Planning for Sea Level Rise: Modeling Costs and Benefits for Coastal Broward County

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Broward County

Climate Change Task Force
May 21, 2015
Broward County: Metropole Project

Using the COAST Tool and Approach to Model the Impacts of Storm Surge & Sea Level Rise: Meeting One – Hollywood Beach, FL

January 29, 2015
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Vice President
Catalysis Adaptation Partners
Freeport, ME
**METROPOLE**: An Integrated Framework to Analyze Local Decision Making and Adaptive Capacity to Large-Scale Environmental Change
Community Case Studies in Brazil, UK and the US
Study Area
WORKSHOP 1

Thursday, January 29

Garfield Community Center, Hollywood
What is the COAST Software Tool?

- COAST = “COastal Adaptation to Sea Level Rise Tool.”
- Predicts dollar damages from varying amounts of sea level rise with storm surges added, and compares benefits of different adaptation actions.
What the COAST Model Results Tell Us:

How much flood damage we might expect from:
- One-time future events;
- Cumulative damage over time, from many different sized storms; and
- How many parcels of land we might lose to sea level rise.

IF NO ACTION IS TAKEN
What Came Out of the Vulnerability Assessment?

For 2030 and 2060:

DAMAGE TO BUILDINGS

• One time Damage
• Cumulative Damage
• Parcels of land lost to sea level rise
What is the COAST Software Tool and Approach?

- It is more than just a model with damage numbers.
- We can work together to explore and create positive options.
- We can make sure our tax dollars are spent wisely.
- It’s a way to get action started.
- YOUR INPUT IS ESSENTIAL IN THESE MEETINGS!
Limits of the Model: CAVEATS

- For this project, the only assets we looked at were buildings.
- We did not look at damage to roads, drains, sewers, or other infrastructure.
- The model only tallies damage from flood water levels, and does not include wind or wave action that would probably come with surges.
- Building contents were not considered.
- Building Values were based on tax assessment number that are often lower than Market Rates.
- All these factors make the model damage numbers conservative.
Data That Went Into the COAST Model for Broward County

Ingredients for the Recipe:
What went into the soup!
What Did We Put Into the Model?

SEA LEVEL RISE ASSUMPTIONS

- Annual Sea Level at Key West
- Projected Sea Level Rise Range based on USACE Guidance
- Historic Key West Sea Level Rise Rate for Comparison

- 2010: Sea level = 0
- 2030: 3-7 inches
- 2060: 9-24 inches
For Cumulative Damages: Used surges from the 10, 50 and 100-year storms using 2014 FEMA Flood Study and Maps, and SLOSH models from other studies.

For One-Time Damages: Used today’s “Nuisance Flood” level at 1.05 feet, and a “Wilma-Sized Event” at 6 feet.

Then ADDED SEA LEVEL RISE TO THESE SURGES OVER TIME.
Recent Historic Hurricane Surge Heights in Florida Area

(above MHHW)

- Hurricane Wilma, Vaca Key, 10/24/2005: 5.80 ft.
- Hurricane Dennis, Appalachicola, 7/10/2005: 6.43 ft.
- Hurricane Opal, Panama City, 10/4/1995: 5.72 ft.
- Hurricane Ivan, Dauphin Island, AL, 9/16/2004: 5.94 ft.
- Hurricane Ivan, Pensacola, 9/16/2004: 5.52 ft.

MEAN: 5.9 ft.

http://tidesandcurrents.noaa.gov/est/Top10_form_ft.pdf
Input: Value of Buildings

We used the building values joined to the tax parcel map layer provided by Broward County’s Property Appraiser.
Locations of the Buildings: Digital Tax Parcels

- COAST virtually flooded the land, measuring the depth of flooding at the center of each parcel.
- Property Appraiser records were used to classify buildings as elevated or not, according to Year Built.
- The COAST model was adjusted to show less damage to elevated buildings than those located on grade.
Input: Digital Elevations - Topography

- COAST uses LiDAR = "Light Detection and Ranging"
- LiDAR = 5 meter resolution
- Area is divided into 5 m squares, with a single elevation for each square
- The LiDAR came from the University of Florida – GeoPlan Center and was prepared by Catalysis Adaptation Partners
We used the nearest tide station at Ft. Lauderdale Bahia Yacht Club.

