2018 HURRICANE PREPAREDNESS WEBINAR

Wednesday, May 30, 2018

10:00AM – 12:00PM

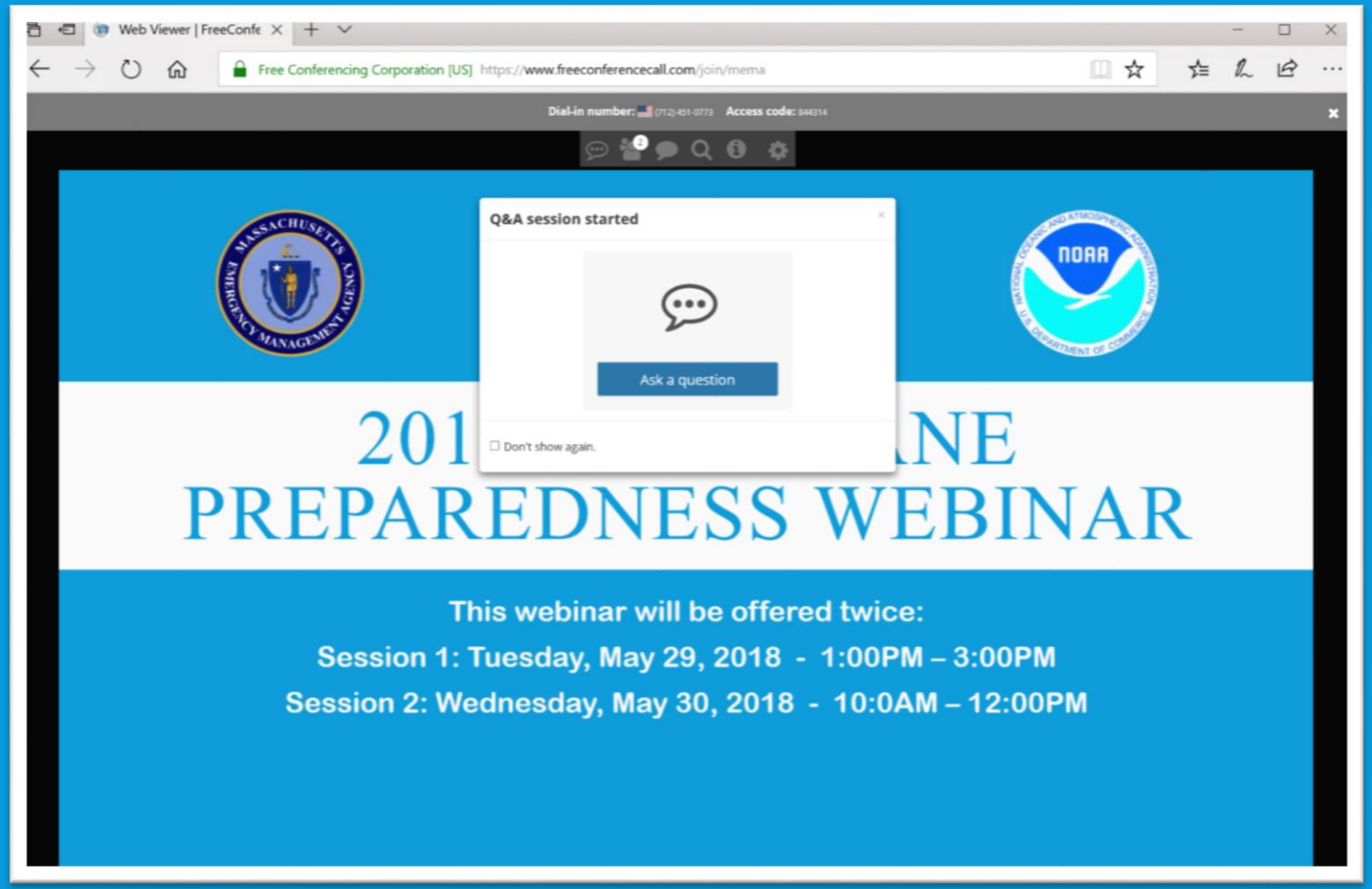
PLEASE STANDBY THE PROGRAM WILL BEGIN SHORTLY

2018 Hurricane Preparedness Webinar

Questions

At conclusion of each presentation we will conduct a Question & Answer session.

When the session has started, click the "Ask a question" button. The host will unmute your line when it is your turn to ask a question.



2018 Hurricane Preparedness Webinar

Agenda

I. **Welcoming Remarks and Overview of Webinar**
   Kurt Schwartz, Director - Massachusetts Emergency Management Agency

II. **Southern New England Tropical Cyclone Climatology and Threats**
   Matthew Belk, Senior Forecaster - National Weather Service, Boston

III. **Recent Changes to NHC Products and Their Success During the 2017 Hurricane Season**
   Daniel Brown, Senior Hurricane Specialist - National Hurricane Center

IV. **Hurricane Evacuation Decision Making in the Face of Uncertainty**
   Paul A. Morey, Hurricane Program Manager – Federal Emergency Management Agency

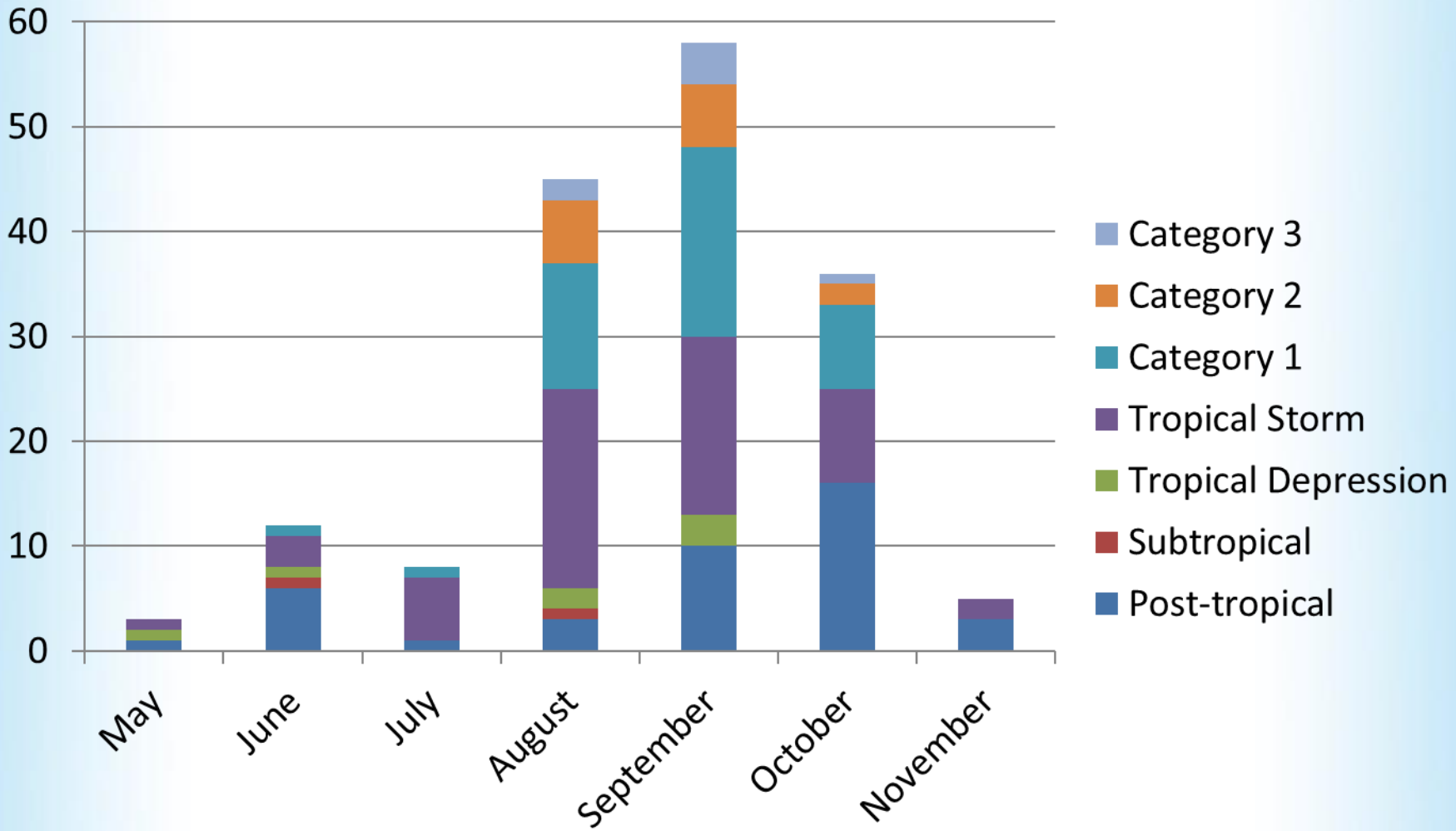
V. **Massachusetts Emergency Management Agency – Preparedness Updates**
   Kurt Schwartz, Director, Massachusetts Emergency Management Agency
   Michael Russas, Response and Field Services Section Chief, Massachusetts Emergency Management Agency

Southern New England Tropical Cyclone Climatology and Threats

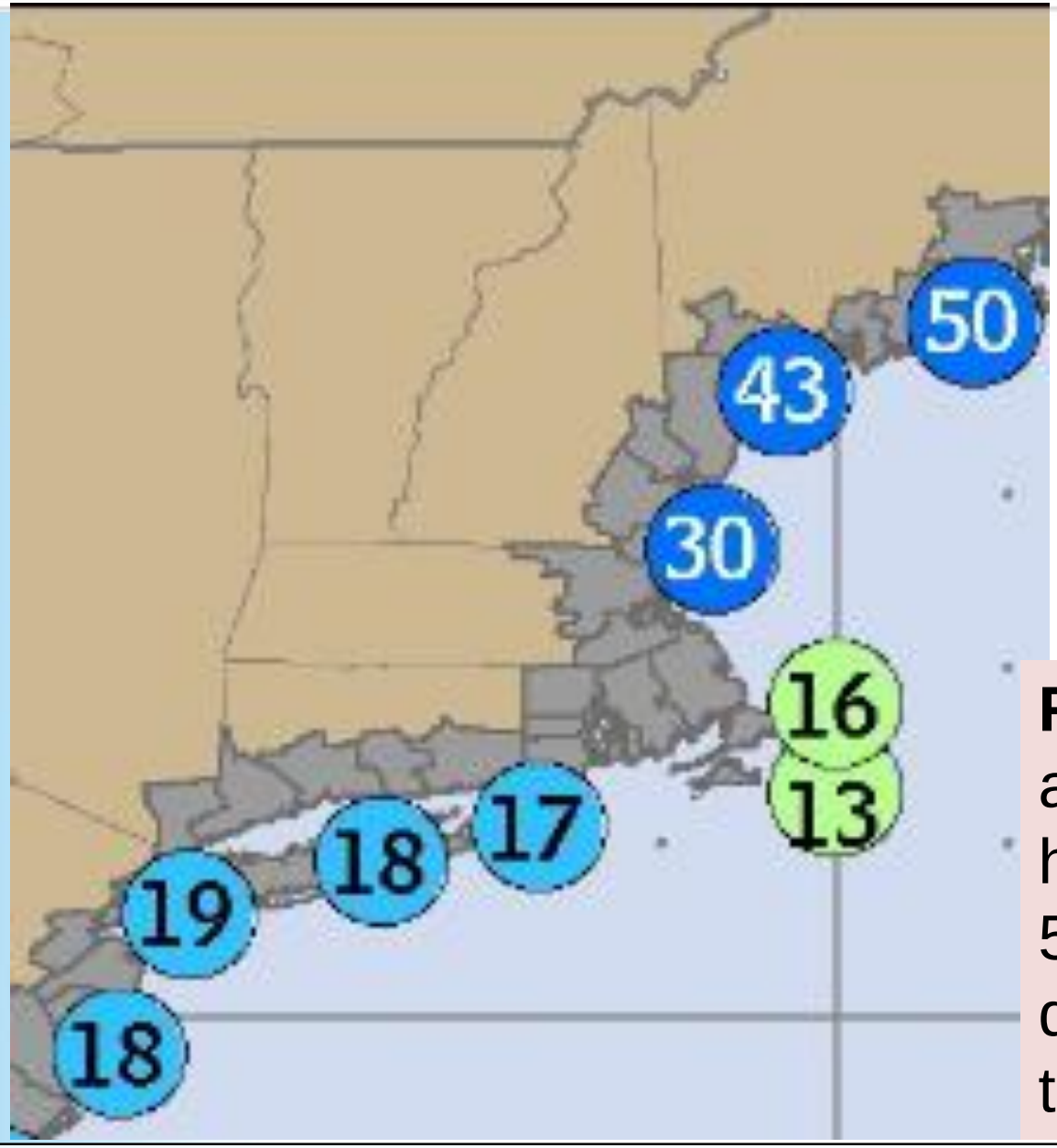
Matthew H. Belk
National Weather Service
Taunton, MA

- Briefly review the climatology of tropical cyclones in southern New England
- Review the hazards and potential impacts from tropical cyclones

Objectives



When is “Hurricane Season”?

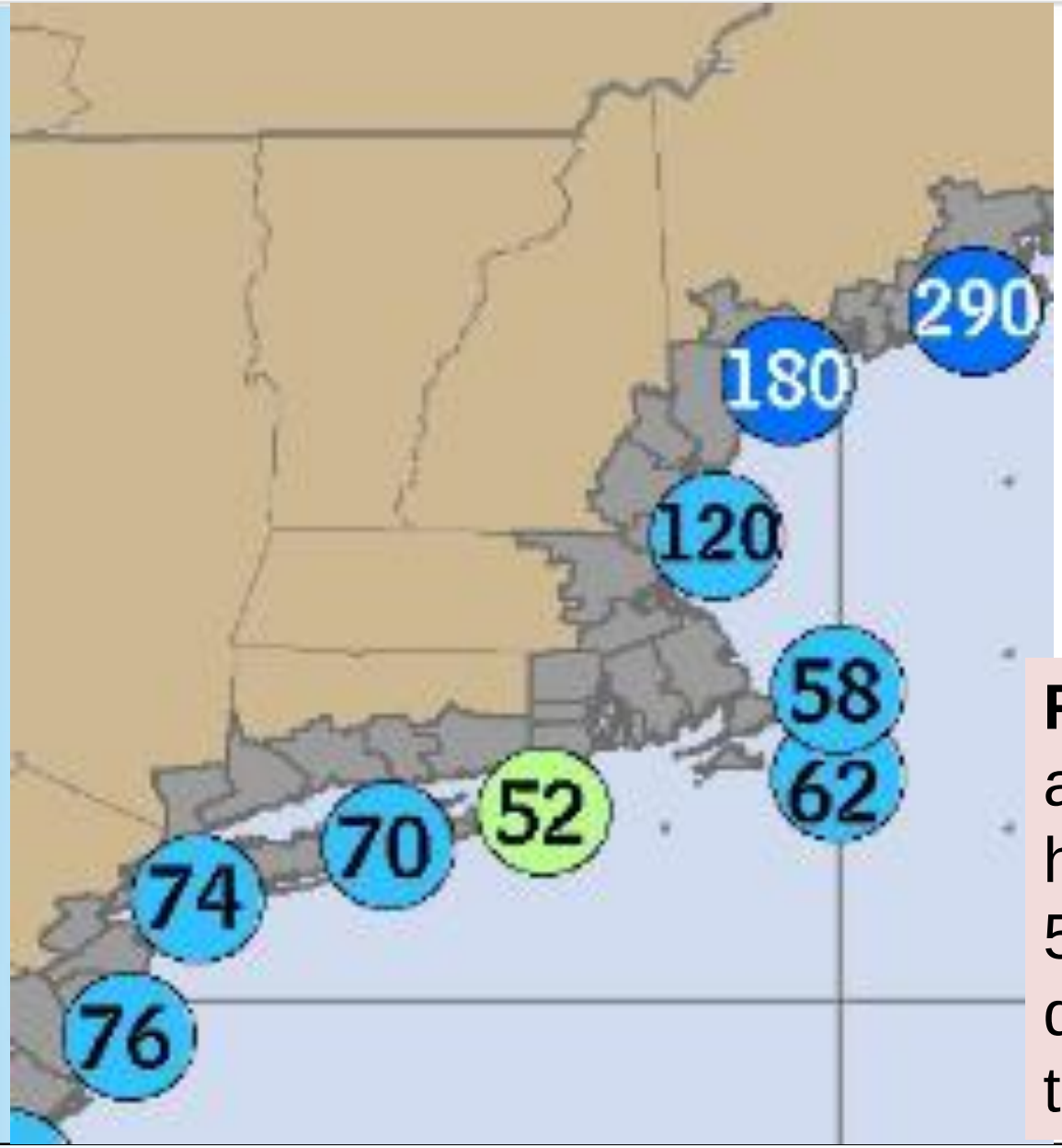


Return Period (Years)

Hurricane (>=64kt)

- 5-7
- 8-11
- 12-16
- 17-24
- 25-50
- Coastal County

Return Period is the average frequency of a hurricane passing within 50 nm (58 mi) of a designated location over the past 100 years.



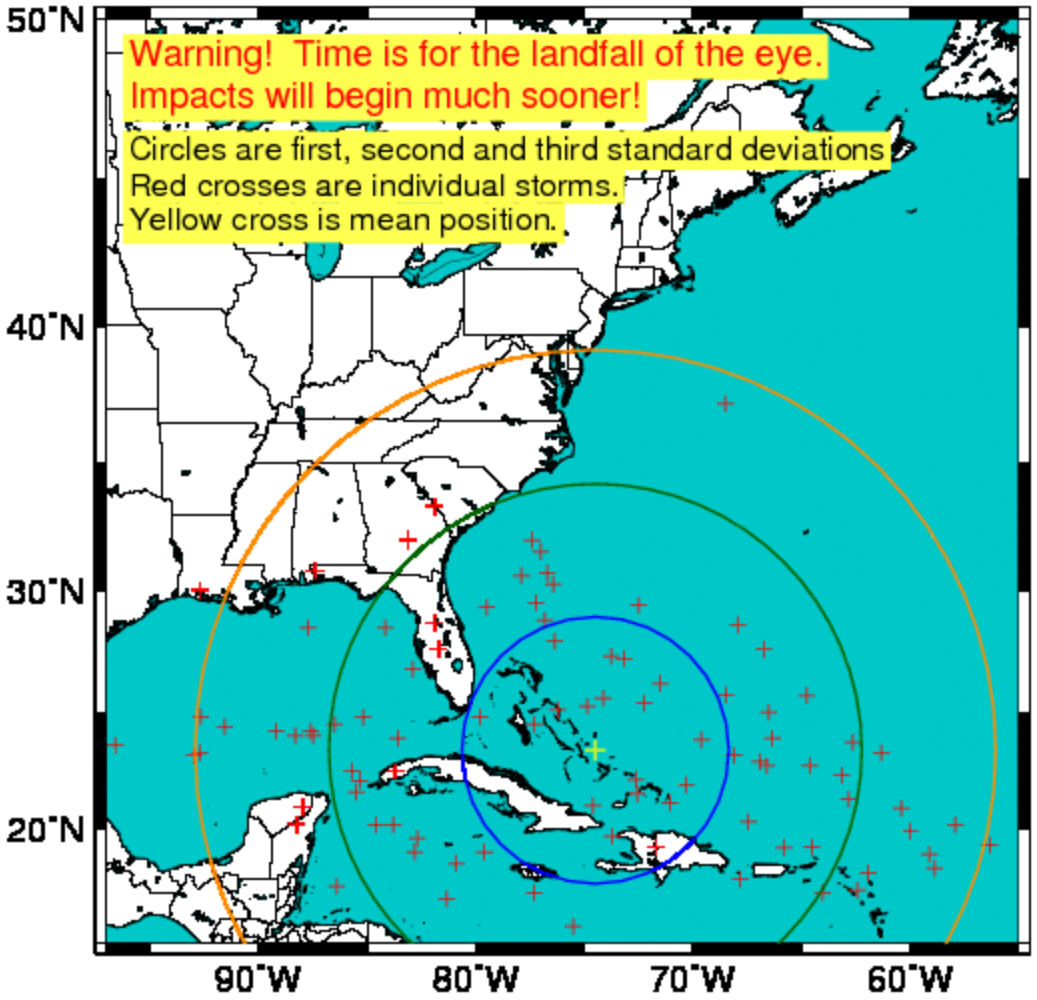
Return Period (Years)

Major Hurricane (>=96kt)

- 14-22
- 23-32
- 33-52
- 53-120
- 121-290
- Coastal County

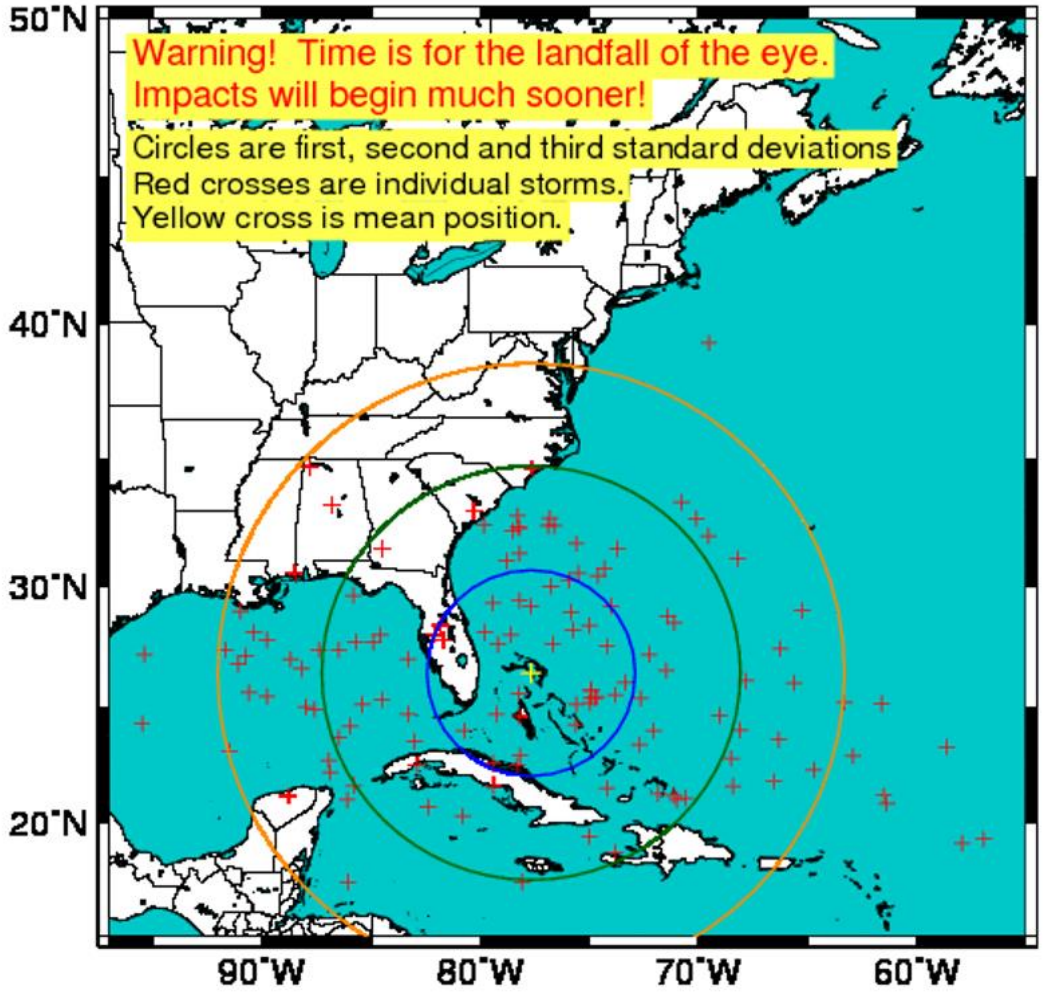
Return Period is the average frequency of a hurricane passing within 50 nm (58 mi) of a designated location over the past 100 years.

Position of All Storms At 120 Hours Before Landfall of Eye



"All Storms" includes: Tropical Storms, Hurricanes, and Post-tropical Cyclones

Position of All Storms At 84 Hours Before Landfall of Eye



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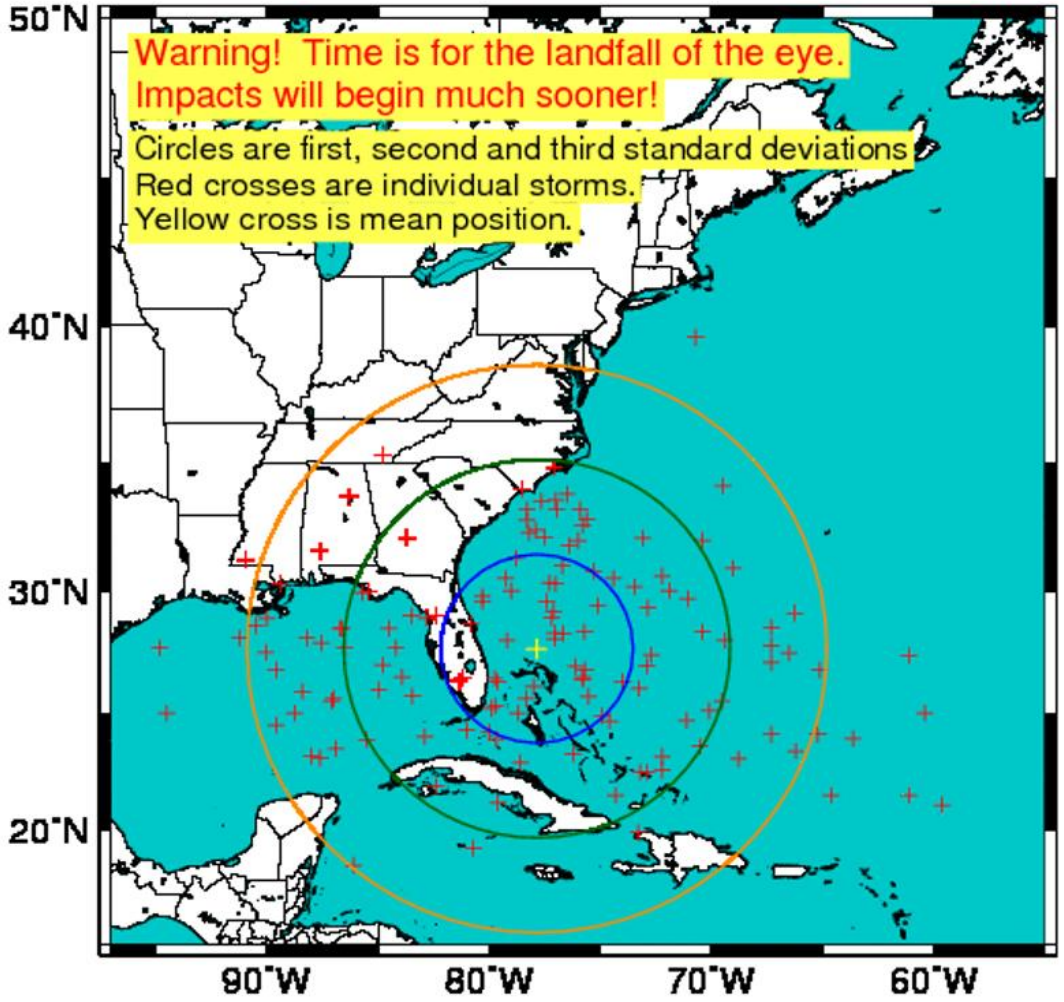
Position of All Storms At 72 Hours Before Landfall of Eye



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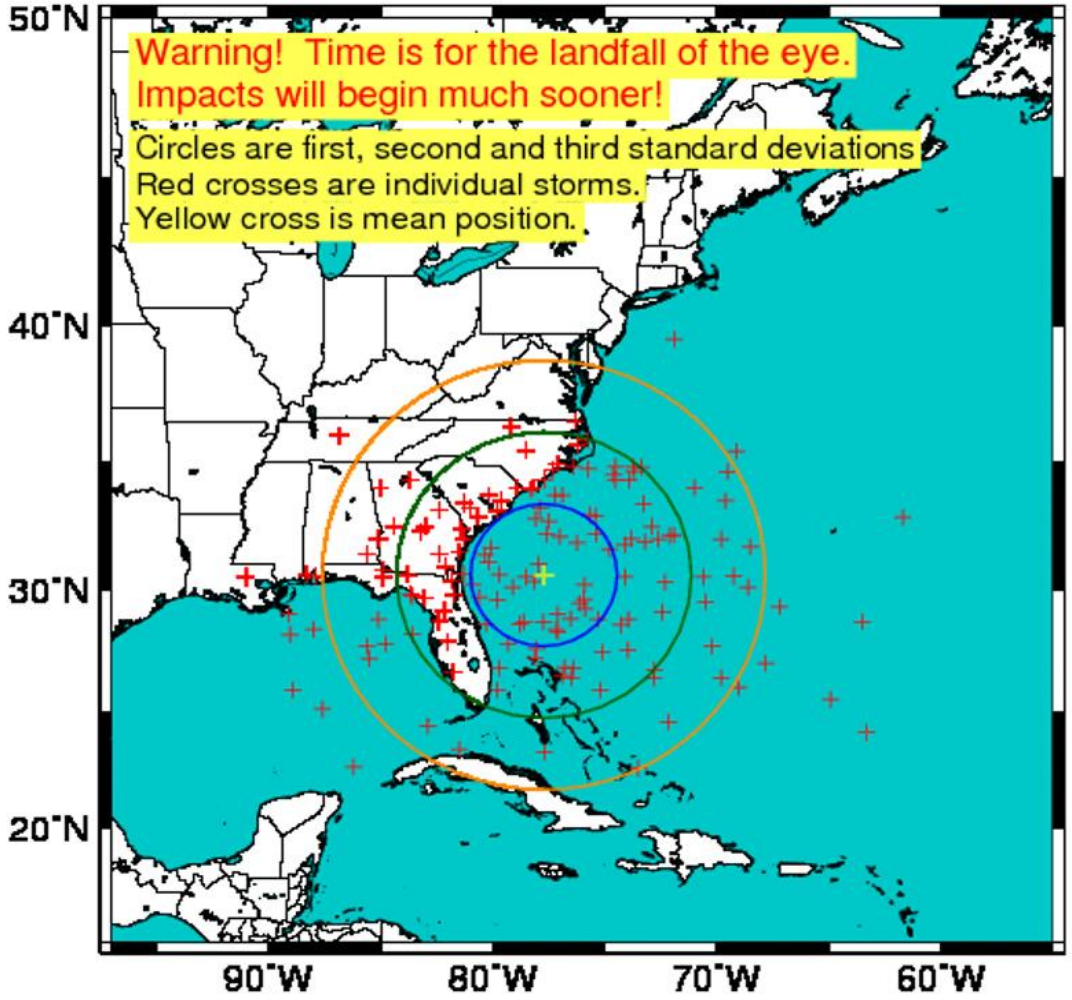
Position of All Storms At 48 Hours Before Landfall of Eye



