Climate Trends in Massachusetts and Its Impact on River Flood Behavior

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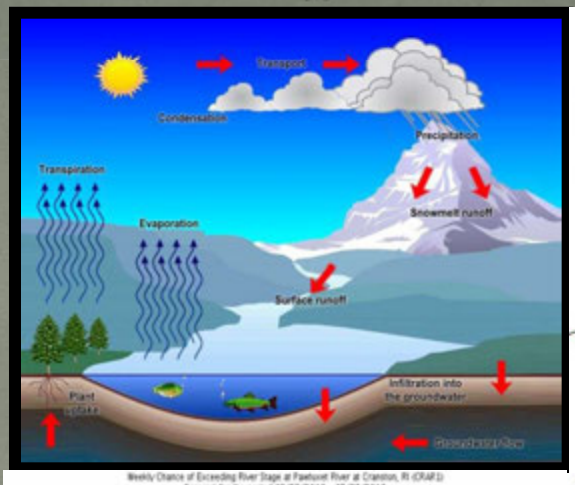
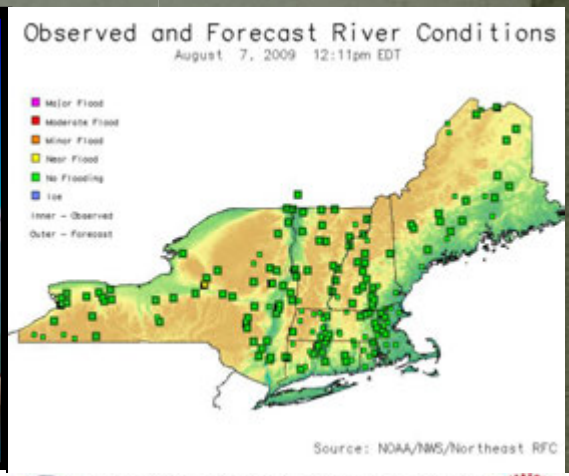
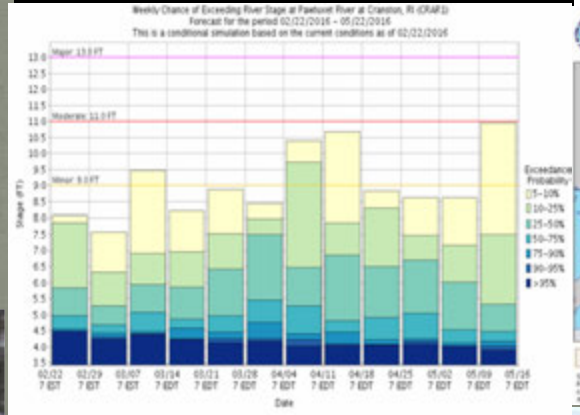
Record flooding along the Shawsheen River during the 2006 Mother's Day Floods

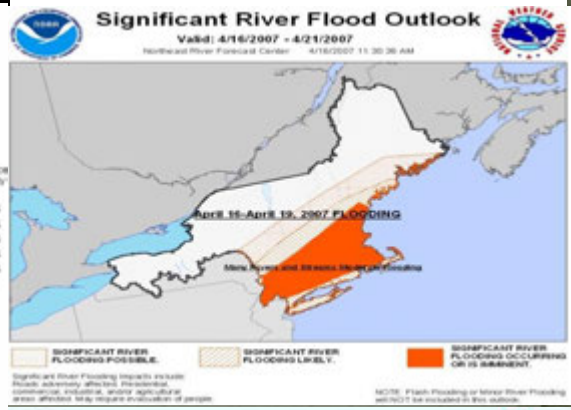
River Forecast Center Responsibilities

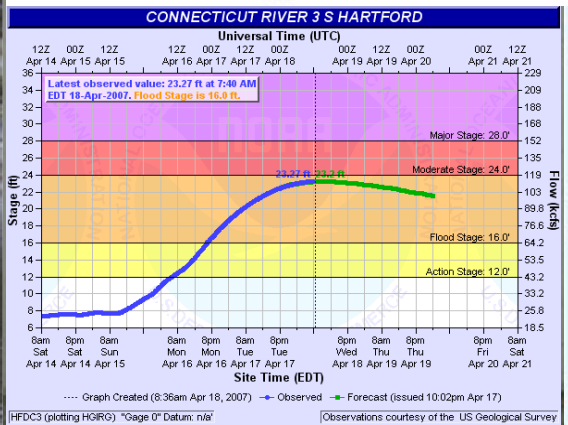
- Calibrate and implement a variety of hydrologic and hydraulic models to provide:
  - River flow and stage forecasts at 180 locations
  - Guidance on the rainfall needed to produce Flash Flooding
  - Ensemble streamflow predictions
  - Ice Jam and Dam Break support
  - Water Supply forecasts
  - Partner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

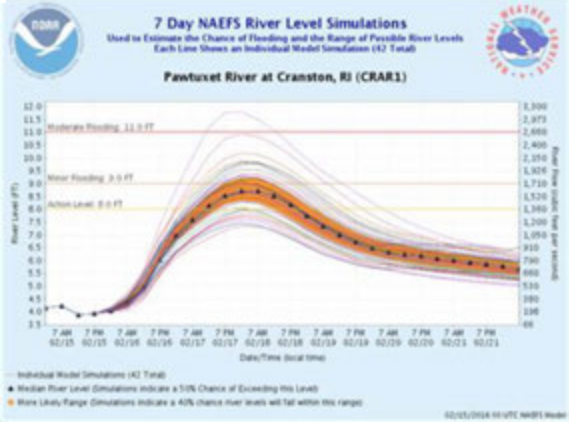












Moderate flooding - Connecticut River at Portland, CT.

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

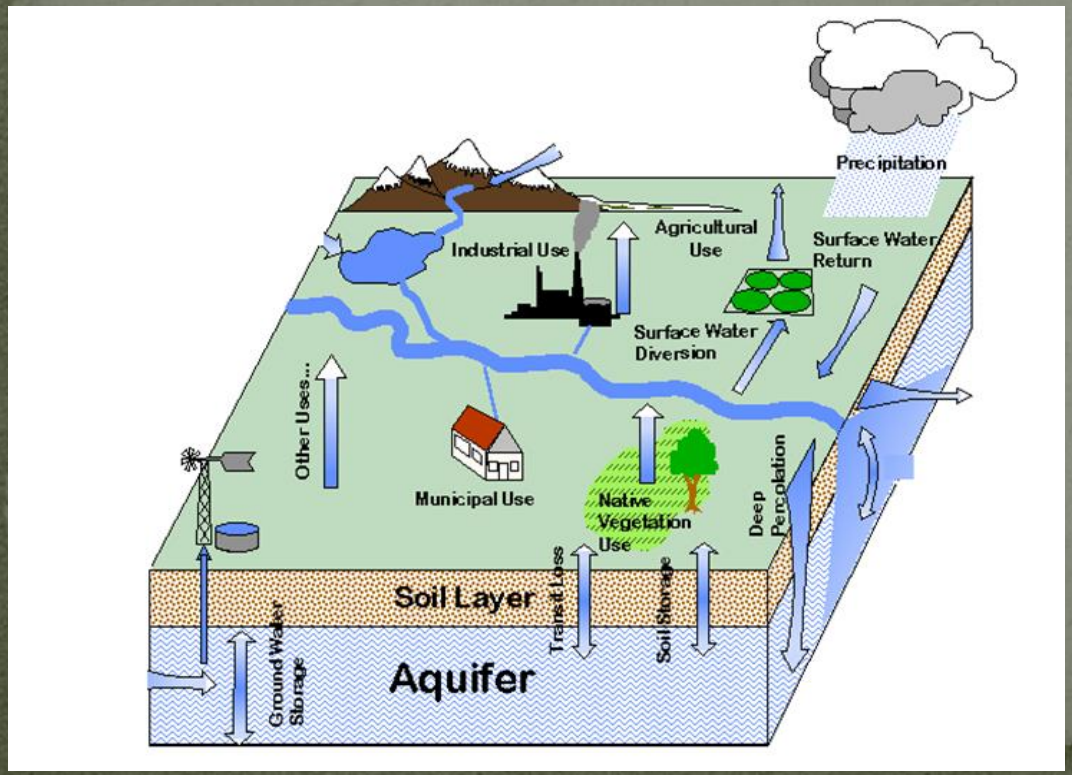
Record flooding along the Fish and Saint John Rivers – northeast Maine, 4/30/2008

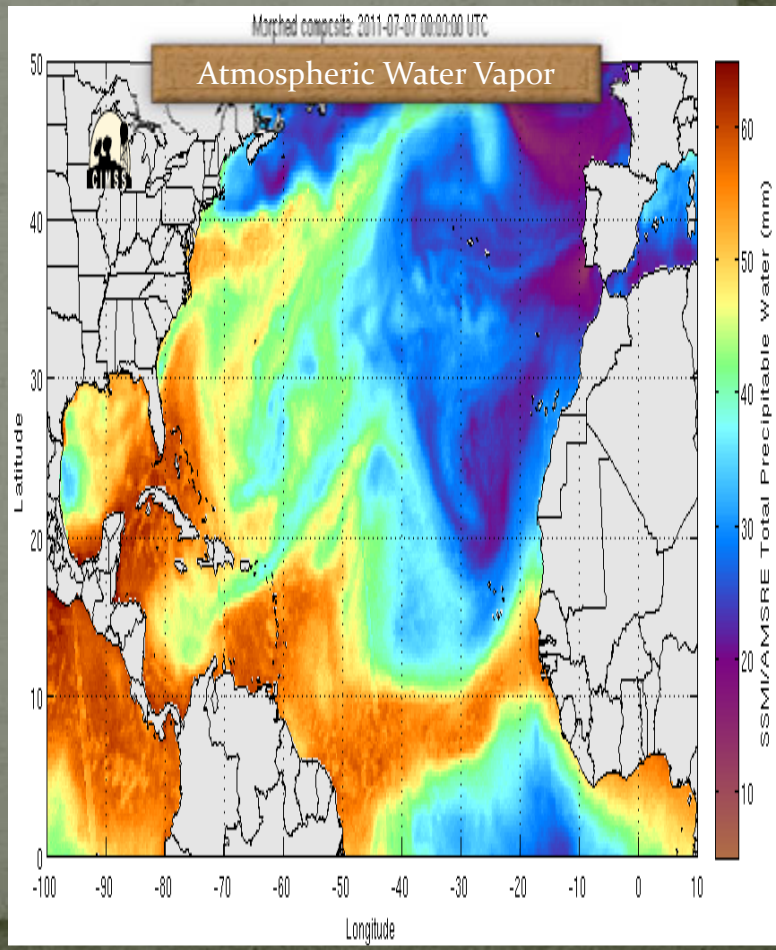
Providence Street – Warwick, RI at 1030 am Wednesday 3/31/10

Home washed off its foundation along the Schoharie Creek, Prattsville, NY – Tropical Storm Irene

Is there a common theme to recent ?

