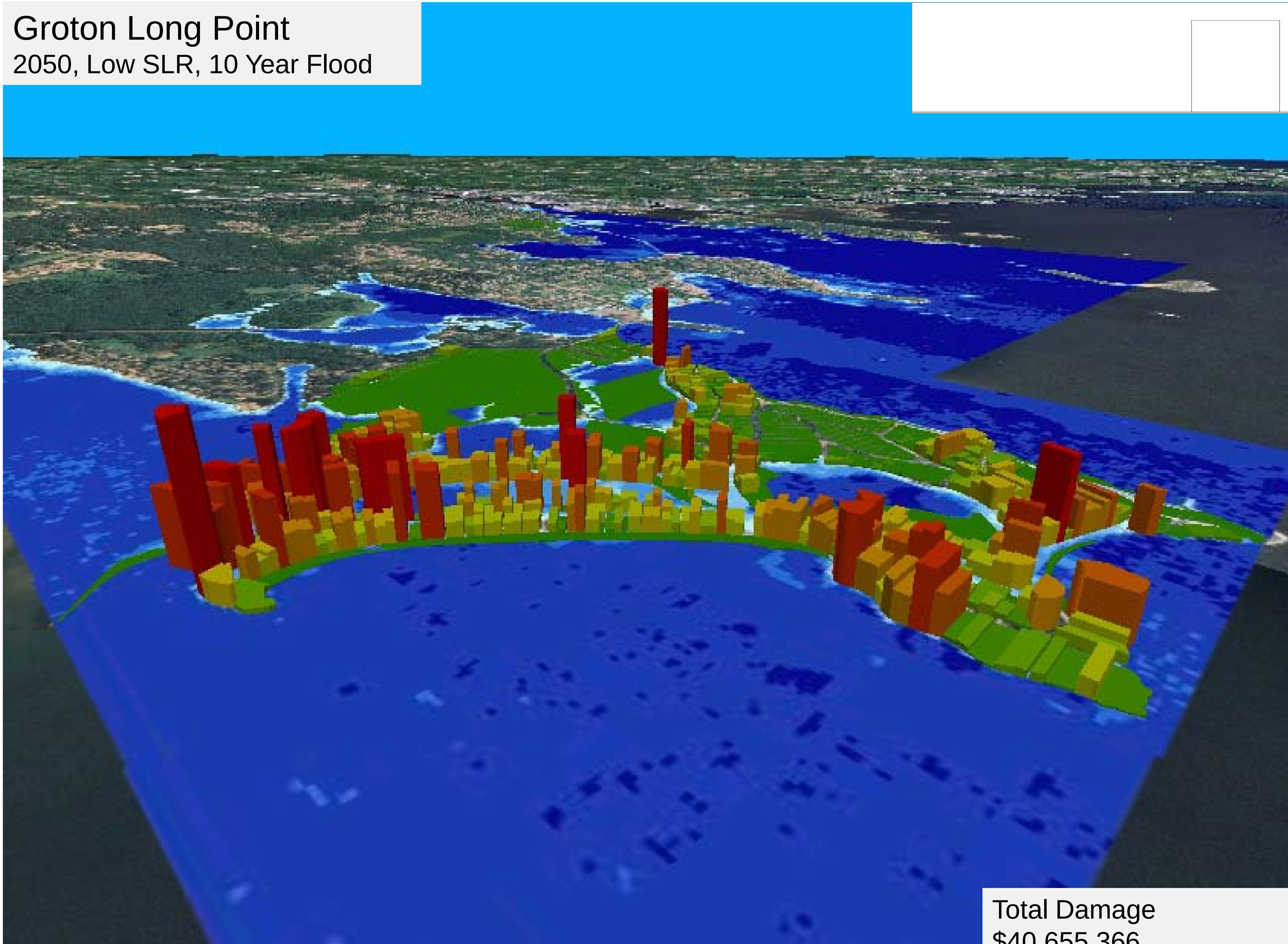
- Wet or dry floodproofing
- Incentives, zoning, and other regulatory changes