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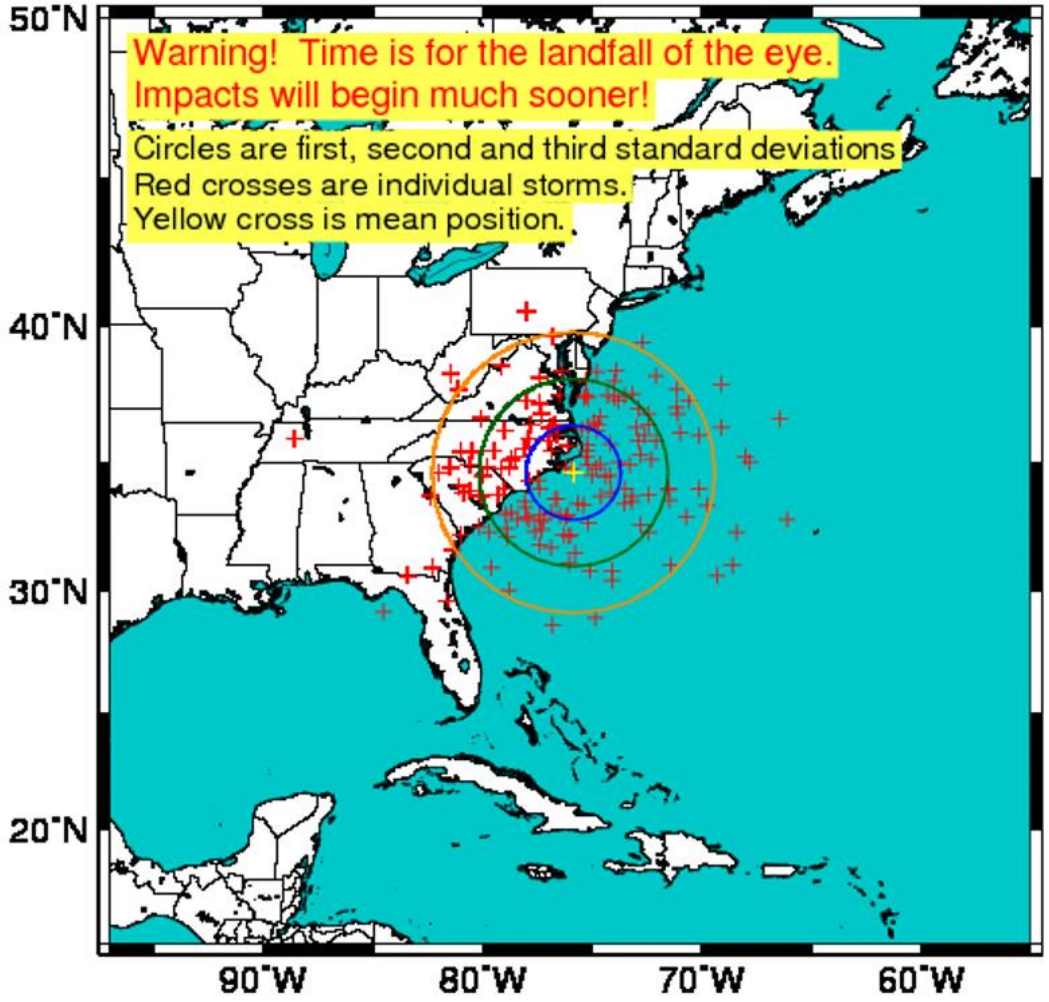
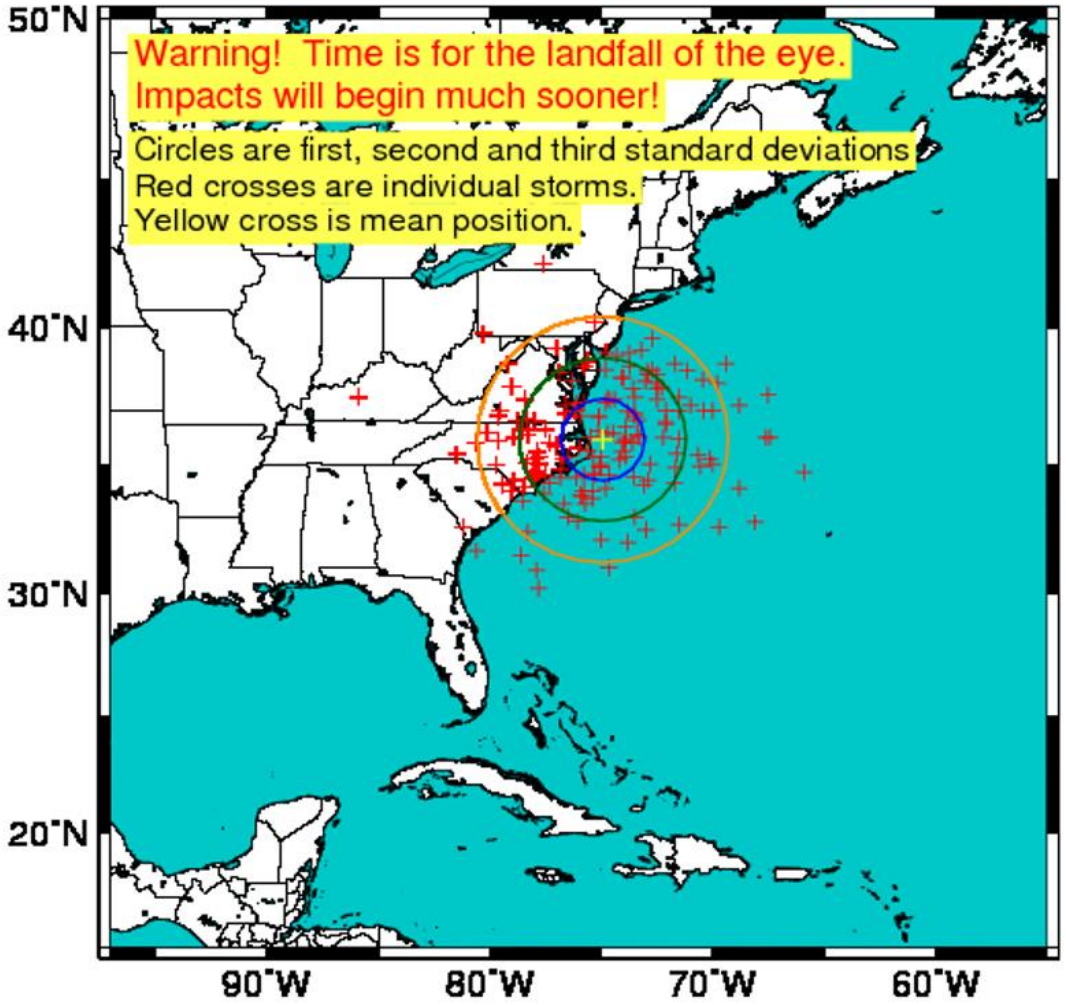
Position of All Storms At 24 Hours Before Landfall of Eye



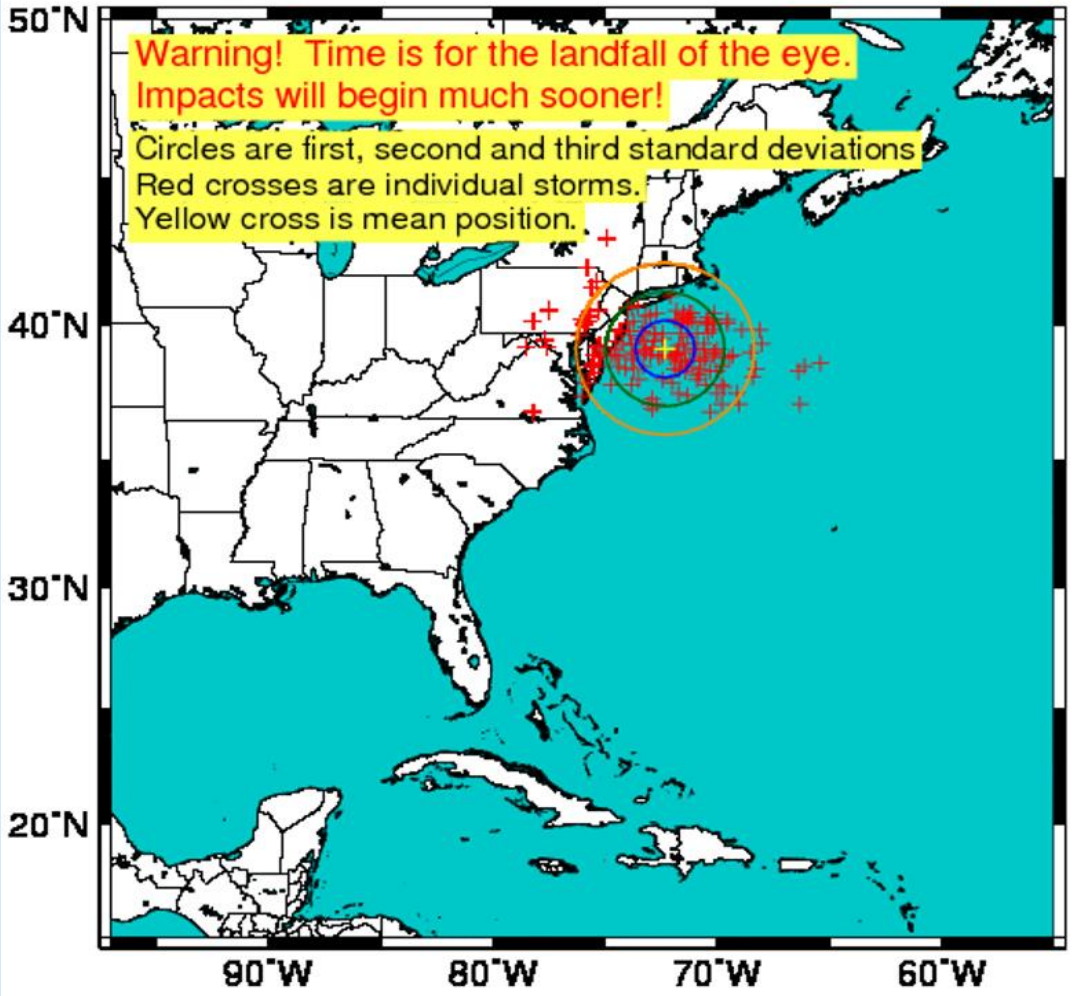
"All Storms" includes: Tropical Storms, Hurricanes, and Post-tropical Cyclones

Position of All Storms At 18 Hours Before Landfall of Eye



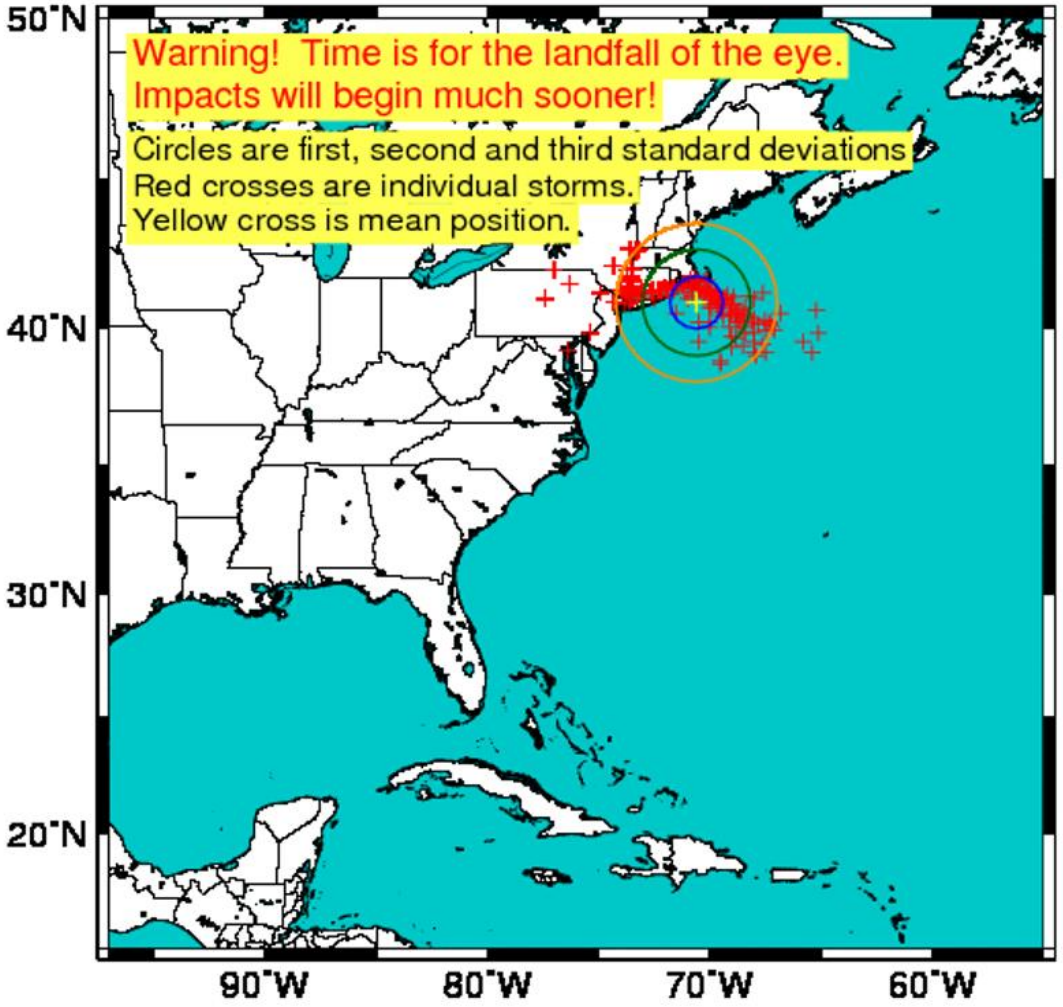
"All Storms" includes: Tropical Storms, Hurricanes, and Post-tropical Cyclones

Position of All Storms At 6 Hours Before Landfall of Eye



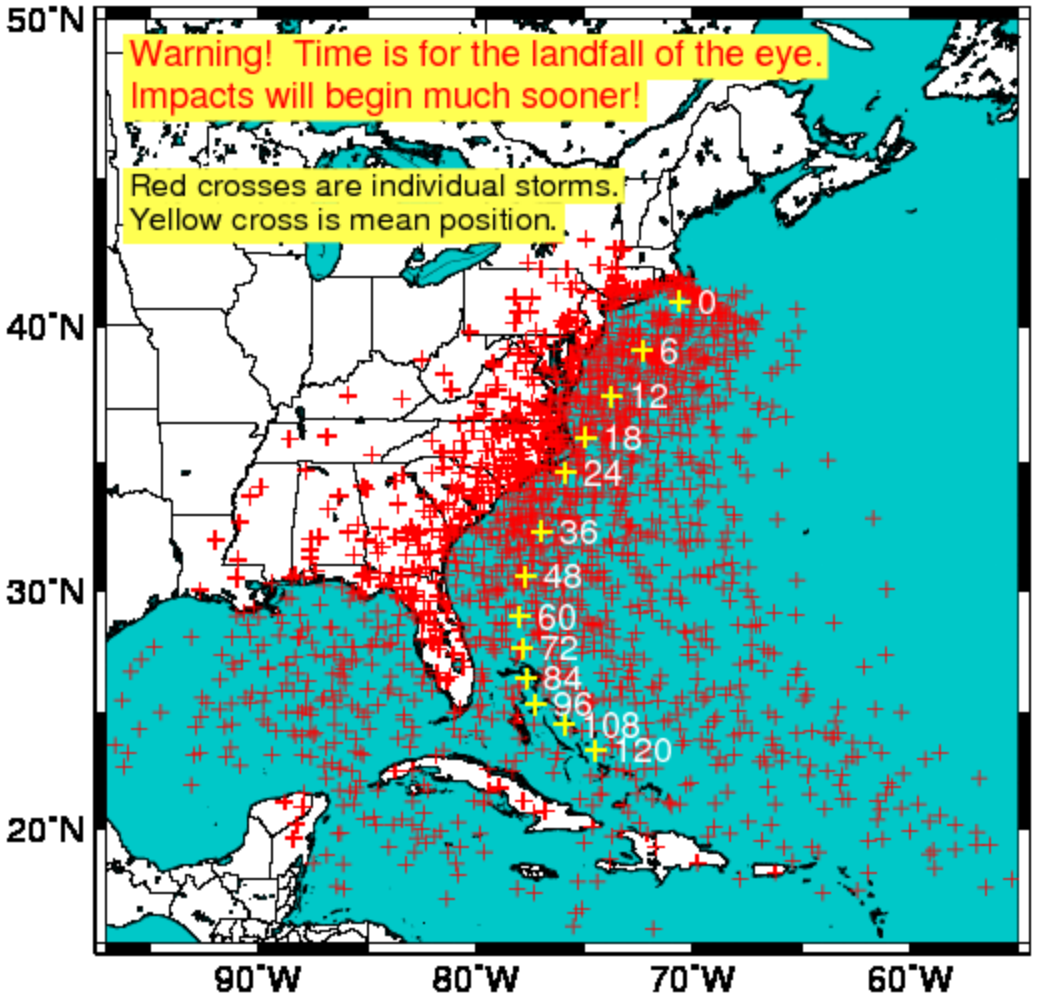
"All Storms" includes: Tropical Storms, Hurricanes, and Post-tropical Cyclones

Position of All Storms At 0 Hours Before Landfall of Eye



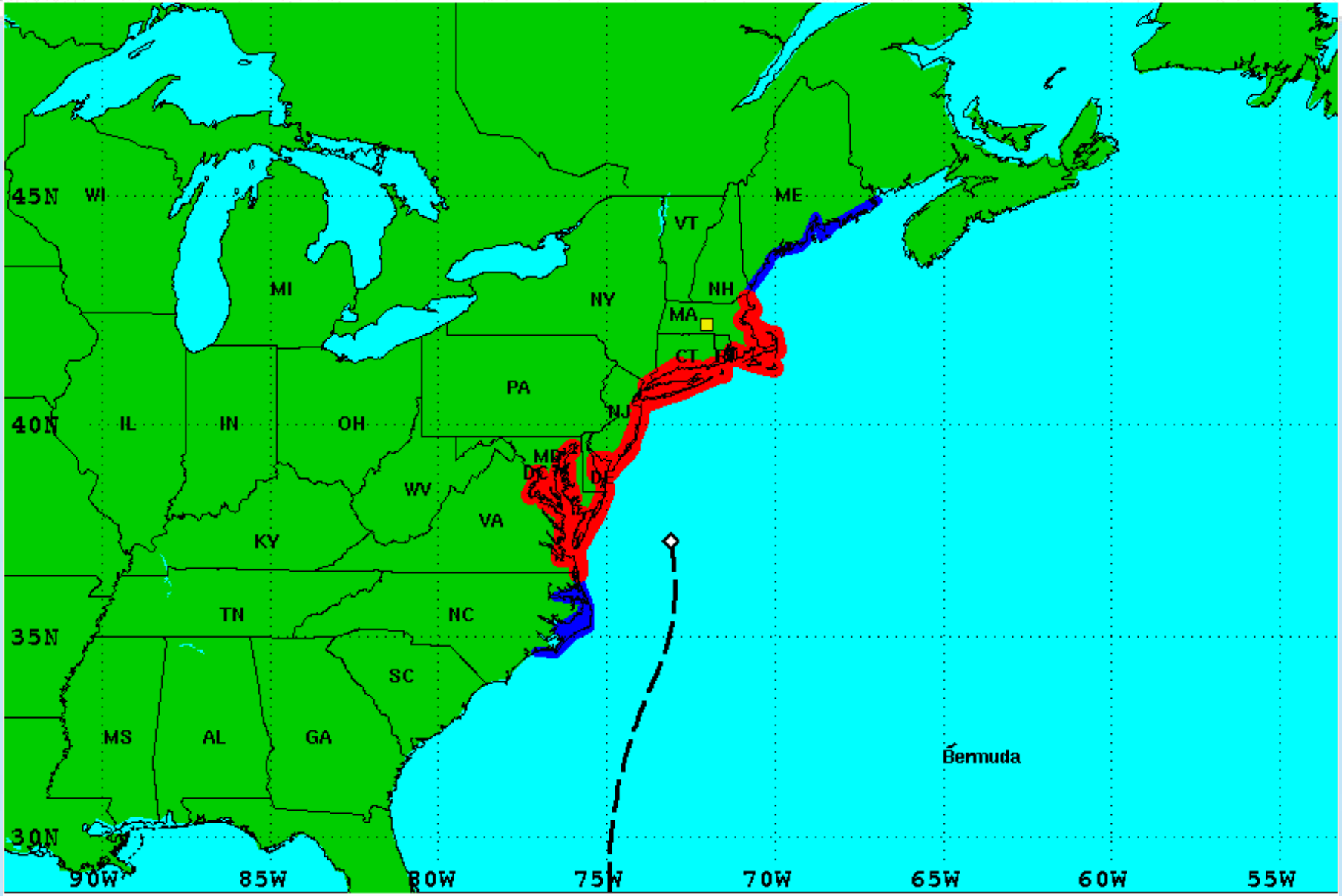
"All Storms" includes: Tropical Storms, Hurricanes, and Post-tropical Cyclones

Position of All Storms Within 120 Hours Before Landfall of Eye



"All Storms" includes: Tropical Storms, Hurricanes, and Post-tropical Cyclones

How long until impacts are experienced in Worcester?



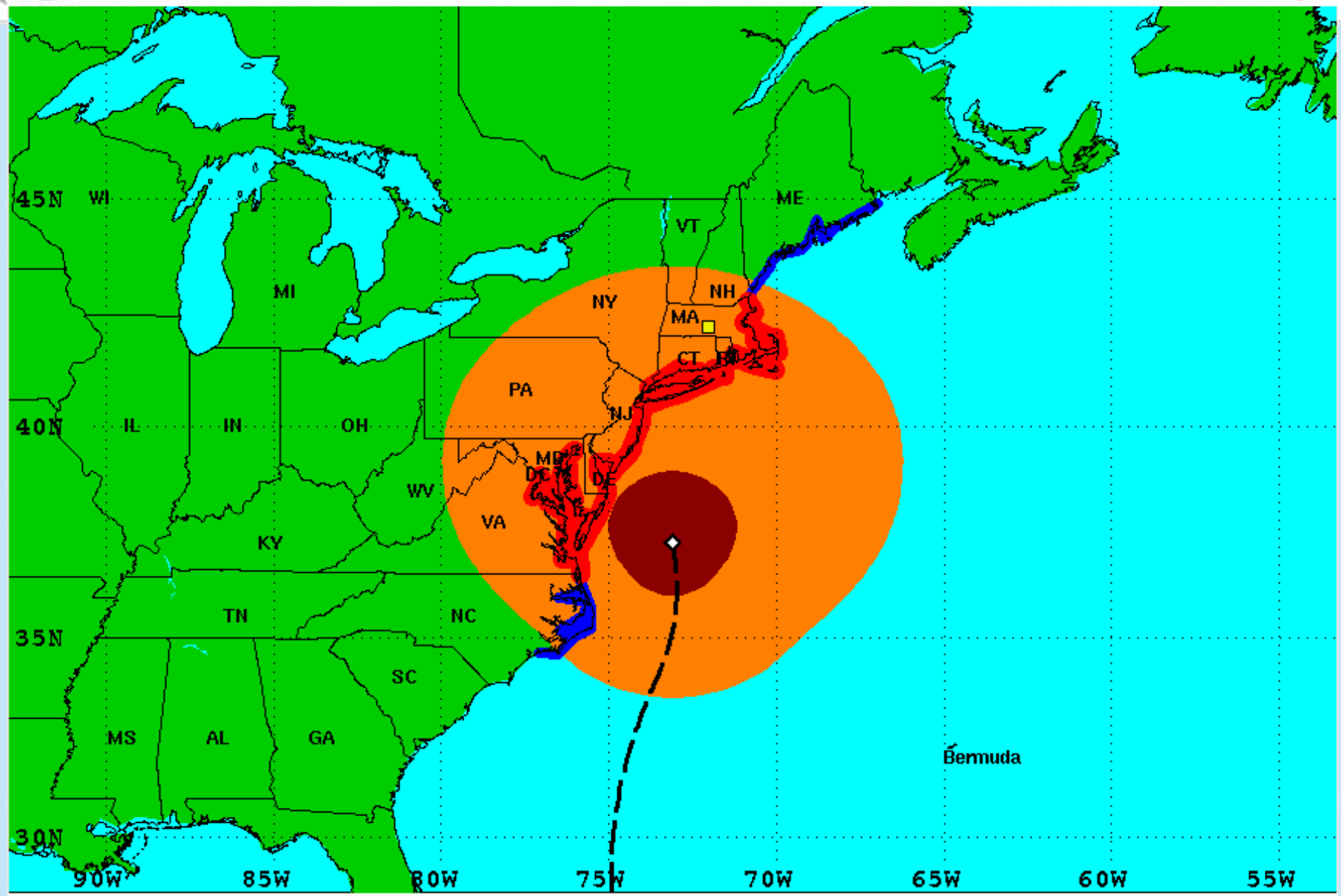
Watches:
- Hurricane Watch
- Tropical Storm Watch

Warnings:
- Hurricane Warning
- Tropical Storm Warning

Sustained Winds:
- Hurricane Force
- Tropical Storm Force

Position:
- Center as of 1100 AM EDT
- Past Track

Already happening for a couple of hours now!



Watches:
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Warnings:
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Sustained Winds:
- Hurricane Force
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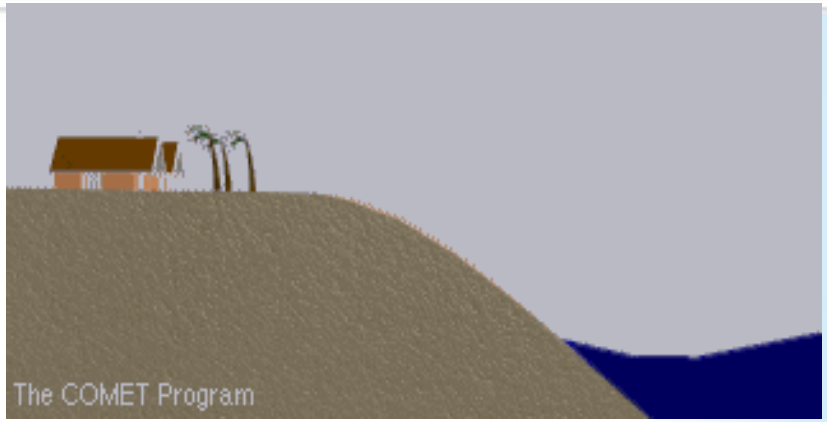
Position:
- Center as of 1100 AM EDT
- Past Track

- Can occur more than 1000 miles in advance of a tropical system – depends on size and intensity
- Often can catch people unaware of the risk because the weather is not “bad” at a particular location
- Shallow beaches perpendicular to swell motion most at risk (i.e. the ocean-exposed south coast of Massachusetts)

Rip Currents

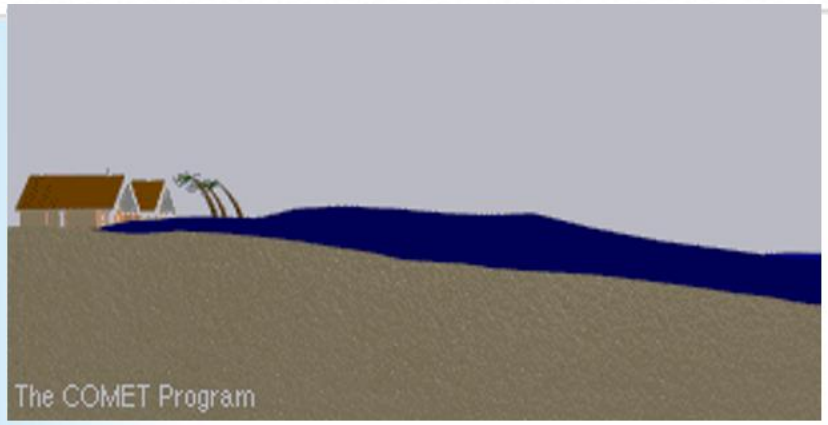
Shallow Shelf Incline



Steep Shelf Incline

- Shallow shelf – results in higher surges and lower waves
  - This is the south coast of Massachusetts
- Steep shelf – results in lower surges and higher waves
  - This is the east coast of Massachusetts

Storm Surge and Shore Slope



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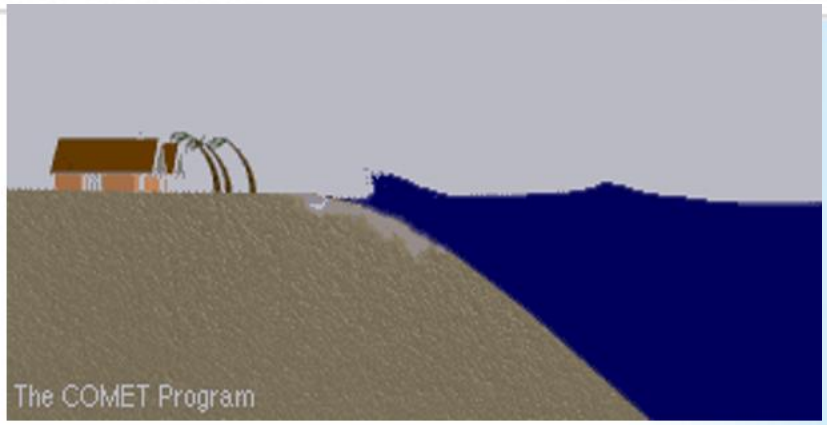


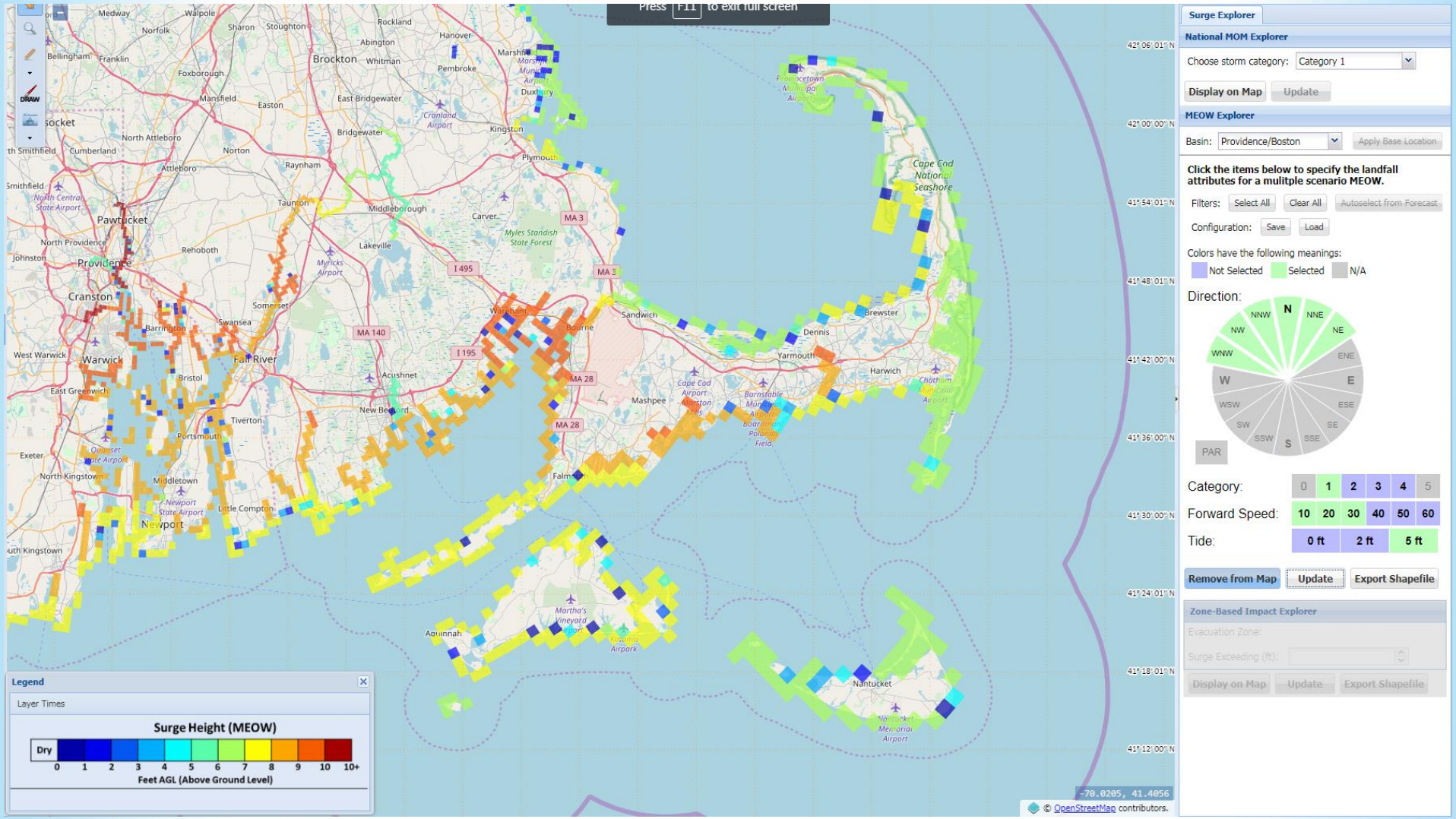
Steep Shelf Incline

- Shallow shelf – results in higher surges and lower waves
  - This is the south coast of Massachusetts
- Steep shelf – results in lower surges and higher waves
  - This is the east coast of Massachusetts