- 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





The Changing Climate

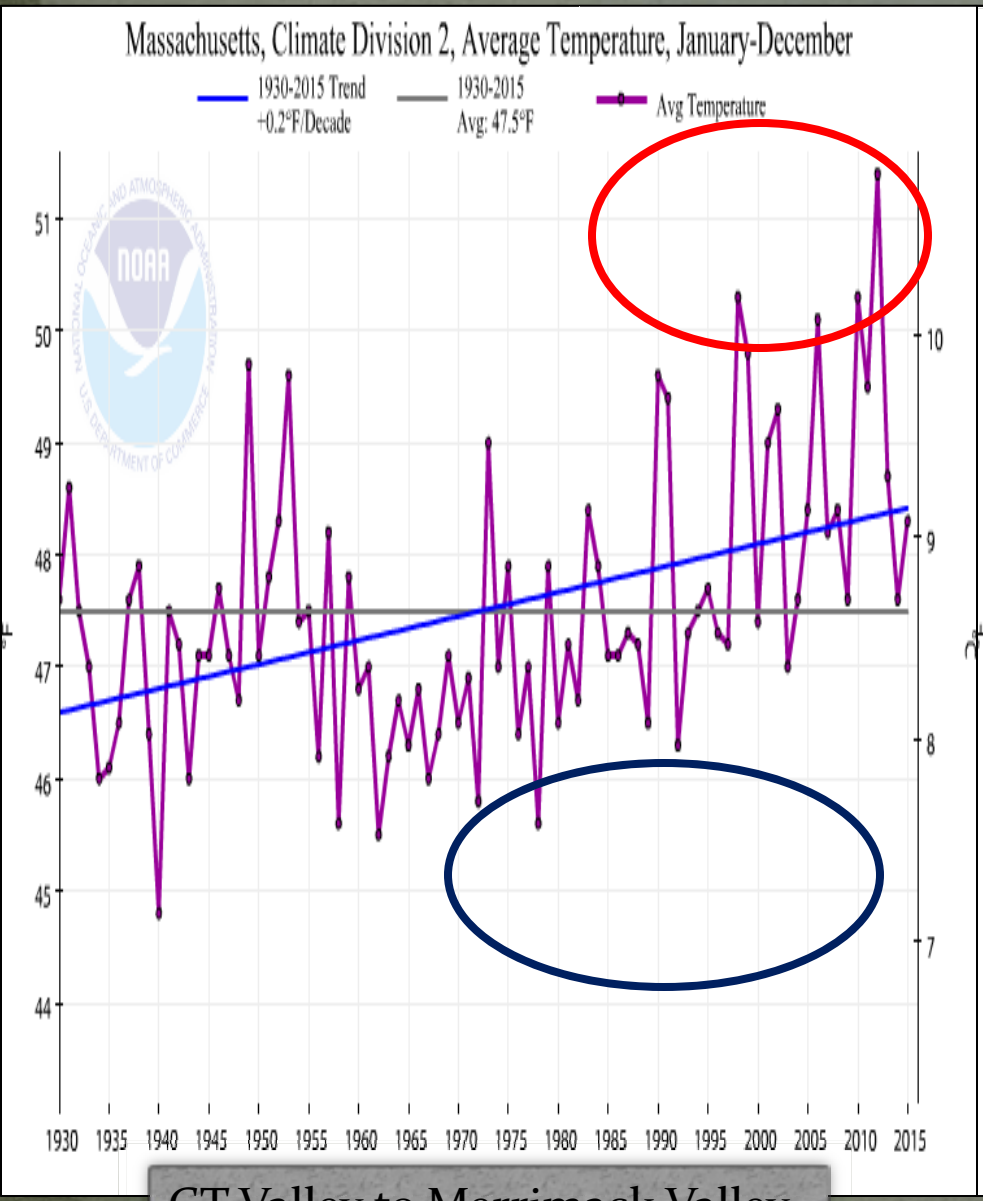
- Common themes across New England:
  - Increasing annual precipitation
  - Increasing frequency of heavy rains
  - Warming annual temperatures
  - Wildly varying seasonal snowfall
- Shift in precipitation frequency (50, 100 yr – 24 hr rain)
- For smaller (<800 sq mi) basins – trend toward increased flood magnitude and/or frequency
  - Most pronounced where significant land use change and/or urbanization has occurred

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

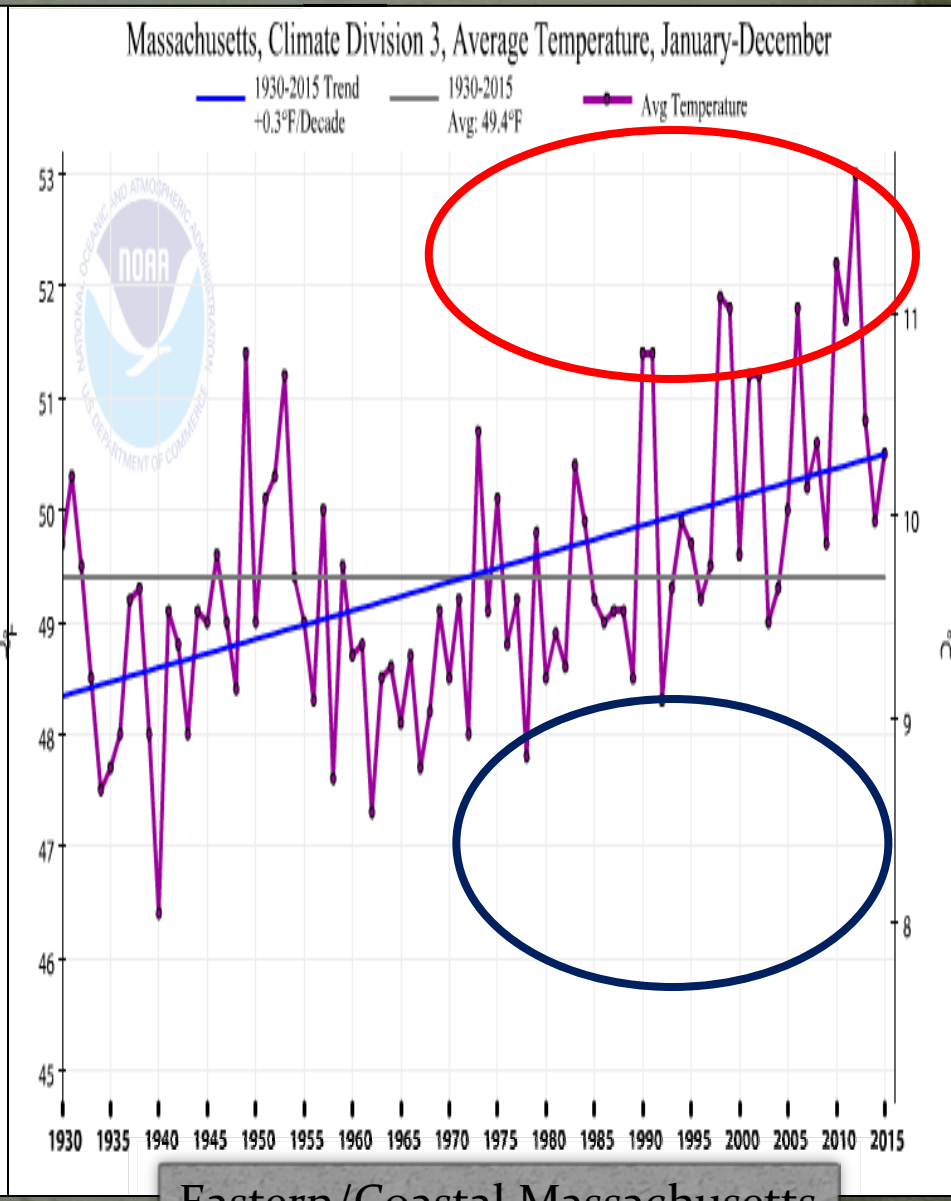
The Eagle-Tribune had it correct: "River Raging" – May 15th, 2006

A Look at Temperature Trends

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



CT Valley to Merrimack Valley



Eastern/Coastal Massachusetts

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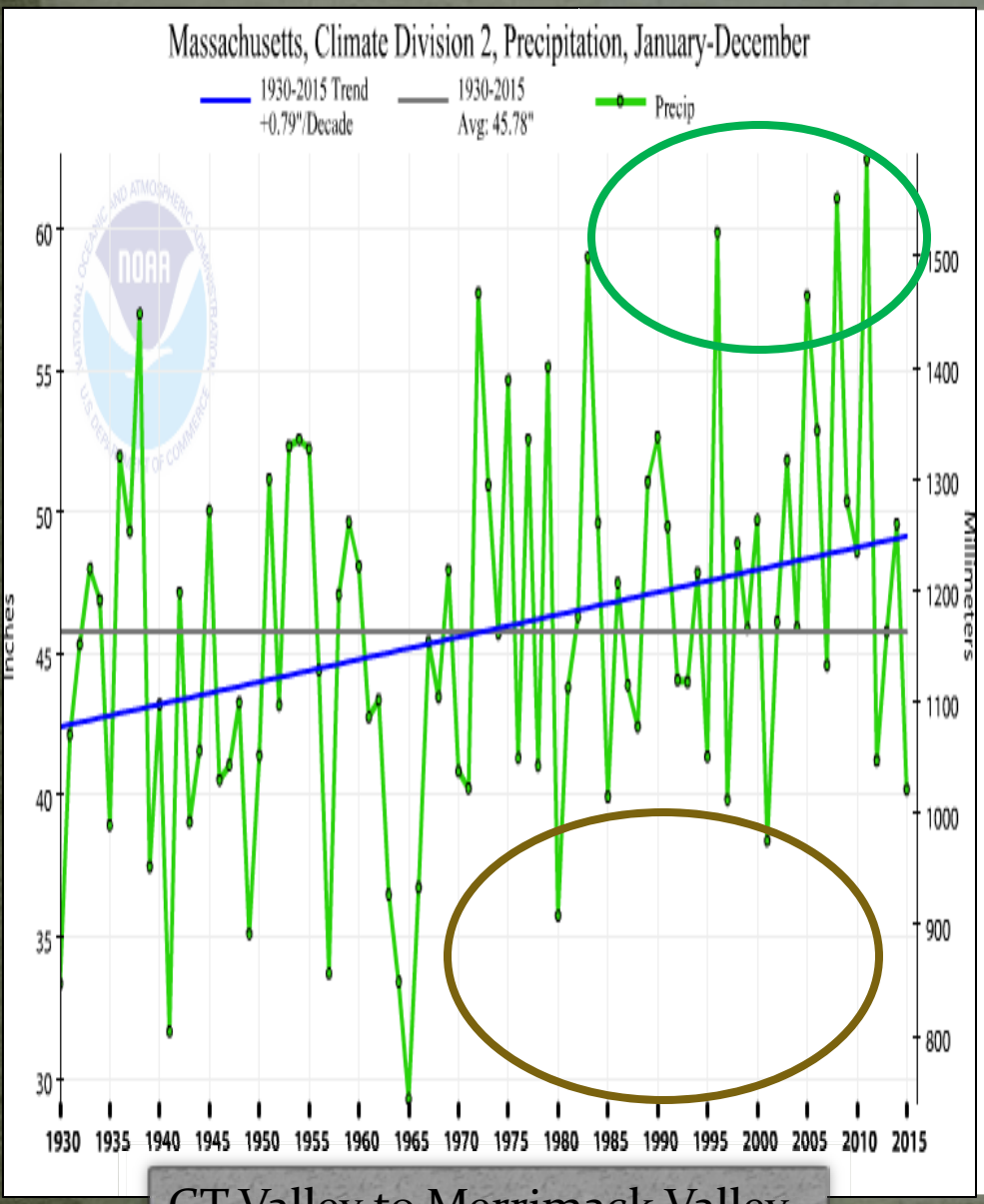

