Stormwater, flooding & climate change
• Water
• Land use & climate adaptation
• Geospatial (mapping) technology
The view from Chez Arnold...
We are an urbanizing state/region/country.
CT land cover change: 1985 - 2010
Developed = 946 $\text{mi}^2$

Turf = 384 $\text{mi}^2$

The “development footprint”...
Impervious Surfaces
Hydrologic Impacts of Development

- More Runoff
- Arriving Faster
The Effects of Urbanization

Falls River, Essex
The Effects of Urbanization

Goodwives River, Darien
The Effects of Urbanization

Trout Brook(?!), West Hartford
The Effects of Urbanization: Park River, CT
43,000 ft^2 of impervious area

1 inch of rain = 26,810 gallons

Annual (48”) = 1,286,880 gallons

= 2 Olympic pools!
Yeah, but is it really that big of a deal?
Stormwater is the #1 source of water pollution in the U.S. (US EPA)
Driven by Climate Change, Algae Blooms Behind Ohio Water Scare Are New Normal

Climate change and increased runoff are triggering more potentially toxic blooms.
More towns (basically, everybody) covered
State and federal properties covered
Same 6 “minimum management measures”
but:
  • More detailed guidance/requirements
  • Heavy emphasis on green infrastructure
  • Stronger maintenance requirements
Cities with Combined Sewers
CSOs in NYC are triggered by as little as 0.05” of rain
Early Thursday morning the plant experienced the highest level of water flow ever recorded…

“Early Thursday morning the plant experienced the highest level of water flow ever recorded…”
Day after **historic rainfall**, help for residents as cleanup continues

Road closures across Long Island as heavy rain falls

Roads across Long Island were flooded Wednesday morning, Aug. 13, 2014, by heavy rain that began overnight. The flooding snarled the morning commute and caused delays and cancellations on the Long Island Rail Road. (Credit: Newsday / Staff)

Related media

On the morning after a storm of biblical proportions deluged Long Island with "historic" and even "deadly" amounts of rainfall, residents were

**Flooding**

August 13, 2014
Erosion

Large portions of Vermont arriving at Long Island Sound after Irene...
Infrastructure Meltdown

Google this!
A partial list of road closings during 2013 Colorado flooding

- U.S. 287 at Big Thompson River in Loveland from Colorado 402 to 5th Street
- U.S. 287 southbound at Wyoming line for commercial vehicles
- Colorado 7 between Lyons and Estes Park
- Colorado 8 between Morrison and U.S. 285
- Colorado 14 between Ted's Place and Walden
- Colorado 30 (Havana Street/Aurora) at Alameda Avenue
- Colorado 44 (104th Avenue) at Riverdale Road
- Colorado 52 eastbound from County Road (CR) 1 to U.S. 287
- Colorado 60 at CR 46
- Colorado 66 between 53rd Street (Longmont) and Lyons
- Colorado 66 between CR 13 and CR 19
- Colorado 72 between 72nd and 80th avenues
- Colorado 72 between Colorado 93 and Colorado 119 (Coal Creek Canyon)
- Colorado 74 between CR 73 (Evergreen) and Morrison
- Colorado 83 (Parker Road) between Florida and Jewell avenues
- Colorado 93 between 64th Avenue and Colorado 128
- Colorado 119 between Boulder and Nederland (Boulder Canyon)
- Colorado 119 between County Line Road and I-25
- Colorado 257 between Colorado 60/Milliken to U.S. 34

Roads that have reopened include:
- U.S. 6 (Vasquez Boulevard) between 60th and 74th Avenues
- U.S. 36 eastbound from Table Mesa Drive to 96th Street
- Colorado 255 (Old Brighton Road) at Colorado Boulevard in Commerce City

Photo By Tim Rasmussen/The Denver Post
Infrastructure meltdown of the geyser kind
“Now a major insurance company is suing Chicago-area municipal governments saying they knew of the risks posed by climate change and should have been better prepared.”…

“The storms are not an act of God, the suit claimed, but a carbon-driven reality...”
Liability, continued

“A frog-fearing New York state man has won a $1.6 million payout [from his town] after a developer drained so much storm water onto his property it turned into a wetland inundated with the slimy amphibians.”
And more to come...

All studies indicate more rainfall, and more intense rainstorms, in the Northeastern U.S.
Our soggy prospects: more rain

100 Years of Precipitation Data for CT

Annual precipitation (inches)

Our soggy prospects: more intense storms

In this study, a range of definitions for extreme precipitation was examined to provide a robust indicator of climate change in the Northeastern United States. All of the definitions...indicate that the occurrences of extreme precipitation events, and the intensity of rainfall, are increasing.
Decadal average anomalies for the number of 2-day, 5-year precipitation events (difference between the decade and the 1901-1960 average precipitation) for the contiguous U.S.
From the National Climate Assessment

Observed Change in Very Heavy Precipitation

Change (%)

- <0
- 0-9
- 10-19
- 20-29
- 30-39
- 40+

-12% 5% 12% 16% 37% 27% 71% 33%
“...the frequency of 2 inch rainfall events has increased since the 1950s and storms once considered a 1 in 100 year event have become more frequent. Such storms are now likely to occur almost twice as often.”

Past Extreme Rainfall Analyses

The National Weather Service (NWS) has been conducting extreme rainfall analyses since the mid-20th century. The NWS climatology includes almost 50 additional years of data. The National Weather Service is working with research partners at the Northeast Regional Climate Center (NRCC) to enhance the regional analysis of extreme rainfall events. The Findings of the latest regional analysis extend the NWS climatology to the New England region and are used to calculate the probability of extreme rainfall events. The Mid-Atlantic analysis extends as far north as Pennsylvania and thus excludes New York and New England. In these states, several regional and state-specific extreme rainfall analyses were conducted in the 1980 and early 2000s, but even these analyses are over a decade old and differences in the data records used do not provide a consistent regional analysis of rainfall extremes.