Its Mean Higher High Water value is 4.57 feet (or 0.37 feet in NAVD 88 elevation).
Depth-Damage Function (DDF)

- Used US Army Corps of Engineers tables for predicted % damage to a building, based upon how deep the floodwaters get at its base.
- Used different damage rate tables for different building types (such as residential or commercial, elevated or not, etc.)
Ten One-Time Damage Estimates

#1 • Year 2015, Nuisance Flood + No Sea Level Rise

#2 • Year 2030, Nuisance Flood + Low Sea Level Rise of 3”

#3 • Year 2030, Nuisance Flood + High Sea Level Rise of 7”

#4 • Year 2060, Nuisance Flood + Low Sea Level Rise of 9”

#5 • Year 2060, Nuisance Flood + High Sea Level Rise of 24”
Ten One-Time Damage Estimates

#6
- Year 2015, Wilma-Sized Storm Surge + No Sea Level Rise

#7
- Year 2030, Wilma-Sized Storm Surge + Low Sea Level Rise of 3”

#8
- Year 2030, Wilma-Sized Storm Surge + High Sea Level Rise of 7”

#9
- Year 2060, Wilma-Sized Storm Surge + Low Sea Level Rise of 9”

#10
- Year 2060, Wilma-Sized Storm Surge + High Sea Level Rise of 24”
Four Cumulative Damage Estimates

#1
- By Year 2030, From All Storms, plus Low Sea Level Rise of 3”

#2
- By Year 2030, From All Storms, plus High Sea Level Rise of 7”

#3
- By Year 2060, From All Storms, plus Low Sea Level Rise of 9”

#4
- By Year 2060, From All Storms, plus High Sea Level Rise of 24”

Note: All Storms = 1, 10, 50 & 100 year storm events
### One-Time Damages – COAST Model

<table>
<thead>
<tr>
<th>Event: 1.05 ft. Surge Nuisance Flood</th>
<th>SLR Scenario</th>
<th>One Time Damage to Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 2015</strong></td>
<td>No Sea Level Rise</td>
<td>$ 0</td>
</tr>
<tr>
<td><strong>Year 2030</strong></td>
<td>Low – 3”</td>
<td>$ 0.1 million</td>
</tr>
<tr>
<td><strong>Year 2030</strong></td>
<td>High – 7”</td>
<td>$ 0.5 million</td>
</tr>
<tr>
<td><strong>Year 2060</strong></td>
<td>Low – 9”</td>
<td>$ 0.7 million</td>
</tr>
<tr>
<td><strong>Year 2060</strong></td>
<td>High – 24”</td>
<td>$ 5.2 million</td>
</tr>
</tbody>
</table>
## One-Time Damages – COAST Model

<table>
<thead>
<tr>
<th>Event: 6 ft. Surge Wilma-Sized Flood</th>
<th>SLR Scenario (Four County Compact Sea Level Rise Projections)</th>
<th>One Time Damage to Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year <strong>2015</strong></td>
<td>No Sea Level Rise</td>
<td>$445.8 million</td>
</tr>
<tr>
<td>Year <strong>2030</strong></td>
<td>Low - 3”</td>
<td>$452.1 million</td>
</tr>
<tr>
<td>Year <strong>2030</strong></td>
<td>High – 7”</td>
<td>$518.4 million</td>
</tr>
<tr>
<td>Year <strong>2060</strong></td>
<td>Low – 9”</td>
<td>$629.7 million</td>
</tr>
<tr>
<td>Year <strong>2060</strong></td>
<td>High – 24”</td>
<td>$862.7 million</td>
</tr>
</tbody>
</table>
Cumulative Damages – COAST Model