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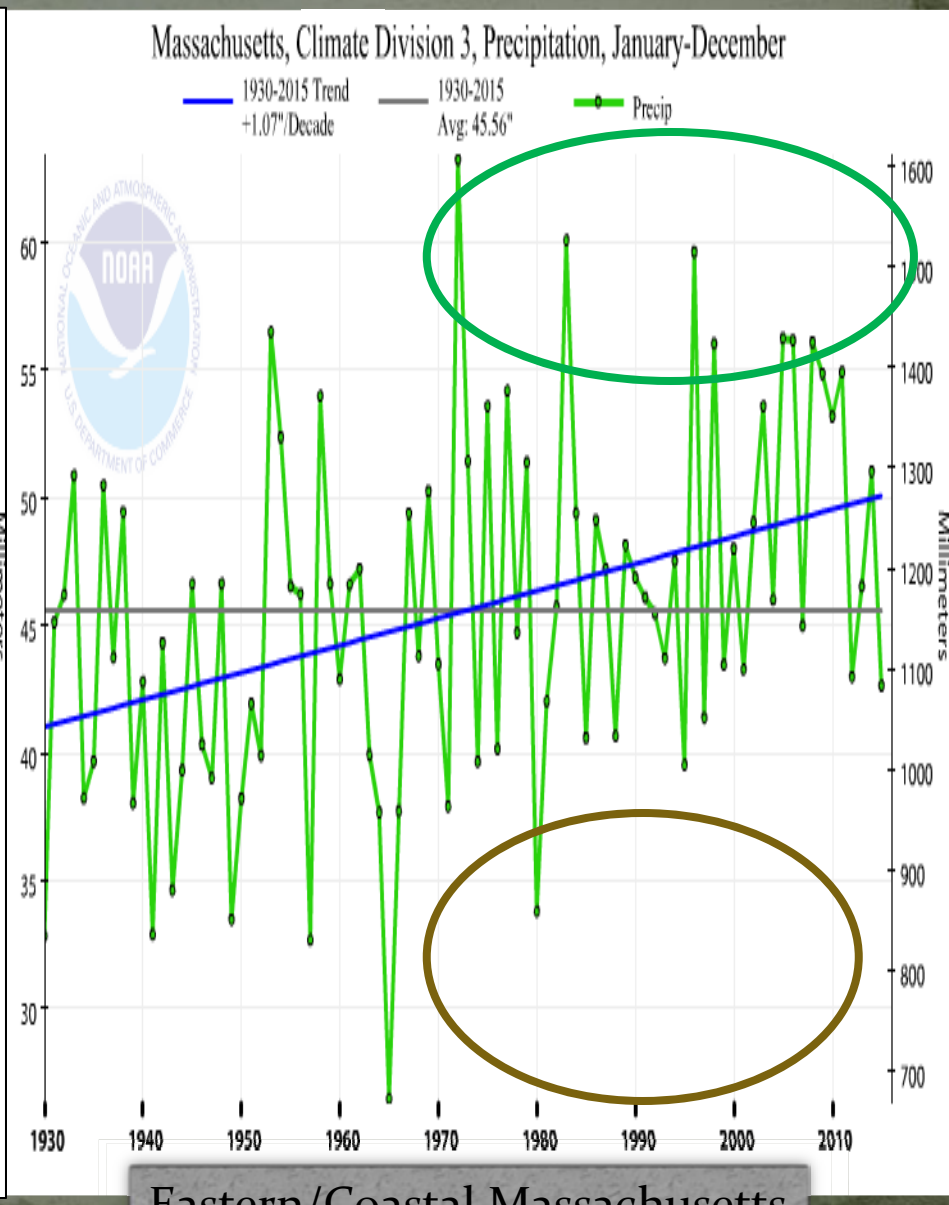
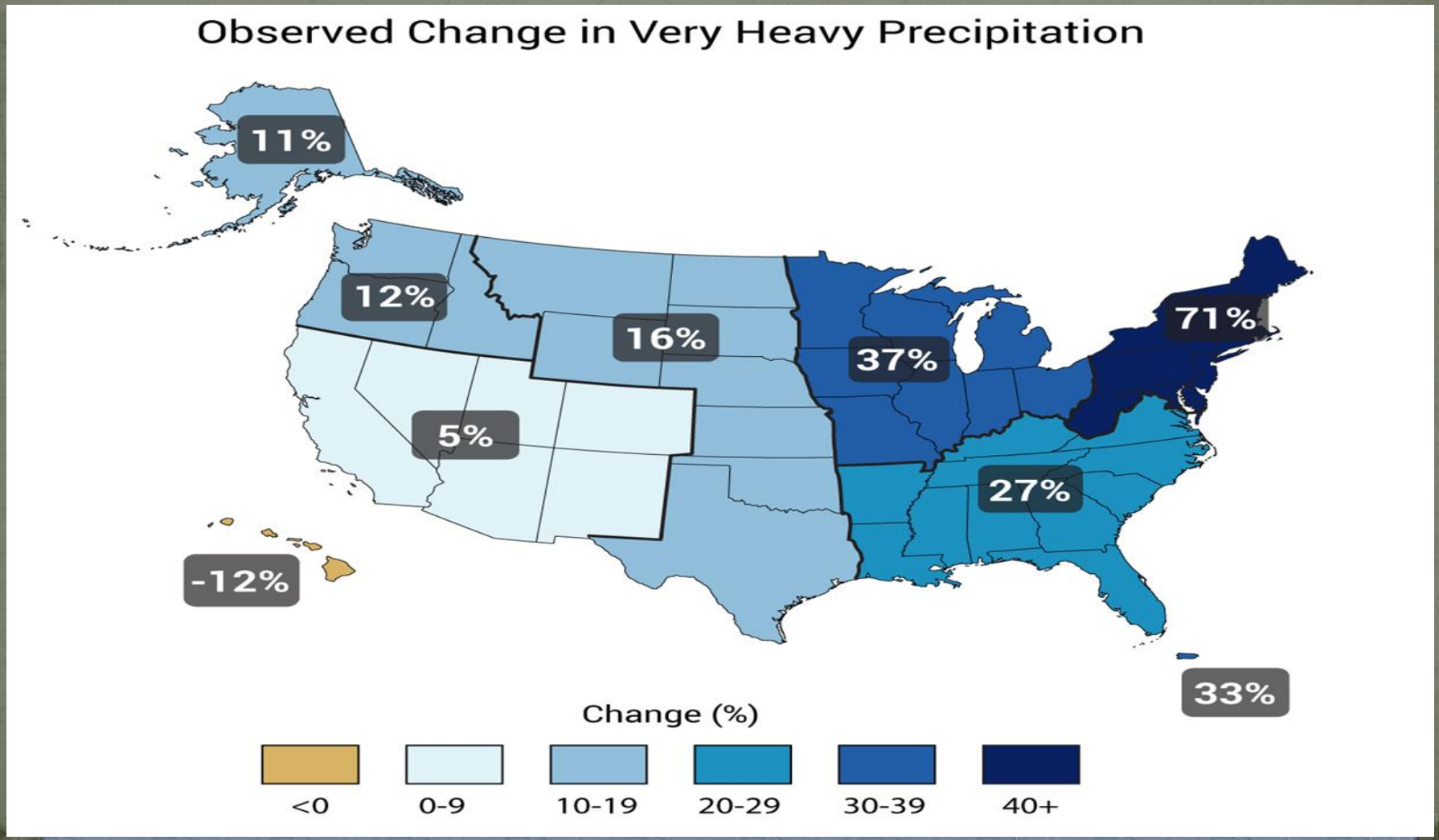


Eastern/Coastal Massachusetts

Change in frequency of Heavy Precipitation

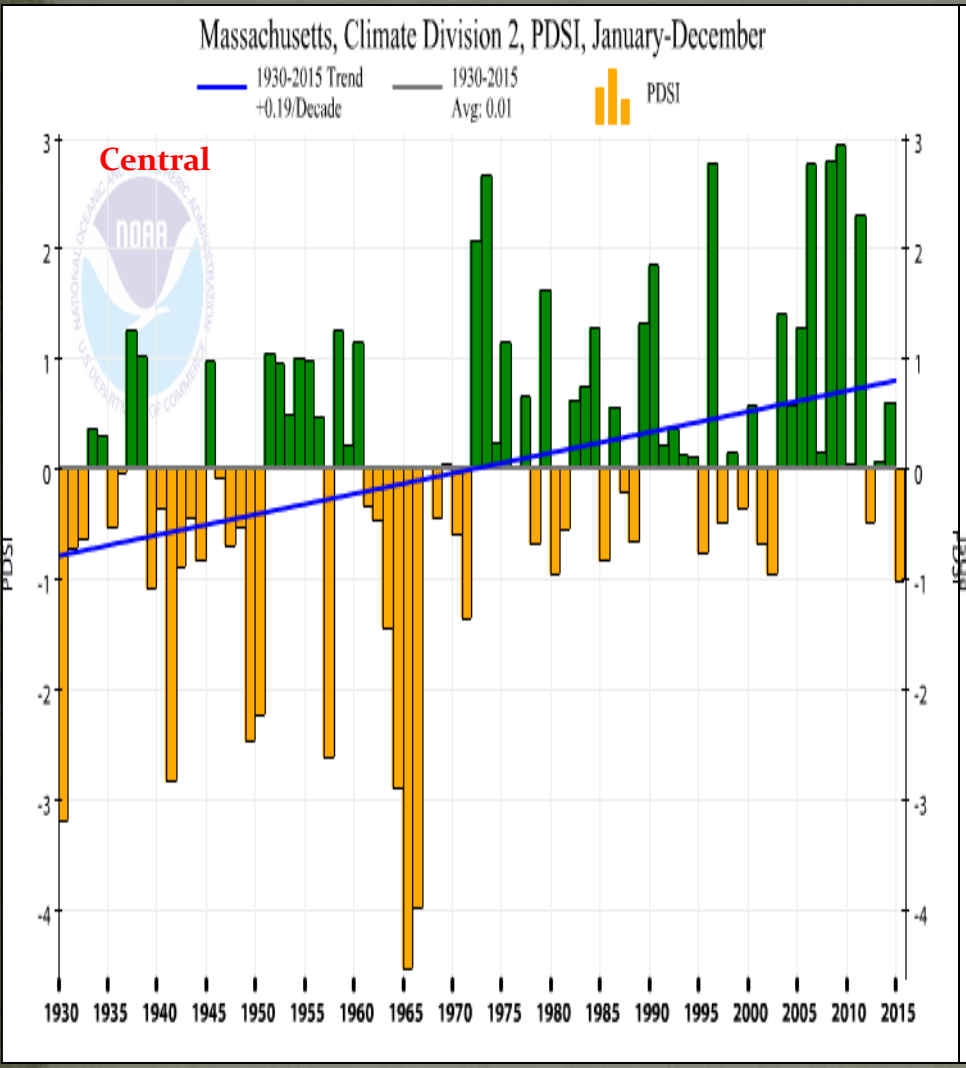
- Intense precipitation events (the heaviest 1%)
- Used to average 6-8 days a year of >1" of rain or more
- Today we are averaging nearly 12-15 days!