Old Orchard Beach – East Grand Avenue Area

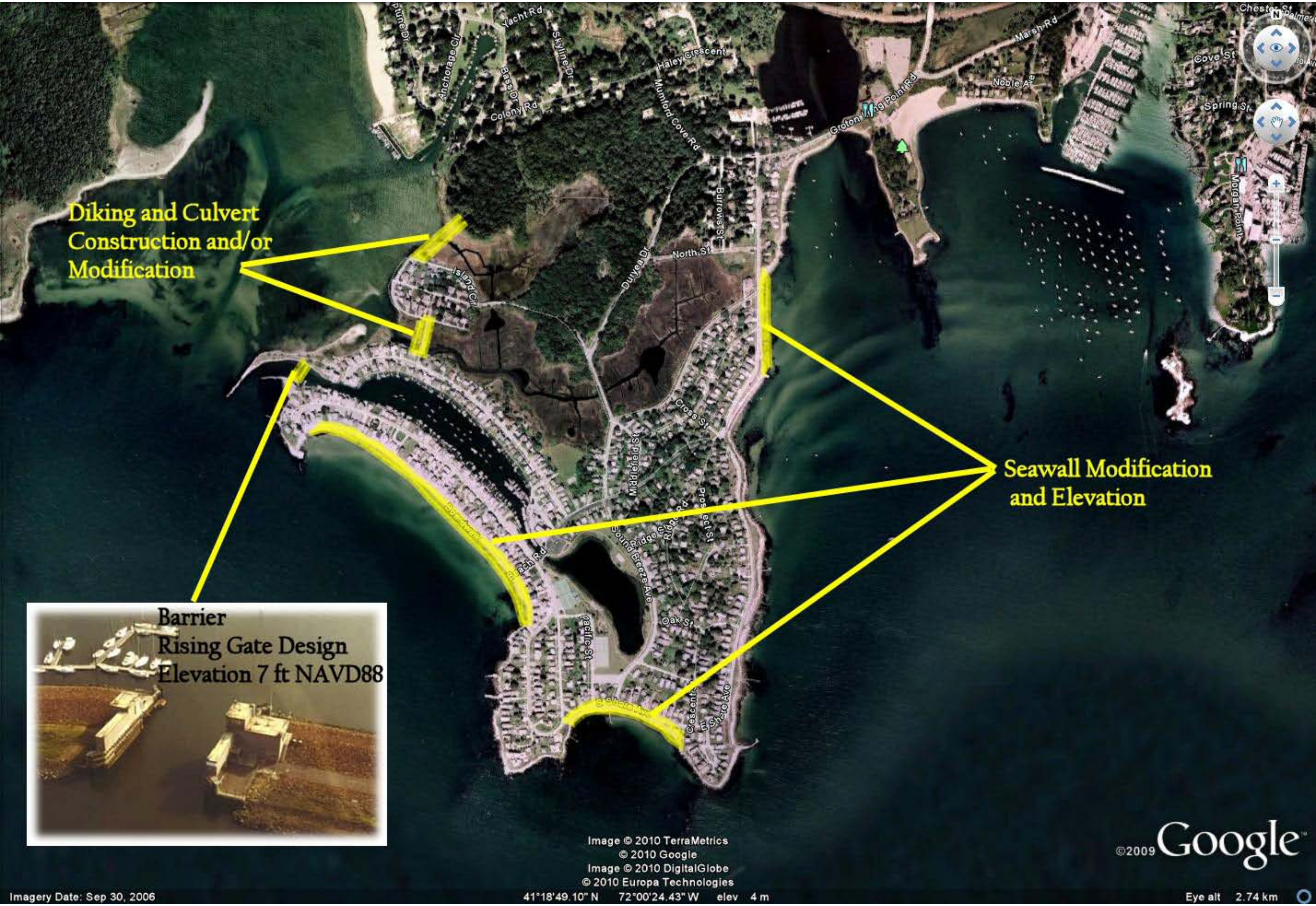

Groton Long Point
Groton Long Point Volunteer Fire Company INC.
B
A
Groton Long Point Association
C
Groton Long Point Real Estate Co

