Climate Trends in Massachusetts and Its Impact on River Flood Behavior

Record flooding along the Shawsheen River during the 2006 Mother’s Day Floods

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Calibrate and implement a variety of hydrologic and hydraulic models to provide:

- River flow and stage forecasts at 180 locations
- Guidance on the rainfall needed to produce Flash Flooding
- Ensemble streamflow predictions
- Ice Jam and Dam Break support
- Water Supply forecasts
- Partner with NOAA Line Offices to address issues relating to Hazard Resiliency, Water Resource Services, Ecosystem Health and Management, and Climate Change

Moderate flooding - Connecticut River at Portland, CT.
Outline

- From a “Practitioner’s Perspective”
- Rainfall/Temperature trends
- Changes in flood & drought behavior
- Challenges going forward
I've been a little busy these past 9 years!

*Job Security in the face of changing flood behavior!!*

Flooding along the Sudbury River in Wayland, MA, March 31st 2010. Photo: NERFC

Record flooding along the Fish and Saint John Rivers – northeast Maine, 4/30/2008

Providence Street – Warwick, RI at 1030 am Wednesday 3/31/10

Home washed off its foundation along the Schoharie Creek, Prattsville, NY – Tropical Storm Irene
Is there a common theme to recent events?

- Several:
  - Slow moving weather systems – a blocked up atmosphere
  - Multiple events in close succession or 1 or 2 slow movers
  - Resulted in saturated antecedent conditions
  - Each fed by a “tropical connection”
    - Plumes of deep moisture
Common themes across New England:
- Increasing annual precipitation
- Increasing frequency of heavy rains
- Warming annual temperatures
- Wildly varying seasonal snowfall

Shift in precipitation frequency (50, 100 yr – 24 hr rain)

For smaller (<800 sq mi) basins – trend toward increased flood magnitude and/or frequency
- Most pronounced where significant land use change and/or urbanization has occurred

The Eagle-Tribune had it correct: “River Raging” – May 15th, 2006

Flooding along the Sudbury River in Wayland, MA, March 31st 2010. Photo: NERFC
A Look at Temperature Trends

http://www.ncdc.noaa.gov/cag

Massachusetts, Climate Division 2, Average Temperature, January-December

- 1930-2015 Trend: +0.2°F/Decade
- 1930-2015 Avg: 47.5°F
- Avg Temperature

CT Valley to Merrimack Valley

Massachusetts, Climate Division 3, Average Temperature, January-December

- 1930-2015 Trend: +0.3°F/Decade
- 1950-2015 Avg: 49.4°F
- Avg Temperature

Eastern/Coastal Massachusetts
Change in frequency of Heavy Precipitation

- Intense precipitation events (the heaviest 1%)
- Used to average 6-8 days a year of >1” of rain or more
- Today we are averaging nearly 12-15 days!

Source: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts
Since the late 60s, similar signature of much shorter, less intense dry periods and longer higher amplitude wet periods
Closer look at drought characteristics

- Short/intense drought episodes:
  - 2014 and 2015
  - Record daily flows
    - Minimums similar to the 1960s drought!
    - But...very short duration with frequent episodes of significant recharge if not flood volumes

- Droughts of yesteryear:
  - 1964-66
  - Prolonged record lows
    - Infrequent periods of recharge
    - But far longer in duration with little significant recharge
Much of the state has seen a 1 to nearly 2 inch increase in the 24hr/100 yr storm!

Thick yellow lines represent 24 hr 100 yr values from TP-40, 1961

http://hdsc.nws.noaa.gov/hdsc/pfds/index.html
Small watersheds feeling the effects
- Changes in frequency/magnitude
- Part land use/urbanization
  - Compounded by encroachment in the floodplain
- Part changing climate

Larger basins with flood control haven’t seen as noticeable a shift
- Most USACE reservoirs are built for 6-8 inch runoff events
- Greater capacity to handle more rain

Urban “flash floods” increasing
- Storm water systems cannot handle the volume of intense rainfall

Record flooding during Mother’s Day Floods; 5/16/06. Photo: Boston Globe

Flooding from the Concord River along Elsie Ave., in Billerica, MA, April 2nd, 2014. Photo: Billerica DPW
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Prior to 1970

Data provided by NOAA and USGS.
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods from 1970-2013

Data provided by NOAA and USGS
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Per Month Prior to 1970 (18 forecast locations)
Southern New England River Basin Normalized
Number of Minor, Moderate, and Major Floods
Per Month from 1970 - 2013 (18 forecast locations)

Month
- JANUARY
- FEBRUARY
- MARCH
- APRIL
- MAY
- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER

Number of Floods
- Major Floods
- Moderate Floods
- Minor Floods

Data provided by NOAA and USGS.
Lower Merrimack River Basin Normalized Number Of Minor, Moderate, & Major Floods Per Year Prior to 1970

Data provided by USGS

Number of Floods Per Year

- Major Floods
- Moderate Floods
- Minor Floods

Location:
- WGT M3
- DNS M3
- MAY M3
- LCN M3
- LOW M3
- WLMM M3
Summary:

- The Northeast has become a “hot spot” for record floods & heavy rainfall in the past 10 years
- Noticeable trends include increased yearly rainfall and increased annual temperatures
  - Portions of Massachusetts have experienced a 1 to 2 inch shift upwards in the 100 yr – 24 hour rainfall
- Smaller watersheds & those with significant urbanization are most vulnerable to increased river & stream flooding
- Drought episodes have become shorter in duration and of a “Flash/Rapid Onset” variety
Far reaching implications:  

*Protect, Adapt or Retreat??*

- Floodplain, land use, infrastructure, dam spillway requirements, drainage requirements, non-point source runoff, bridge clearances, “hardening” of critical facilities in the floodplain, property values etc...
- Flood Insurance – work to increase participation
- How much risk are we willing to insure and accept?

Graphic courtesy of Cameron Wake, University of New Hampshire
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