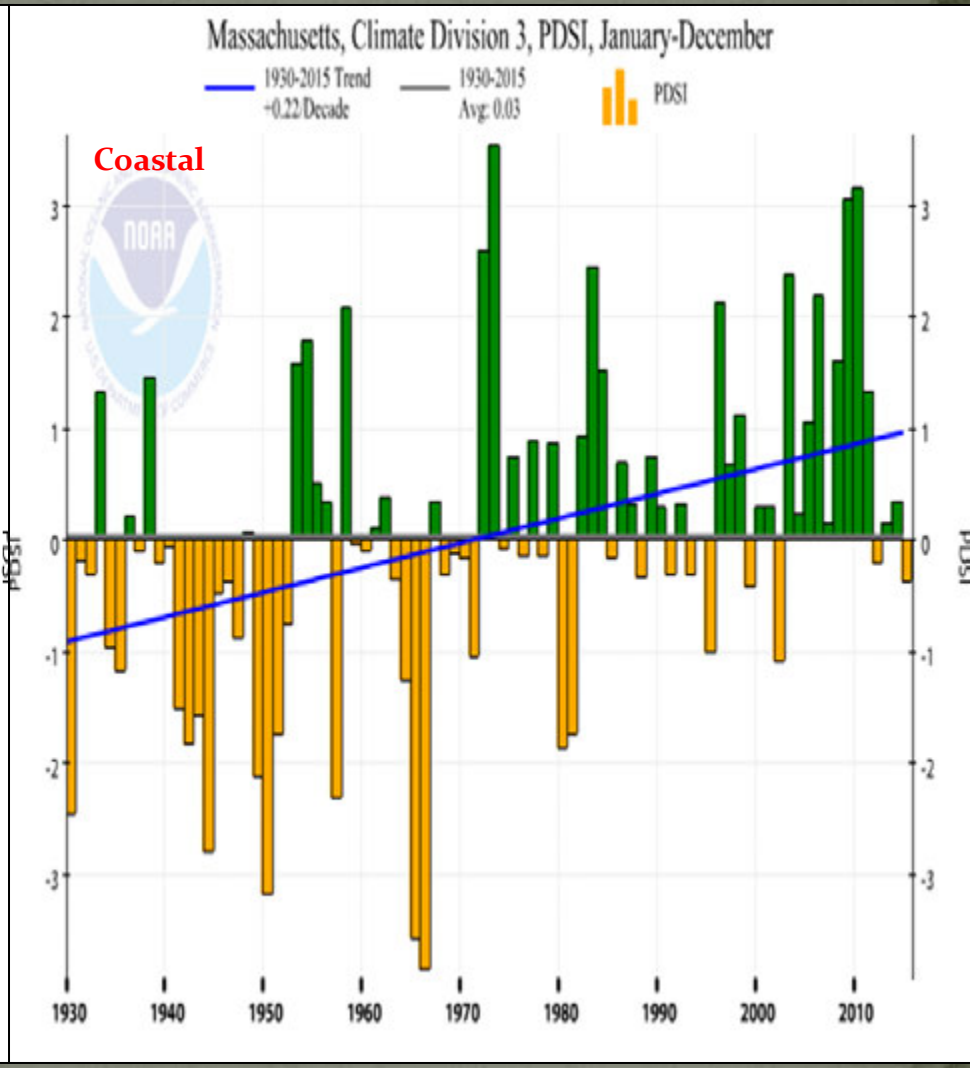


Source: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts

Changes in the Palmer Drought Index

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



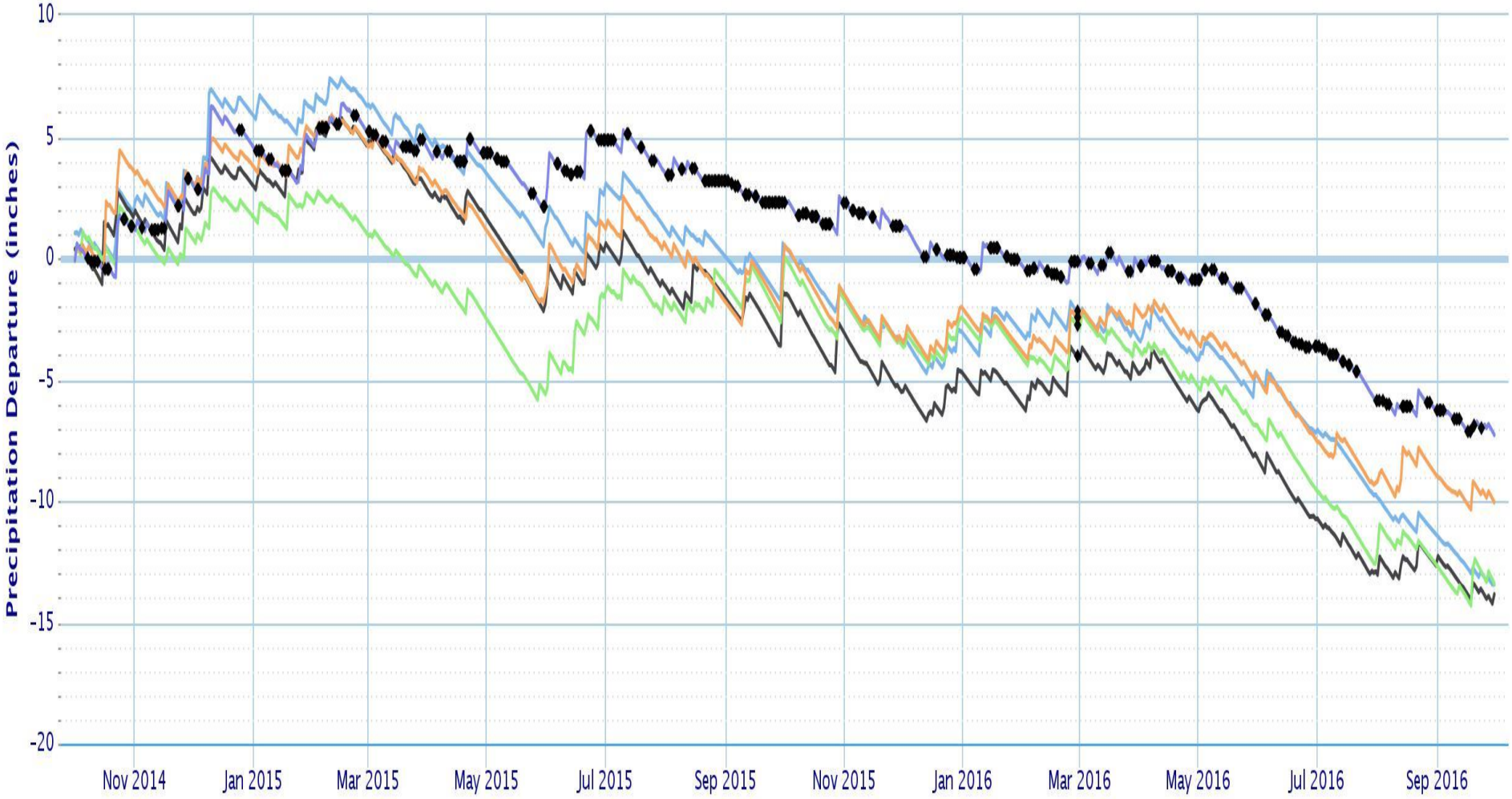


Since the late 60s, similar signature of much shorter, less intense dry periods and longer higher amplitude wet periods

Accumulated Precipitation Departure from Normal

October 2014 – September 2016

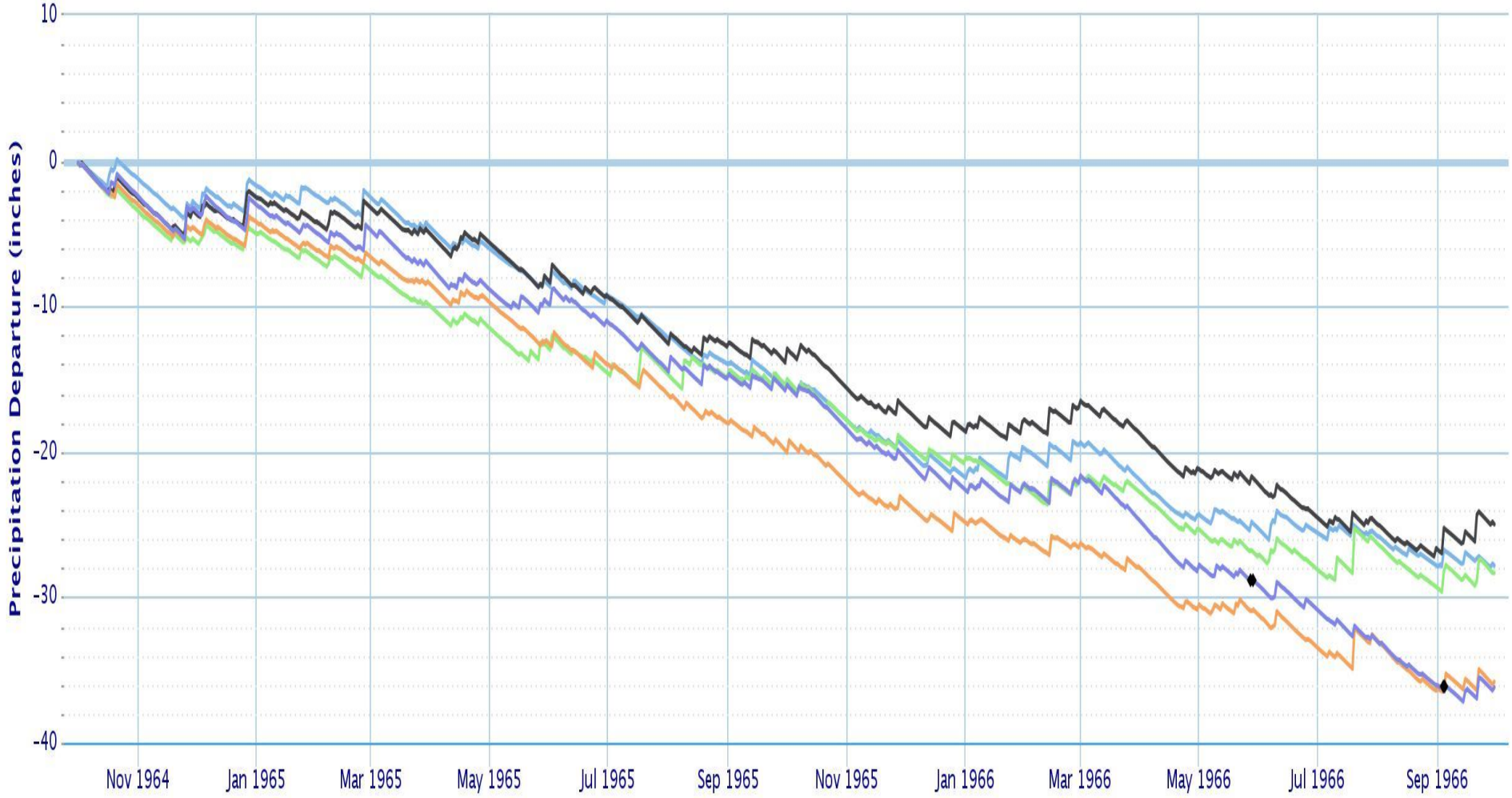
Green/black diamonds represent subsequent/missing values