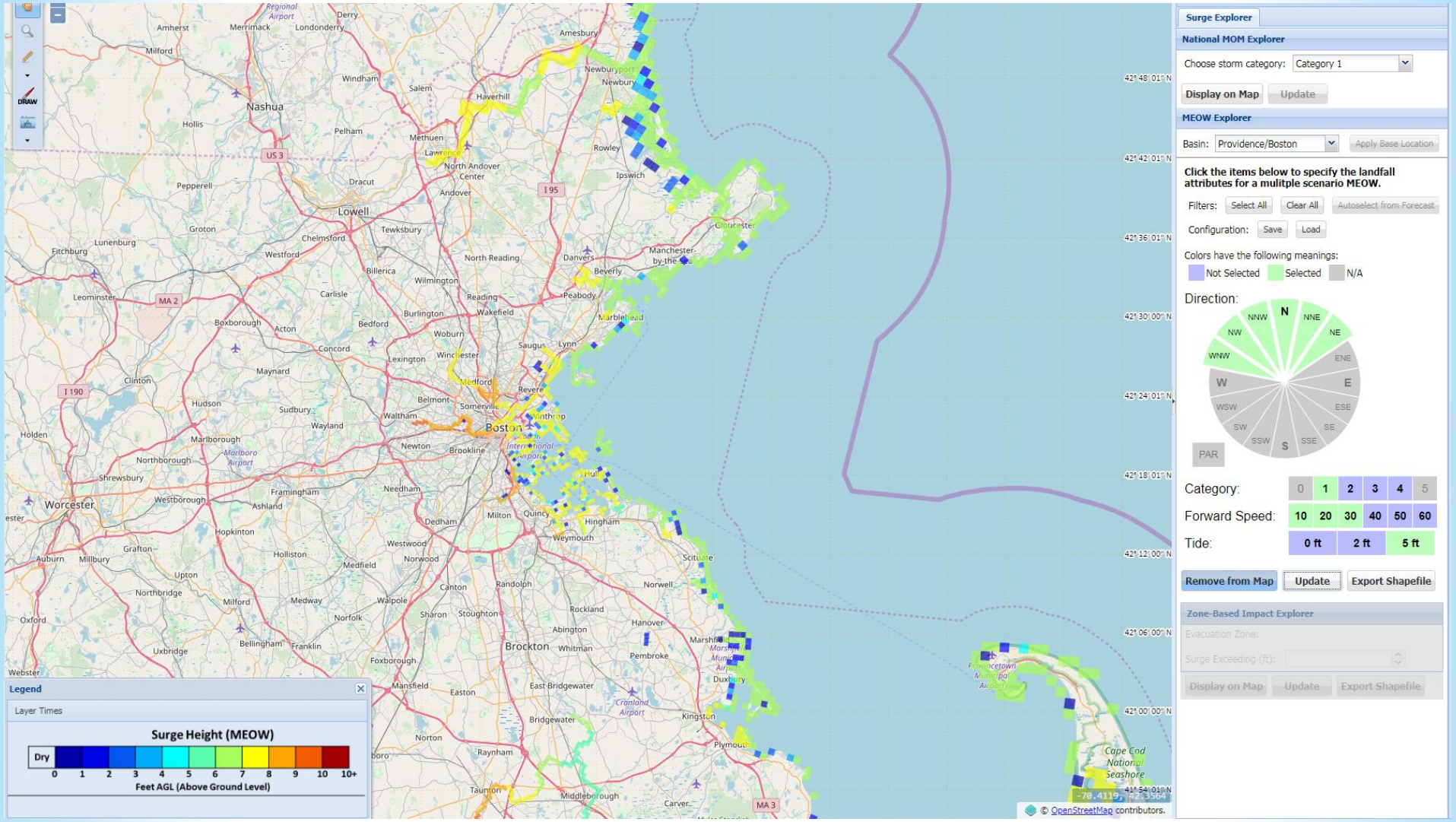
Storm Surge and Shore Slope

- Tremendous storm surges on south-facing bays, with the most significant surge occurring within one hour of landfall
- Wave run-up causes coastal flooding to begin as much as 6 hours before eye comes ashore
  - In spite of the storm's rapid acceleration.
- Surges of 12 to 15 feet have been observed
- Potential for 20+ foot inundation AGL from Cat 3 storm exists for the head of Buzzard's Bay, MA

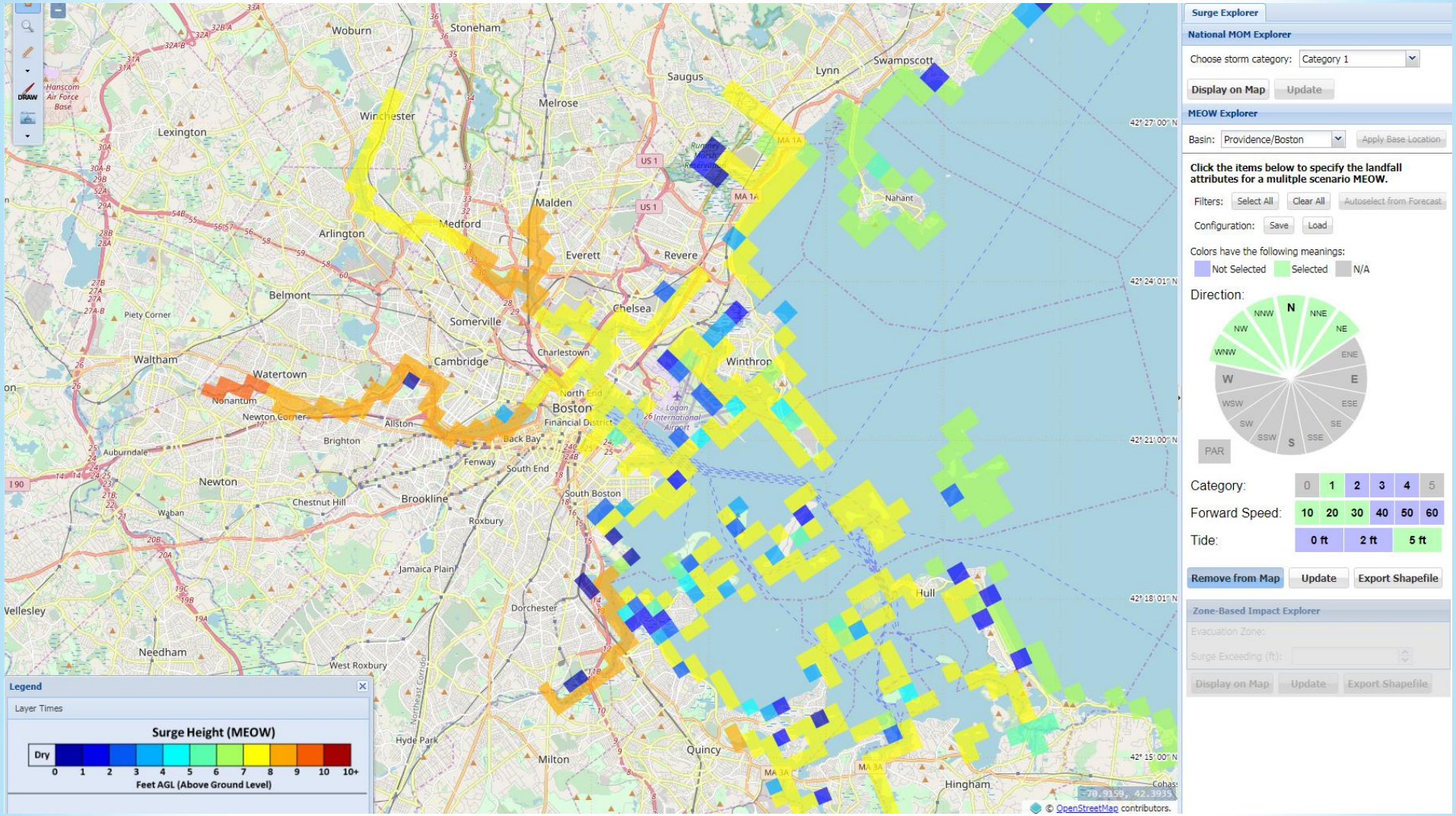
Storm Surge



Inundation Potential For A Cat 1



Inundation Potential For A Cat 1



Inundation Potential For A Cat 1

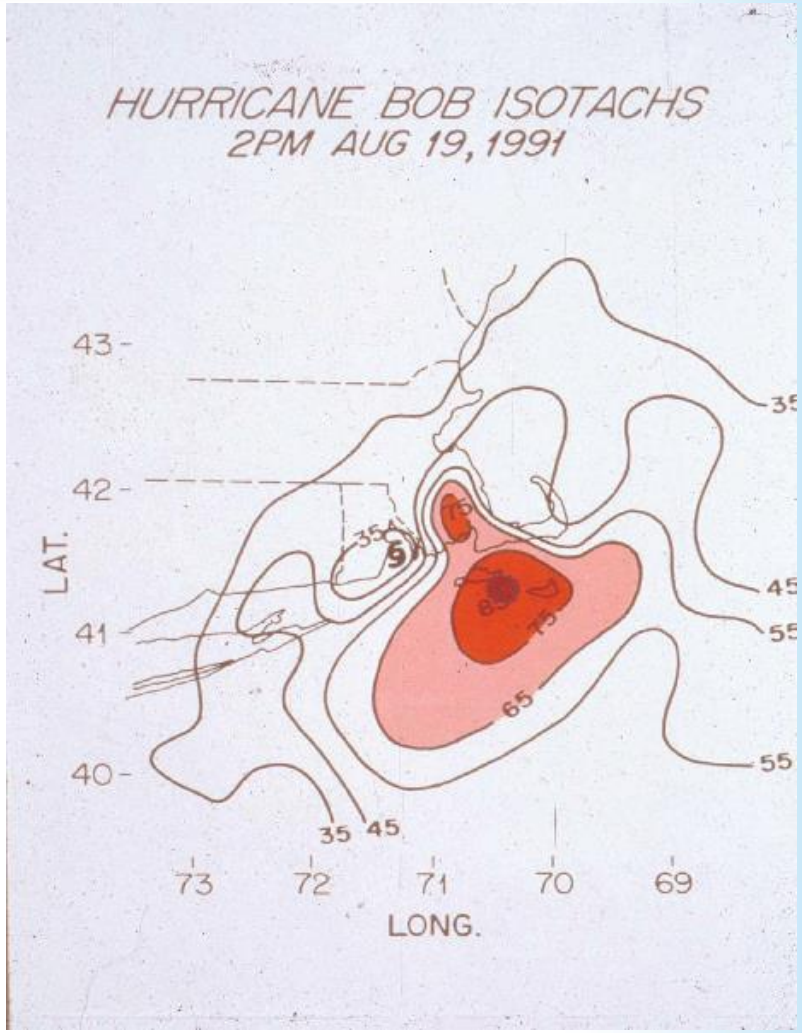
- Rapid Average forward motion at landfall
  - 33 mph (51 km/hr)
- The Great New England Hurricane of 1938 made the trip from Cape Hatteras, NC to Providence, RI in 8 hours!
  - Forward speed at landfall was at least 51 mph (82 km/hr) and estimated as high as 60 mph (97 km/hr)
- Interaction with Jet Stream
  - Key contributor to the location/magnitude of the heavy rains, high winds and storm surges.
  - Systems often were showing a phase change from purely tropical to extratropical (more like a Nor'easter!).

Rapid Acceleration

- Short duration (relatively) of sustained tropical storm and hurricane force winds
  - Tropical Storm = up to 12 hours
  - Hurricane force = 3-6 hours
- High winds focused right of the track
  - Acceleration dramatically adds to gust potential on right side of storm
  - Milton, MA, Blue Hill Observatory, elevation 629 ft
  - 1938 – sustained 121 mph peak gust 186 mph!

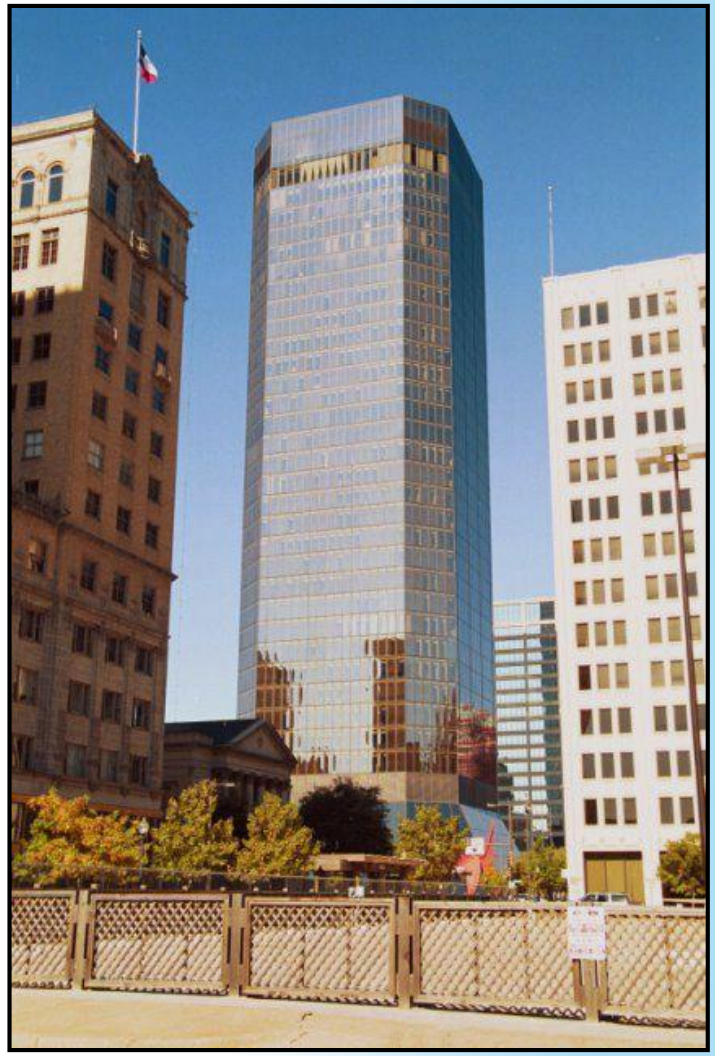
High Winds

- Radius of maximum winds (RMW) varied considerably
  - As small as 25 mi/40 km in Hurricane Bob 1991
  - As large as 40 mi/64 km in the Great New England Hurricane 1938
- Where this core goes will determine:
  - Where wind damage will be the greatest
  - Where storm surges will be the highest



High Winds

March 2000
Ft. Worth, TX
F2 intensity
(115-140 mph)
tornado damage



Hurricanes and Tall Buildings

March 2000
Ft. Worth, TX
F2 intensity
(115-140 mph)
tornado damage

What about a Category 3
(111-129 mph) hurricane for
a half hour?

Hurricanes and Tall Buildings

- **When you think "hurricane/tropical storm", think "flooding"!**
- Historically, water (mainly storm surge) is responsible for most deaths from tropical cyclones
  - More recently though most deaths have been a result of inland fresh water flooding
- Slower, larger storms usually produce more rainfall
- Even weak, or weakening, storms can produce a lot of rainfall
- Antecedent soil conditions and local topography matter!

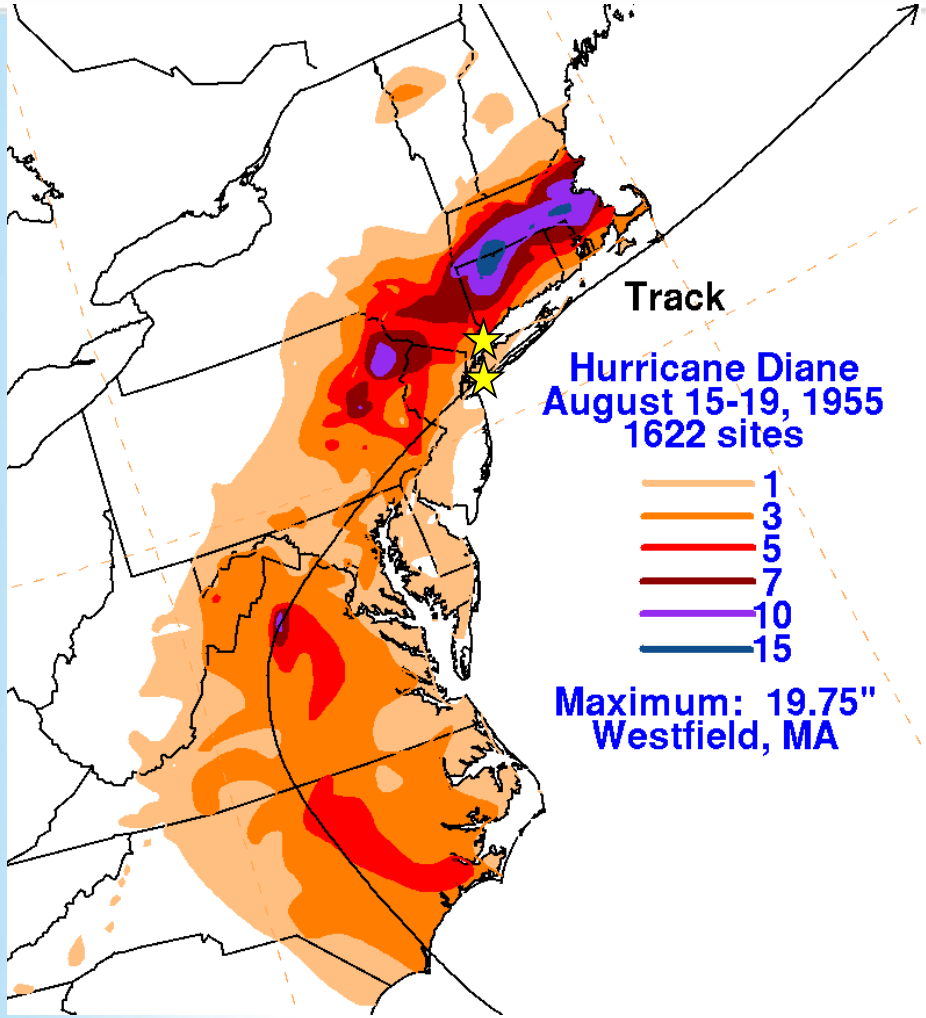
Flooding Rainfall

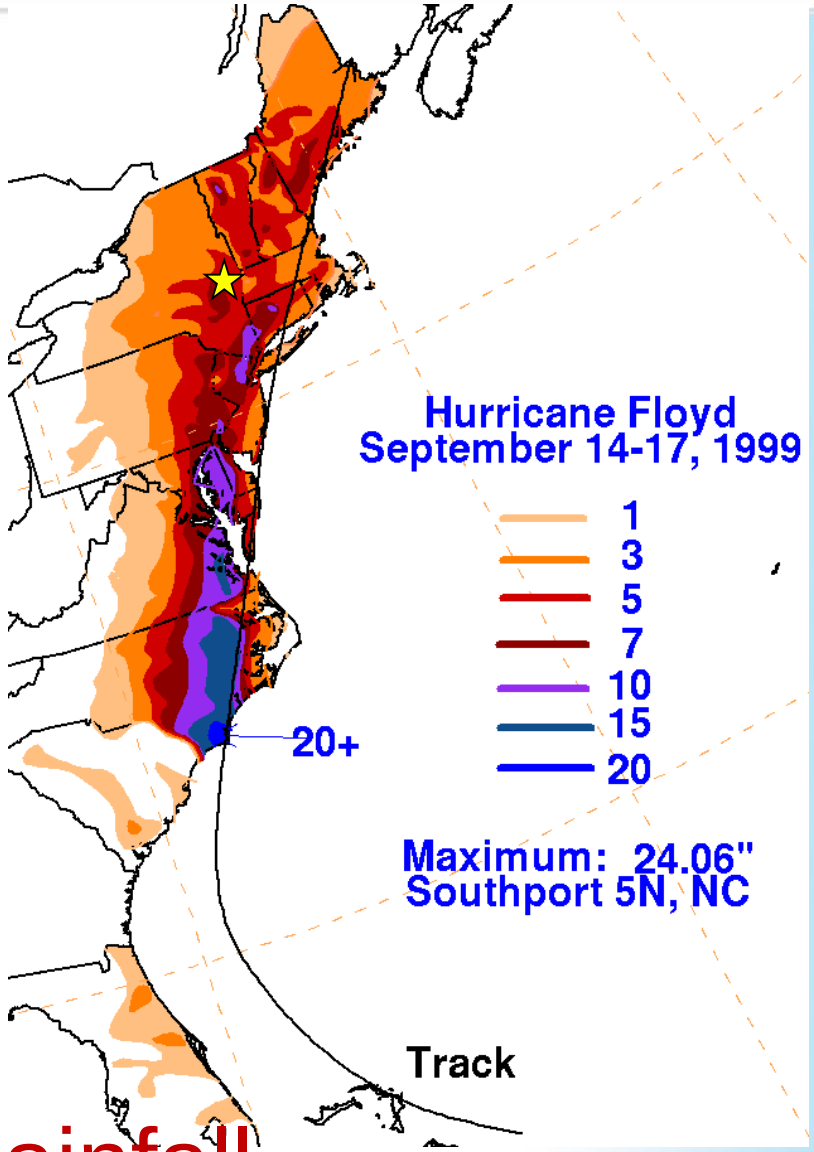
- Doesn't have to hit New England directly to have an impact
- Typical rainfall for a tropical cyclone in southern New England is 6-10 inches (mainly to the left of the track - but not always)
- More than half of the tropical cyclones impacting southern New England since 1900 have resulted in major river/stream flooding

Flooding Rainfall

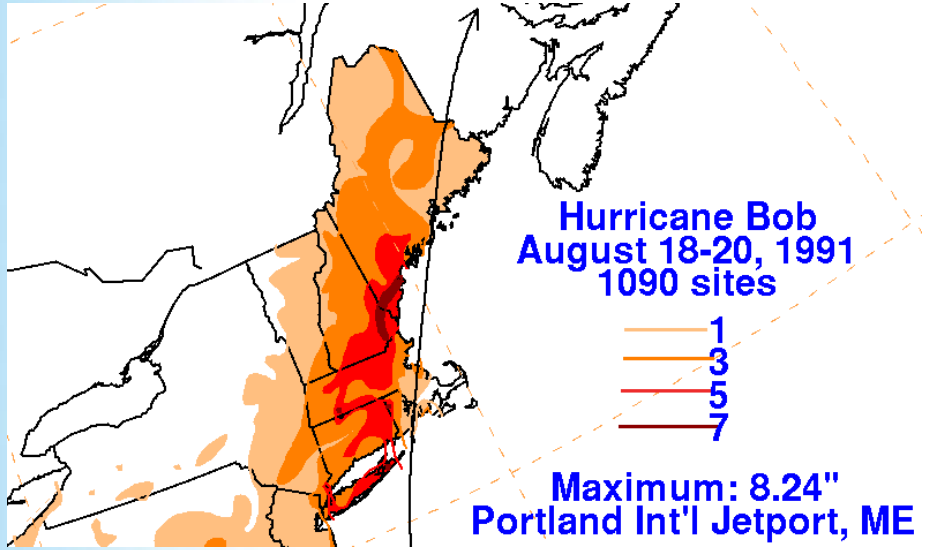
- Heavy rains can arrive 12 to 15 hours in advance of the eye.
- Heaviest rainfall is “almost always” to the west of the track (left of track)
- Primary mechanisms for this left of track location include jet interactions, topography and coastal frontogenesis
- Classic examples:
  - Hurricane Bob and Hurricane Donna

