Building Resilience
Hazard Assessment and Design

Peer-to-Peer Network Meeting

Friday, February 15, 2019
COMMUNITY-BASED SUSTAINABLE DEVELOPMENT

New Ecology’s work is to bring the benefits of sustainable development to the community level, with a concerted emphasis on underserved populations. A mission-driven nonprofit, we seek to address global environmental and equity issues by making the built environment more efficient, healthier, durable, and resilient. We are nationally recognized for our work on affordable and multifamily housing, community and government buildings, educational facilities, renewable energy and local infrastructure and for the positive effect we have on the people who live and work in these places.
Outline

• What and why?
• Mapping - Communities, Governments, and Institutions
• Hazard Assessment – Vulnerability and Risk
• NEI’s Building-Level Approach, Examples, and Design
• Financing Resilience
• Workshop Exercise
• Q&A
What is Resilience?
Adapting to changing climate.

Why now?
Abnormal is the new normal.
Last year is the hottest year on record for the third consecutive year. In a database of more than 5,000 cities provided by AccuWeather, about 90 percent recorded annual mean temperatures higher than normal. Enter your city below to see how much warmer (or cooler) it was.

**Philadelphia, Pa.**

- **Temperature**: Average: 59.4°F, 2.5°F above normal

**Precipitation**

- Total: 35.3" = 6.3" less

Cumulative monthly precipitation, in inches, compared with normal. Precipitation totals are rainfall plus the liquid equivalent of any frozen precipitation.
GE to sell Fort Point HQ, give back $87 million to state

Work was underway in August on General Electric's Fort Point offices. —David L. Ryan/The Boston Globe

By The Boston Globe updated at 2:03 PM
Predicted Disasters

- Rain and flooding
- Snow
- Storm
- Tornado
- Drought
Sudden Disasters

- Fire
- Terrorist attack
- Mechanical failure
- IT security breach
Chronic Hazards

- Pests
- Mold
- Extreme heat
Mapping
Communities, Governments, Institutions
National Climate Assessment

The National Climate Assessment summarizes the impacts of climate change on the United States, now and in the future.

A team of more than 300 experts guided by a 60-member Federal Advisory Committee produced the report, which was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences.

GlobalChange.gov
U.S. Global Change Research Program

2014 National Climate Assessment, U.S. Global Change Research Program
1800 G Street, NW, Suite 9100, Washington, D.C. 20006 USA
Tel: +1 202 334 6300 | Fax: +1 202 334 9300 | Contact Us | Privacy Policy | Site Map
Climate Data Grapher

User-generated time series graphs of climate data, both observed and projected (future and historical). A video tutorial on how to use the Climate Data Grapher can be found [here](#).

More...
CREST Maps

The results of the mapping tasks associated with the CREST project can be found in the [Map Viewer](#).

There are four main sections of maps:

1. and 2. Old Saybrook Study Area and New Haven Study Area

Two 4-mile pilot areas were selected and studied in detail. Each area contains:

- Detailed analysis of existing coastal structures, defined [here](#) as either shore or inland, either hard, medium or soft, and as either natural or not. MHW stands for Mean High Water.
- Shoreline photos were taken in high density along the two pilot areas and are indicated by a yellow dot. In the map viewer, click on each yellow dot to view the photo. Click on the photo itself to make it bigger.

To go directly to the study areas in the map viewer, look for this button in the upper right.

2. Wave Nodes and NOAA Buoys

Five points distributed along the shore of Connecticut in Long Island Sound were chosen as locations for reporting results from the wave modeling work. They are shown by a red square and are numbered.

There is a page for each point, 8797, 12470, 15631, 16339, 18277, as well as some information in the map when the point is clicked. The blue squares are two NOAA buoys.
We help cities around the world become more resilient to the physical, social, and economic challenges that are a growing part of the 21st century.
CLIMATE READY DC
The District of Columbia’s Plan to Adapt to a Changing Climate
Fig. 10  Inland Flooding - 100-year 24-hour storm (Source: Kleinfelder with manhole flooding by MWH, riverine flooding by VHB, November 2015)
Fig. 15 **Number of days above 90°F** (Source: Kleinfelder based on ATMOS research, November 2015)
Hazard Assessment
Vulnerability and Risk
# Identify Hazards

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Flooding</td>
<td>Carbon Monoxide Poisoning</td>
</tr>
<tr>
<td>Coastal Erosion</td>
<td>Disease</td>
</tr>
<tr>
<td>Drought</td>
<td>Emergency Communications Failure</td>
</tr>
<tr>
<td>Inland Flooding and Stormwater</td>
<td>Heat Outage</td>
</tr>
<tr>
<td>Extreme Heat</td>
<td>Mold</td>
</tr>
<tr>
<td>Extreme Cold</td>
<td>Pest Range Expansion</td>
</tr>
<tr>
<td>Major Thunderstorm</td>
<td>Power Outage</td>
</tr>
<tr>
<td>Snow or Ice Storm</td>
<td>Toxin Exposure</td>
</tr>
<tr>
<td>Terrorist Attack</td>
<td>Water Outage</td>
</tr>
<tr>
<td>Tornado</td>
<td></td>
</tr>
<tr>
<td>Urban Fire</td>
<td></td>
</tr>
</tbody>
</table>
Vulnerability and Risk Assessment