Accumulated Precipitation Departure from Normal

October 1964 – September 1966

Green/black diamonds represent subsequent/missing values



(Click to hide/show lines)

Boston Area, MA (ThreadEx):Precip Dprt

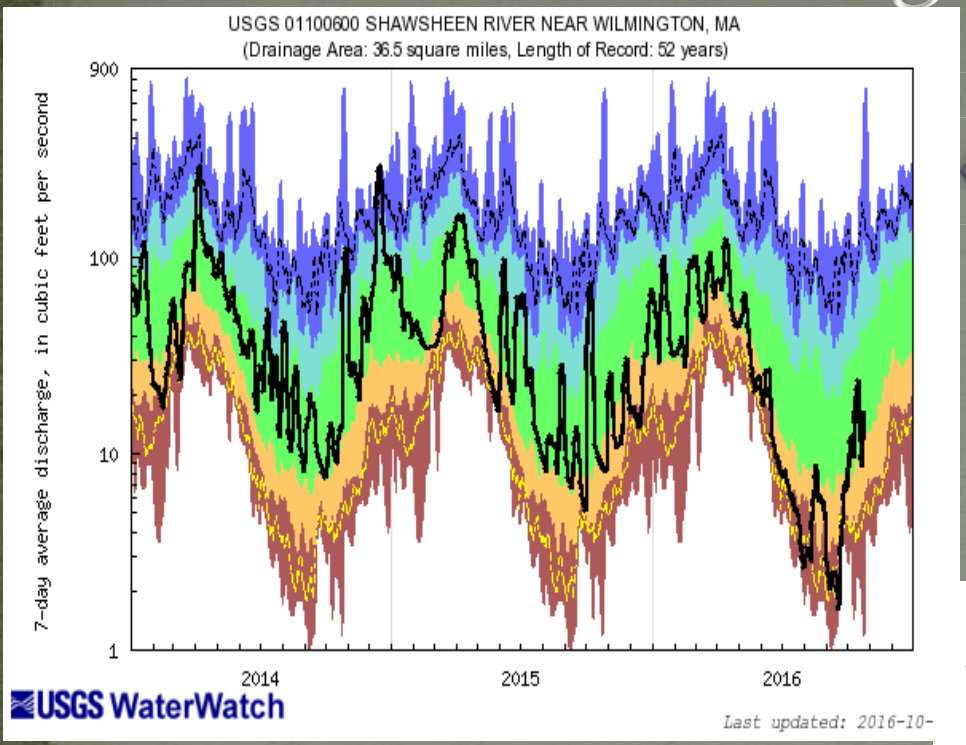
Worcester Area, MA (ThreadEx):Precip Dprt

AMHERST, MA:Precip Dprt

BARRE FALLS DAM, MA:Precip Dprt

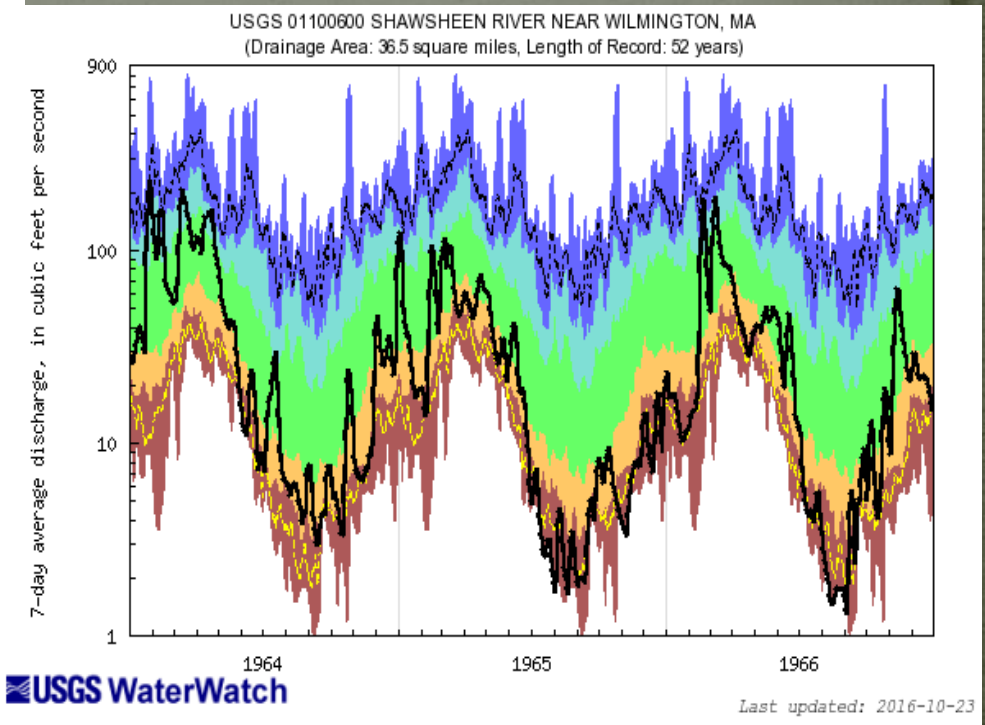
MAYNARD, MA:Precip Dprt

Closer look at drought characteristics



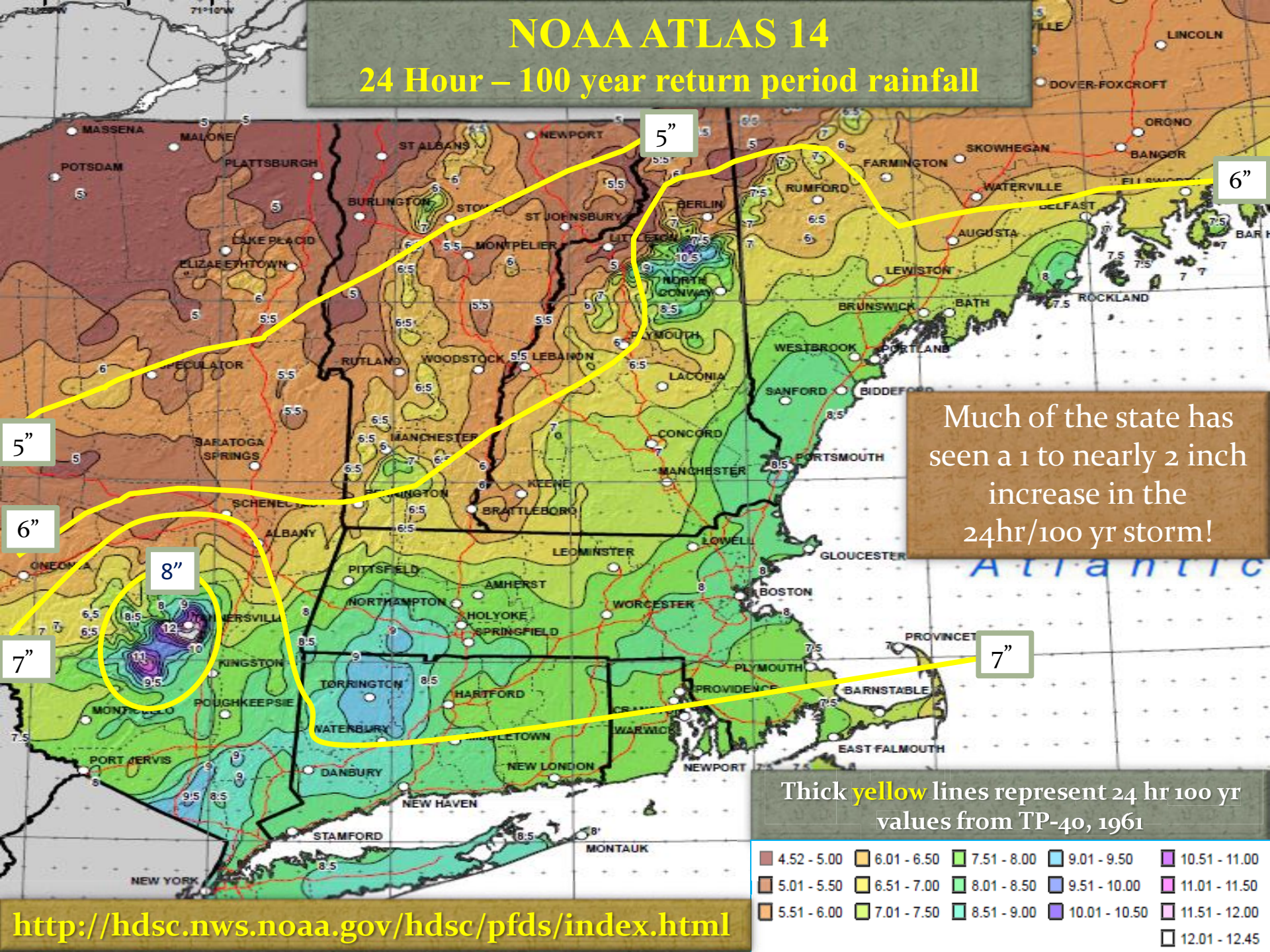
- Short/intense drought episodes:
  - 2014 and 2015
- Record daily flows
  - Minimums similar to the 1960s drought!
  - But…very short duration with frequent episodes of significant recharge if not flood volumes

- Droughts of yesteryear:
  - 1964-66
- Prolonged record lows
  - Infrequent periods of recharge
  - But far longer in duration with little significant recharge