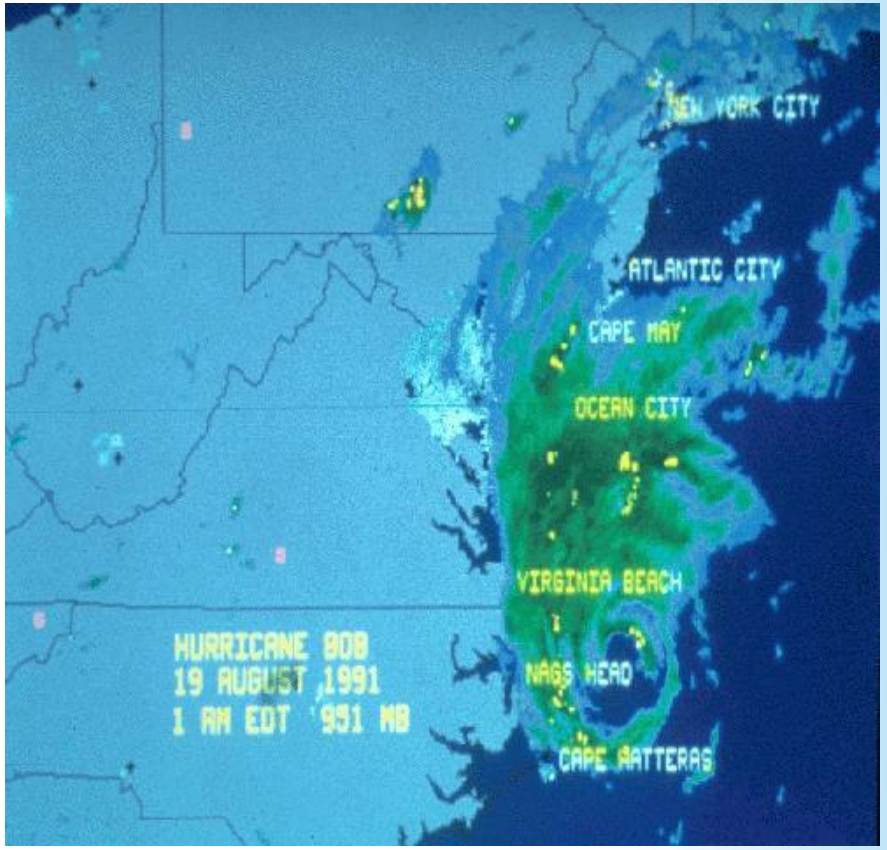
Rainfall Characteristics





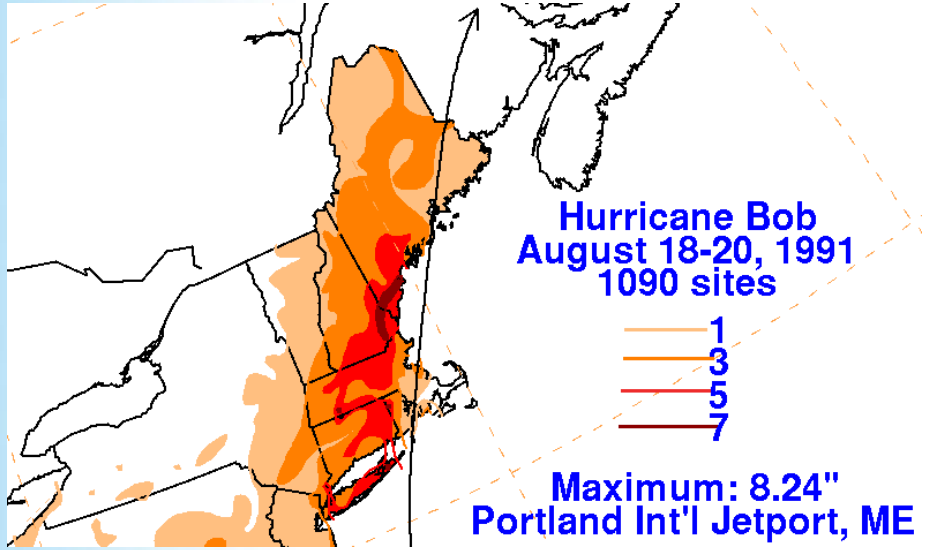
Flooding Rainfall

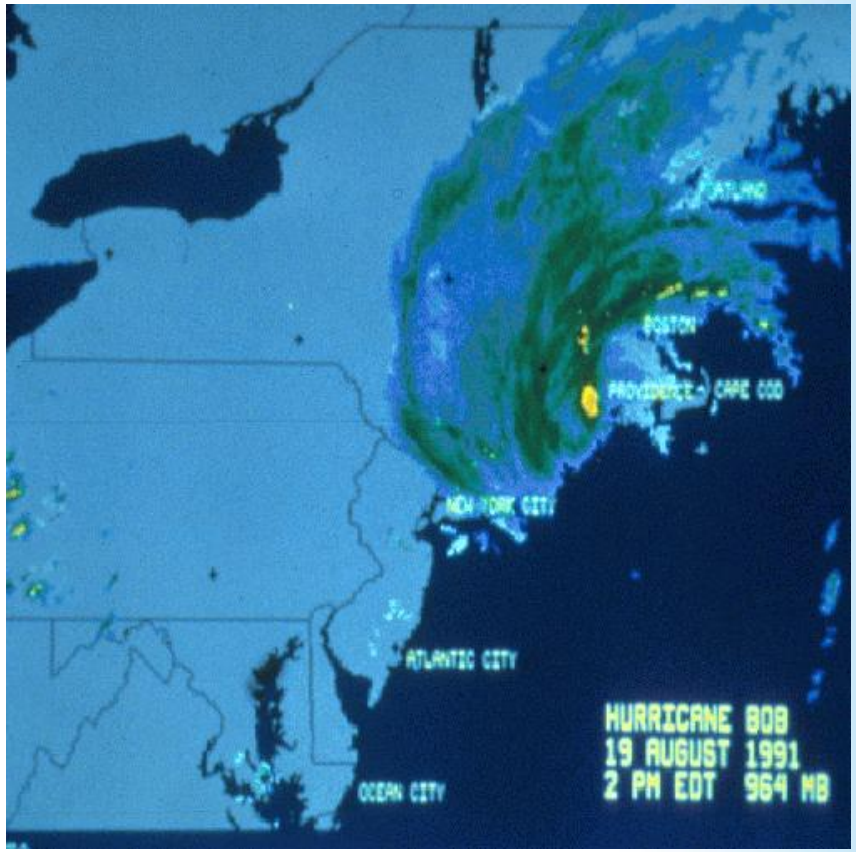




13 hours before landfall of eye in New England

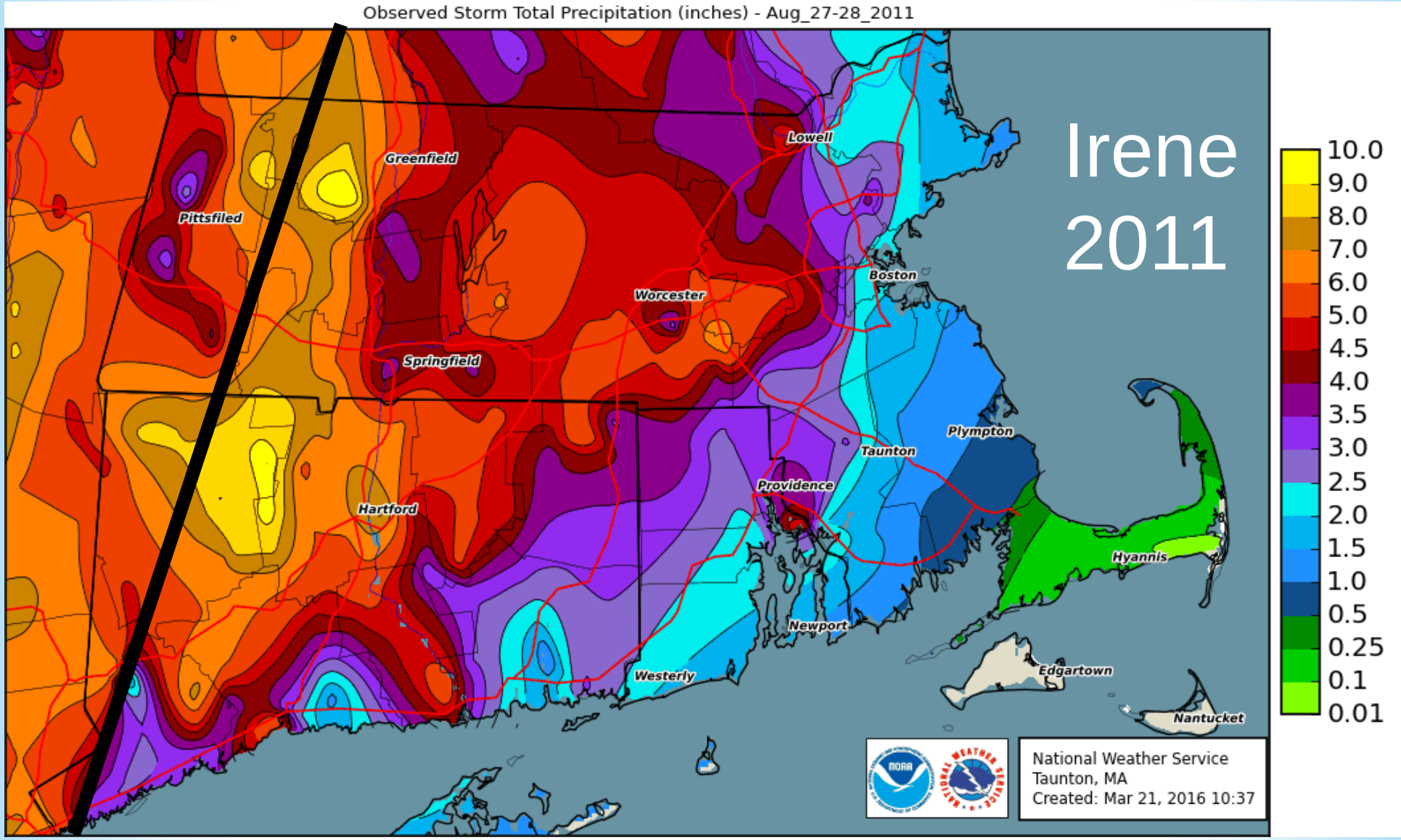
Flooding Rainfall



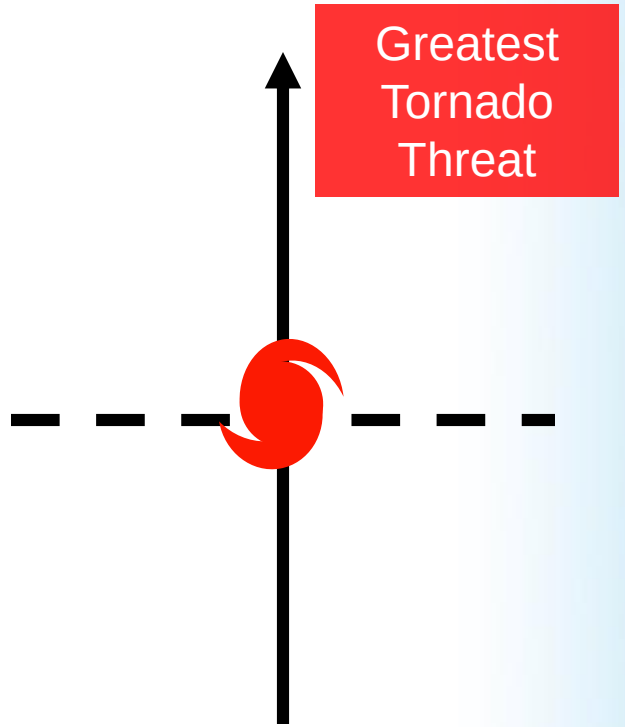


At landfall of eye in New England

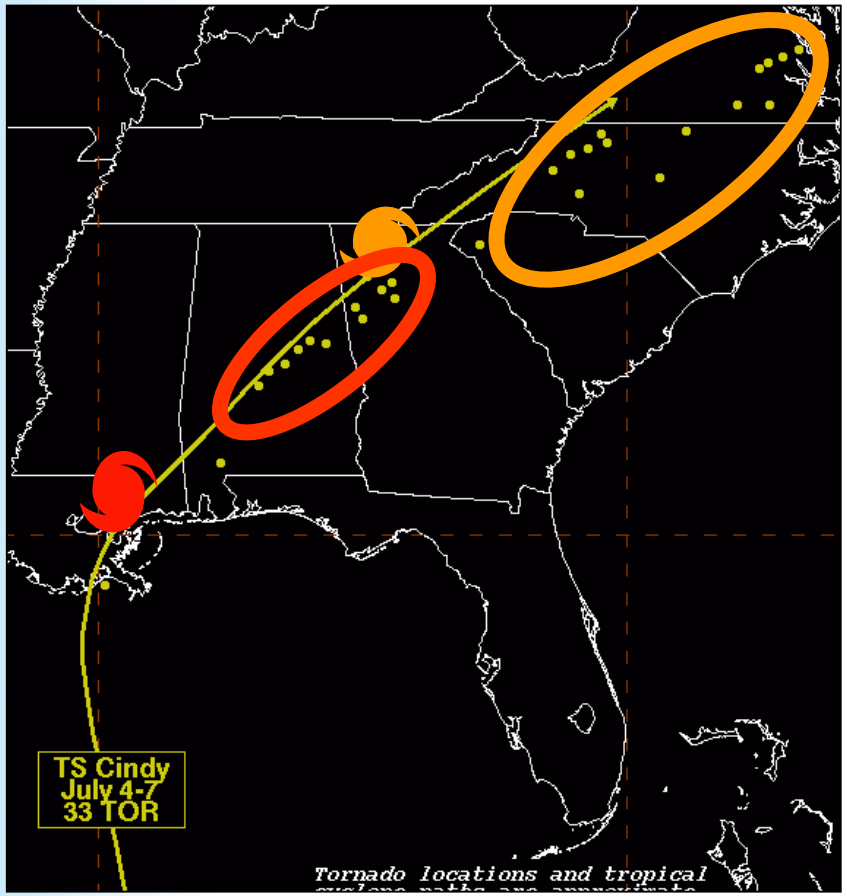
Flooding Rainfall

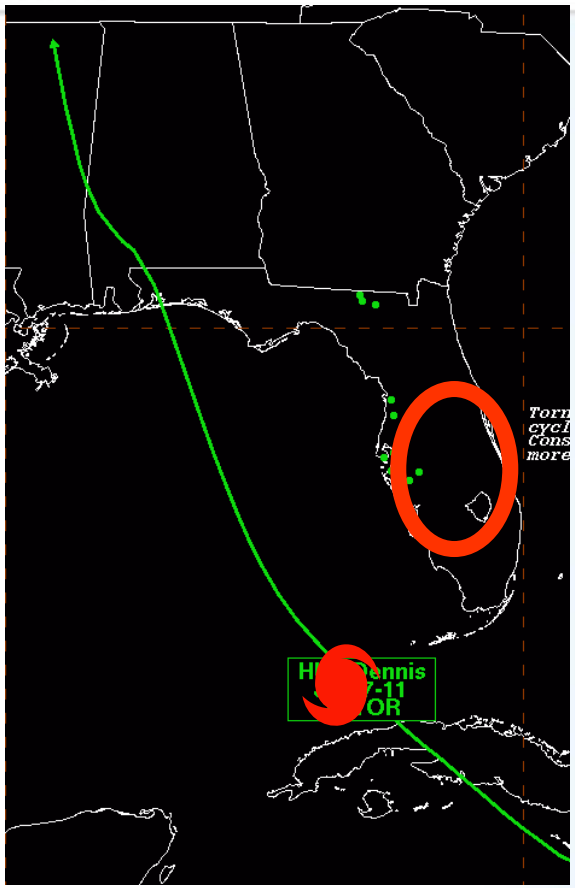

Observed Storm Total Precipitation (inches) - Aug_27-28_2011
Irene
2011
Lowell
Greenfield
Pittsfiled
Boston
Worcester
Springfield
Plympton
Taunton
Providence
Hartford
Hyannis
Newport
Westerly
Edgartown
Nantucket
10.0
9.0
8.0
7.0
6.0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.25
0.1
0.01
National Weather Service
Taunton, MA
Created: Mar 21, 2016 10:37

- Almost all tropical systems produce at least one tornado or waterspout!
- Tornadoes can form hundreds of miles ahead of a tropical storm or hurricane
- 90% of these tornadoes or waterspouts develop in the “right front” quadrant
- Tornadoes often form in the outer bands of the tropical cyclone



Tornadoes





Tornadoes in Cindy and Dennis (2005)

Thank You!

Questions?

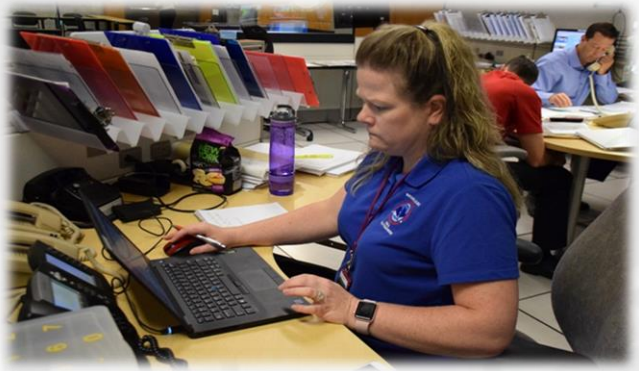
Successes and Challenges of the 2017 Hurricane Season

Daniel Brown, Robbie Berg, and Mike Brennan
National Hurricane Center

Massachusetts Emergency
Management Agency Webinar
May 29-30, 2018

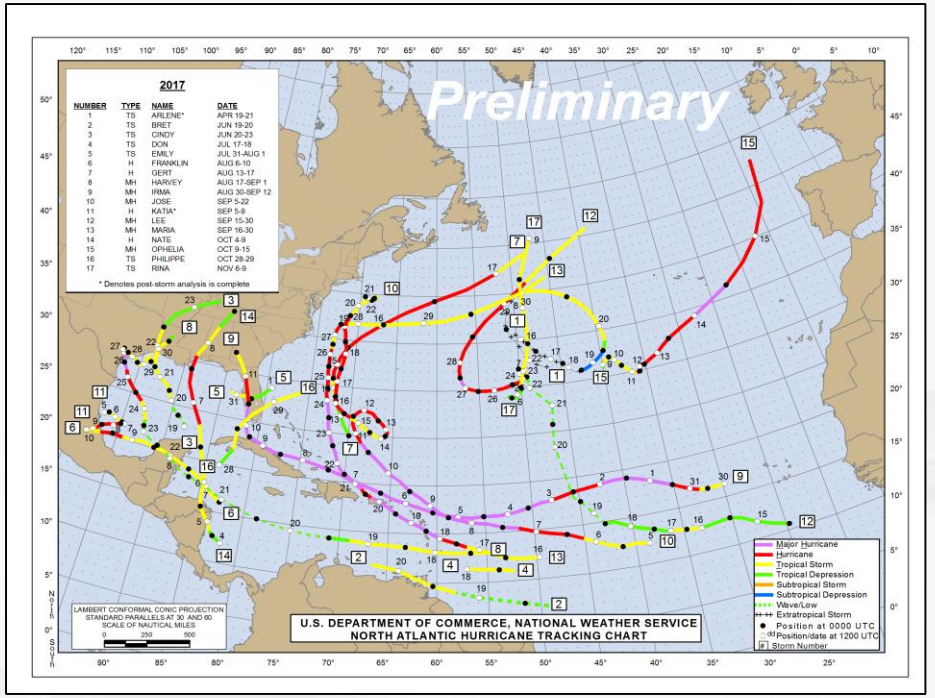
Key Successes of the 2017 Hurricane Season

- Record low NHC Track Errors (Atlantic)
- Launch of the ability to issue watches and warning before formation (Potential Tropical Cyclones)
- First ever Storm Surge Warning issued in the United States
  - Very few, if any, storm surge related fatalities in the U.S.
- On Site Decision Support Coordinator ensured consistency throughout the NWS
- Test of continuity of operations (Irma)

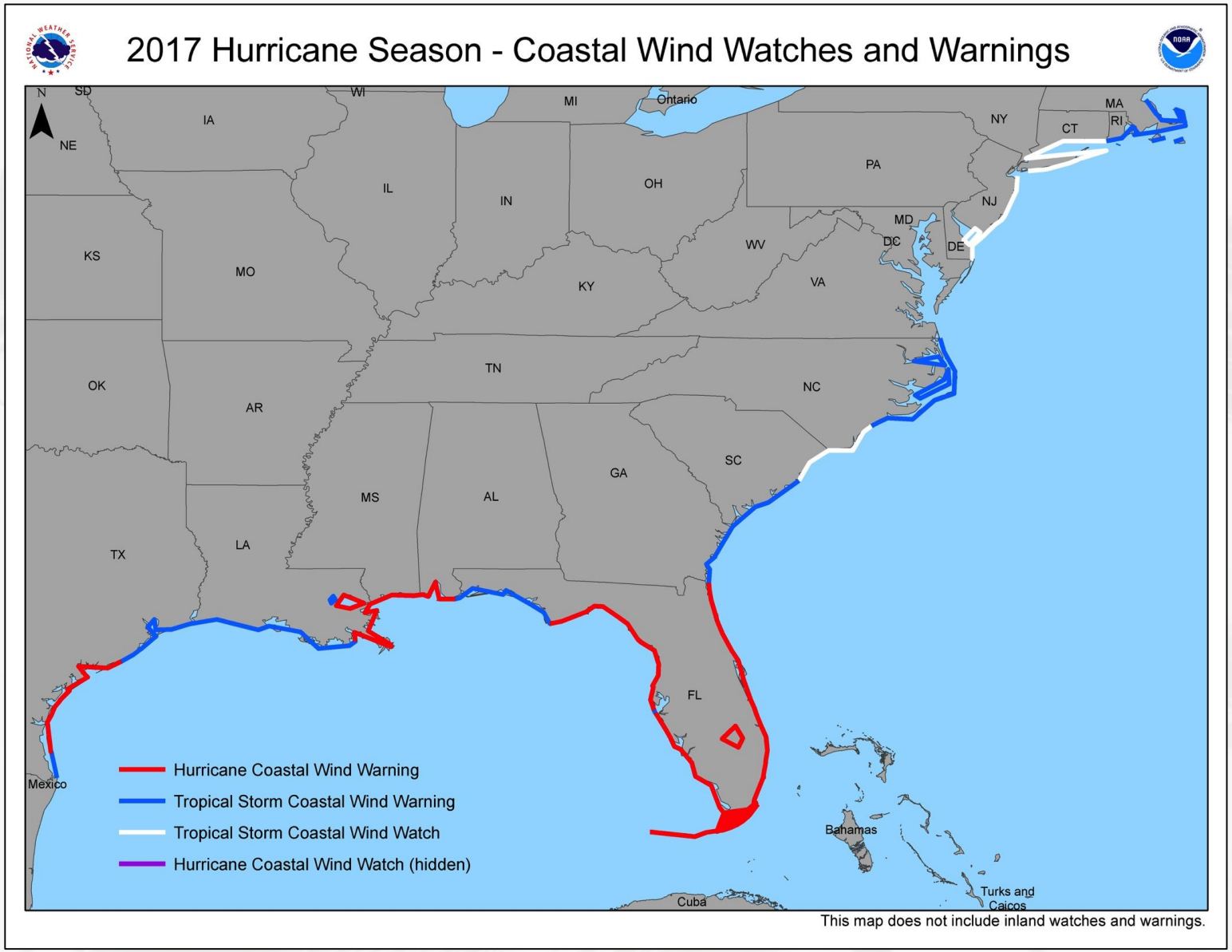


2017 Hurricane Season
Facts and Figures

- 17 named storms, including 10 hurricanes, and 6 major hurricanes
  - 7th most active season on record (by ACE)
  - Most major hurricanes since 2005
- Five category 5 landfalls
  - 4 by Irma and 1 by Maria – all in the Caribbean
- Costliest year on record for the U.S. with $265 billion in damage
  - 2nd (Harvey), 3rd (Maria), and 5th (Irma) costliest U.S. storms

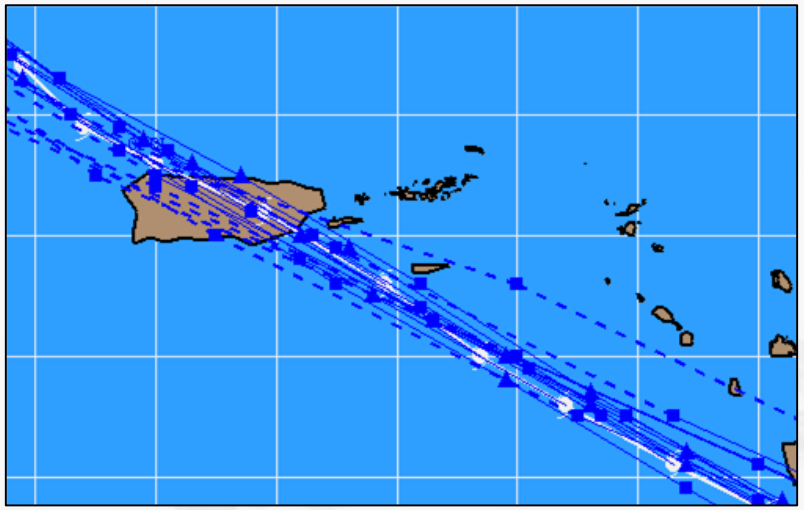


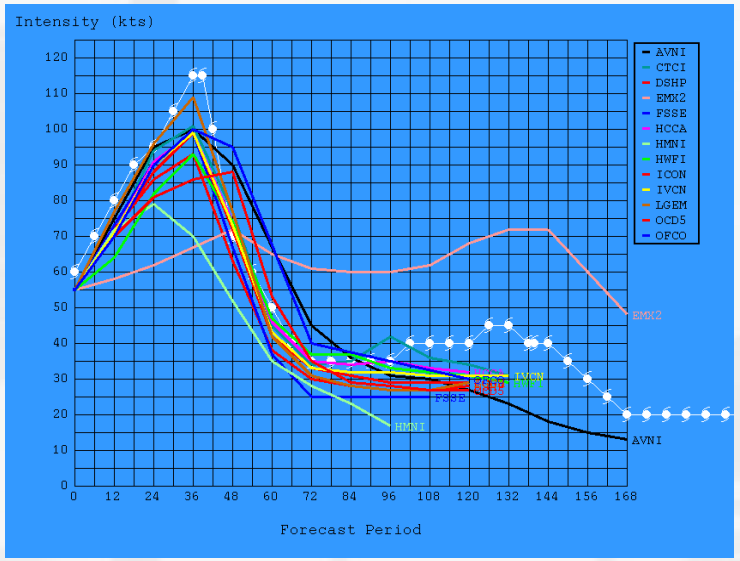
Much of the U.S. Gulf and Atlantic Coastline Under Watches or Warnings in 2017



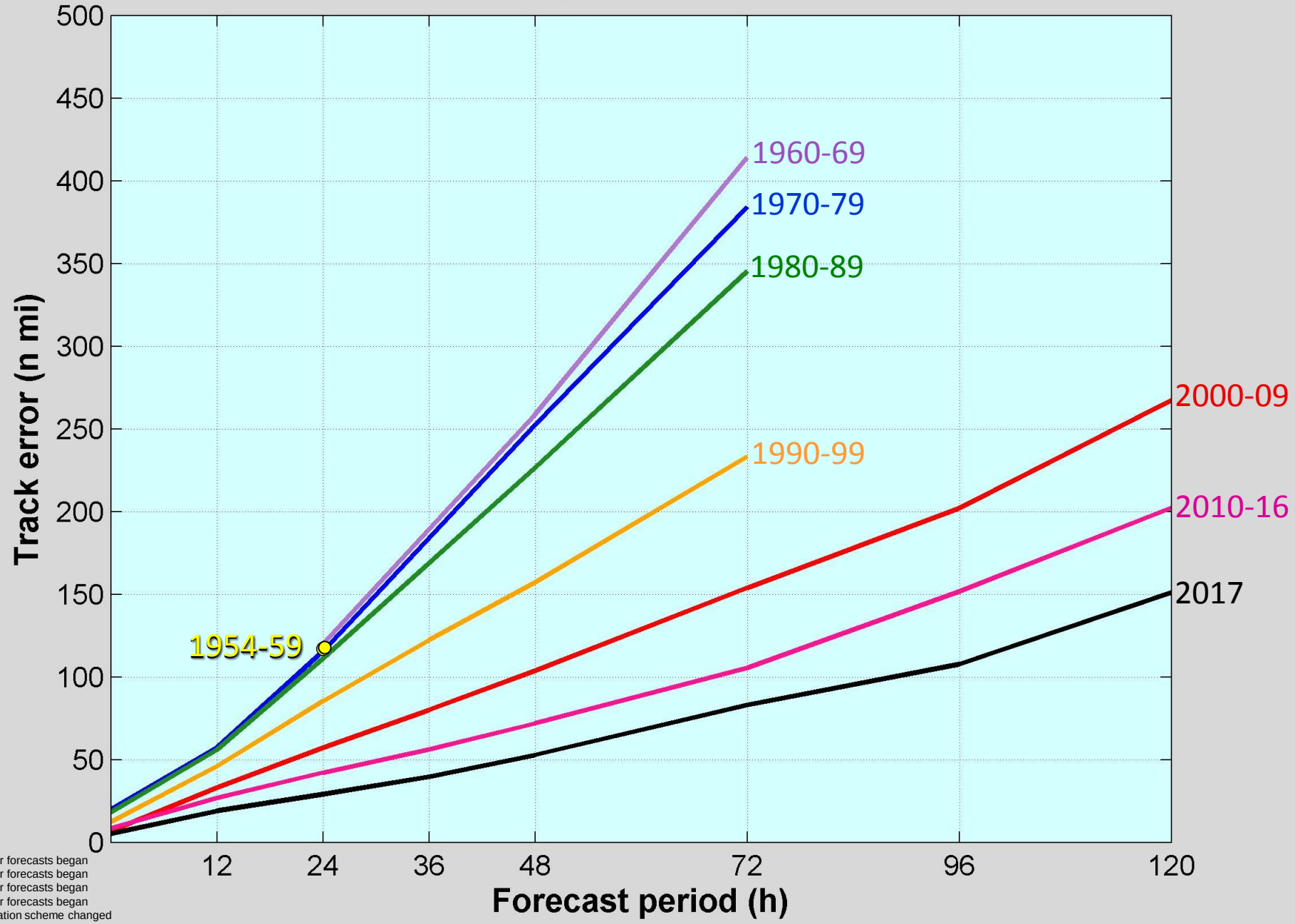
2017 Season in Review: Forecast Accuracy

- Record low average NHC Atlantic track errors at all forecast lead times
- Track errors for Harvey, Irma, and Maria much lower than the 5-year mean
  - Very consistent pre-Puerto Rico landfall forecasts for Maria.
- About 36 hours prior to Harvey's landfall the forecast successfully called for Harvey to intensify from a tropical storm to major hurricane





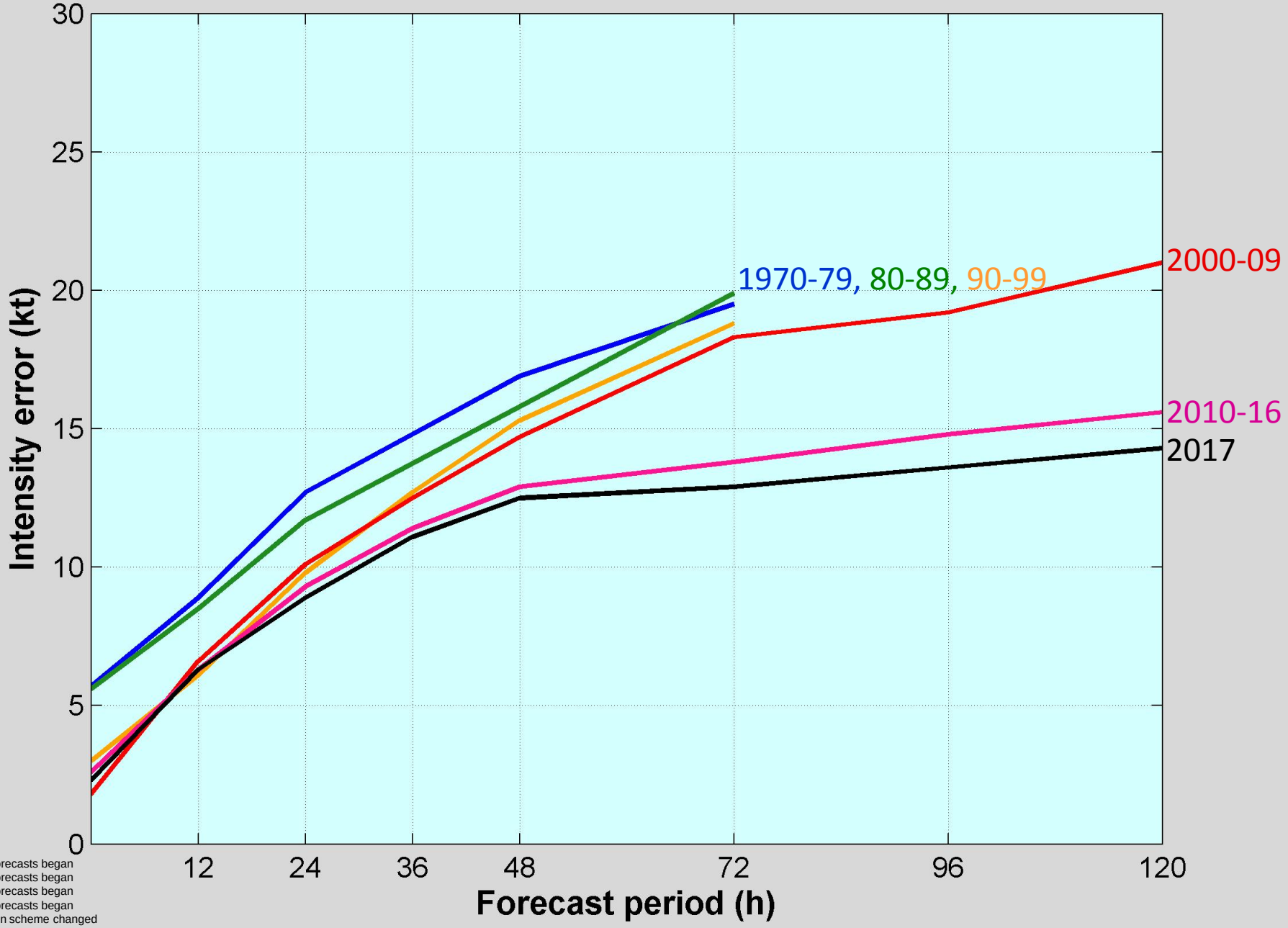
NHC Official Average Track Errors
Atlantic Basin Tropical Storms and Hurricanes



1954: 24 hour forecasts began
1961: 48 hour forecasts began
1964: 72 hour forecasts began
1967: 12 hour forecasts began
1970: Verification scheme changed
1988: 36 hour forecasts began
2001: 96 and 120 hour forecasts began (became public in 2003)

Source: NHC ENR/JPC 4/2018

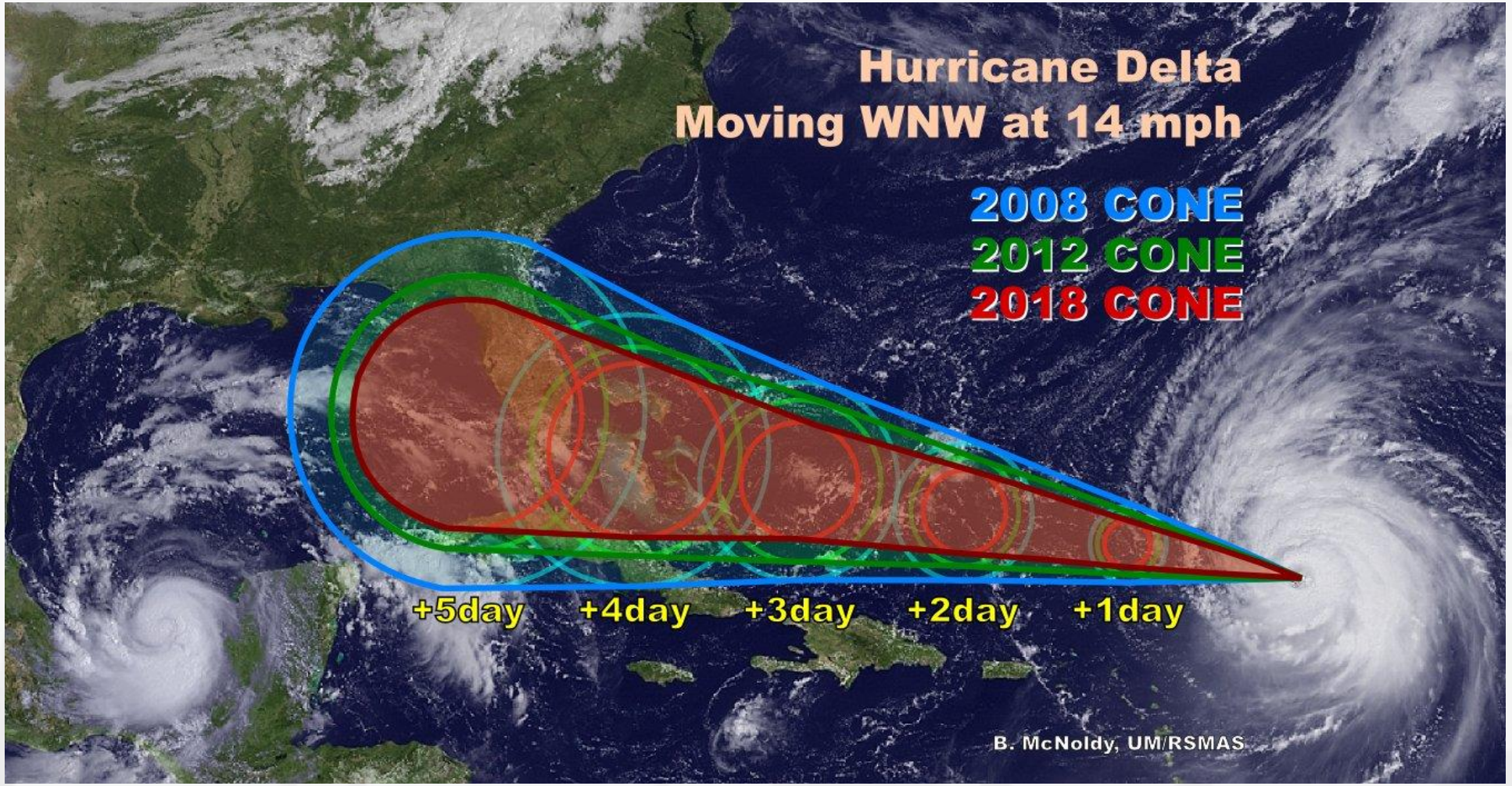
NHC Official Average Intensity Errors
Atlantic Basin Tropical Storms and Hurricanes



1954: 24 hour forecasts began
1961: 48 hour forecasts began
1964: 72 hour forecasts began
1967: 12 hour forecasts began
1970: Verification scheme changed
1988: 36 hour forecasts began
2001: 96 and 120 hour forecasts began (became public in 2003)

Source: NHC ENR/JPC 4/2018

Shrinking Forecast Cone



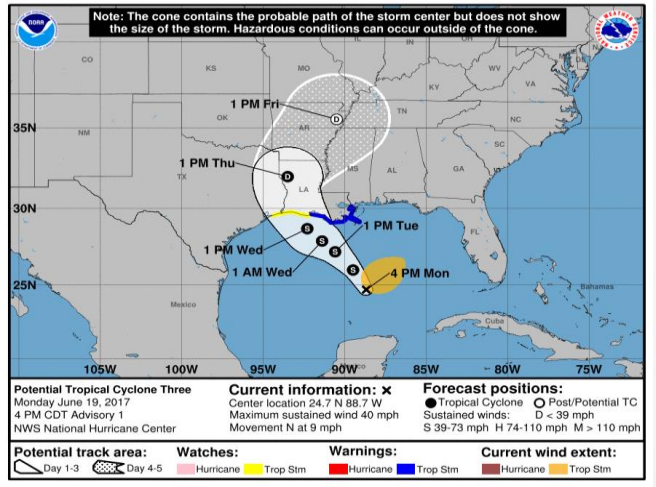
Not an Impact Graphic!

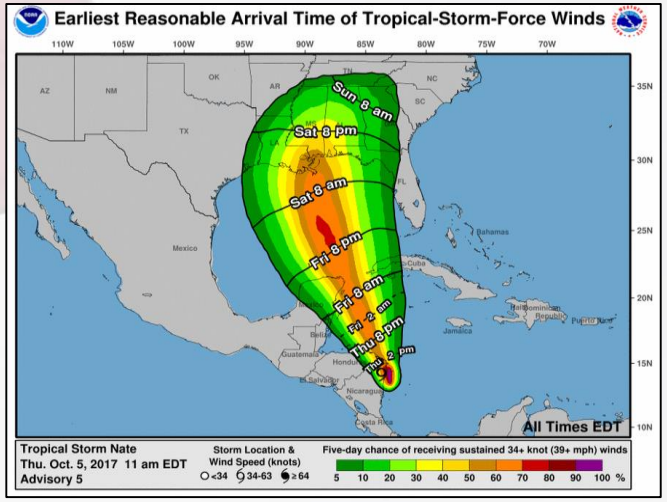
No reduction in storm size = More impacts occurring outside the cone!