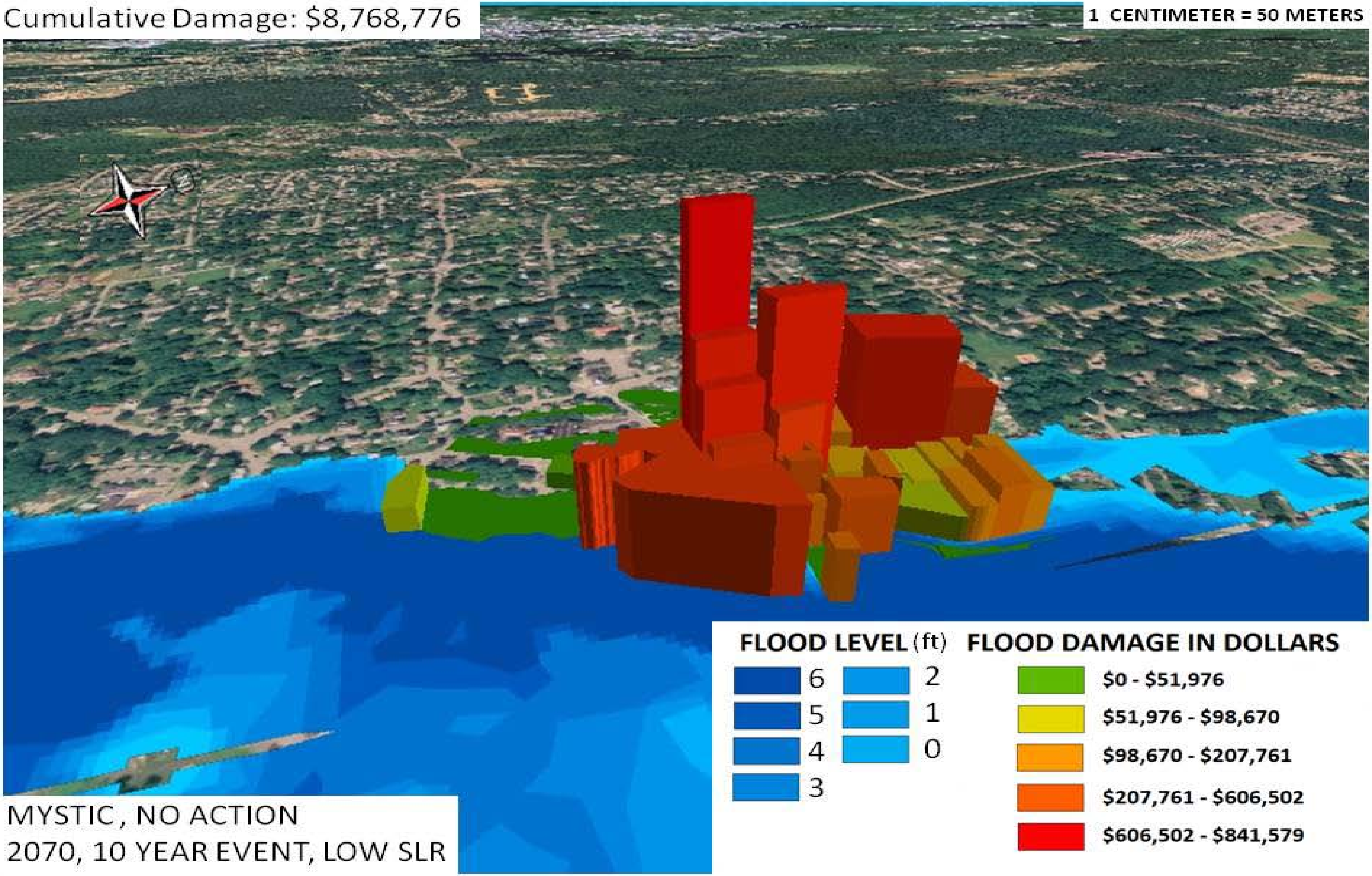
Groton Long Point

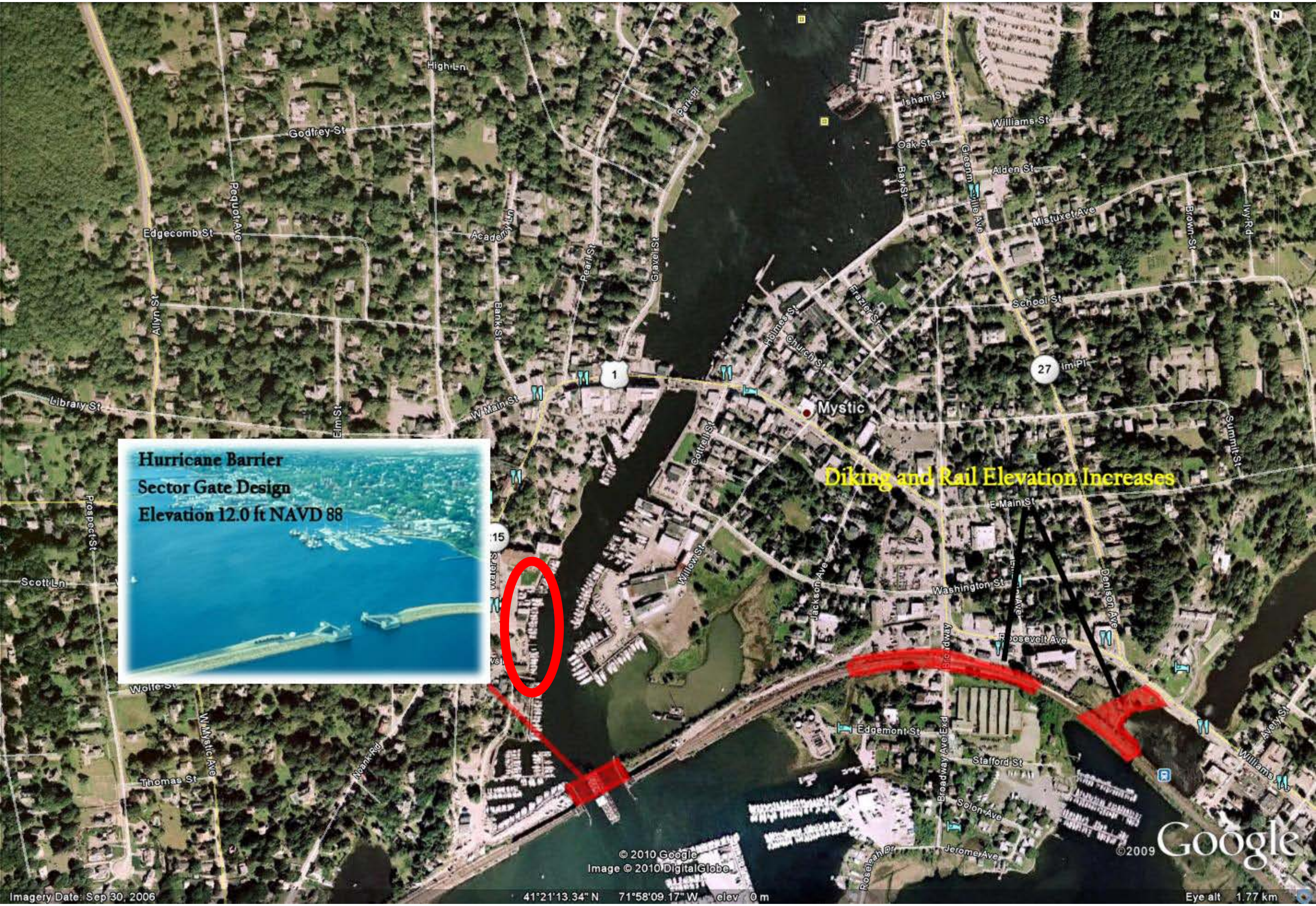
2050, Low SLR, 10 Year Flood



Total Damage
$40,655,366


Diking and Culvert Construction and/or Modification
Seawall Modification and Elevation
Barrier
Rising Gate Design
Elevation 7 ft NAVD88
Image © 2010 TerraMetrics
© 2010 Google
Image © 2010 DigitalGlobe
© 2010 Europa Technologies
Imagery Date: Sep 30, 2006
41°18'49.10" N 72°00'24.43" W elev 4 m
Eye alt 2.74 km
©2009 Google


Cumulative Damage: $8,768,776
1 CENTIMETER = 50 METERS
FLOOD LEVEL (ft)
6
5
4
3
2
1
0
FLOOD DAMAGE IN DOLLARS
$0 - $51,976
$51,976 - $98,670
$98,670 - $207,761
$207,761 - $606,502
$606,502 - $841,579
MYSTIC, NO ACTION
2070, 10 YEAR EVENT, LOW SLR