NOAA ATLAS 14

24 Hour – 100 year return period rainfall



http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

Trends in Flood Frequency:
From the Practitioner's perspective

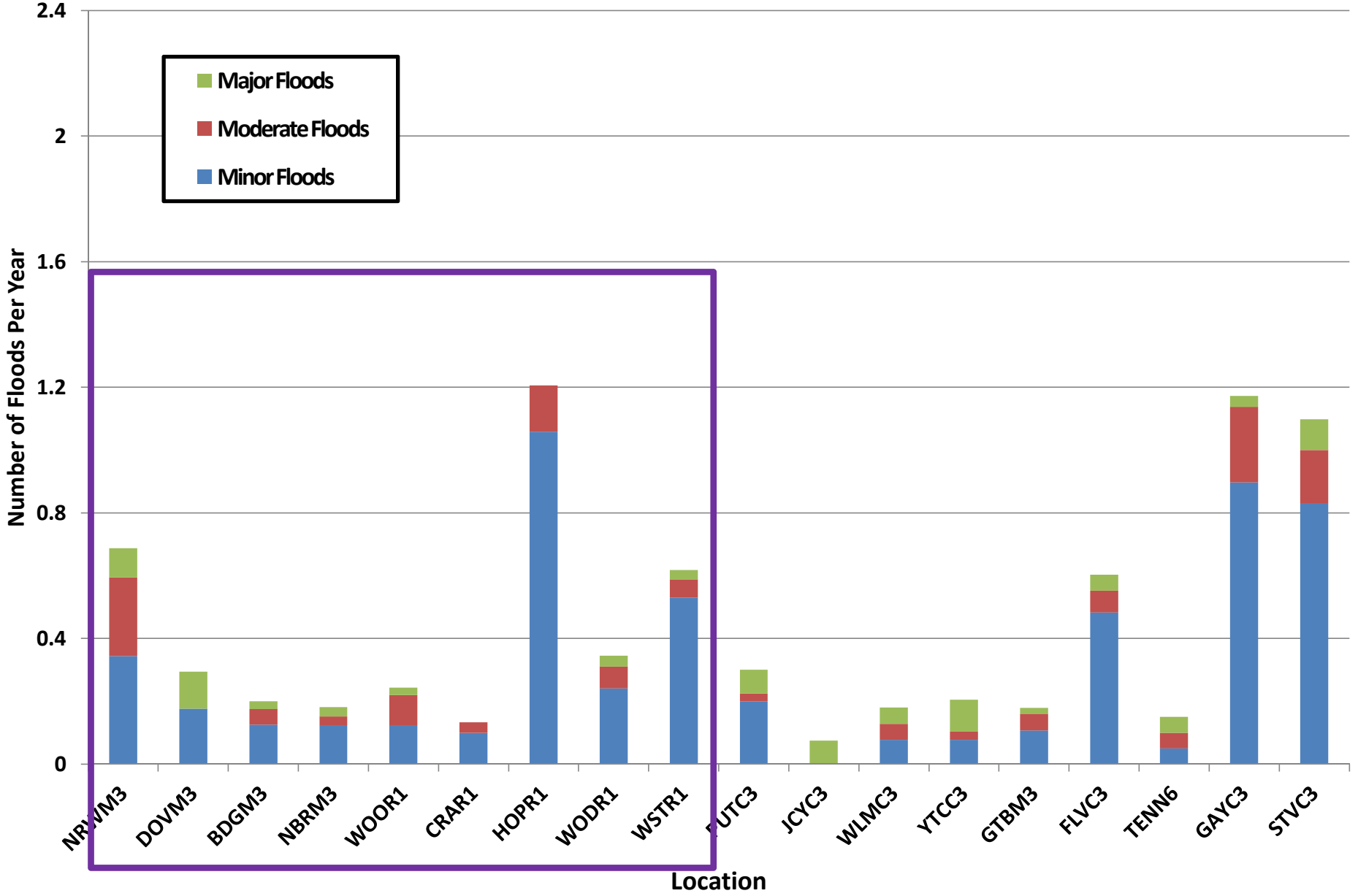
- Small watersheds feeling the effects
  - Changes in frequency/magnitude
  - Part land use/urbanization
    - Compounded by encroachment in the floodplain
  - Part changing climate
- Larger basins with flood control haven't seen as noticeable a shift
  - Most USACE reservoirs are built for 6-8 inch 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 USGS science for a changing world



Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods from 1970-2013

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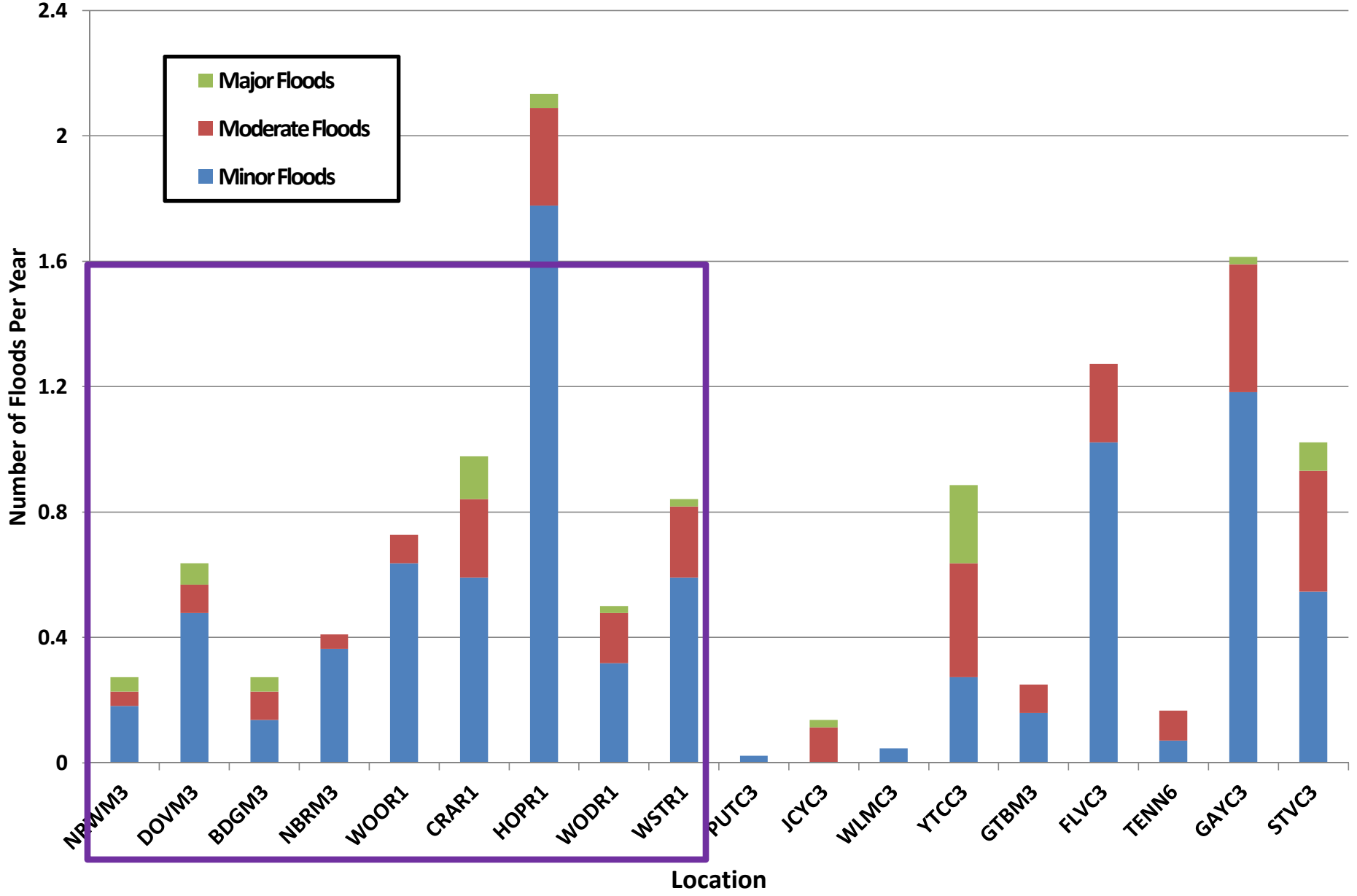

Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Per Month Prior to 1970 (18 forecast locations)

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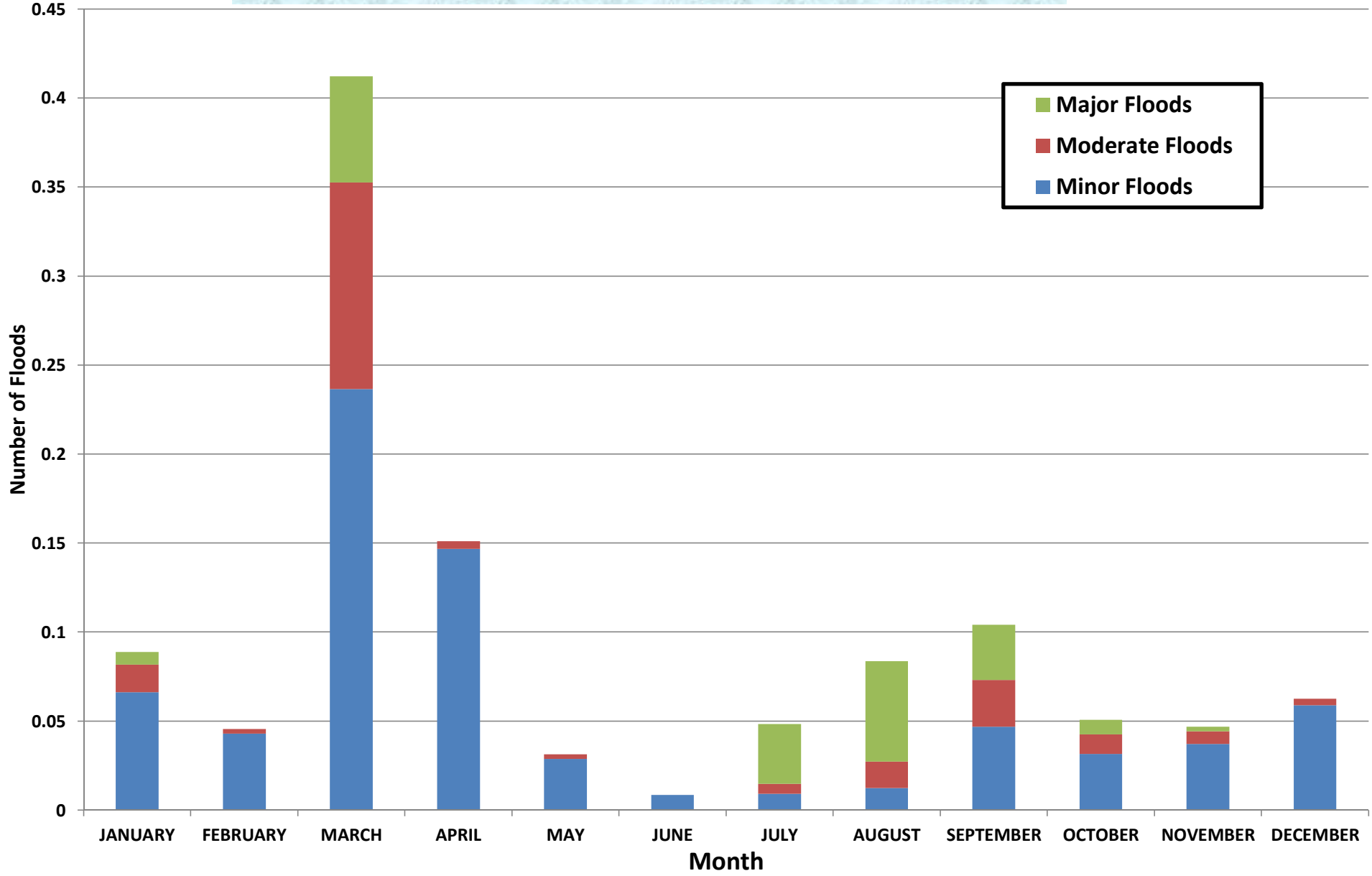