Graphic courtesy of B. McNoldy UM/RSMAS

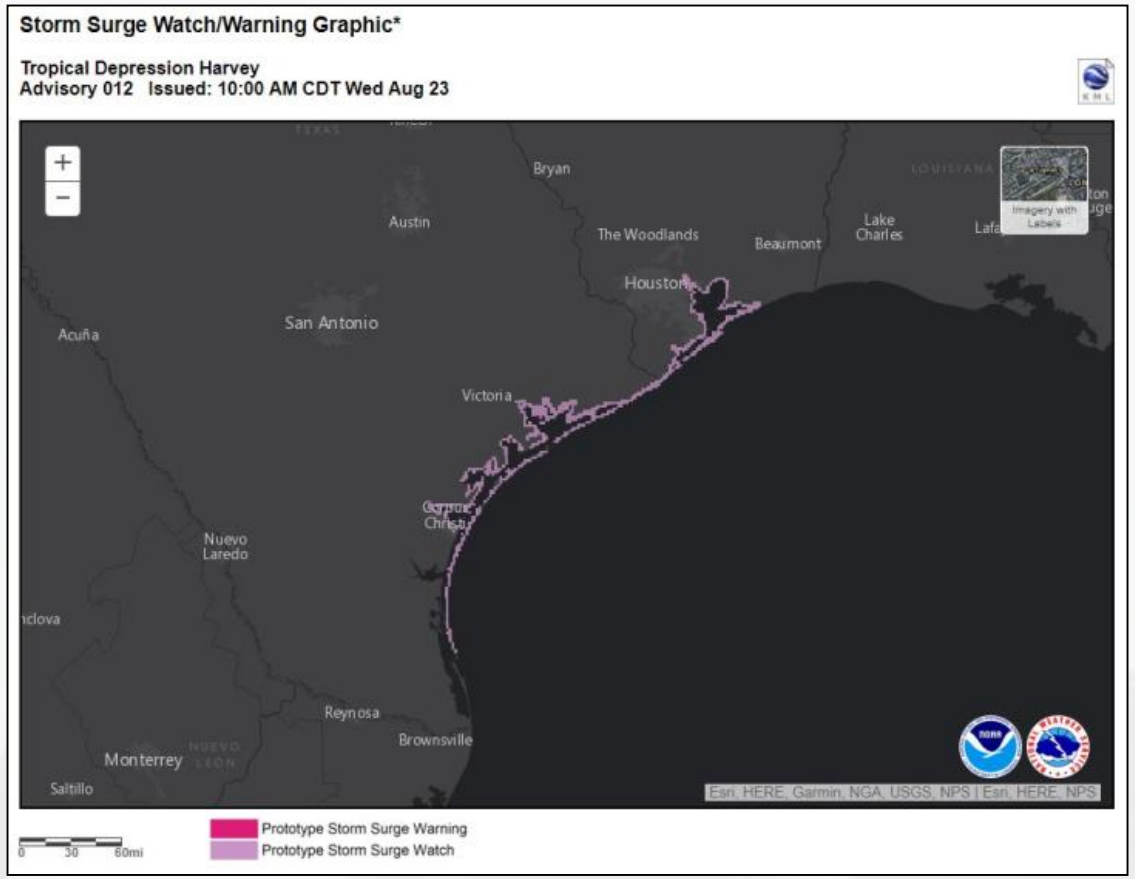
2017 Hurricane Program Successes

- Potential Tropical Cyclone Advisories
  - Allows issuance of watches & warnings
  - Resulted in additional lead time on systems developing near land
  - Used for 7 systems in the Atlantic basin, 6 went on to develop into a tropical storm or hurricane
- Time of Arrival Graphics
  - Earliest Reasonable
  - Most Likely
  - Accounts for typical track, intensity, and size forecast uncertainty





Storm Surge Watch/Warning Debut



Operationally launched the first ever Storm Surge Watch and Warning for the United States.

Storm Surge Watch/Warning

STORM SURGE WARNING

There is a **danger** of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within **36 hours**.

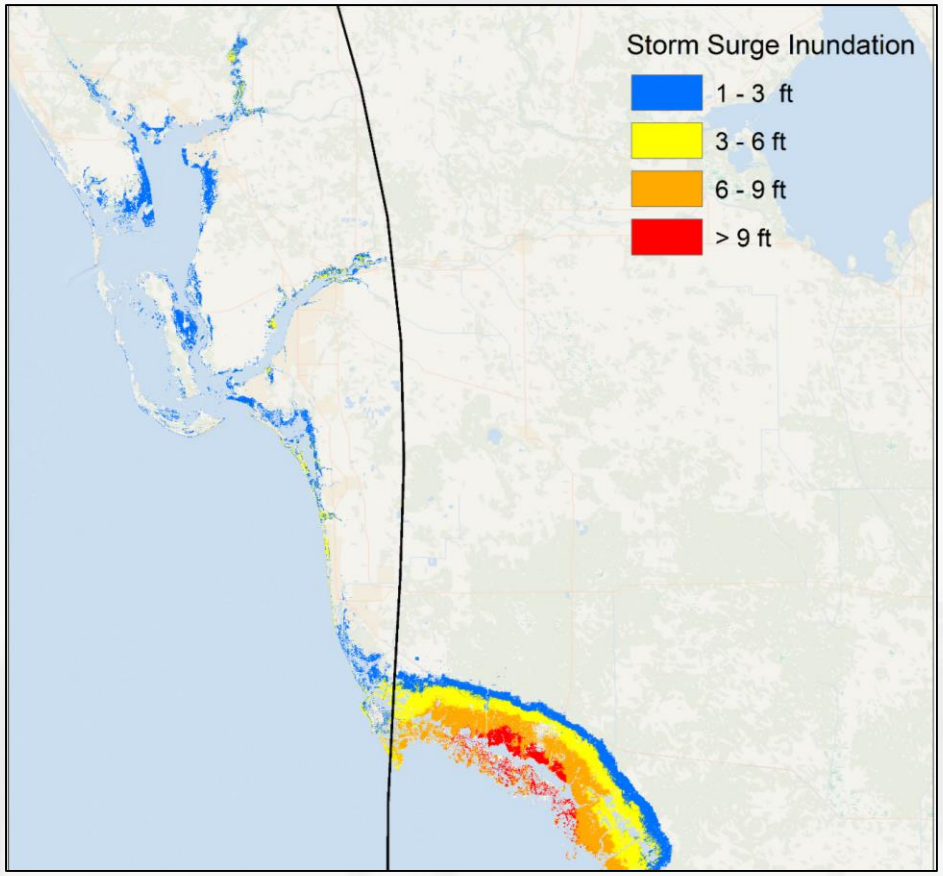
STORM SURGE WATCH

There is the **possibility** of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within **48 hours**.

Storm Surge Forecasts

Sensitivity to Track

Observed Track and Simulated Storm Surge

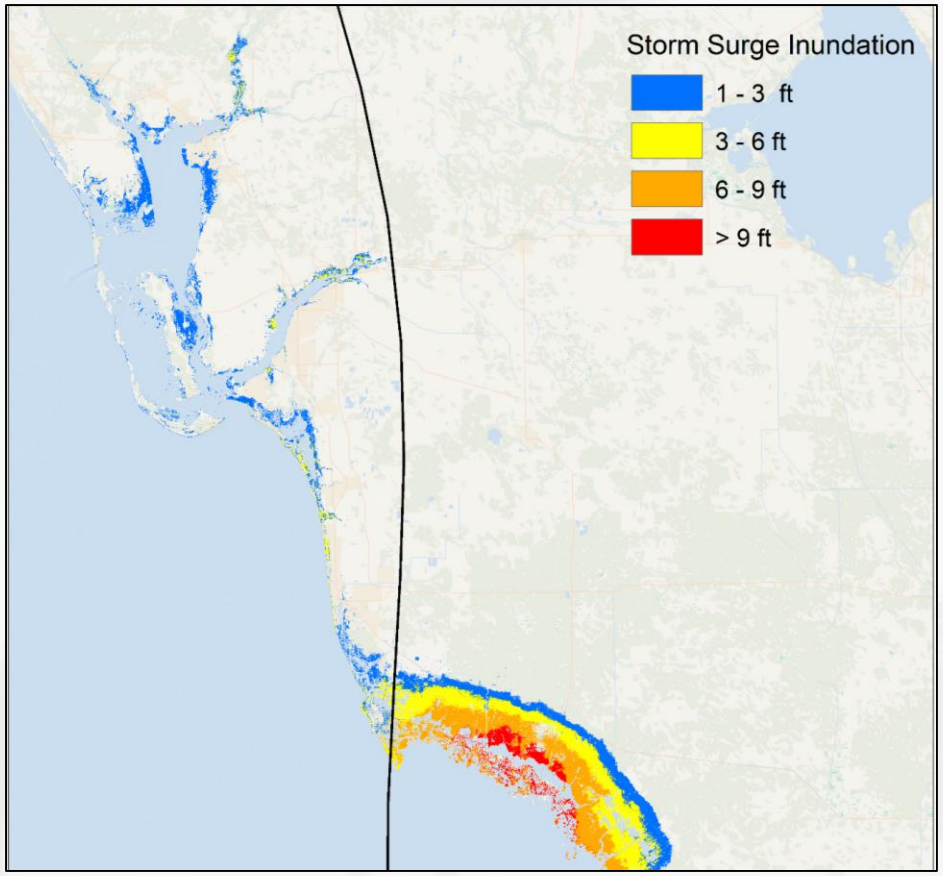


~50,000 people with 3+ foot surge

Storm Surge Forecasts

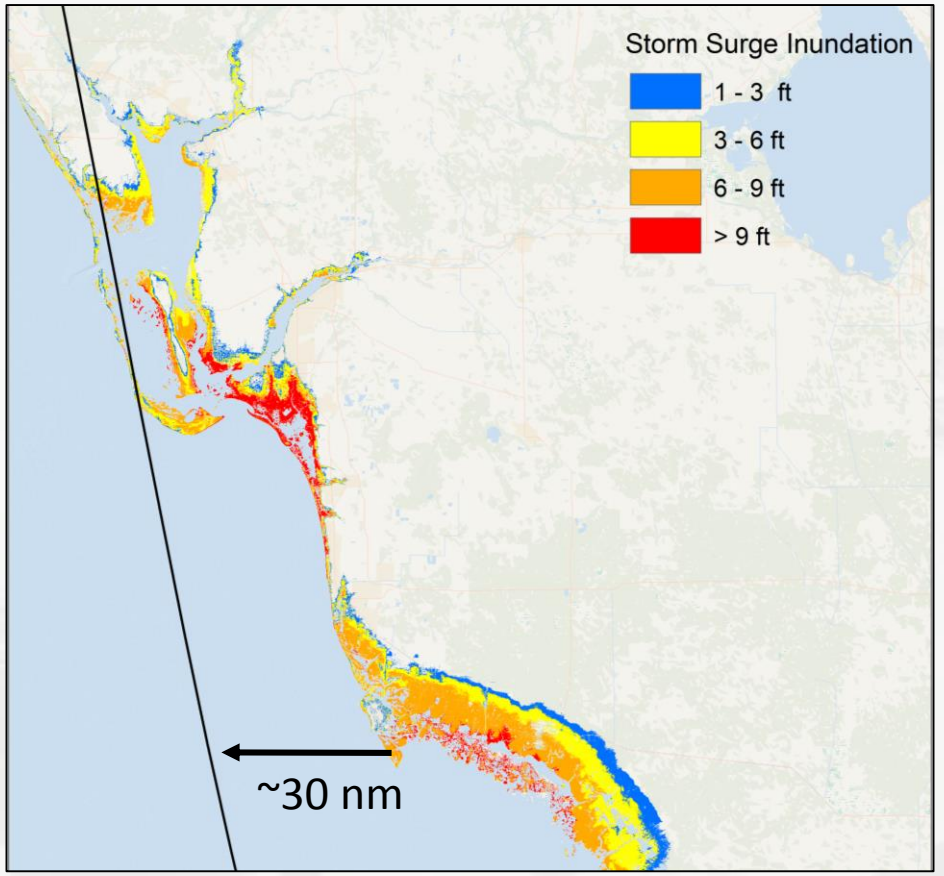
Sensitivity to Track

Observed Track and Simulated Storm Surge



~50,000 people with 3+ foot surge

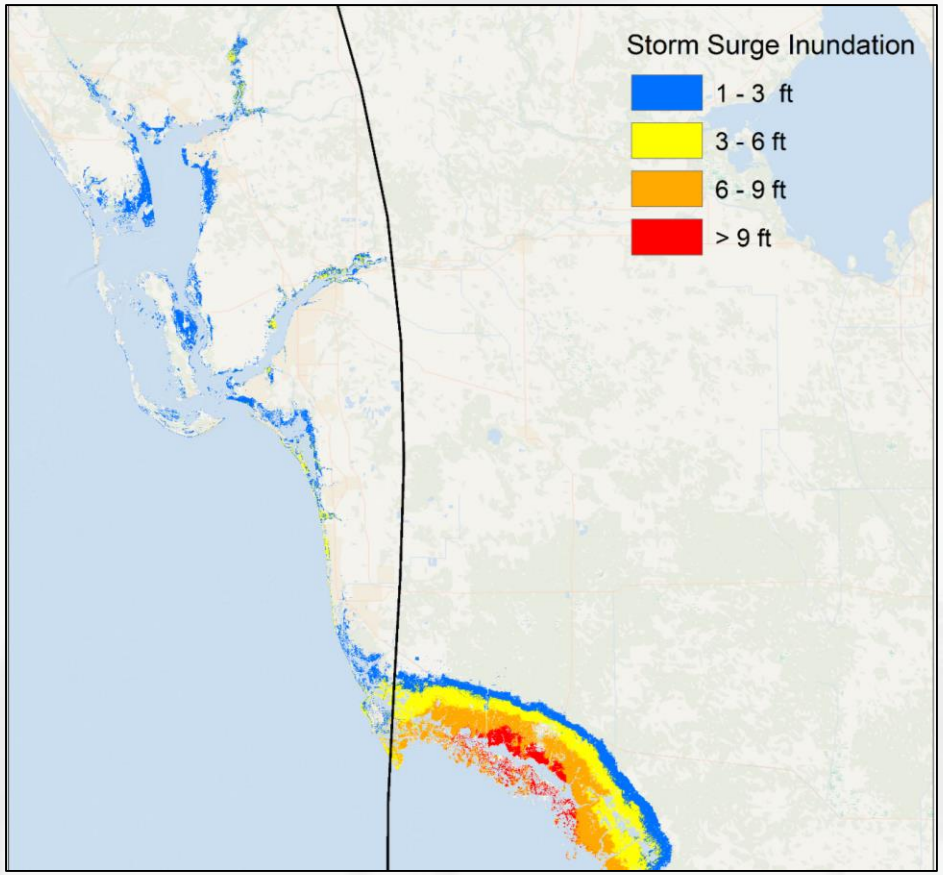
Forecast Track and Simulated Storm Surge



Storm Surge Forecasts

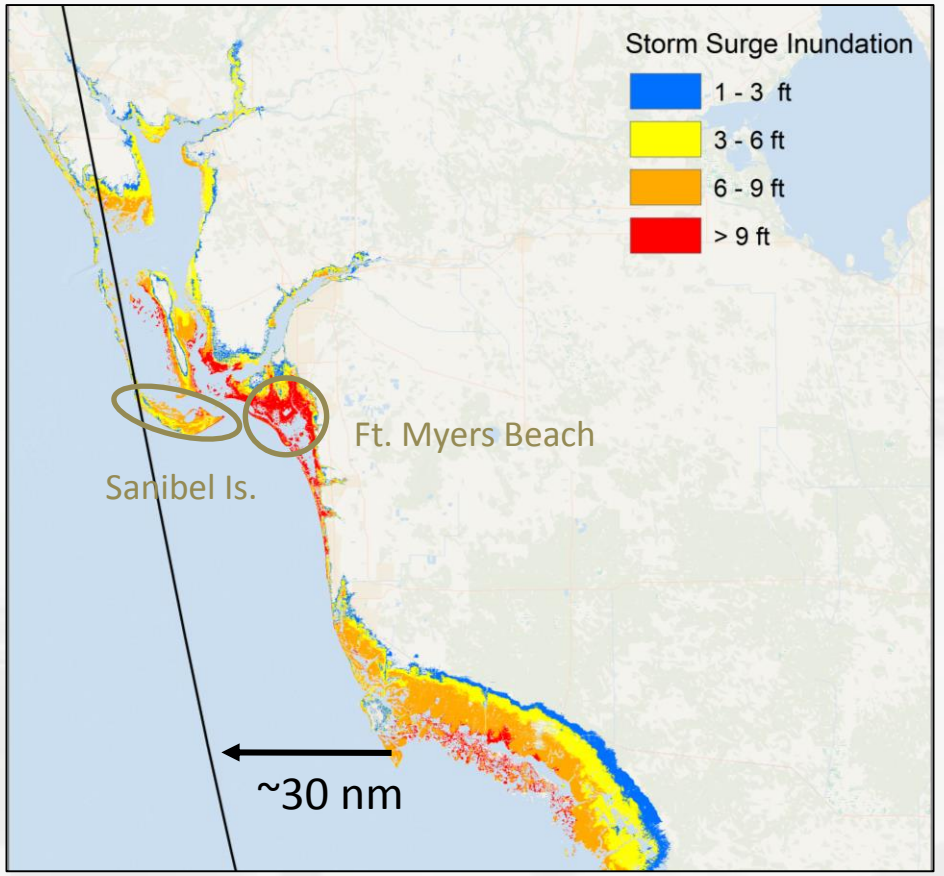
Sensitivity to Track

Observed Track and Simulated Storm Surge



~50,000 people with 3+ foot surge

Forecast Track and Simulated Storm Surge



~200,000 people with 3+ foot surge

Hurricane Irma

Significant Surge Impacts Far from the Center

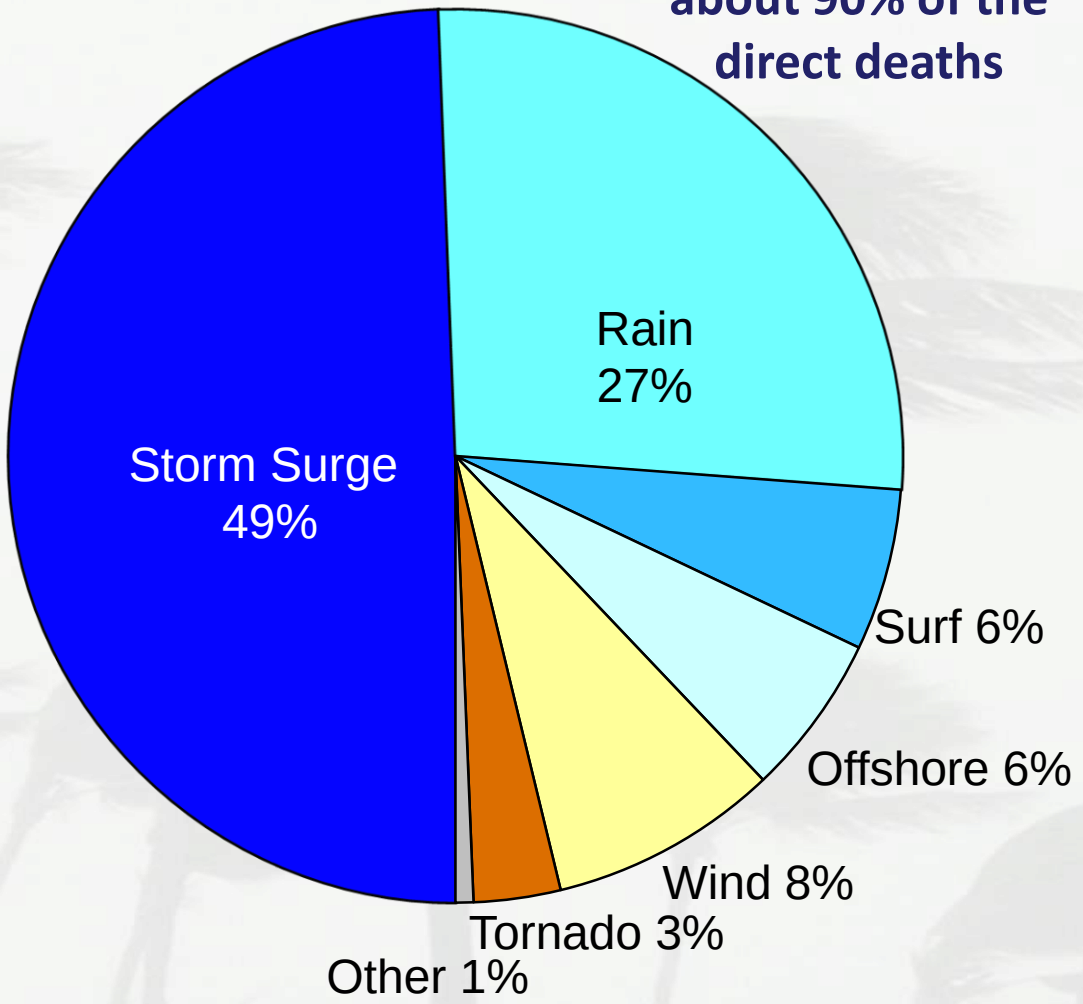
Hurricane Irma
NHC Preparations and Continuity of Operations

- Threat resulted in full activation of NHC's preparedness plan
- Shelter-in-place for 48 h during the event height of the event
- Two NHC Hurricane Specialists, TAFB forecast, and support staff sent to WPC (backup office)

U.S. Atlantic Tropical Cyclone Deaths

Wind-driven waves and storm surge threaten to inundate homes in Miami, Florida - 1945

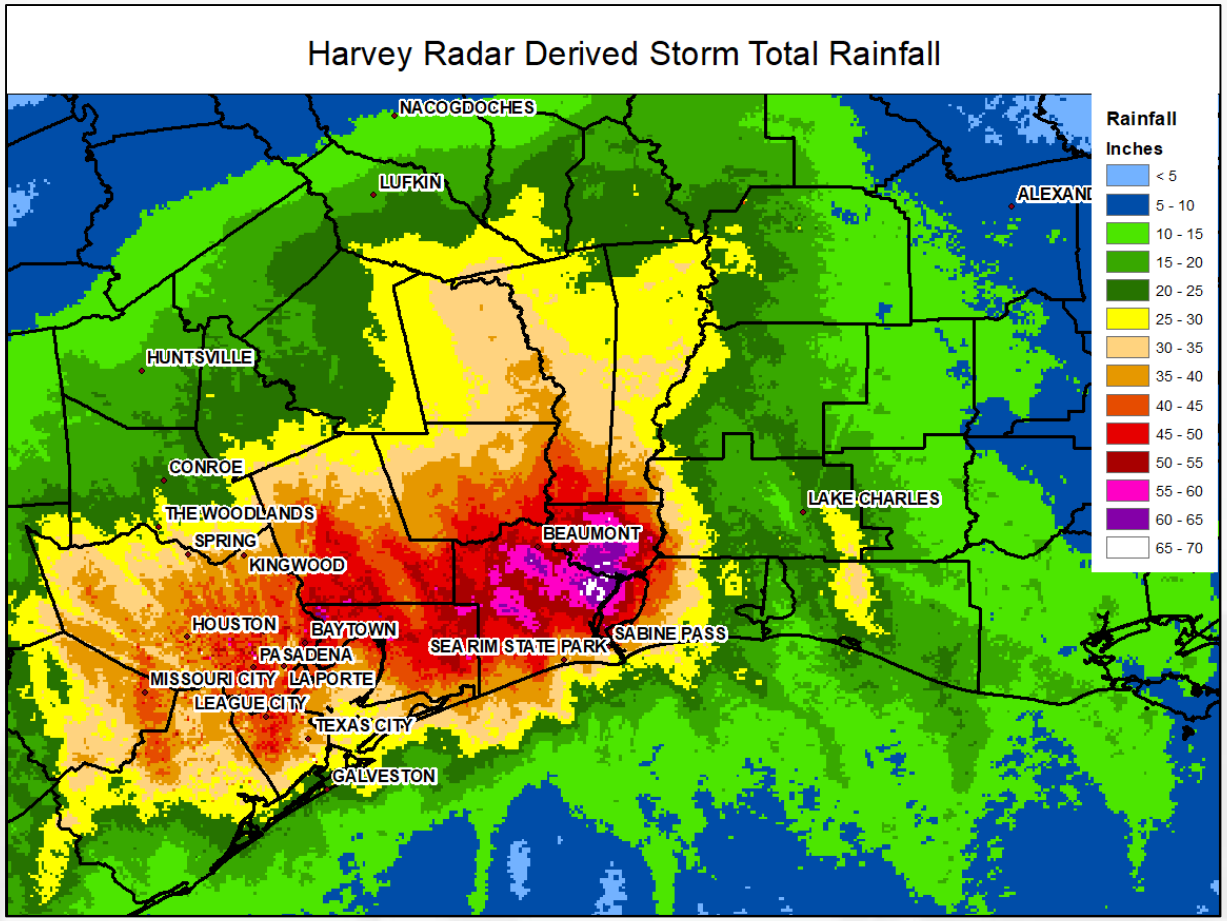
Water accounts for about 90% of the direct deaths



Rappaport 2014

Hurricane Harvey

68 Direct Fatalities in Texas; All But 3 from Freshwater Flooding

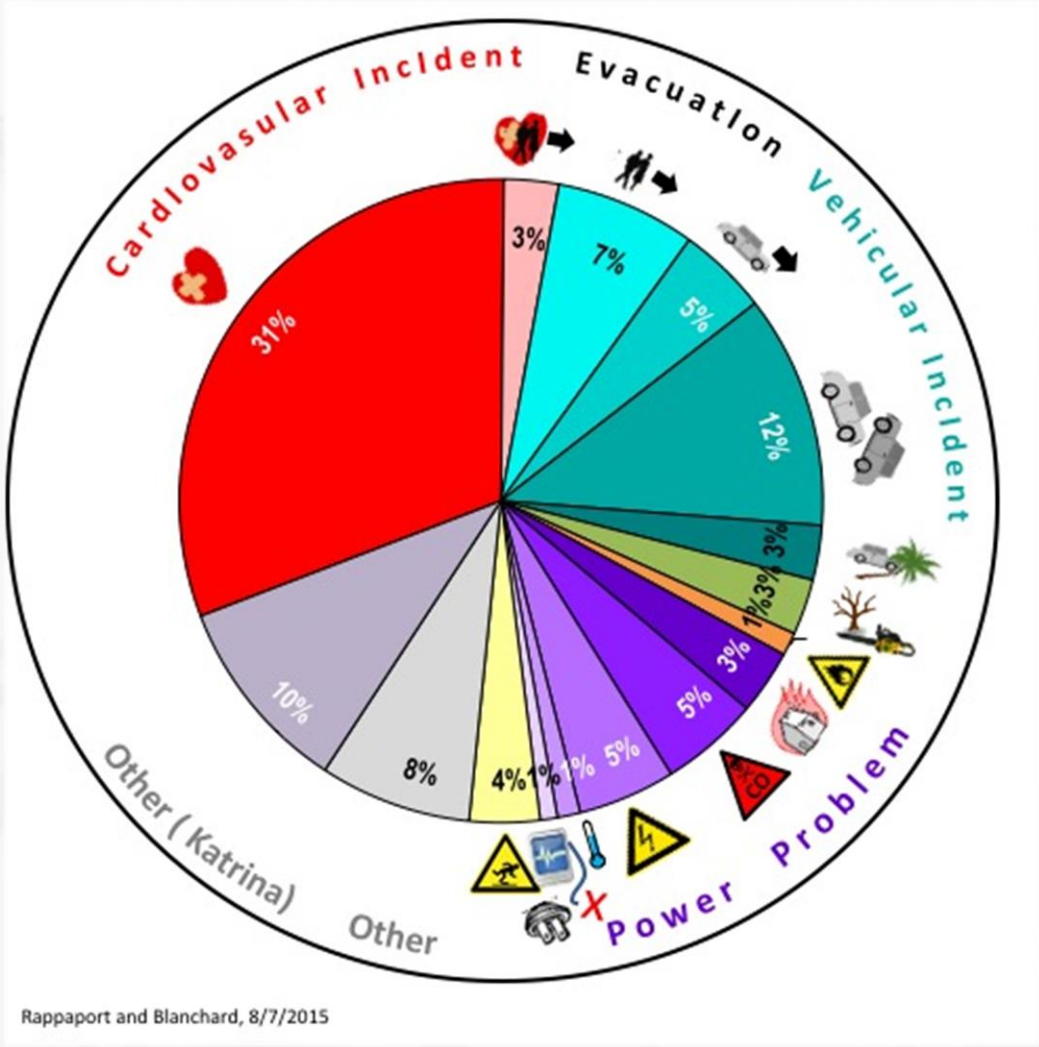


- 60.58 inches of rain recorded at Nederland, Texas which broke the U.S. tropical cyclone rainfall record of 52 inches set in Hawaii in 1950.
- Widespread extreme rainfall event – 18 reports of more than 4 ft of rain

Hurricane Irma

Fatalities Before and After the Storms

Most frequent factors: cardiovascular, loss of electricity, vehicle accident, and evacuation

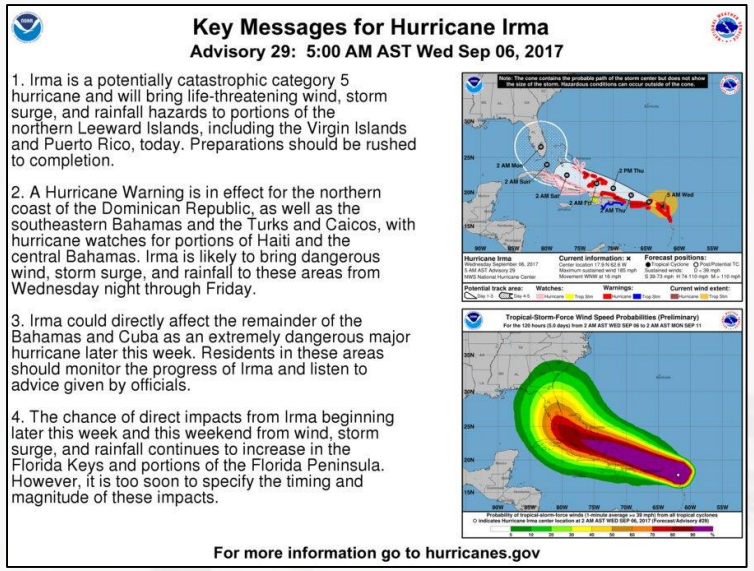


Rappaport and Blanchard, 8/7/2015

Key Message Graphic and Initial Wind Field on Cone Graphic

- NHC Key Message Graphic
  - Combines Key Messages from the NHC Discussion and pertinent advisory graphics
  - Available via NHC social media accounts and on NHC website

- Storm size information (initial wind field) was added to the cone graphic in 2017
  - Helped to illustrate hazardous wind conditions that occur outside the cone



Key Messages for Hurricane Irma
Advisory 29: 5:00 AM AST Wed Sep 06, 2017

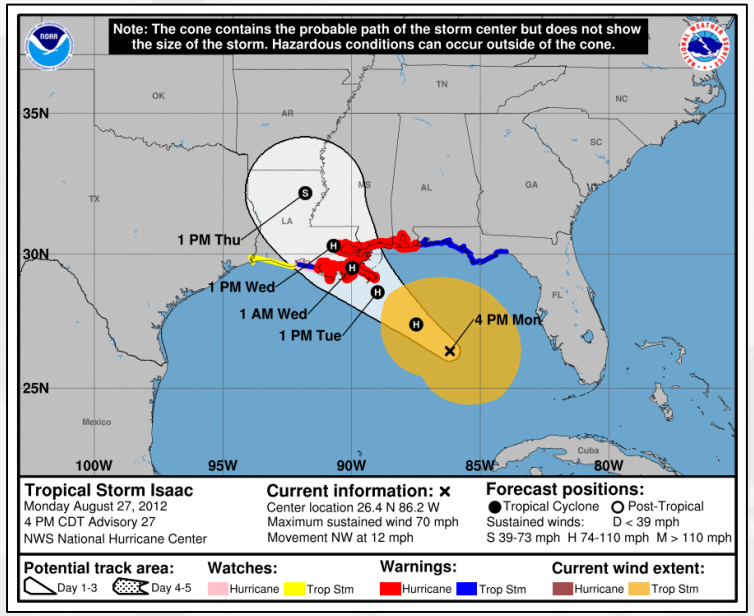
1. Irma is a potentially catastrophic category 5 hurricane and will bring life-threatening wind, storm surge, and rainfall hazards to portions of the northern Leeward Islands, including the Virgin Islands and Puerto Rico, today. Preparations should be rushed to completion.

2. A Hurricane Warning is in effect for the northern coast of the Dominican Republic, as well as the southeastern Bahamas and the Turks and Caicos, with hurricane watches for portions of Haiti and the central Bahamas. Irma is likely to bring dangerous wind, storm surge, and rainfall to these areas from Wednesday night through Friday.

3. Irma could directly affect the remainder of the Bahamas and Cuba as an extremely dangerous major hurricane later this week. Residents in these areas should monitor the progress of Irma and listen to advice given by officials.

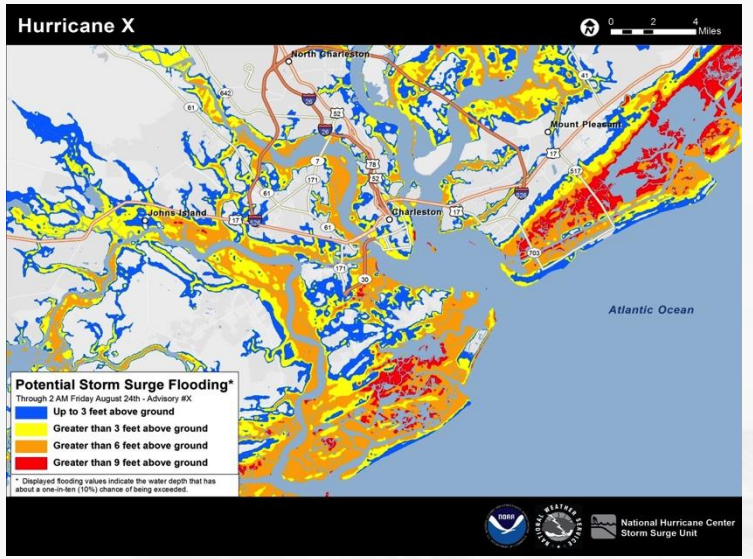
4. The chance of direct impacts from Irma beginning later this week and this weekend from wind, storm surge, and rainfall continues to increase in the Florida Keys and portions of the Florida Peninsula. However, it is too soon to specify the timing and magnitude of these impacts.