<table>
<thead>
<tr>
<th>Timescale</th>
<th>SLR Scenario (Four County Compact Sea Level Rise Projections)</th>
<th>Cumulative Damage to Buildings by Scenario Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-2030</td>
<td>Low – 3”</td>
<td>$1.009 billion</td>
</tr>
<tr>
<td>2014-2030</td>
<td>High – 7”</td>
<td>$1.132 billion</td>
</tr>
<tr>
<td>2031-2060</td>
<td>Low – 9”</td>
<td>$2.339 billion</td>
</tr>
<tr>
<td>2031-2060</td>
<td>High – 24”</td>
<td>$4.125 billion</td>
</tr>
<tr>
<td>2014-2060</td>
<td>Low – 9”</td>
<td>$3.348 billion</td>
</tr>
<tr>
<td>2014-2060</td>
<td>High – 24”</td>
<td>$5.257 billion</td>
</tr>
</tbody>
</table>

Note: All Storms = 1, 10, 50 & 100 year storm events
### Buildings & Land Lost to Sea Level Rise – COAST Model

**TOTAL 2014 to 2060**

<table>
<thead>
<tr>
<th>SLR Scenario (Four County Compact Sea Level Rise Projections)</th>
<th>Value of Buildings Lost to Sea Level Rise by Scenario Date</th>
<th>Value of Land Lost to Sea Level Rise by Scenario Date</th>
<th>No. of Parcels Lost to Sea Level Rise by Scenario Date</th>
<th>Total Value of Buildings and Land Lost to Sea Level Rise by Scenario Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low – 9”</td>
<td>$114 million</td>
<td>$312 million</td>
<td>53</td>
<td>$426 million</td>
</tr>
<tr>
<td>High – 24”</td>
<td>$248 million</td>
<td>$543 million</td>
<td>199</td>
<td>$791 million</td>
</tr>
</tbody>
</table>

Total Number of Study Area Parcels = 6,955
199 Parcels Lost by 2060 in High Scenario = 2.8% of Total Number
Value of 199 Parcels Lost by 2060 = 8.4% of Total Assessed Value
Broward County Study Area

- Location 1 - North
Total Storm Damage = $0.1M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Total Storm Damage = $0.5M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Total Storm Damage = $0.7M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Total Storm Damage = $5.2M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Total Storm Damage = $452.1M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Total Storm Damage = $518.4M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Total Storm Damage = $629.7M for entire study area, not just for extent pictured here.

- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Wilma-sized Flood in 2060 with High SLR – Broward County Study

Total Storm Damage = $862.7M for entire study area, not just for extent pictured here.
- Removed from Asset Inventory Due to Permanent Inundation from Sea Level Rise (if no action taken)
- Building Damage from Storm Surge

For General Planning Purposes Only
Options Fall Into Four Categories

1) Do nothing.
2) Fortify.
3) Accommodate.
4) Relocate.
### Accommodate: Modify the IMPACT of water (e.g., elevate, floodproof...)

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can significantly reduce damage from both sea level rise and storm surge.</td>
<td>Can be very expensive.</td>
</tr>
<tr>
<td></td>
<td>Can be unsightly to some.</td>
</tr>
<tr>
<td></td>
<td>May reduce access to buildings during floods.</td>
</tr>
<tr>
<td></td>
<td>May still have substantial post-flood clean-ups.</td>
</tr>
</tbody>
</table>
Accommodation Examples: Elevate and Floodproof

Elevate

Floodproof

Accommodation Example: Elevate

Elevation example – “Stiltsville” near Miami
WORKSHOP 2
Thursday, March 26, 2015
I.T. Parker Community Center, Dania Beach
Participants chose to model:

- **Elevation in V-Zones (red)**
  - 75% of buildings elevated
  - Elevated to current code PLUS 2 feet

- **Floodproofing in A-Zones (green)**
  - 75% of buildings floodproofed
  - Protected to 8 feet
Action 2: Relocate Over Time

A form of rolling easement where:

- Voluntary buyouts are offered in two phases across Broward County.
  - Phase 1: for parcels expected to have high tide at their center by 2030 (red).
    - 50% participation modeled
  - Phase 2: for parcels expected to have high tide at their center by 2060 (green).
    - 75% participation modeled

Parcels in red = lost to sea level rise 2010-2030.
Parcels in green = Parcels lost to sea level rise 2030-2060.