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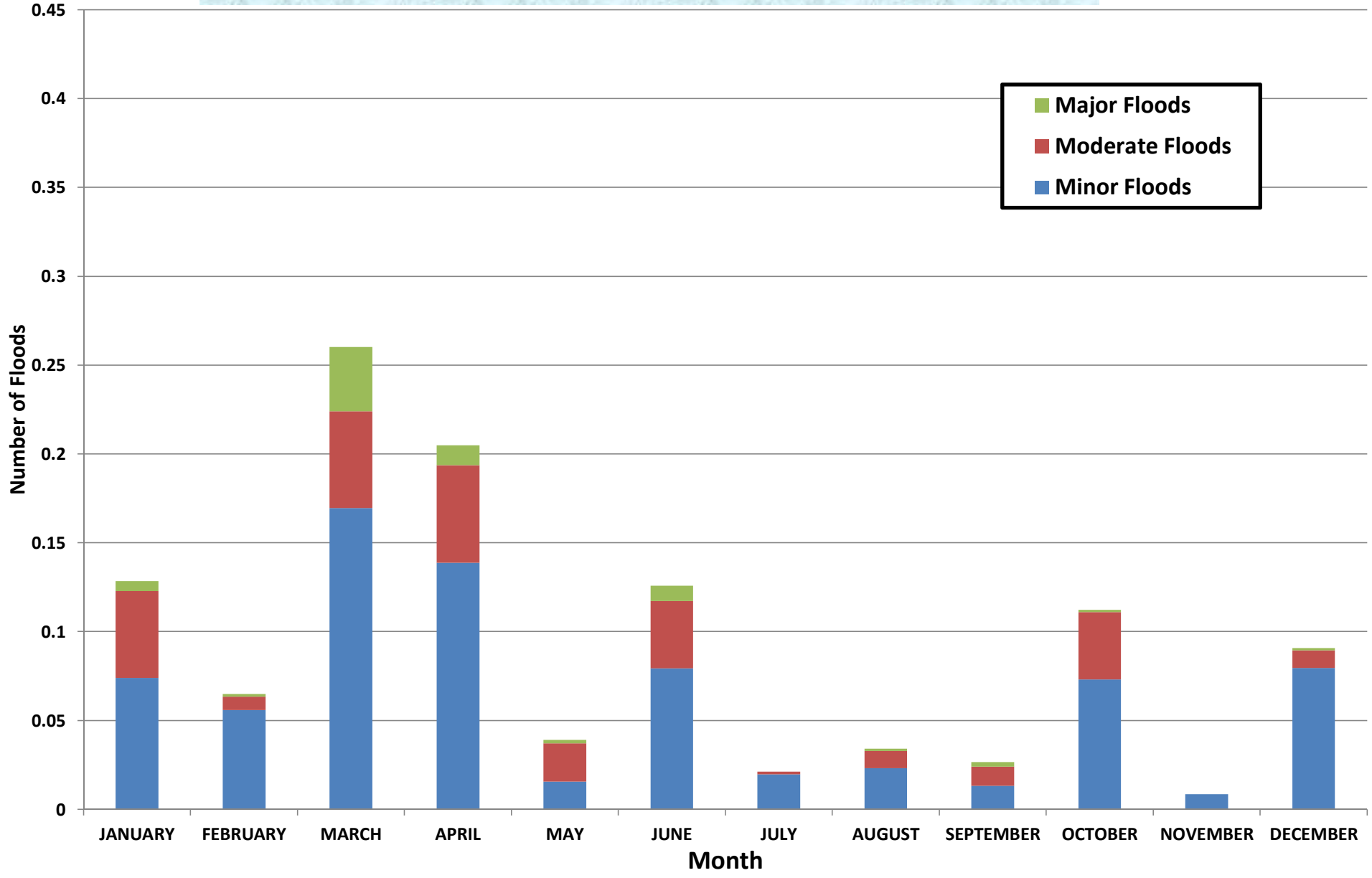

Lower Merrimack River Basin Normalized Number Of Minor, Moderate, & Major Floods Per Year Prior to 1970

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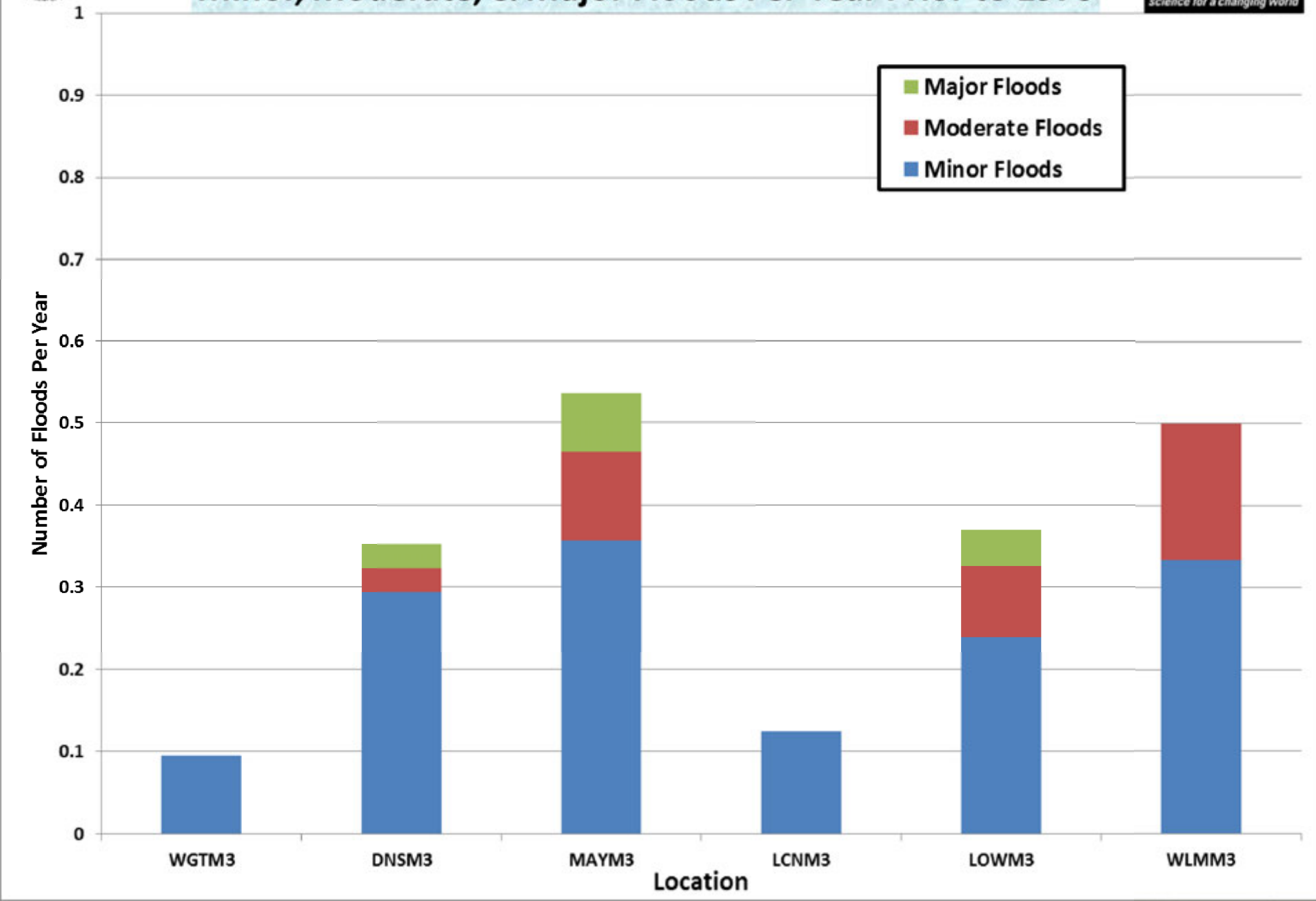