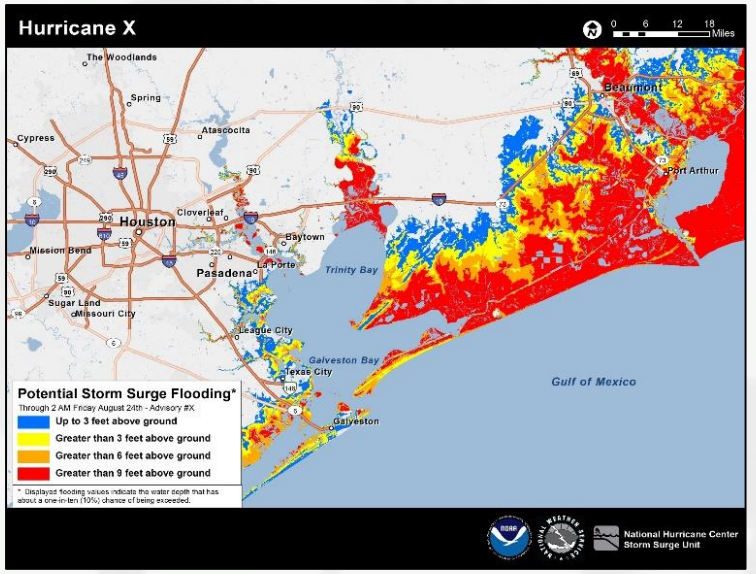
For more information go to hurricanes.gov



Potential Storm Surge Flooding Map

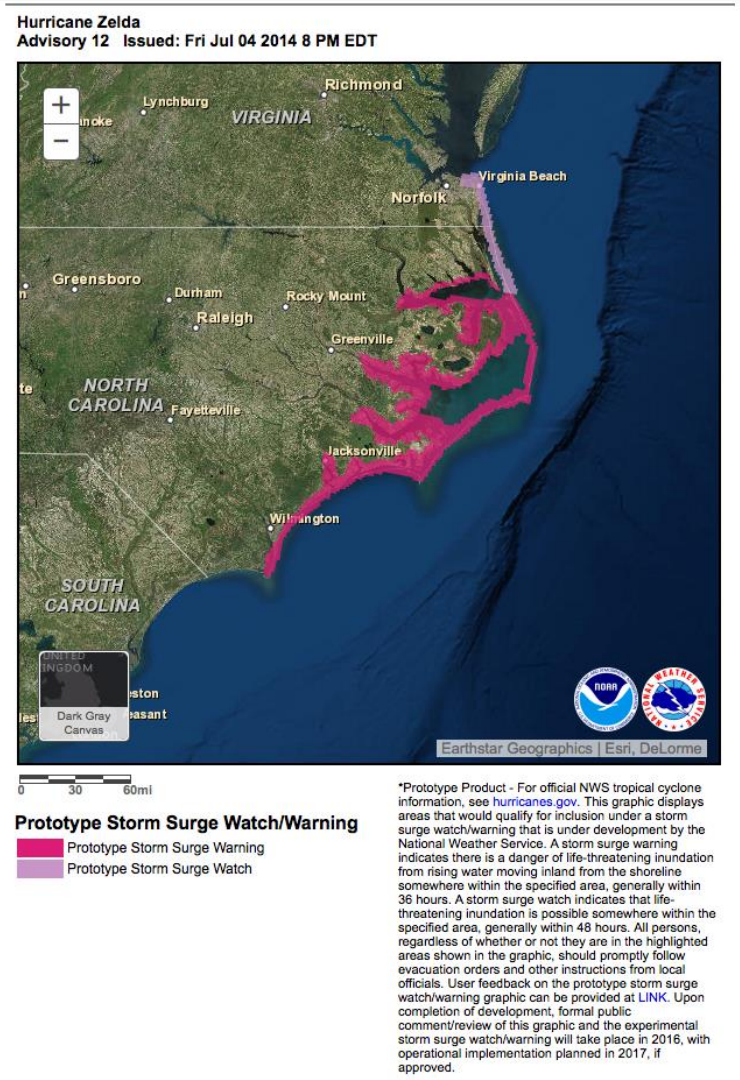
- Provides a quantitative risk assessment for decision makers.
- Shows height above ground that the water could reach.
  - Depicts the reasonable worst-case scenario at any individual location.
  - Shows inundation levels that have a 10% chance of being exceeded.
- First map issued at the same time as the initial hurricane watch or in some cases, with a tropical storm watch.
- Available about 60 to 90 minutes following the advisory release.





Storm Surge Watch & Warning

- Intended to enhance public response to instructions from local officials, and to help guide emergency management decisions.
- Highlights areas that have a significant risk of life-threatening inundation from storm surge.
- Issued 48 hours before possibility of life-threatening surge, *or other hazards that would hinder evacuations*.
- Represents collaboration of NHC's Hurricane Specialists, Storm surge experts, and local NWS WFOs.

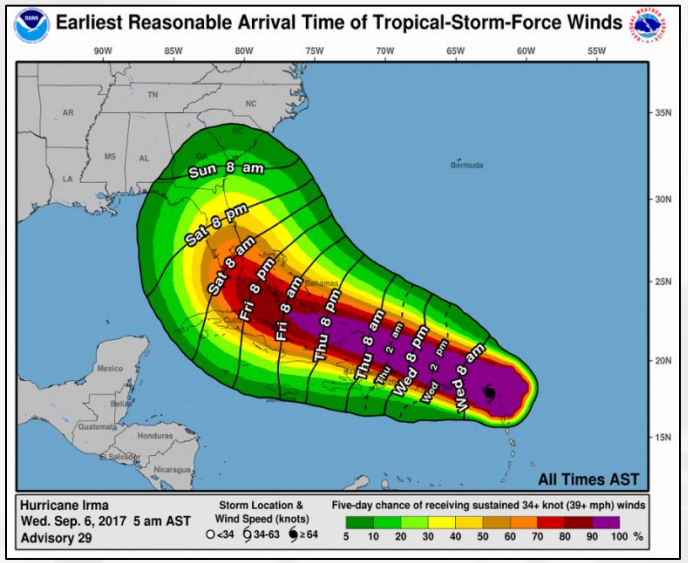


2018 Product Changes

- **Overall Messaging**
  - NHC Public Advisories will now discuss forecast information beyond 48 hours
  - Format of WPC Public Advisories will mirror NHC Public Advisories
  - WPC will issue Storm Summary products as needed providing observed rainfall and wind information during U.S. landfalling tropical cyclones

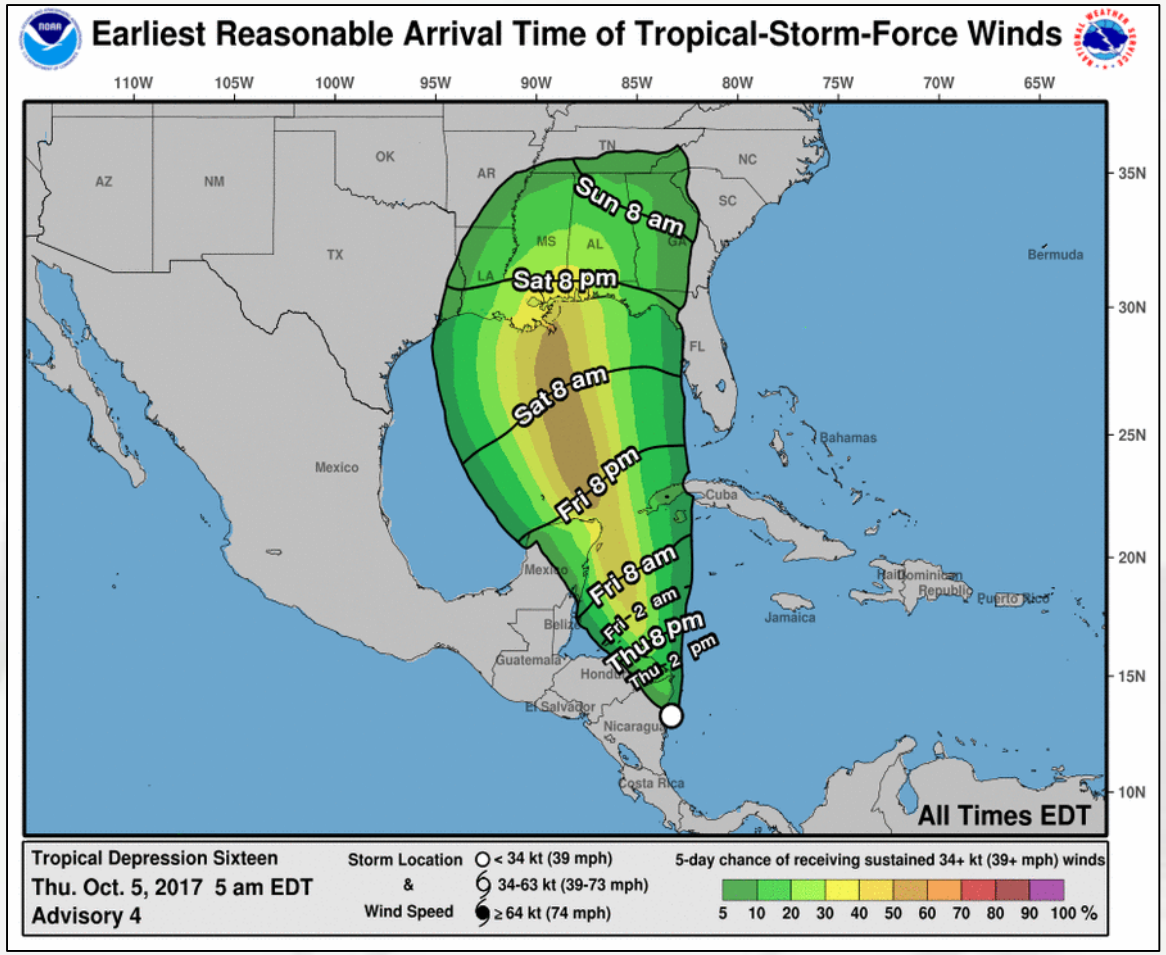
```
STORM SUMMARY NUMBER 1 FOR HURRICANE HARVEY RAINFALL AND WIND
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
500 AM EDT SAT AUG 26 2017

...HURRICANE HARVEY OBSERVED RAIN TOTALS AND WIND REPORTS...

FOR A DETAILED GRAPHICAL DEPICTION OF THE LATEST
WATCHES...WARNINGS AND ADVISORIES...PLEASE SEE WWW.WEATHER.GOV

AT 400 AM EDT...THESE ARE THE MOST RECENT RAINFALL AND WIND
REPORTS FROM HURRICANE HARVEY.  PLEASE REFER TO THE NATIONAL
HURRICANE CENTER FOR THE LATEST PUBLIC ADVISORIES ON HURRICANE
HARVEY.

...SELECTED STORM TOTAL RAINFALL IN INCHES FROM 800 PM EDT THU AUG
24 THROUGH 400 AM EDT SAT AUG 26...

...TEXAS...
ARANSAS                          10.54
AUSTWELL 6 SSE                    9.61
VICTORIA 2 SW                     9.37
EDNA                              8.24
BRAZORIA NWR                      7.86
SAN ANTONIO RIVER NEAR MCFAD      7.37
BRAZORIA COUNTY AIRPORT           7.12
PALACIOS MUNICIPAL AIRPORT        6.38
HOUSTON SOUTHWEST AIRPORT         5.39
GARCITAS CREEK NEAR INEZ          5.27
TIVOLI 3 NNE                      4.86
GALVESTON                         3.02
CORPUS CHRISTI 5W                 2.89

...SELECTED PEAK WIND GUSTS IN MILES PER HOUR EARLIER IN THE
EVENT...

...TEXAS...
PORT ARANSAS 2 ENE                132
COPANO VILLAGE 1 ENE              125
LAMAR 2 SSW                       110
```

- **Wind Products**
  - NHC will begin issuing 48-h hurricane-force wind radii forecasts (previously out to 36 h)
  - Time of Arrival graphics become operational



Time of Arrival Graphics

Become Operational in 2018

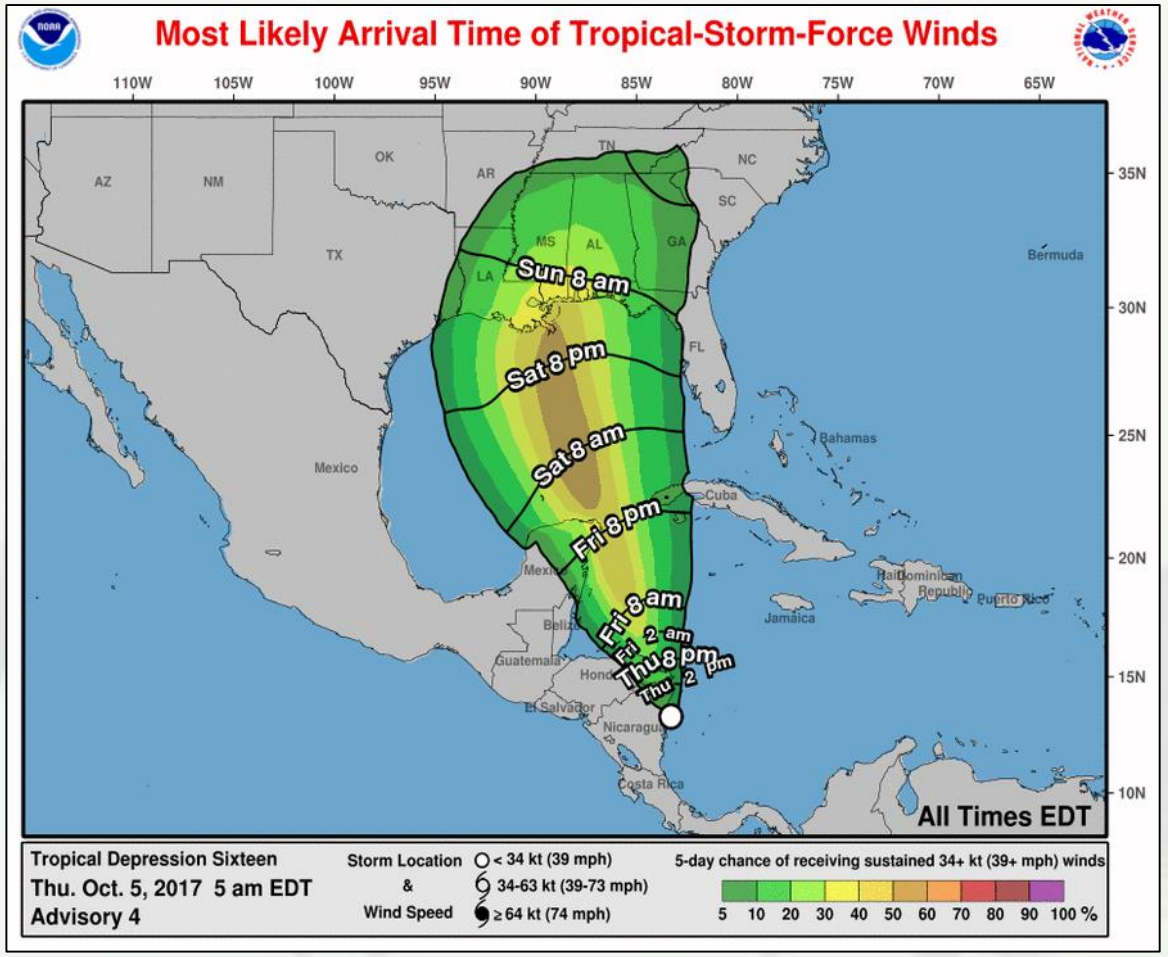


Earliest Reasonable Arrival of TS Winds

- Shows earliest reasonable arrival time of TS winds (black contours) and cumulative TS wind speed probabilities (colors)
- Identifies the time window that users at individual locations can safely assume will be free from TS winds
  - Based on the time that has ≤ 10% chance of seeing sustained TS winds before the indicated time
- Best for users with low tolerance for risk

Time of Arrival Graphics

Become Operational in 2018



Most Likely Arrival of TS Winds

- Shows most likely arrival time of TS winds (black contours) and cumulative TS wind speed probabilities (colors)
- Shows the time before or after which the onset of sustained TS winds is equally likely
- Best for users that are willing to risk not having completed preparations before TS winds arrive

Beyond 2018: Research Plan

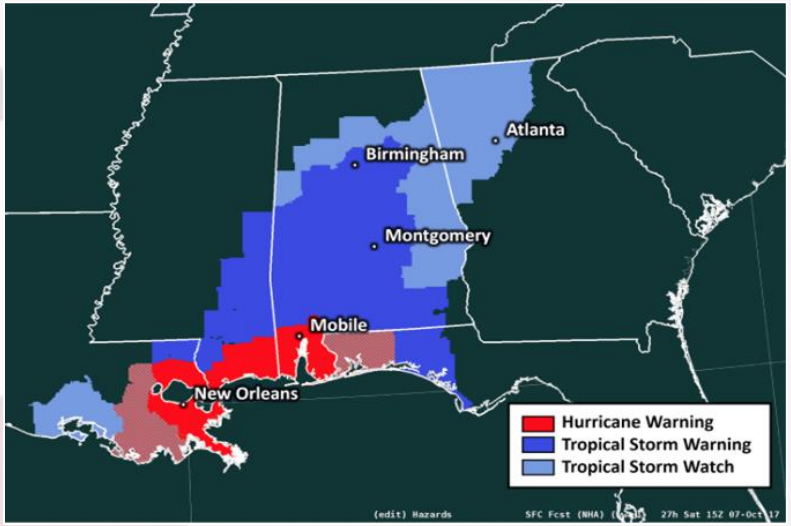
Hurricane Forecast Improvement Project Goals:

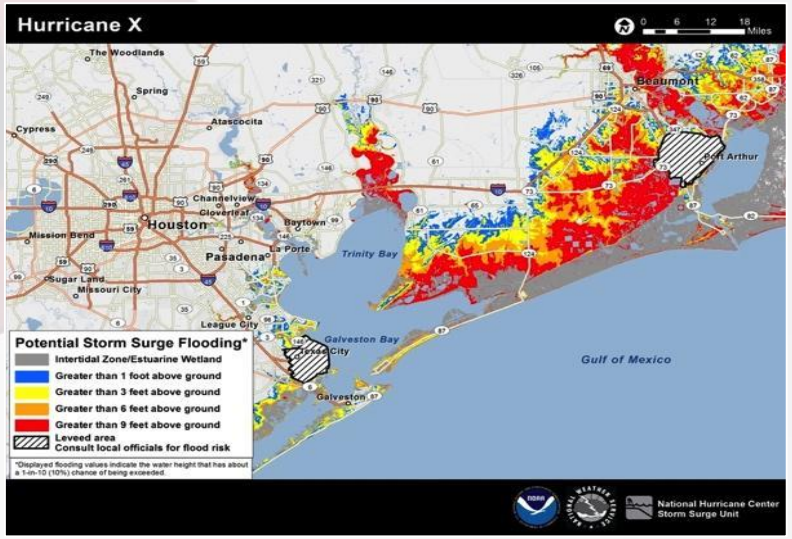
- Reduce forecast (model) guidance errors, including during rapid intensification, by 50% from 2017
- Produce 7-day forecast guidance as good as the 2017 5-day forecast guidance
- Improve guidance of pre-formation disturbances, including timing, track, and intensity forecasts, by 20% from 2017
- Improve hazard guidance and risk communication based on social and behavioral science to modernize the tropical cyclone product suite for actionable lead-times for storm surge and all other threats

Beyond 2018: Developing a 3-10 Year Vision

The conversation:

- Graphic showing inland AND coastal tropical cyclone watches and warnings
- Improve inland flood threat communication through new WPC products and education
- Extend real-time storm surge guidance to 72 hours before landfall
- Official forecast points out to 7 days
- Improve understanding and communication of **indirect** hazards






Thanks!
Comments/Questions
#NOAAHurricaneAware
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
NATIONAL WEATHER SERVICE
Hurricane Irma
Data: MODIS/Terra (NASA Worldview)

Messaging Reminders for 2018

Planning for the Threat
Hurricane Evacuation Decision Making

Paul A. Morey
FEMA Region I
Hurricane Program Manager

Decision Making in the Face of Uncertainty

Key Questions:

Will we be impacted by the storm, and if so when? For how long?

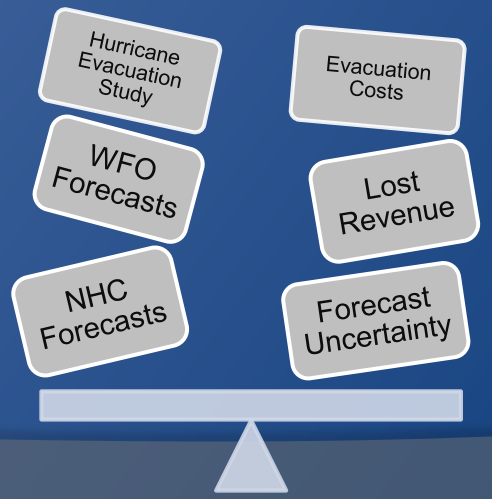
How severe will flooding from storm surge be?

What about wind and inland flooding from rain?

Who do we need to evacuate?

When does the evacuation need to start and how long will it take?

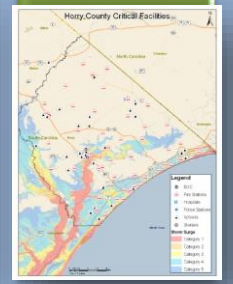
HES and NHC/NWS products assist/support you with evacuation decision making



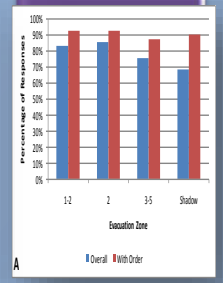
Hurricane Evacuation Studies (HES)

Hazards Analysis
- SLOSH Model Development
- Surge MOMS

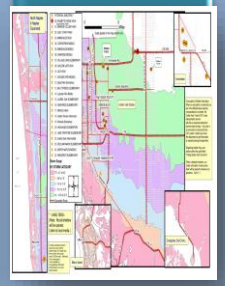
Vulnerability Analysis
- **Identify at Risk:**
- Populations
- Infrastructure
- Critical Facilities



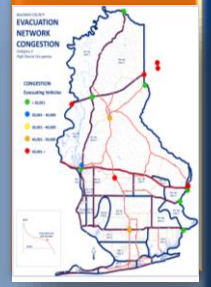
Behavioral Analysis
- Public Survey
- Analysis of Survey Responses



Shelter Analysis
- Determining the Shelter Need
- Estimate Number of Shelter Spaces
- Potential Vulnerability



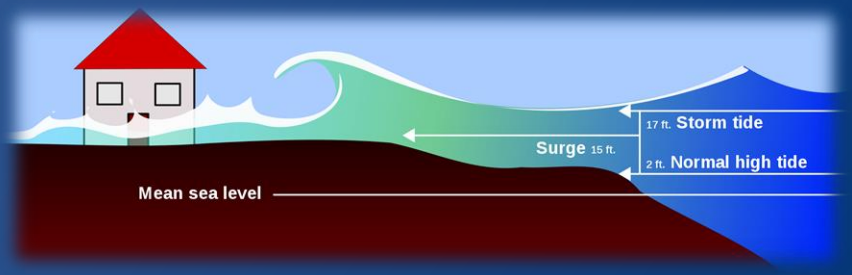
Transportation Analysis
- Analysis of Traffic Volumes, Evac. Routes, and Destinations
- Traffic Patterns
- Clearance Times



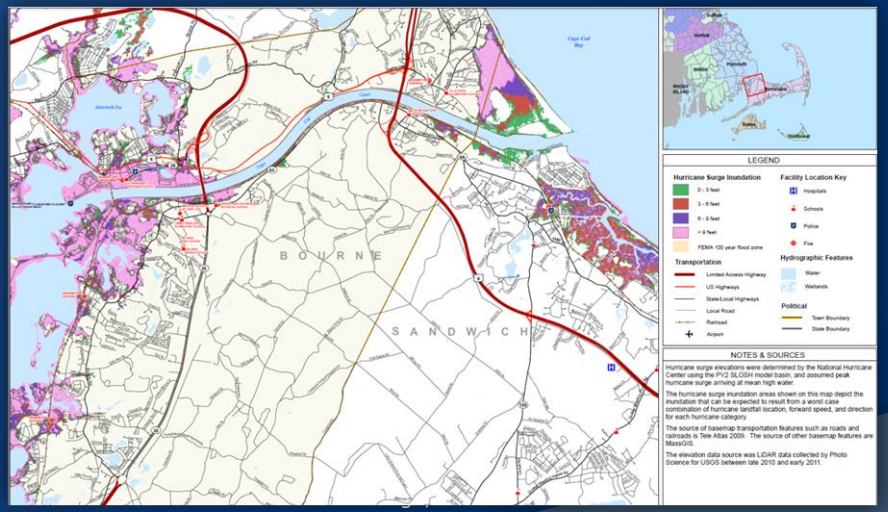
Critical Information for Planning and Response…

Hazards Analysis

Understanding Storm Surge Potential



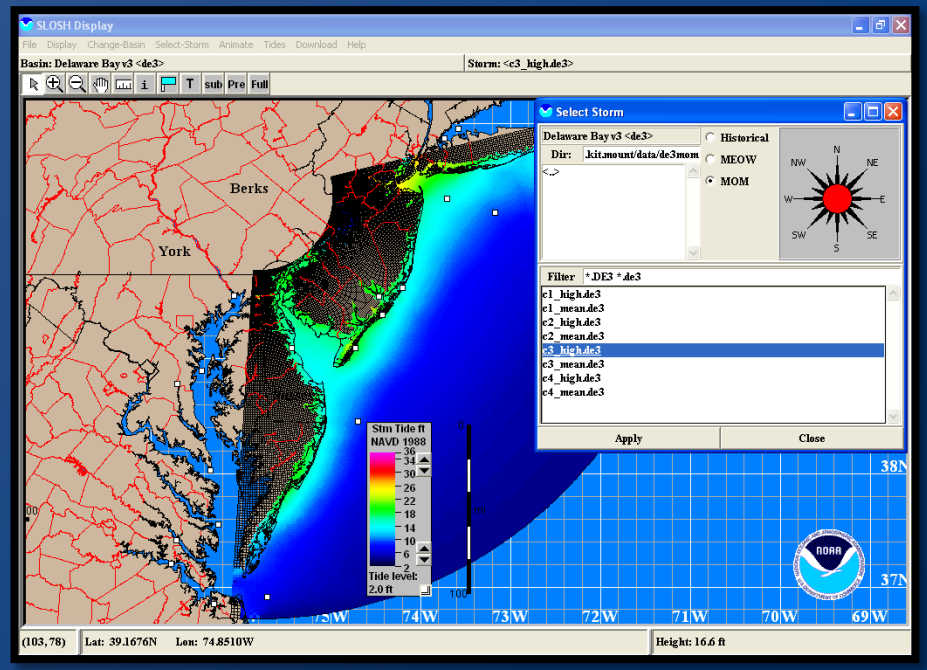
- Storm surge has the highest potential for death and damage
- Storm surge is the main reason we evacuate the coast
- Worst Case Scenario Surge Maps used to assess risk in your community



Analysis: **Hazard** Vulnerability Behavioral Shelter Transportation
Products: Surge Maps Evacuation Zones Planning Data Clearance times

What are the zones based on?

Storm surge vulnerable areas created using the SLOSH model



Maximum of Maximum Storm Surge Potential "MOM"

- **Consist of thousands of runs**
- **Different intensities, pressure, angles of approach, forward speed, wind radii**
- **One per category – Worst case scenarios – Risk Maps not Forecasts**
- **Addresses forecast uncertainty at longer timeframes**

Analysis: Hazard Vulnerability Behavioral Shelter Transportation
Products: Surge Maps Evacuation Zones Planning Data Clearance times

Evacuation Zones

"Know Your Zone"

- Communicate risk to the public
- Communicate evacuation orders by zone

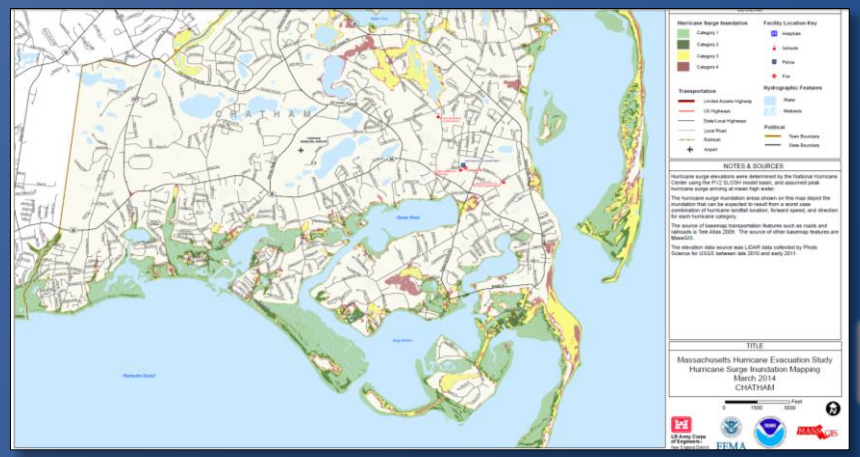
Analysis: Hazard Vulnerability Behavioral Shelter Transportation

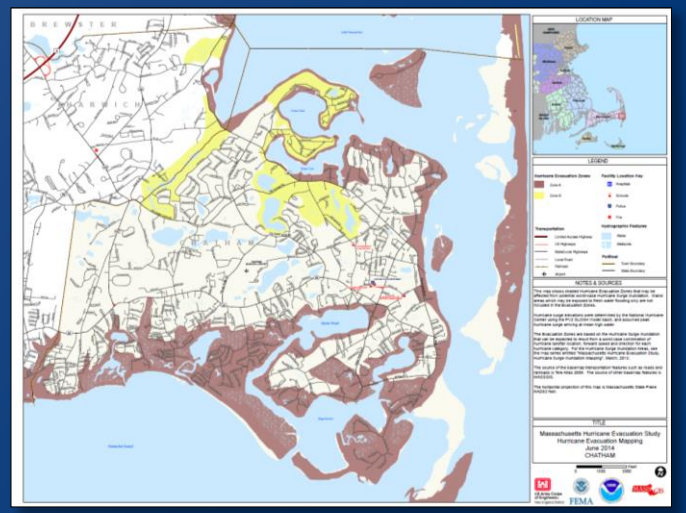
Products: Surge Maps **Evacuation Zones** Planning Data Clearance times

Evacuation Zones

"Know Your Zone"

- Communicate risk to the public
- Communicate evacuation orders by zone



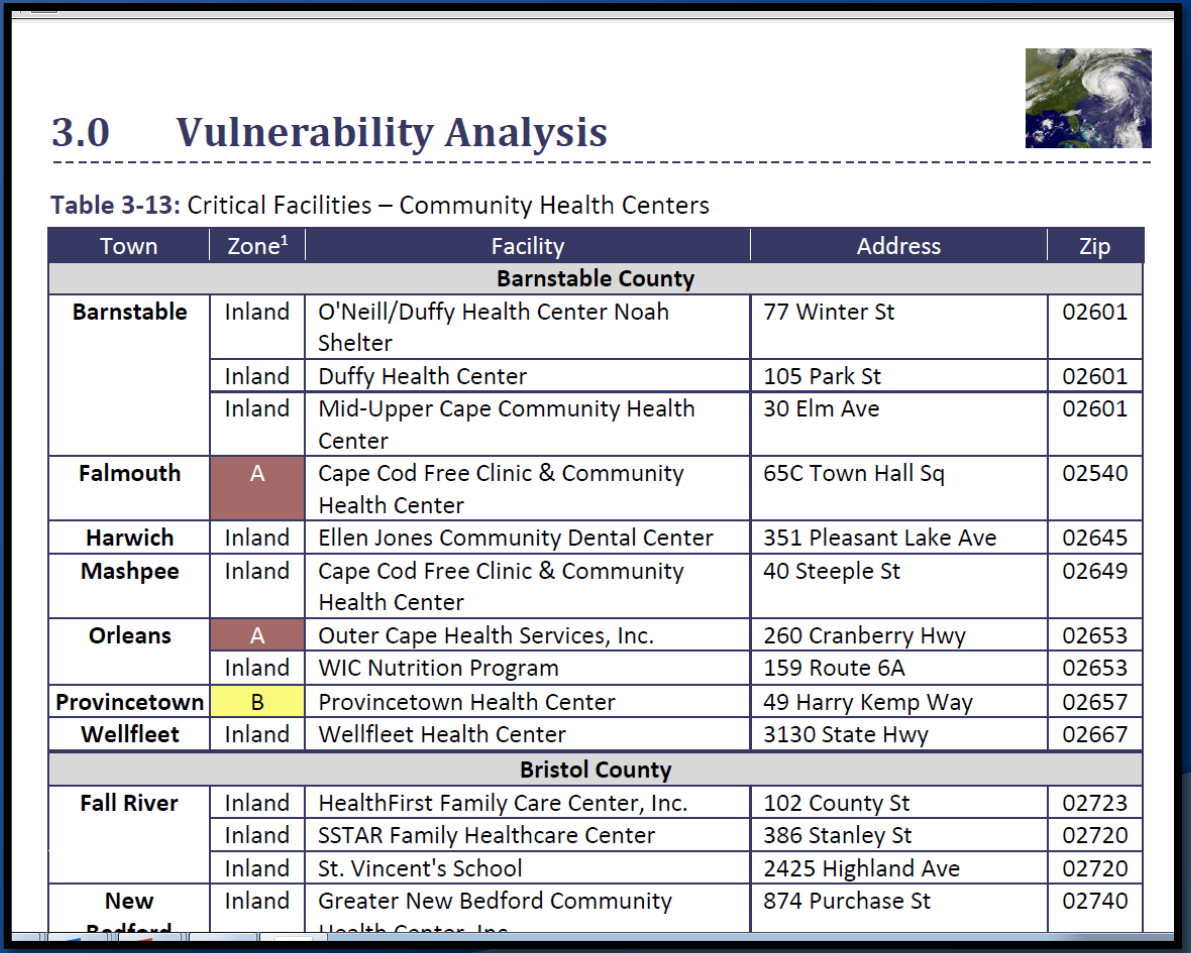


Analysis: Hazard Vulnerability Behavioral Shelter Transportation
Products: Surge Maps **Evacuation Zones** Planning Data Clearance times

Vulnerability Analysis

Who may need to evacuate and What is at risk

- Citizens residing in surge prone areas
- Critical facilities
- Mobile/Manufactured home communities
- Vulnerable shelters
- Colleges/Universities



3.0 Vulnerability Analysis

Table 3-13: Critical Facilities – Community Health Centers

Town	Zone[1]	Facility	Address	Zip
Barnstable County				
Barnstable	Inland	O'Neill/Duffy Health Center Noah Shelter	77 Winter St	02601
	Inland	Duffy Health Center	105 Park St	02601
	Inland	Mid-Upper Cape Community Health Center	30 Elm Ave	02601
Falmouth	A	Cape Cod Free Clinic & Community Health Center	65C Town Hall Sq	02540
Harwich	Inland	Ellen Jones Community Dental Center	351 Pleasant Lake Ave	02645
Mashpee	Inland	Cape Cod Free Clinic & Community Health Center	40 Steeple St	02649
Orleans	A	Outer Cape Health Services, Inc.	260 Cranberry Hwy	02653
	Inland	WIC Nutrition Program	159 Route 6A	02653
Provincetown	B	Provincetown Health Center	49 Harry Kemp Way	02657
Wellfleet	Inland	Wellfleet Health Center	3130 State Hwy	02667
Bristol County				
Fall River	Inland	HealthFirst Family Care Center, Inc.	102 County St	02723
	Inland	SSTAR Family Healthcare Center	386 Stanley St	02720
	Inland	St. Vincent's School	2425 Highland Ave	02720
New Bedford	Inland	Greater New Bedford Community Health Center, Inc.	874 Purchase St	02740

Hurricane Behavioral Analysis

- Attitudes about risk from hurricane hazards – Primarily storm surge
- Evacuation intentions and past experiences
- Evacuation destinations
- Evacuation routes
- Sources of forecast information

Table 4-2: Perceived Vulnerability of Home – Believe Home would Flood Dangerously

Category 2			Category 3			Category 4		
A / 1-2	B / 3-4	Non-Surge	A / 1-2	B / 3-4	Non-Surge	A / 1-2	B / 3-4	Non-Surge
28%	18%	15%	46%	33%	25%	67%	54%	37%

Shelter Analysis

Understanding Shelter Need

Key Sheltering Information:

- Location/Identification
- Potential Shelter Demand
- Flood Risk
- Capacity
- ARC vs. Local Shelter
- Pet Friendly

Table 5-8: Public Sheltering Demand and Sheltering Capacity – Plymouth County

Community	Scenario A Low Occ	Scenario A High Occ	Scenario B Low Occ	Scenario B High Occ	Shelter Capacities*
Duxbury	203	216	331	347	0
Hingham	334	339	542	549	230
Hull	531	561	531	561	0
Kingston	178	183	304	311	2,910
Marion	215	231	233	249	0
Marshfield	799	839	915	956	0
Mattapoisett	169	193	214	239	0
Plymouth	531	629	1,178	1,341	2,918
Rochester	8	10	56	59	0
Scituate	393	424	518	553	0
Wareham	974	1060	1,070	1,163	0
Totals	**4,335**	**4685**	**5,892**	**6,328**	**6,058**

* Based on American Red Cross National Shelter Survey (NSS) database shelter capacities.