Extreme Rainfall Since the 1960s

The previous climatologies have been based on the premise that the extreme rainfall series do not change through time. Therefore it is assumed that older analyses reflect current conditions. Recent analyses show that this is not the case, particularly in New York and New England where the frequency of 2 inch rainfall events has increased since the 1950s and storms once considered a 1 in 100 year event have become more frequent. Such storms are now likely to occur almost twice as often.
Storm Frequency Analysis

100 year flood? 500 year storm?

- Probability of occurrence of a given precipitation event
- Based on magnitude and duration of a rainfall event, e.g., “the 100-year, 24 hour storm is 8.1 inches”
- Calculated from past data for a measurement location
## Probability and Return Period

<table>
<thead>
<tr>
<th>Recurrence interval (years)</th>
<th>Probability of occurrence in any given year</th>
<th>Percent chance of occurrence in any given year</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1 in 100</td>
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</tr>
<tr>
<td>50</td>
<td>1 in 50</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>1 in 25</td>
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<td>1 in 10</td>
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</tr>
<tr>
<td>5</td>
<td>1 in 5</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>1 in 2</td>
<td>50</td>
</tr>
</tbody>
</table>
Technical Paper 40 (TP-40)

- NOAA report published in 1961
- Rainfall data for every county in the country
  - Frequency/recurrence intervals of 1 yr to 100 years
  - Storm durations of 30 minutes to 4 days
The “100-yr storm” is the new 50

<table>
<thead>
<tr>
<th>Recurrence Interval</th>
<th>TP-40 (in)</th>
<th>Updated values (in)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5</td>
<td>2.80</td>
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<tr>
<td>5</td>
<td>4.0</td>
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<tr>
<td>100</td>
<td>7.0</td>
<td>8.25</td>
</tr>
</tbody>
</table>

Probability model for New London, CT, updated with recent rainfall data.
Future considerations & strategies
1. Updated info & guidance

A Revised TP-40?: “ATLAS-14”

-- Longer period of record
-- Denser data network
-- Greater ranges of durations and recurrence
2. Better analysis and monitoring
3. Major infrastructure projects

**Tunnels & Conduits**

- **South & North Tunnel**
  - South Tunnel is under design
  - Construction will begin 2014
  - Deep rock tunnel with 19 foot diameter and 2.5 miles long
Roads & stream crossings

- identify priority flood-prone areas
- Revise drain and culvert standards based on the new precipitation regime
- Build this into the capital expenditures plan
Drainage systems

- identify priority flood-prone areas
- Revise drain and pipe standards based on the new precipitation regime
- Build this into the capital expenditures plan
4. Green Infrastructure
Major urban centers leading the way

Philadelphia AFTER Green City, Clean Waters Initiative

NRDC Switchboard Blog
UConn campus
5. Policy & planning revisions

100-Year Floodplains in the Lamprey River Watershed:
Flood Insurance Rate Maps (FIRMs), Updated (2005) Conditions, and 2100 Conventional Buildout

Map Description:
[Map details and legend]

1. [Map area 1]
2. [Map area 2]
3. [Map area 3]
Planning & policy revisions, the sequel

New Floodplain Maps for a Coastal New Hampshire Watershed and Questions of Legal Authority, Measures and Consequences

National Sea Grant Law Center Grants Program
University of Mississippi

Produced by the Vermont Law School Land Use Clinic

June 2012

Supreme Court jurisprudence provides some indication that some courts are willing to amend their zoning regulations to avoid still numerous case-by-case circumstances.

Compensable regulatory taking has occurred.
Barriers to Action by Town Type

<table>
<thead>
<tr>
<th>Type of Barrier</th>
<th>Coastal (n=24&lt;sup&gt;1&lt;/sup&gt;)</th>
<th>Riverine (n=44&lt;sup&gt;2&lt;/sup&gt;)</th>
<th>Inland (n=89)</th>
<th>All types (n=151&lt;sup&gt;3&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of funding</td>
<td>66%</td>
<td>75%</td>
<td>71%</td>
<td>71%</td>
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<tr>
<td>Insufficient state/federal coord.</td>
<td>42%</td>
<td>50%</td>
<td>43%</td>
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<tr>
<td>Lack of public information</td>
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<td>45%</td>
<td>33%</td>
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<td>Other issues take priority</td>
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<td>39%</td>
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<td>Climate change skepticism</td>
<td>8%</td>
<td>18%</td>
<td>34%</td>
<td>26%</td>
</tr>
<tr>
<td>Insufficient private/public coord.</td>
<td>13%</td>
<td>18%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td>Insufficient staff</td>
<td>13%</td>
<td>16%</td>
<td>21%</td>
<td>19%</td>
</tr>
<tr>
<td>Other barriers</td>
<td>8%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
</tbody>
</table>

<sup>1</sup> Coastal includes towns that are both coastal & riverine. Overlapping towns: Groton, Milford, New London, Old Saybrook, Stratford, Waterford.

<sup>2</sup> Riverine includes towns that are both coastal & riverine.

<sup>3</sup> Barrier data was gathered from 151 of 169 towns, with an 89% response rate overall.

Dr. Mark Boyer, Dept. of Political Science, UConn
Climate Adaptation Academy

Today May 5
5:30 PM
A Talk by
Julianna
Barrett
Climate Change in CT
THANKS!