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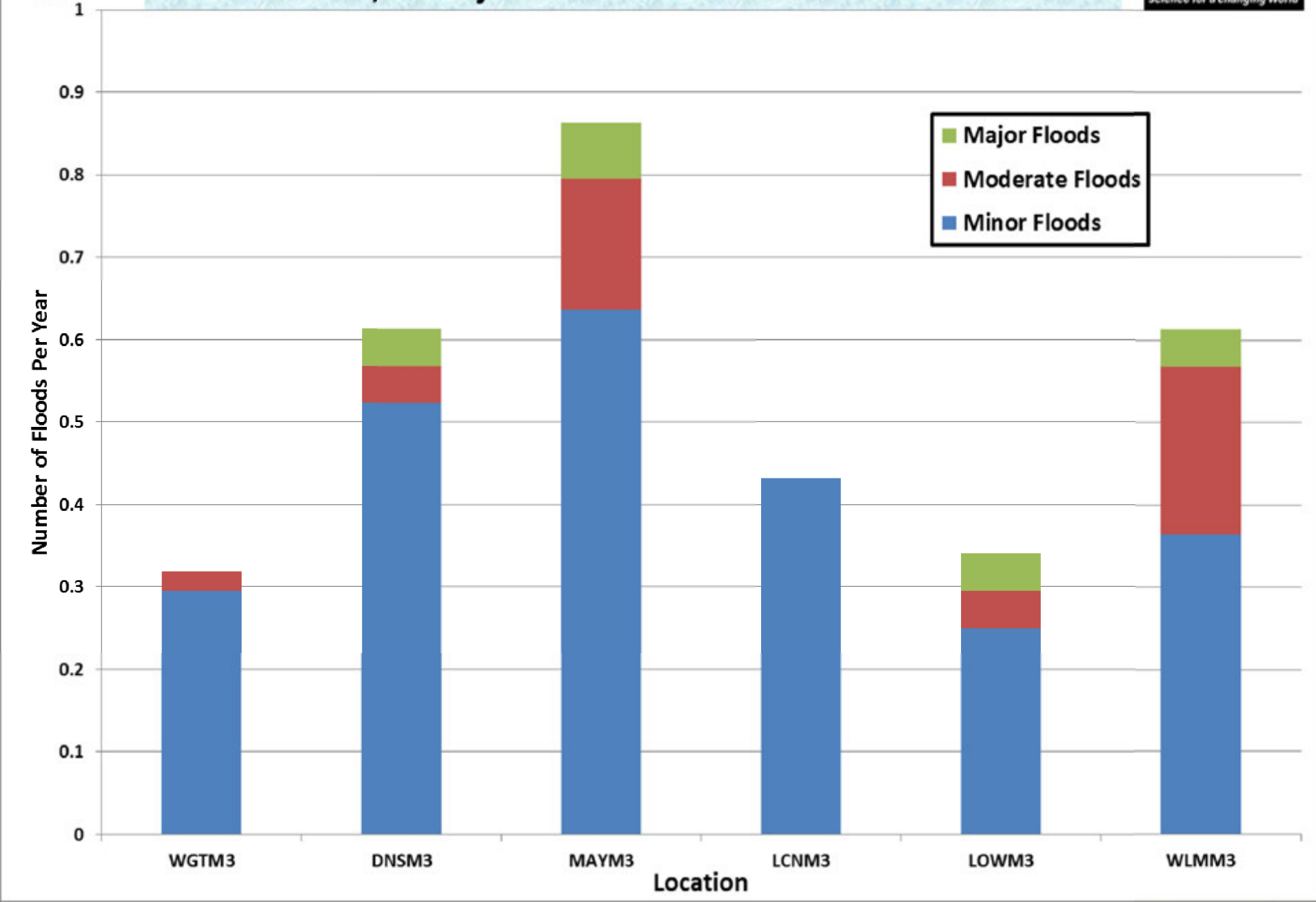
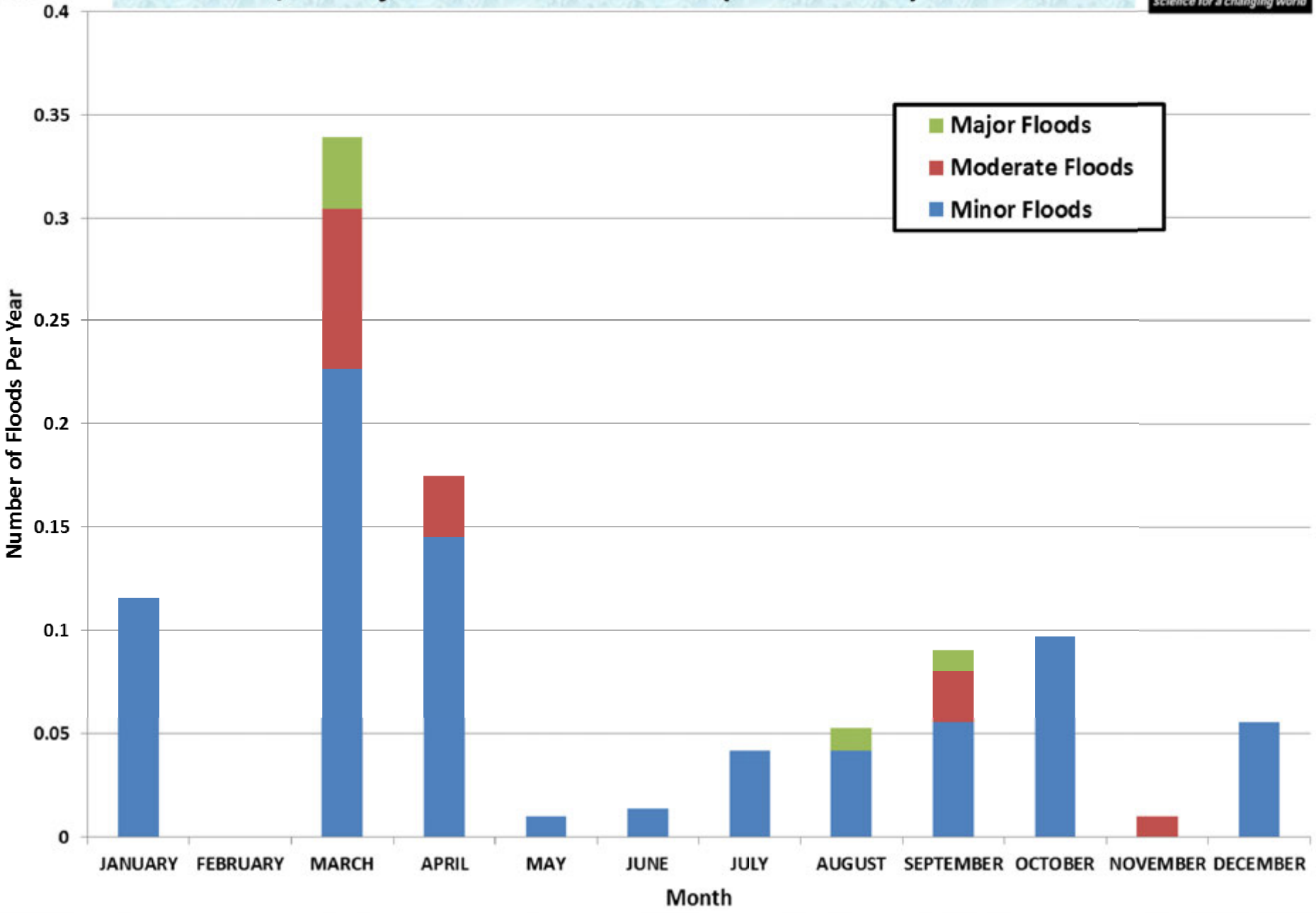


Lower Merrimack River Basin Normalized Number Of Minor, Moderate, & Major Floods Per Month (6 Locations) Prior to 1970

Data provided by USGS science for a changing world



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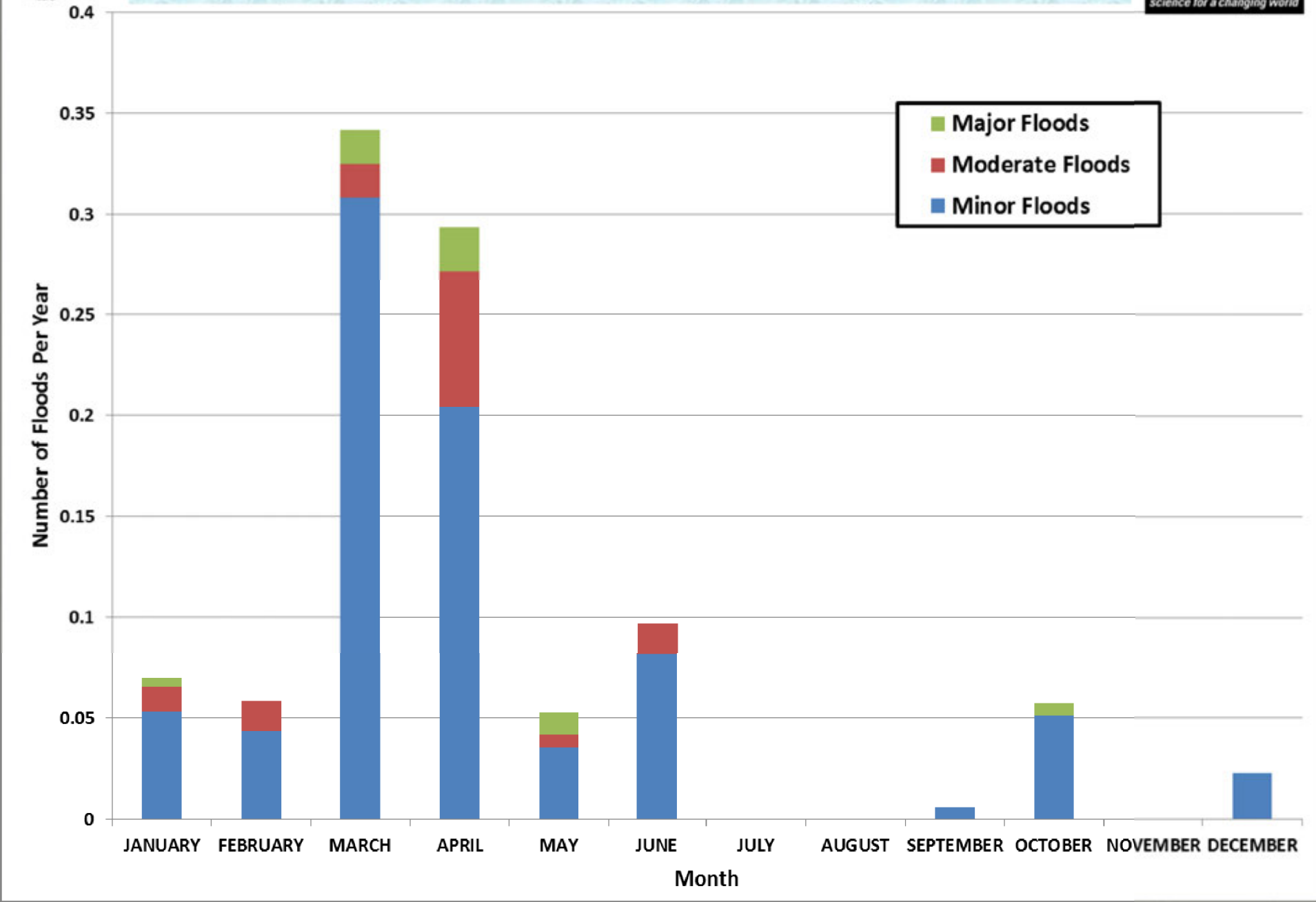


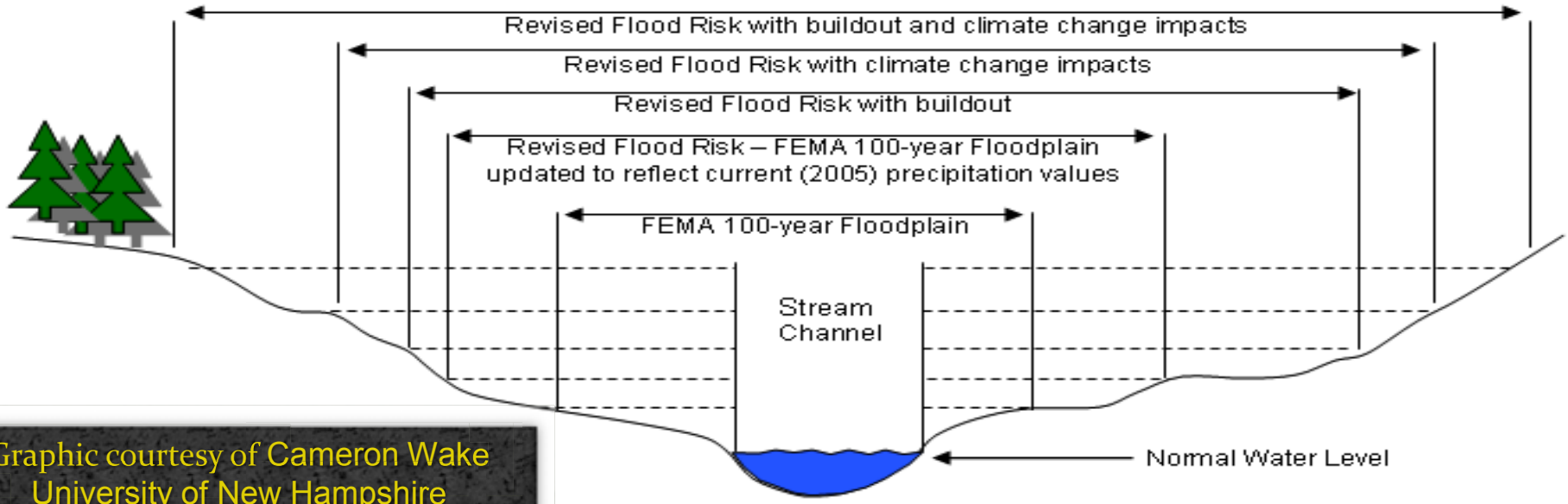
Summary:

- 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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