Transportation Analysis

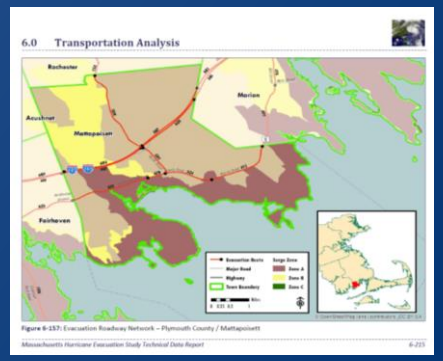
Understand traffic congestion potential based upon evacuation decisions

- Traffic Patterns (bottle necks)
- Evacuating Vehicles

Clearance Time tables

Variables of:

- Response
- Population
- Evacuation Scenarios (one way, Multi state)
- Storm Category



Evacuation Clearance Times

Timeline

H= -48 H= -36 H= -24 H= -18 H= -12 H= -6 H=0 H=+6 H=+12 H=+18 H=+26

Evacuation Start Time

Forecasted Onset of TS winds or surge

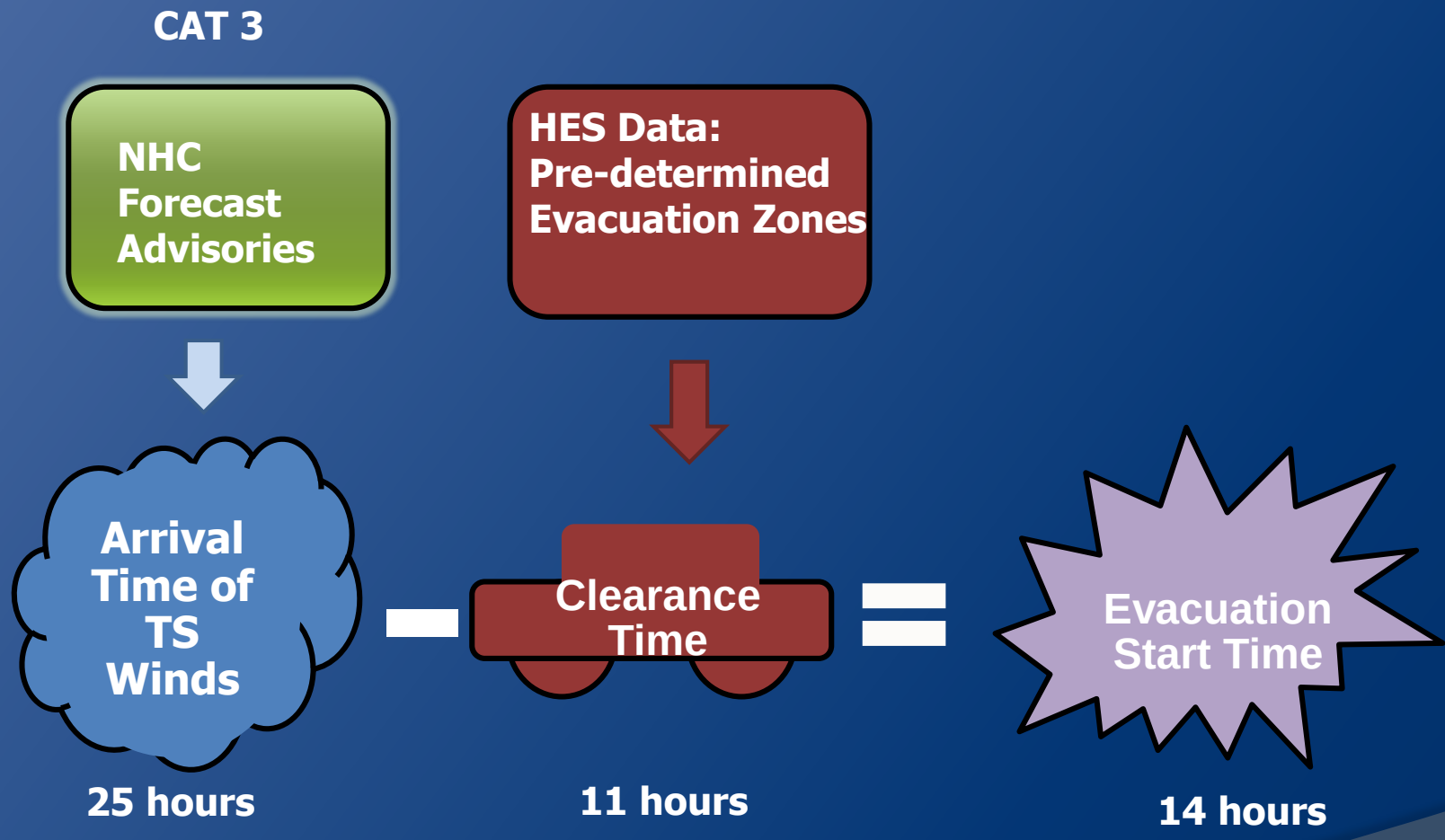
Example Clearance Time = 48hrs

Begins when the first evacuating vehicle enters the road network, ends when the last vehicle reaches an assumed point of safety

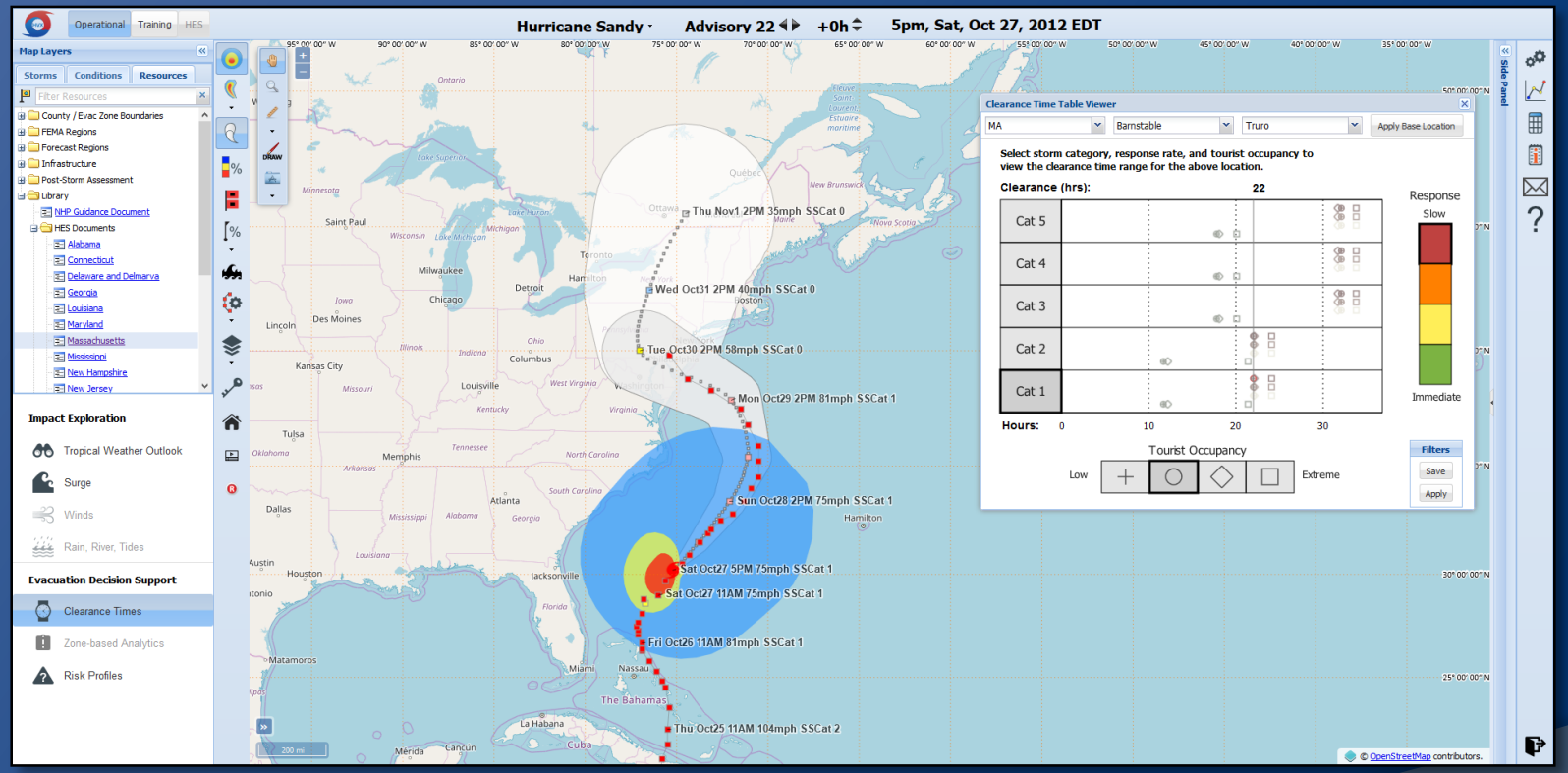
Analysis: Hazard Vulnerability Behavioral Shelter **Transportation**

Products: Surge Maps Evacuation Zones Planning Data Clearance times

Evacuation Decision Calculation



HES in Web Based HURREVAC – "HVX"



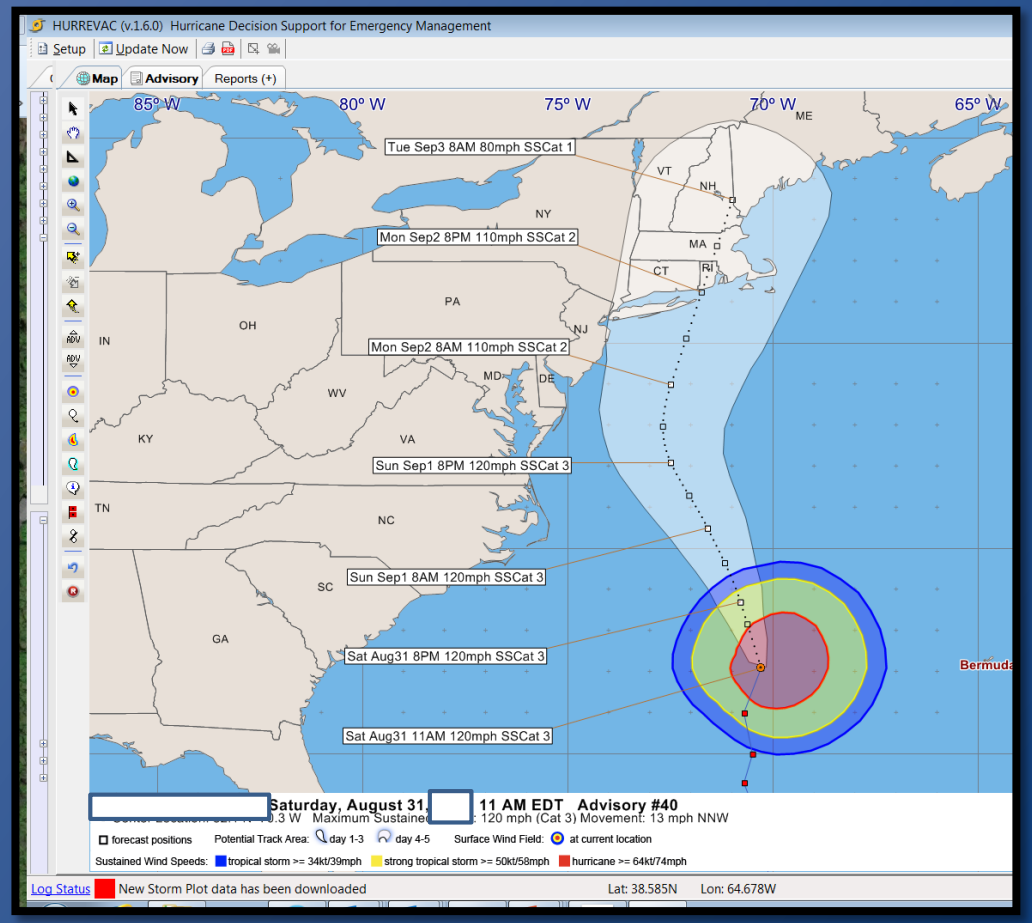
The Hurricane Evacuation Study:

Informs your plans with data from the 5 analysis

Supports your response operations by providing:

- **Information on which populations and facilities to evacuate**
- **Information on shelter risk capacity and demand**
- **Timing guidance in HURREVAC**
- **Clearance Times for specific storm scenarios**
- **Information on critical traffic bottlenecks and suggested traffic control points**

Hurricane Scenario



Advisory 40

Issued at 11AM

Saturday August 31st

Cat 3

Moving 13mph

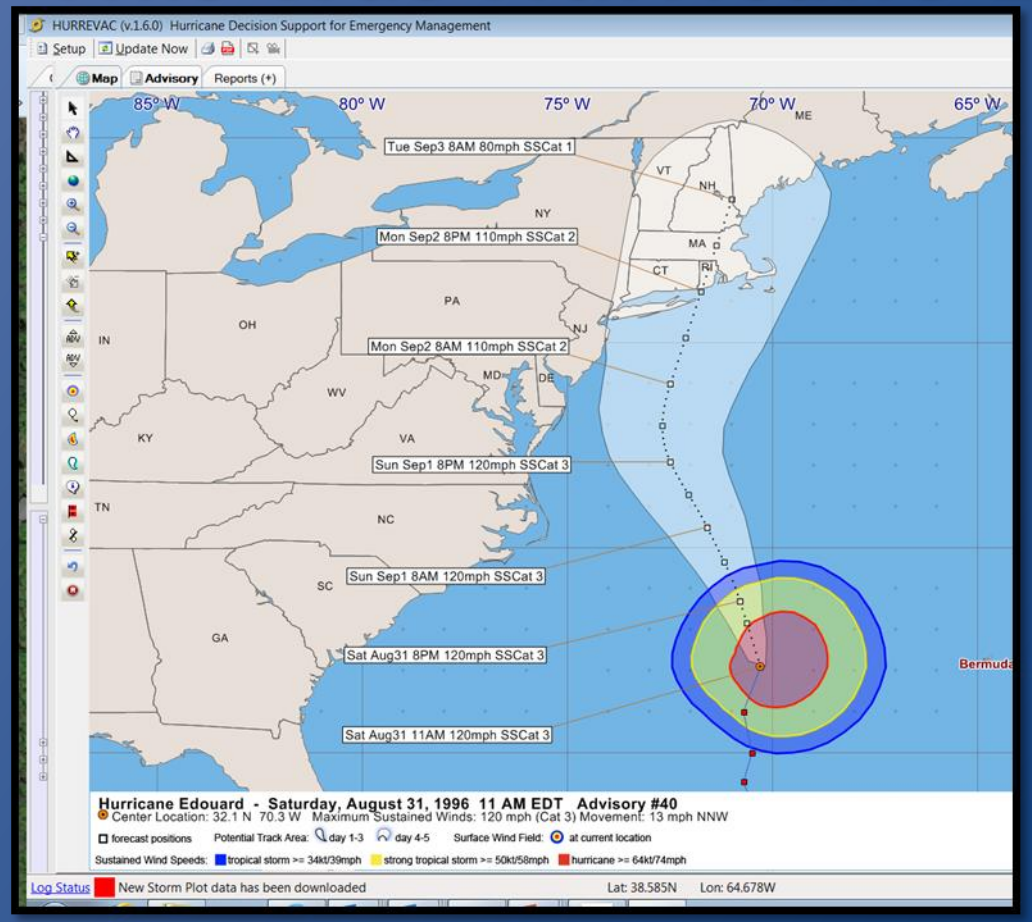
Storm located off the coast of GA/SC

Assume a 24 hour CT

Lower/Outer Cape community

Mobilize response assets? Call for an evacuation? When do you take action?

This was Hurricane Edouard 1996

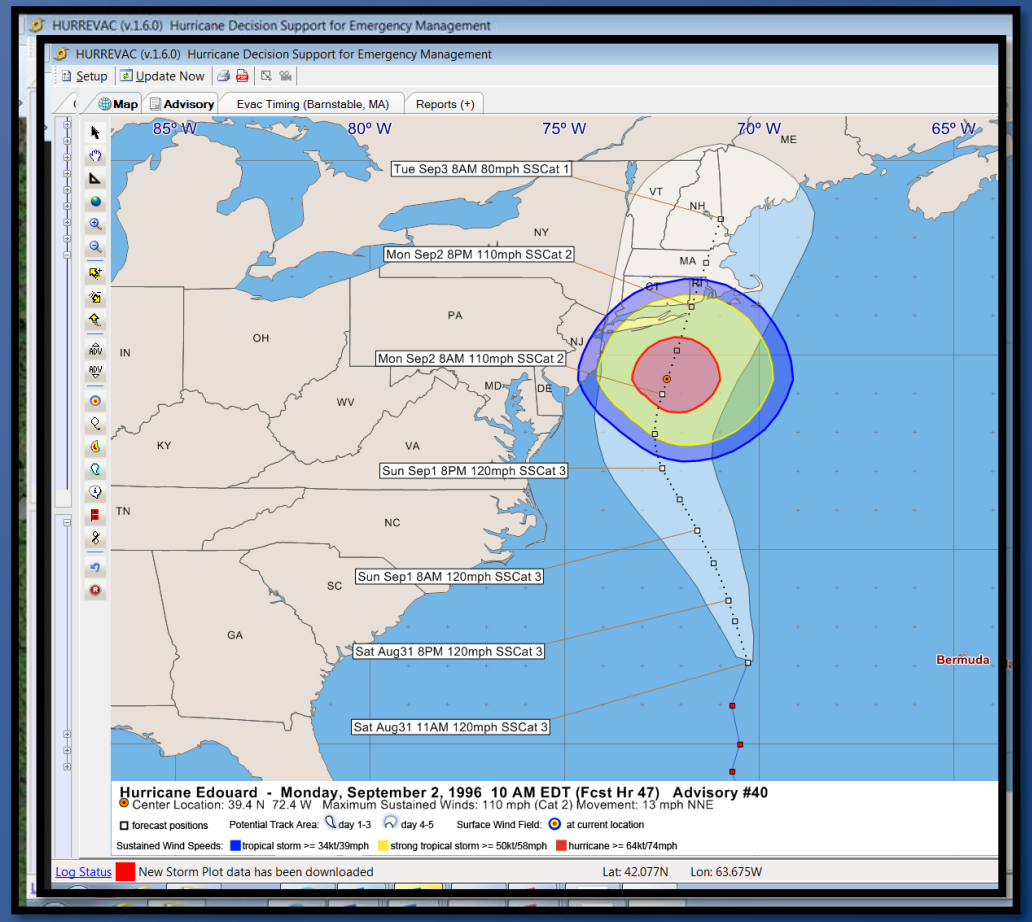


In this scenario, given a 24 hour Clearance Time, evacuations would have to begin early Sunday AM in order to be complete before the onset of TS force winds.

This would leave 24 hours from the issuance of this advisory to make an evacuation decision, notify the public, and mobilize response assets.

How many more advisories will you have to influence your decision making considering your timeline?

This was Hurricane Edouard 1996



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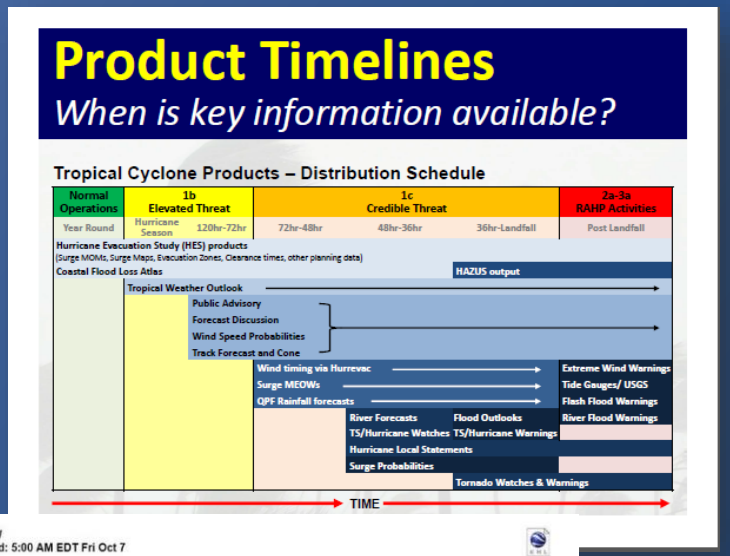
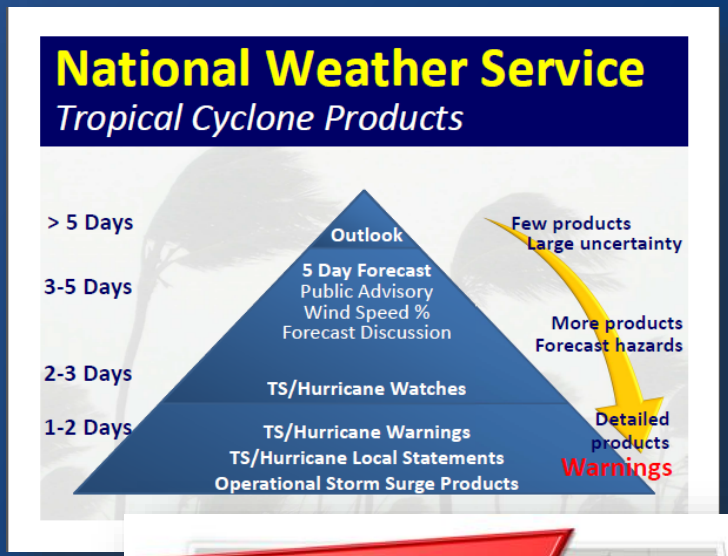
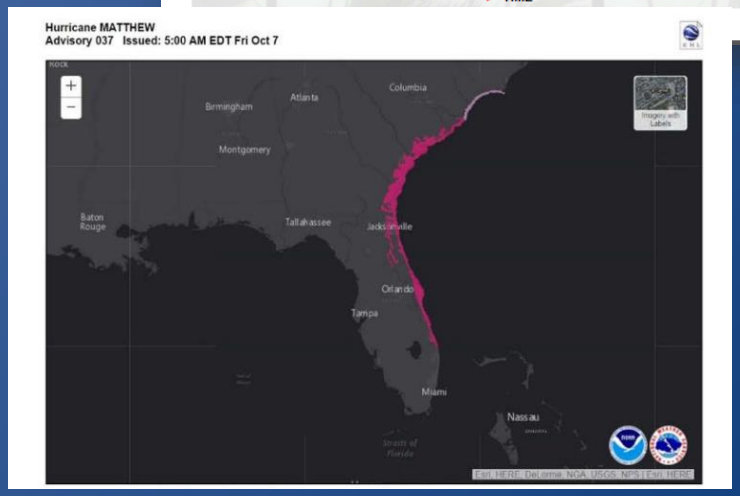
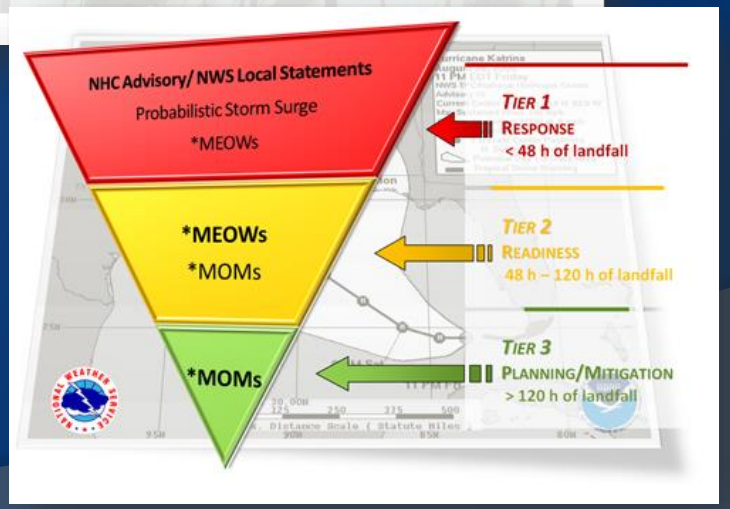
How many more advisories will you have to influence your decision making considering your timeline?

Key forecast products, clearance times and local planning factors guide Evacuation Decision Making and other Response Actions



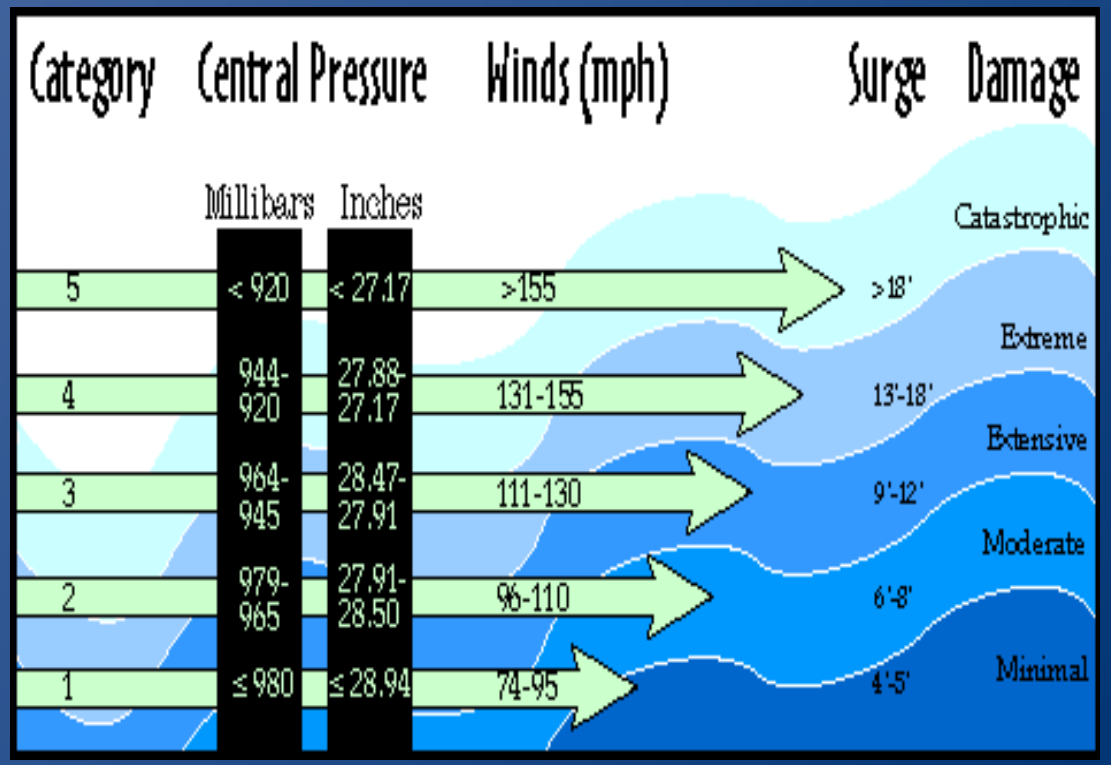






Saffir-Simpson Hurricane Wind Scale

Surge, rainfall, and pressure fit the scale like a square peg in a round hole



KATRINA (3)

IKE (2)

SANDY (ET)

CHARLEY (4)

Think impacts!

Questions?