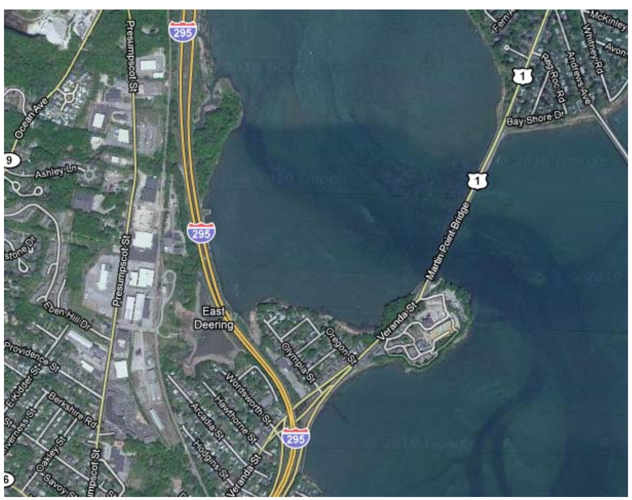


Hurricane Barrier
Sector Gate Design
Elevation 12.0 ft NAVD 88
Diking and Rail Elevation Increases
Mystic
High Ln
Godfrey St
Edgecomb St
Library St
Scott Ln
Wolfe St
Thomas St
Allyn St
Pequot Ave
Elm St
Academy Ln
Bank St
Pearl St
Gravel St
Park Pl
W Main St
Prospect St
W Mystic Ave
Noank Rd
Cottrell St
Willow St
Holmes St
Church St
Frazier St
Isham St
Oak St
Bay St
Williams St
Alden St
Greenmanville Ave
Mistuxet Ave
Brown St
Ivy Rd
School St
Elm Pl
Summit St
E Main St
Washington St
Jackson Ave
Broadway
Roosevelt Ave
Denison Ave
Edgemont St
Stafford St
Broadway Ave Ext
Solon Ave
Jerome Ave
Roseleah Dr
Avery St
Williams St
1
27
215
© 2010 Google
Image © 2010 DigitalGlobe
©2009
Google
Imagery Date: Sep 30, 2006
41°21'13.34" N 71°58'09.17" W elev 0 m
Eye alt 1.77 km

Scenarios		Max. Water Elev. (ft., NAVD88)	Engineering Options	Construction Costs	Annual Maintenance Costs
Sea level rise, normal tides	A	3.2 – 4.0	No action up to minimal flood proofing and infrastructure elevation along river.	Insignificant	Insignificant
	B	5.5 – 6.5	Hurricane Barrier at Mystic River entrance.	$18 Million	$75,000
100-year storm event in 2010	C	5.4			
	D	7.4			
10-year storm in 2070, Hi SLR	E	7.0			
	F	8.9	Hurricane Barrier at Mystic River entrance. ***ADDITIONAL FORTIFICATION*** ***and elevating the railroad, as well as increased diking to east.***	$27-30 Million	$100,000
100-year storm in 2070, Hi SLR	G	8.6			
	H	10.5	Hurricane Barrier at Mystic River entrance. ***FURTHER FORTIFICATION*** ***and elevating the railroad, as well as increased diking to east.***	$35 Million	$120,000

Machias Bridge, Machias

(pressure transducer placed in 8/11)



Martin's Point Bridge, Falmouth

The Old Port, 3/10 at high tide (D. Yakovleff)

The Old Port, 10/11 at high tide (M. Craig)