Vulnerability – **Sensitivity** to a hazard and the **capacity to adapt** to the hazard.
Vulnerability and Risk Assessment

Risk – Likelihood and consequence of a hazard.
# Vulnerability and Risk Assessment

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Vulnerability</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity</td>
<td>Adaptive Capacity</td>
</tr>
<tr>
<td>Stormwater Flooding</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Sewer Backup</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Tornado</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>High Winds</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
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<td>Medium</td>
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<tr>
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</table>
NEI’s Approach: Existing Buildings
DC LAUNCHES NATION’S FIRST MULTIFAMILY HOUSING RESILIENCE TOOL

DC Department of Energy and Environment Launches Nation’s First Multifamily Housing Resilience Tool to Support Preservation of Capital’s Affordable Housing Stock

Funding from Department of Energy and Environment granted to Enterprise Community Partners, working in partnership with New Ecology, Inc., the National Housing Trust and Clean Energy Group

WASHINGTON, D.C. – Dec. 14, 2017 – Soon, affordable housing owners in the District of Columbia will have new tools to promote resilience and resource conservation in their buildings. Through funding from the District’s Department of Energy and Environment (DOEE) Solar for All program, Enterprise Community Partners (Enterprise) announced today that it has assembled a new team of advisors with New Ecology, Inc., the National Housing Trust and Clean Energy Group to develop a vulnerability and resilience opportunity assessment tool for affordable housing owners to promote sustainability and resilience in their properties. The project will advance the goals of Climate Ready DC, the DC’s plan to prepare for the impacts of climate change including heatwaves, flooding, and severe storms.

The program seeks to influence the broader affordable housing sector to design, develop and operate climate-resilient, energy-efficient and solar-ready homes. Nearly 19 million families nationwide are housing insecure, either homeless or paying more than half of their monthly income on housing, and climate change aggravates an already short supply of affordable housing. Enterprise believes that this program will help catalyze the affordable housing industry in the District and around the nation to strategically integrate resilience planning in their development, operations, and preservation plans.
Example 1
Masonry Multifamily
High Rise

Building Characteristics

- Norfolk, NE
- Fork in the Elkhorn River, FEMA 1% Annual Chance Flood Zone behind Unaccredited Levee
- Built in 1972
- 9 Floors
- 92 1BR Affordable Units
Hazards

- Stormwater Flooding and Sewer Backup
- Tornado and High Winds
- Extreme Heat and Cold
- Extended Electric, Gas, and Water Outage
### Example Audit 1
Masonry Multifamily
High Rise

**Vulnerability and Risk**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Vulnerability</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity</td>
<td>Likelihood</td>
</tr>
<tr>
<td></td>
<td>Adaptive Capacity</td>
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<tr>
<td>Stormwater Flooding</td>
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</tr>
</tbody>
</table>
# Develop and Implement Measures

<table>
<thead>
<tr>
<th>Rank</th>
<th>Hazard</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stormwater Flooding</td>
<td>Flood Barriers, Perimeter Drains, Elevate Electrical Panels, Relocate Hazardous Chemicals, Elevator Controls</td>
</tr>
<tr>
<td>2</td>
<td>Tornado</td>
<td>Structural and Glazing Wind Loading Review, Remove Roof Ballast Stone</td>
</tr>
<tr>
<td>2</td>
<td>Sewer Backup</td>
<td>Backflow Preventer</td>
</tr>
<tr>
<td>3</td>
<td>Extended Water Outage</td>
<td>Potable Water Storage</td>
</tr>
<tr>
<td>4</td>
<td>Extreme Cold</td>
<td>Insulate, Air Seal, Replace Windows</td>
</tr>
<tr>
<td>4</td>
<td>Extreme Heat</td>
<td>(see Extreme Heat)</td>
</tr>
<tr>
<td>5</td>
<td>High Winds</td>
<td>Structural and Glazing Wind Loading Review, Remove Roof Ballast Stone</td>
</tr>
<tr>
<td>6</td>
<td>Extended Electric Outage</td>
<td>Backup Generator</td>
</tr>
</tbody>
</table>
Scenario: Flood

- Unaccredited Levee
- 1% Annual Chance Flood
- History of Flooding
- Continued Occupancy and Building Systems Operations
- Rapid Removal of Water and Repair
Example 2
Commercial Office Building

Building Characteristics

• Stamford, CT
• Close Proximity to Rippowam River
• Built in 1986
• 10 Floors
• 250,000 Square Feet
• City Emergency Operations Center
Hazards