Note:
* For parcels in red – Cash payment today with title transferring in 2020
* For parcels in green – Cash payment in 2025 with title transferring in 2030
* Voluntary buyouts not offered for undeveloped land.
### Avoided Damages by 2060 – With High or Low SLR: BENEFITS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Avoided Damages Low SLR (9”)</th>
<th>Avoided Damages High SLR (24”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action 1: Elevate &amp; Floodproof</td>
<td>$1,257.5</td>
<td>$1,791.1</td>
</tr>
<tr>
<td>Action 3: Voluntary Relocation</td>
<td>$207.6</td>
<td>$177.9</td>
</tr>
</tbody>
</table>

Figures Discounted 3.3%
## Cost Estimates By Year 2060 – For Each Action: COSTS

<table>
<thead>
<tr>
<th>Action</th>
<th>Low Cost Estimate ($ millions)</th>
<th>High Cost Estimate ($ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action 1: Elevate &amp; Floodproof</td>
<td>$57.0</td>
<td>$116.6</td>
</tr>
<tr>
<td>Action 3: Voluntary Relocation</td>
<td>$350.8</td>
<td>$526.1</td>
</tr>
</tbody>
</table>

Figures Discounted 3.3%
### Benefit Cost Ratios of Actions by Year 2060

<table>
<thead>
<tr>
<th>Action 1: Elevate &amp; Floodproof</th>
<th>Benefit/Cost Ratios – Using Low Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low SLR</td>
</tr>
<tr>
<td>Action 3: Voluntary Relocation</td>
<td>22.05</td>
</tr>
<tr>
<td>10% Participation Now, 50% in 2030</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Discounted 3.3%, Values over 1.0 are considered positive.
### Benefit Cost Ratios of Actions by Year 2060

<table>
<thead>
<tr>
<th>Action</th>
<th>Low SLR</th>
<th>High SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevate &amp; Floodproof</td>
<td>10.78</td>
<td>15.35</td>
</tr>
<tr>
<td>Voluntary Relocation</td>
<td>0.39</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Discounted 3.3%, Values over 1.0 are considered positive.
### Polling Questions

1. **Floodproof & Elevate:** Given the results of the COAST model do you think this action deserves further study by Broward County?

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>91%</td>
<td>50</td>
</tr>
<tr>
<td>No</td>
<td>9%</td>
<td>5</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td>55</td>
</tr>
</tbody>
</table>

6. **Relocate Over Time:** Given the results of the COAST model, do you think this action deserves further study by Broward County? (Multiple Choice)

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>78%</td>
<td>42</td>
</tr>
<tr>
<td>No</td>
<td>22%</td>
<td>12</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td>54</td>
</tr>
</tbody>
</table>
### Polling Questions

2. **Floodproof & Elevate:** Do you think Broward County should require elevations of structures in Broward County after they are damaged by more than 50% by a storm surge event to a higher level than the current code requires? (such as the 100 year flood height plus 2 or 3 feet versus just the 100 year flood height as required today in most jurisdictions?)

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>80%</td>
<td>45</td>
</tr>
<tr>
<td>No</td>
<td>20%</td>
<td>11</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td>56</td>
</tr>
</tbody>
</table>

3. **Floodproof & Elevate:** Do you think Broward County should pursue sources of funding to help private property owners elevate properties located in the FEMA V-zone as a way to prevent storm surge damage?

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>52%</td>
<td>29</td>
</tr>
<tr>
<td>No</td>
<td>48%</td>
<td>27</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td>56</td>
</tr>
</tbody>
</table>
### Polling Questions

#### 4. Floodproof & Elevate: Do you think Broward County should pursue sources of funding to help private property owners flood-proof their properties located in the FEMA A zone as a way to prevent storm surge damage?

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>58%</td>
<td>32</td>
</tr>
<tr>
<td>No</td>
<td>42%</td>
<td>23</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td>55</td>
</tr>
</tbody>
</table>

#### 5. Floodproof & Elevate: After looking at the model results and participating in the group discussions of the two actions modeled, do you prefer the "floodproof and elevate" option over "voluntary relocation"?

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>57%</td>
<td>32</td>
</tr>
<tr>
<td>No</td>
<td>43%</td>
<td>24</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td>56</td>
</tr>
</tbody>
</table>
Polling Questions

• Next steps:
  • Completion of report on modeling and workshops by Catalysis
  • Preparation of webpage presenting findings
  • Adaptive Capacity Index report
Questions?

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