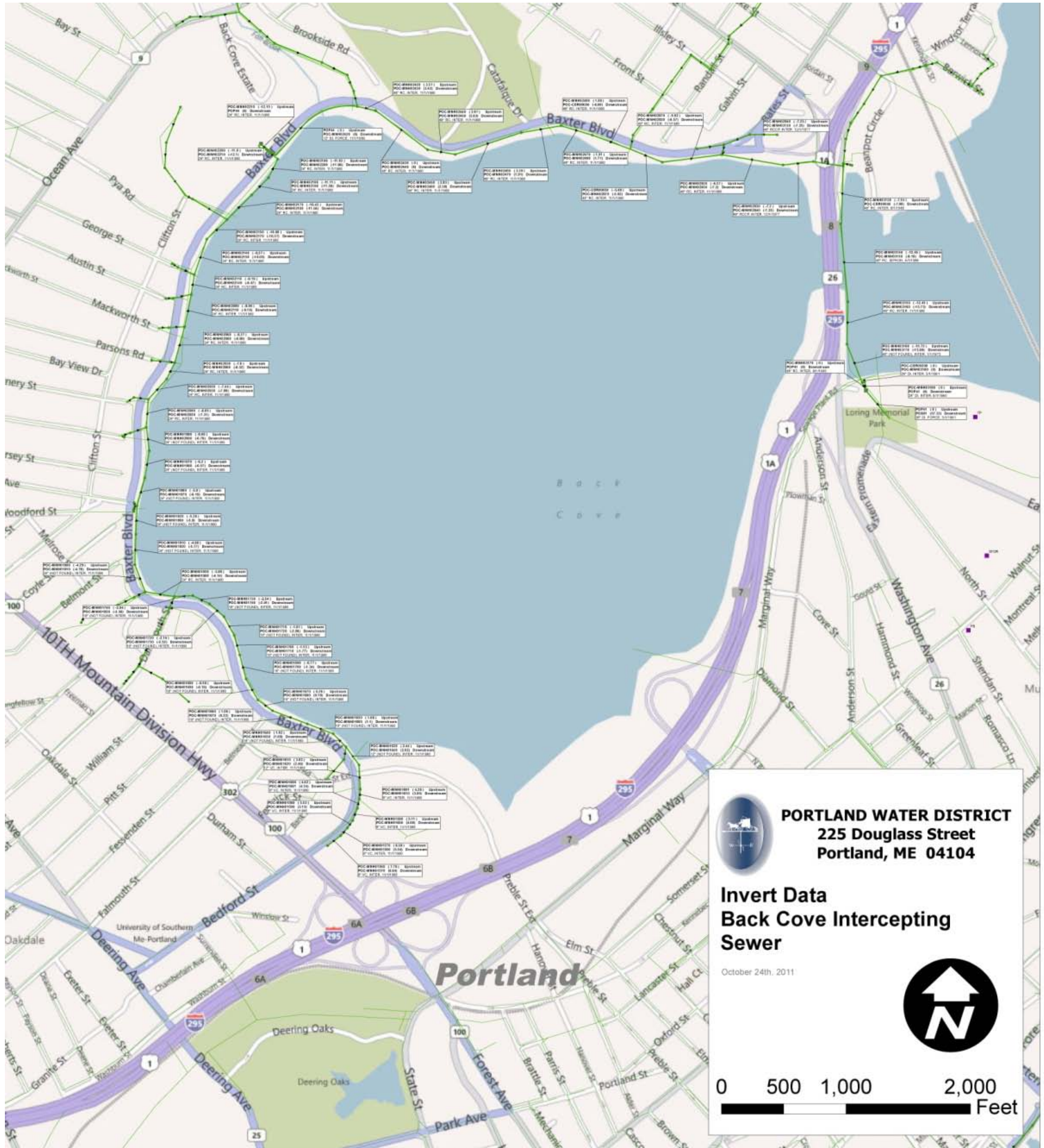
Area at risk of inundation from 1-meter (3.3 ft.) rise in sea level with storm surge of 80 cm (2.6 ft.)