- Coastal Flooding, Stormwater Flooding and Sewer Backup
- Extreme Heat
- Extended Electric Outage
## Develop and Implement Measures

<table>
<thead>
<tr>
<th>Rank</th>
<th>Hazard</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All</td>
<td>Emergency Management Manual</td>
</tr>
<tr>
<td>2</td>
<td>Extreme Heat</td>
<td>Cool Roof, Window Shading, Window Replacement</td>
</tr>
<tr>
<td>2</td>
<td>Flooding</td>
<td>Backwater Valves, Surface Stormwater Management</td>
</tr>
<tr>
<td>3</td>
<td>Extended Power Outage</td>
<td>Quick Connects for Mobile Equipment, Solar+Storage</td>
</tr>
<tr>
<td>4</td>
<td>Extended Water Outage</td>
<td>Potable Water Storage</td>
</tr>
</tbody>
</table>
Backwater valves are installed where the wastewater pipe exits the building, so sewage only flows outward. Valves have a hinged flapper that remains open to allow outward flow, but seals tightly if there is backpressure.

Backwater valves are situated above the external sewer line and should be installed in buildings that have sewer connections below the highest manhole cover in the sewer system, especially if the property is within the Special Flood Hazard Area (SFHA). Although sewer blockage can occur any time, it is most likely to happen during storms when large amounts of water and debris move through the system.
Co-Benefits: Cost Savings

Solar PV + Battery Storage

- Reduced electricity demand charges, backup power supply, more electricity generated on site used on site
Example 3
Multifamily Low Rise

**Year Built:** 1963  
**Most Recent Year Rehabbed:** 2000  
**Total Square Feet:** 118,716  
**Total # Apartments:** 202  
**Total # Bedrooms:** 329  
**Total # Stories:** 2 and 3  
**Basement? Conditioned?:** Yes, yes  
**Water Meter Configuration:** 1 meter per building  
**Electric Meter Configuration:** 220 tenant, 16 common meters
Because of hydrostatic pressure, component floodproofing barriers should be designed to a maximum of 3 ft.

Image: Colin Hayes.

Dry component floodproofing is often an effective solution for equipment that cannot be elevated or relocated out of basements.

Image: MAP Architects, New York Engineers.
Co-Benefits

Measure with Co-Benefits

• Insulation, Air Sealing, and Window Replacement
  • Heating and Cooling Energy Savings,
    Improved Passive Survivability, Improved
    Wind Load Performance, Improved Comfort,
    Improved Functionality, Reduced
    Maintenance

Measure without Co-Benefits

• Backup Generator
  • Increased Building Services, Increased
    Operations and Maintenance Costs
<table>
<thead>
<tr>
<th>Recommended Measure</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated Electrical Equipment</td>
<td>$50,000</td>
</tr>
<tr>
<td>Mold Remediation</td>
<td>$75,000</td>
</tr>
<tr>
<td>Sump Pumps</td>
<td>$3,000</td>
</tr>
<tr>
<td>Backwater Valves</td>
<td>$55,000</td>
</tr>
<tr>
<td>Building Floodproofing</td>
<td>$640,000</td>
</tr>
<tr>
<td>Cool Roof</td>
<td>$225,000</td>
</tr>
<tr>
<td>Surface Stormwater Management</td>
<td>$165,000</td>
</tr>
<tr>
<td>High Efficiency Ventilation</td>
<td>$1,315,000</td>
</tr>
<tr>
<td>Develop Emergency Management Manual</td>
<td>O&amp;M</td>
</tr>
</tbody>
</table>
Co-Benefits: Cost Savings

Solar PV + Battery Storage

- Reduced electricity demand charges, backup power supply, more electricity generated on site used on site
NEI’s Approach: Design
New Ecology, Inc. | Boston/Providence/Baltimore/Wilmington | Community-Based Sustainable Development

- HVAC, DHW on Roof
- Apartments Above Parking
- Passive House Envelope Design
- Backup LED Lights, Cell Phone Charging
- BFE = 8'
- 8’ + 5’ = 13’
- 8’
- Conditioned Community Resilience Space
- Backflow Prevention
- Generator with 72-hour Runtime
- Stormwater Storage and Infiltration
Financing Resilience

- Capital planning and investment timing
- Avoids future losses but does not generate cash flows
- Benefit-cost analysis demonstrates the business case
- Relate payments to benefits and account for ability to pay
CT Resilience Resources

circa.uconn.edu/stamford-resilience/
Exercise

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Are ground-level apartments located above the base flood elevation (BFE, the elevation to which floodwaters are expected to rise in a 1% annual chance or 100-year flood)?</td>
</tr>
<tr>
<td>1</td>
<td>Wet Floodproofing</td>
</tr>
<tr>
<td>11</td>
<td>Elevated Living Spaces</td>
</tr>
</tbody>
</table>
Q&A
Thank you!

Tom Chase
Senior Project Manager
New Ecology, Inc.
chase@newecology.org