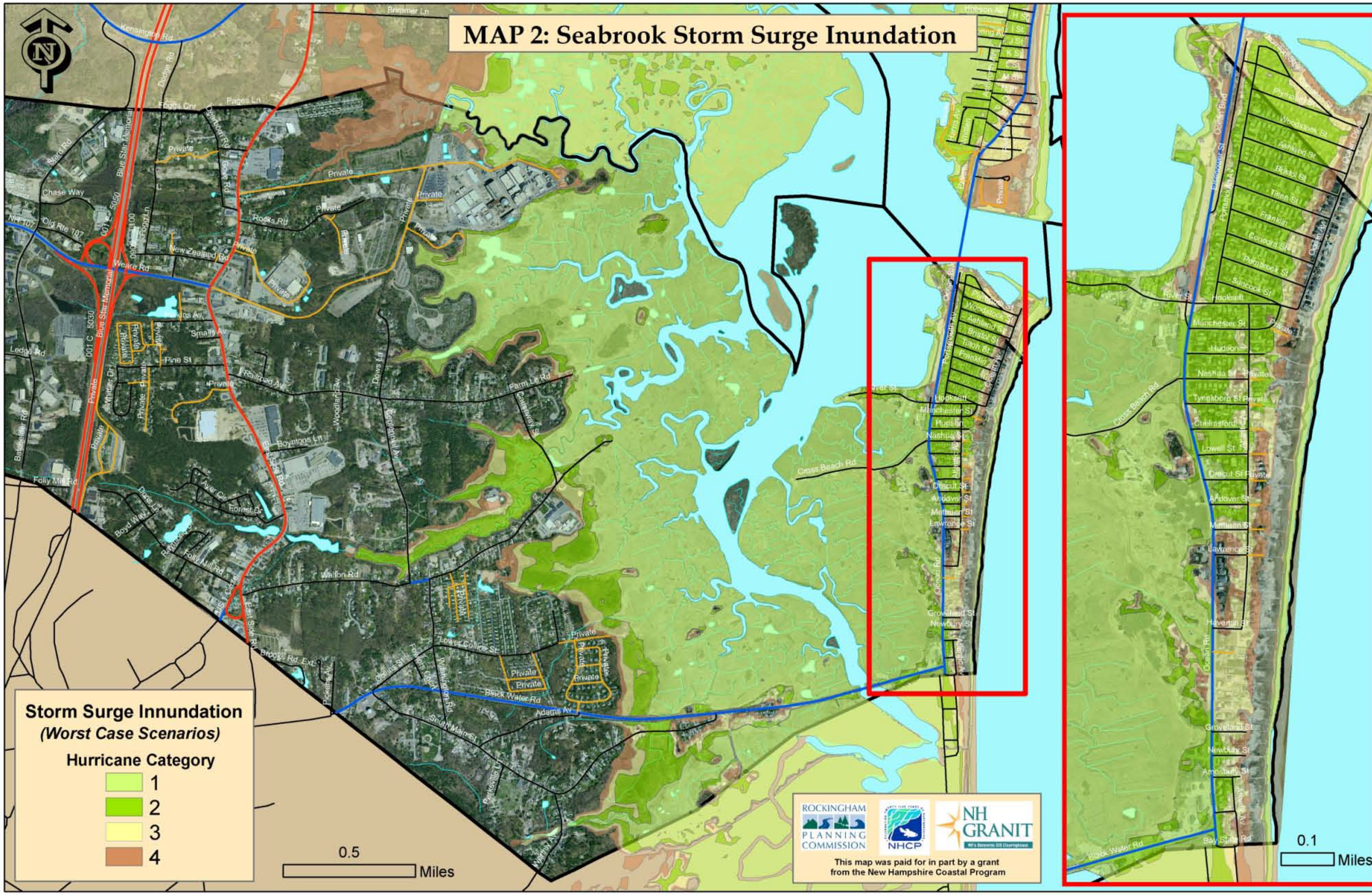
- Current sea level
- Low estimate
- Central estimate
- High estimate

Elevations based on computer models, not actual surveys. High, central, and low estimates indicate amount of land potentially inundated. Range in estimates reflects uncertainty in underlying elevation model. Inundation shown does not reflect coastal protection efforts that may prevent some low-lying areas from being flooded as sea level rises. Map does not depict inland areas below modeled sea level where not connected directly to the sea. Some hydraulically isolated areas that are below the predicted rise in sea level may become inundated as water tables rise.

CLEAN AIR COOL PLANET

Prepared by Stratus Consulting Inc.
Elevation data: USGS, 2009
Storm surge data: NOAA CO-OPS
Imagery: MaineGIS, 2001


PORTLAND WATER DISTRICT
225 Douglass Street
Portland, ME 04104
Invert Data
Back Cove Intercepting
Sewer
October 24th, 2011
0 500 1,000 2,000
Feet
N
Baxter Blvd
Back Cove
Portland
10TH Mountain Division Hwy
Loring Memorial Park
Deering Oaks
University of Southern Me-Portland
Marginal Way
Washington Ave
Forest Ave
Park Ave
Bedford St
Ocean Ave
Brookside Rd
Bay St
Front St
Baxter Blvd
Deering Ave
State St
Preble St Ext
Elm St
Oakdale
Catafalque Dr
Back Cove Estates
George St
Austin St
Mackworth St
Parsons Rd
Bay View Dr
Clifton St
Woodford St
Pitt St
William St
Durham St
Fessenden St
Falmouth St
Anderson St
Cove St
Diamond St
Marginal Way
Hammond St
Sheridan St
North St



MAP 2: Seabrook Storm Surge Inundation
Storm Surge Innundation
(Worst Case Scenarios)
Hurricane Category
1
2
3
4
0.5
Miles
0.1
Miles
ROCKINGHAM PLANNING COMMISSION
NHCP
NH GRANIT
This map was paid for in part by a grant from the New Hampshire Coastal Program

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	50 yr flood	67.8	52.4	120.2
	100 yr flood	37.6	60	97.6


Sea Isle City, NJ
Geotextile Tubes

Learn the alchemy
True human beings know.
The moment you accept
    what troubles you've been given,
The door will open.

- Jalallabad Rumi, 13th Century Persia

Contact info:

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http://efc.muskie.usm.maine.edu

Thank you!