Paul A. Morey
FEMA Region I
Hurricane Program Manager
617-956-7628
paul.morey@fema.dhs.gov

State Preparedness Update

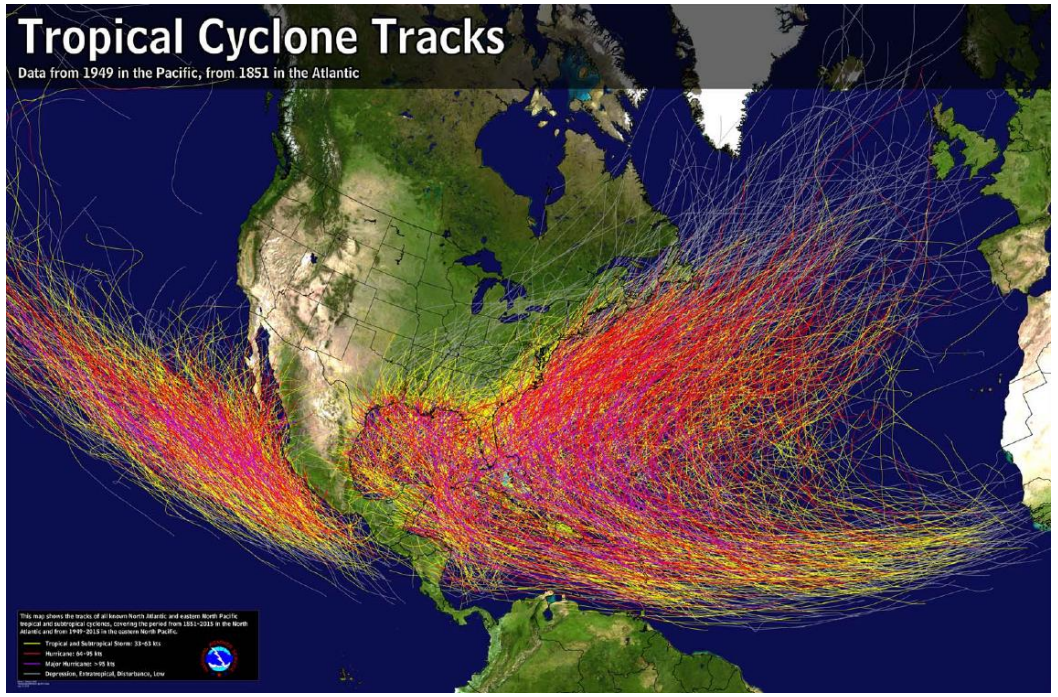
Director Kurt Schwartz

Massachusetts Emergency Management Agency

MEMA Preparedness Update

Overview

- Inundation and Evacuation Planning
- Recommendations for Communities
- MEMA Hurricane Working Groups
- What to expect from MEMA



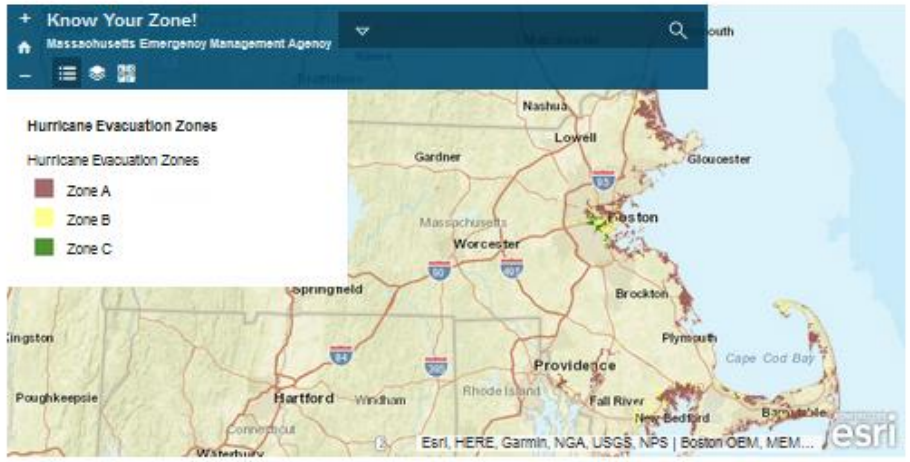
Inundation and Evacuation Planning

Hurricane Evacuation Zones

Know Your Zone! Learn if You Live or Work in a Hurricane Evacuation Zone

Evacuation may be necessary during a hurricane or tropical storm due to risk of storm surge. Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide. The destructive power of storm surge and large battering waves is often the greatest threat to life and property during a storm, and can result in loss of life, destroyed buildings, beach and dune erosion, and road and bridge damage along the coast.

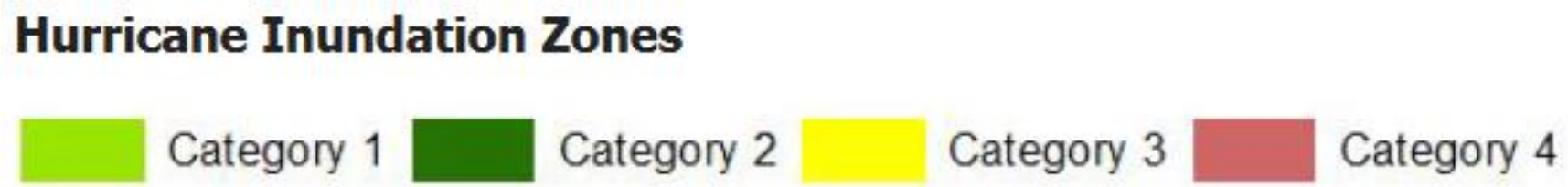
If you live, work, or plan to vacation in one of Massachusetts's coastal communities, or near a river or other waterway connected to the ocean, you should "Know Your Zone." Use the interactive map below or the evacuation zone maps for your community to learn whether your home or business is in a pre- designated hurricane evacuation zone.



- **Inundation maps available on MEMA website**
  - Interactive and Static
- **Evacuation zones available on MEMA website**
  - Interactive and Static
- **Know Your Zone campaign**

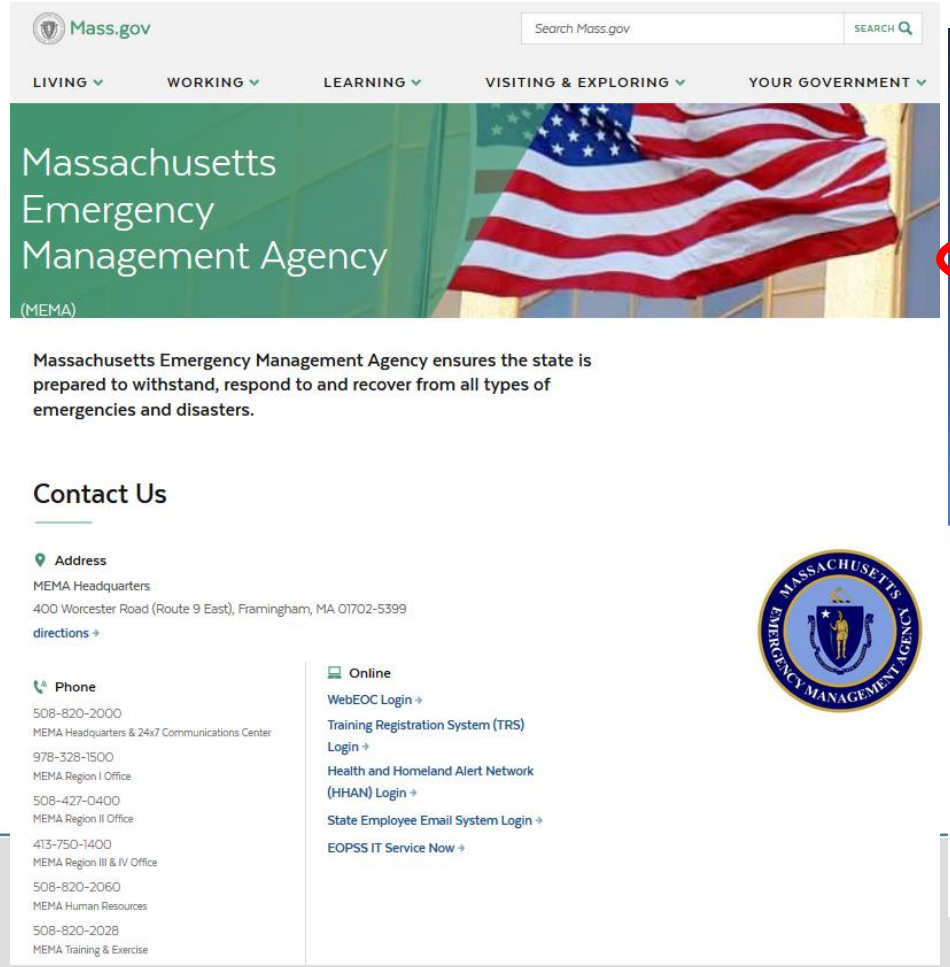
Hurricane Inundation Maps

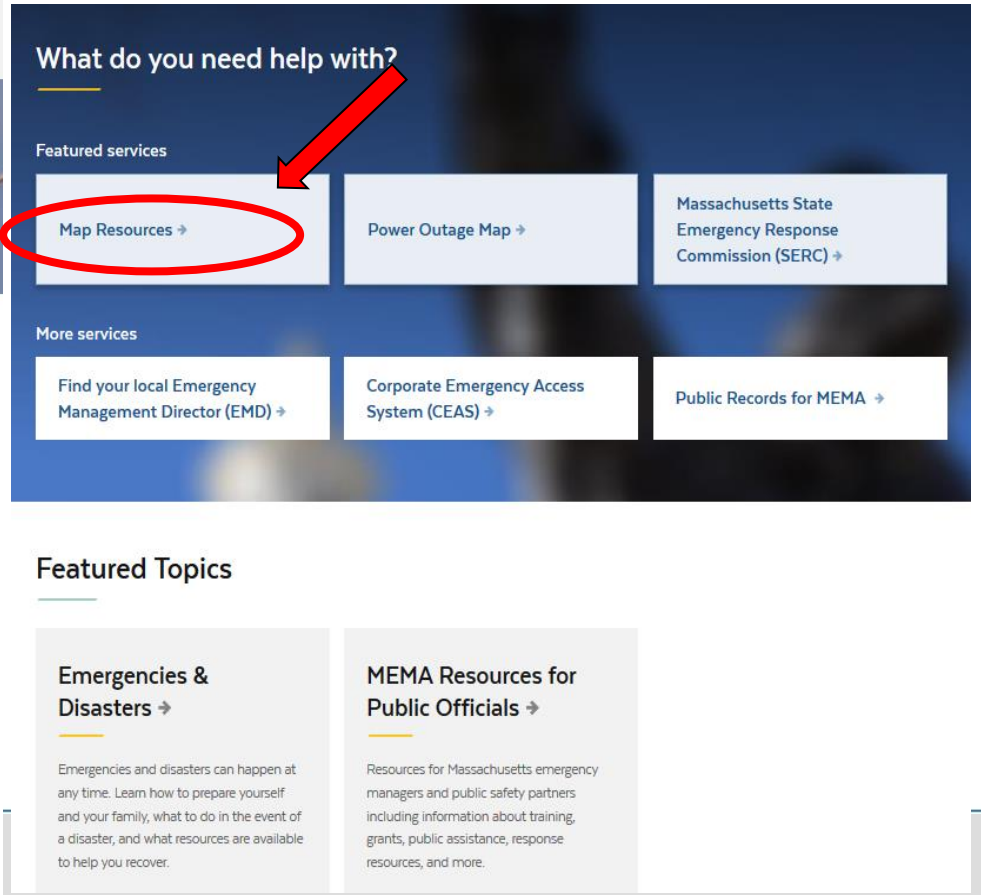
- **Inundation Maps**
  - Show areas that may experience flooding during a tropical storm or hurricane
  - U.S. Army Corps of Engineers uses the Sea, Lake, and Overland Surges from Hurricanes model developed by the NWS to predict storm surge and winds to create hurricane inundation maps
  - Maps estimate the flooding that may occur for Category 1, Category 2, Category 3, and Category 4 hurricanes
  - Help define the hurricane evacuation zones



Hurricane Inundation Maps

- **Where to find the Hurricane Inundation Interactive Map: www.mass.gov/mema**





Hurricane Inundation Maps

Map Resources

Emergency Management Maps are a standard set of public maps used in planning, briefing and response activities.

Massachusetts Emergency Management Agency has a gallery of maps that can be used to support statewide planning and response efforts.

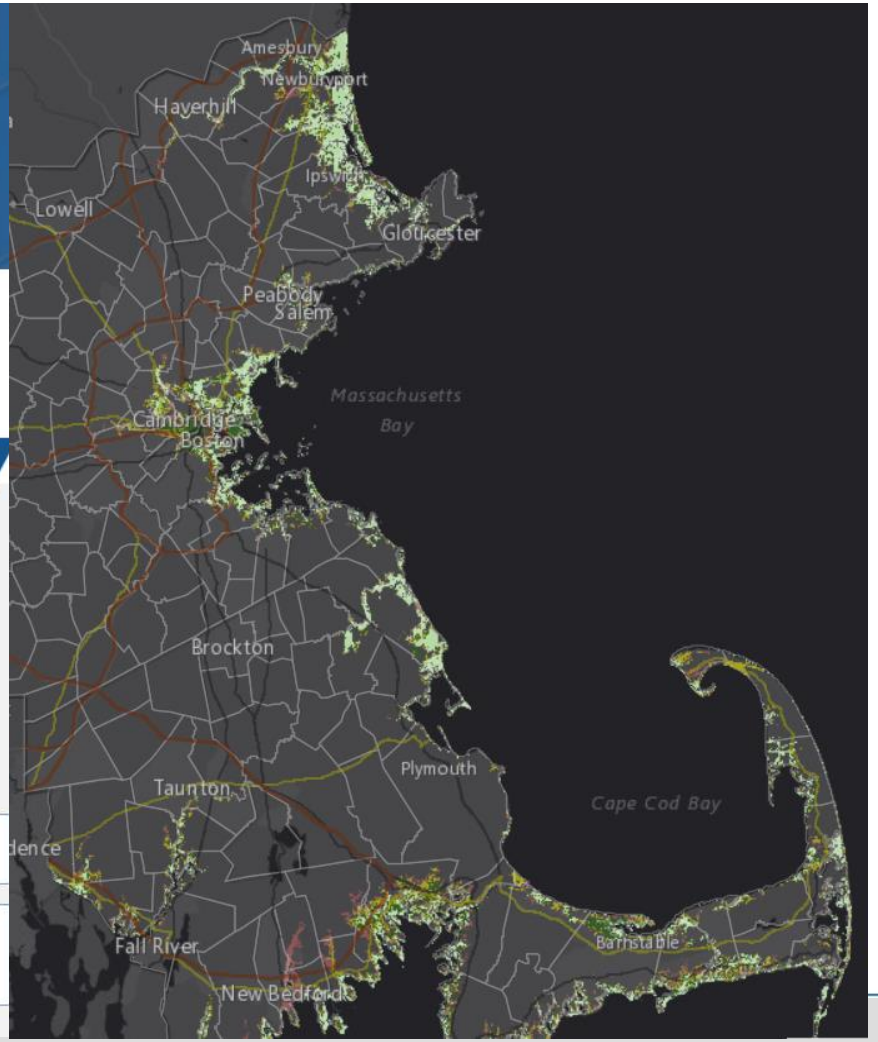
What would you like to do?

Top tasks

- Real-time power outages →
- Live Weather Radar and Forecast Resources →

All other tasks

- Hurricane Evacuation Zones →
- Hurricane Inundation Zones →
- FEMA Flood Zones →
- Pilgrim Nuclear Power Plant Emergency Planning Zone →
- Locations of Hospitals, Fire Stations and Police Stations →
- Locations of Airfields →



What you need to know

Hurricane Evacuation Zones →

ADDITIONAL RESOURCES

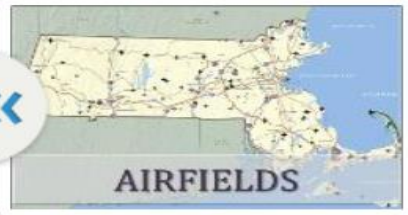
ArcGIS User Login

Hurricane Storm Surge Planning Tool

Hurricane Evacuation Zone PDFs by Community

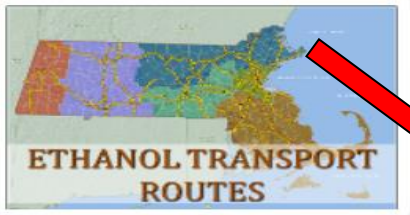
Additional Map Resources

Featured Maps



Airplane and Helicopter Fields

Cultural and Historical Facilities

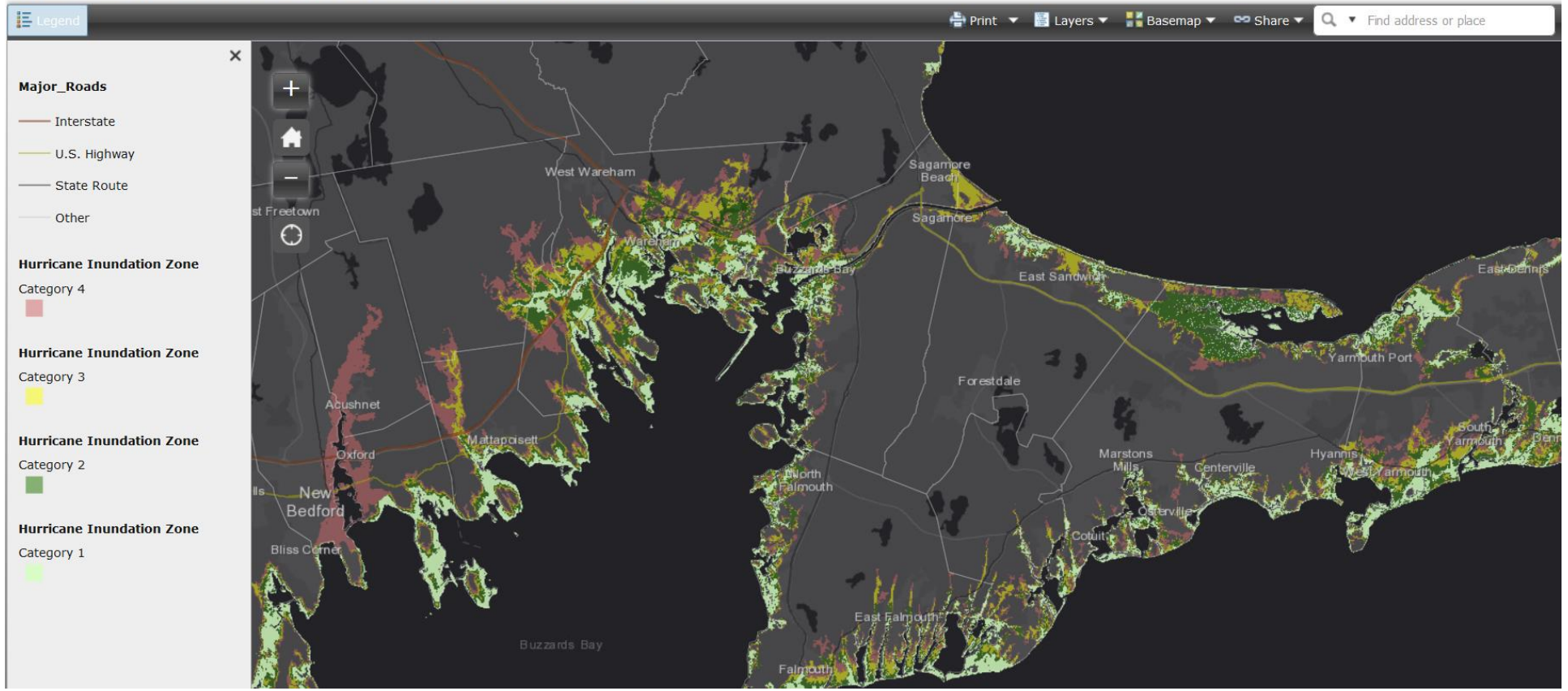


Ethanol Transport Routes

SLOSH (Sea, Lake and Overland Surge Heights)

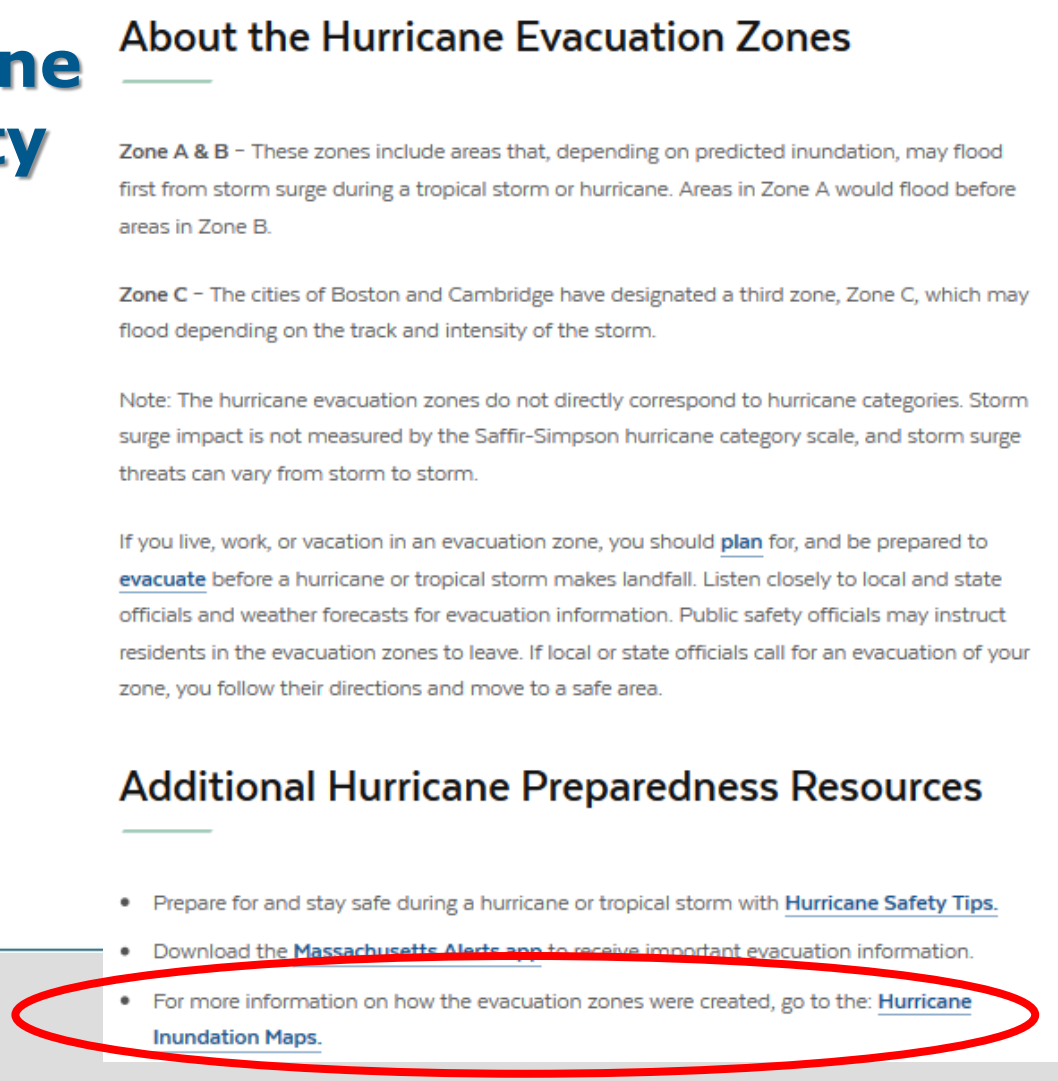
Hurricane Inundation Maps

Massachusetts Hurricane Inundation Zones



Hurricane Inundation Maps

- **Where to find Hurricane Inundation Community Maps:**
  - MEMA Website
  - Mapping Resources
  - Hurricane Evacuation Zones



About the Hurricane Evacuation Zones

Zone A & B – These zones include areas that, depending on predicted inundation, may flood first from storm surge during a tropical storm or hurricane. Areas in Zone A would flood before areas in Zone B.

Zone C – The cities of Boston and Cambridge have designated a third zone, Zone C, which may flood depending on the track and intensity of the storm.

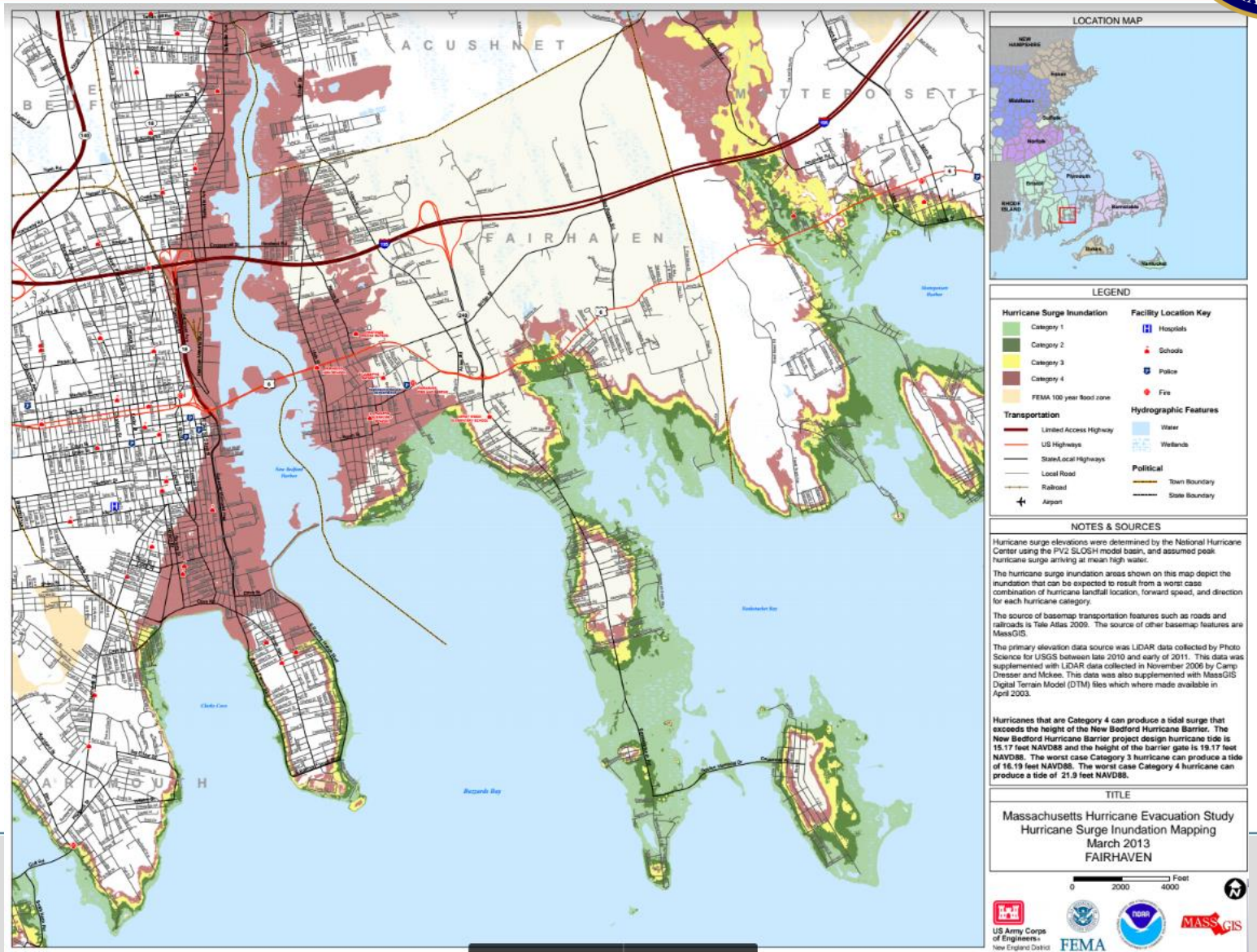
Note: The hurricane evacuation zones do not directly correspond to hurricane categories. Storm surge impact is not measured by the Saffir-Simpson hurricane category scale, and storm surge threats can vary from storm to storm.

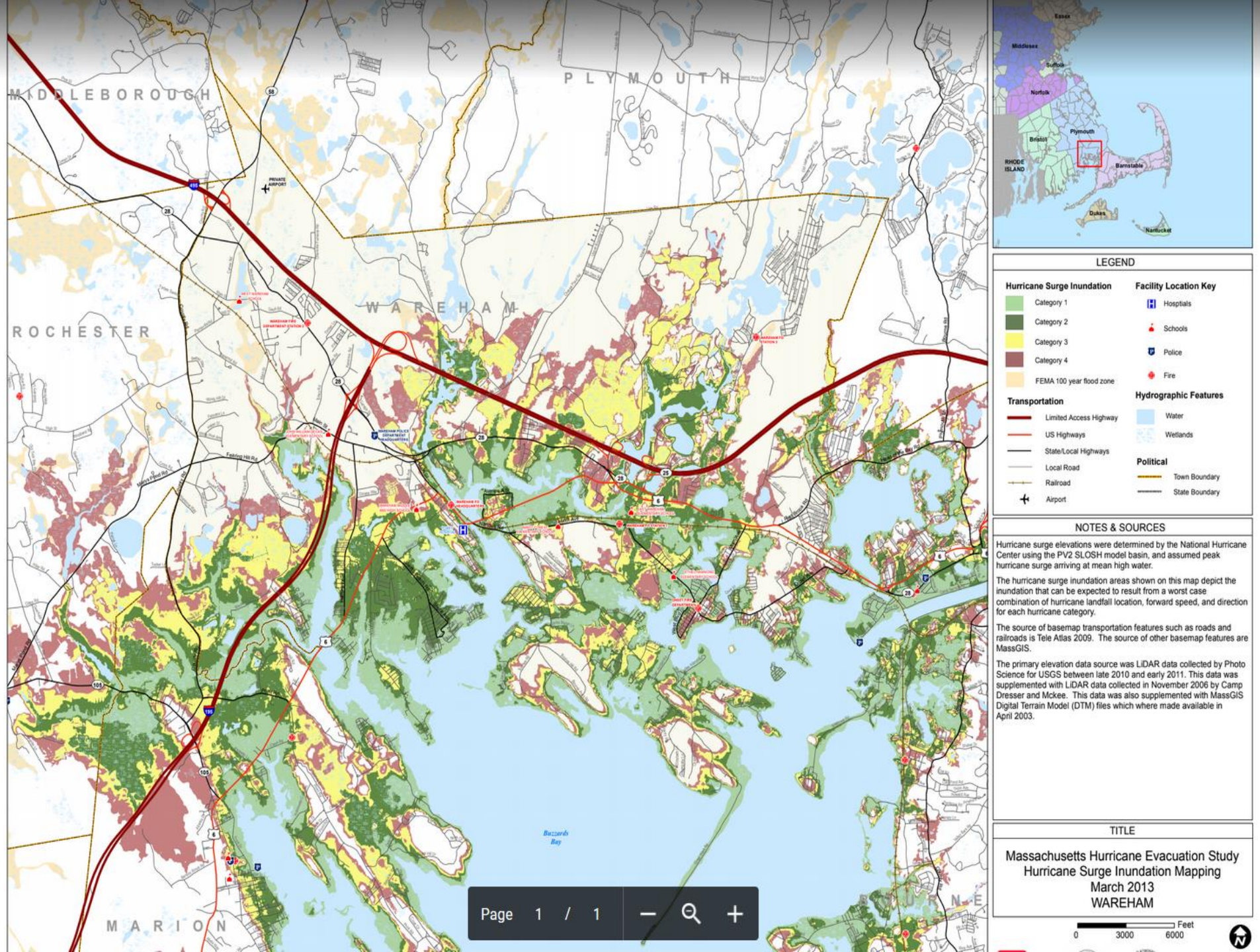
If you live, work, or vacation in an evacuation zone, you should **plan** for, and be prepared to **evacuate** before a hurricane or tropical storm makes landfall. Listen closely to local and state officials and weather forecasts for evacuation information. Public safety officials may instruct residents in the evacuation zones to leave. If local or state officials call for an evacuation of your zone, you follow their directions and move to a safe area.

Additional Hurricane Preparedness Resources

- Prepare for and stay safe during a hurricane or tropical storm with **Hurricane Safety Tips.**
- Download the **Massachusetts Alerts app** to receive important evacuation information.
- For more information on how the evacuation zones were created, go to the: **Hurricane Inundation Maps.**

Hurricane Inundation Maps




MIDDLEBOROUGH
PLYMOUTH
WAREHAM
ROCHESTER
MARION
BOURNE
Buzzards Bay
Page 1 / 1
Essex
Middlesex
Suffolk
Norfolk
Plymouth
Bristol
RHODE ISLAND
Barnstable
Dukes
Nantucket
LEGEND
Hurricane Surge Inundation
Category 1
Category 2
Category 3
Category 4
FEMA 100 year flood zone
Transportation
Limited Access Highway
US Highways
State/Local Highways
Local Road
Railroad
Airport
Facility Location Key
Hosptials
Schools
Police
Fire
Hydrographic Features
Water
Wetlands
Political
Town Boundary
State Boundary
NOTES & SOURCES
Hurricane surge elevations were determined by the National Hurricane Center using the PV2 SLOSH model basin, and assumed peak hurricane surge arriving at mean high water.
The hurricane surge inundation areas shown on this map depict the inundation that can be expected to result from a worst case combination of hurricane landfall location, forward speed, and direction for each hurricane category.
The source of basemap transportation features such as roads and railroads is Tele Atlas 2009. The source of other basemap features are MassGIS.
The primary elevation data source was LiDAR data collected by Photo Science for USGS between late 2010 and early 2011. This data was supplemented with LiDAR data collected in November 2006 by Camp Dresser and Mckee. This data was also supplemented with MassGIS Digital Terrain Model (DTM) files which where made available in April 2003.
TITLE
Massachusetts Hurricane Evacuation Study
Hurricane Surge Inundation Mapping
March 2013
WAREHAM
Feet
0
3000
6000
N

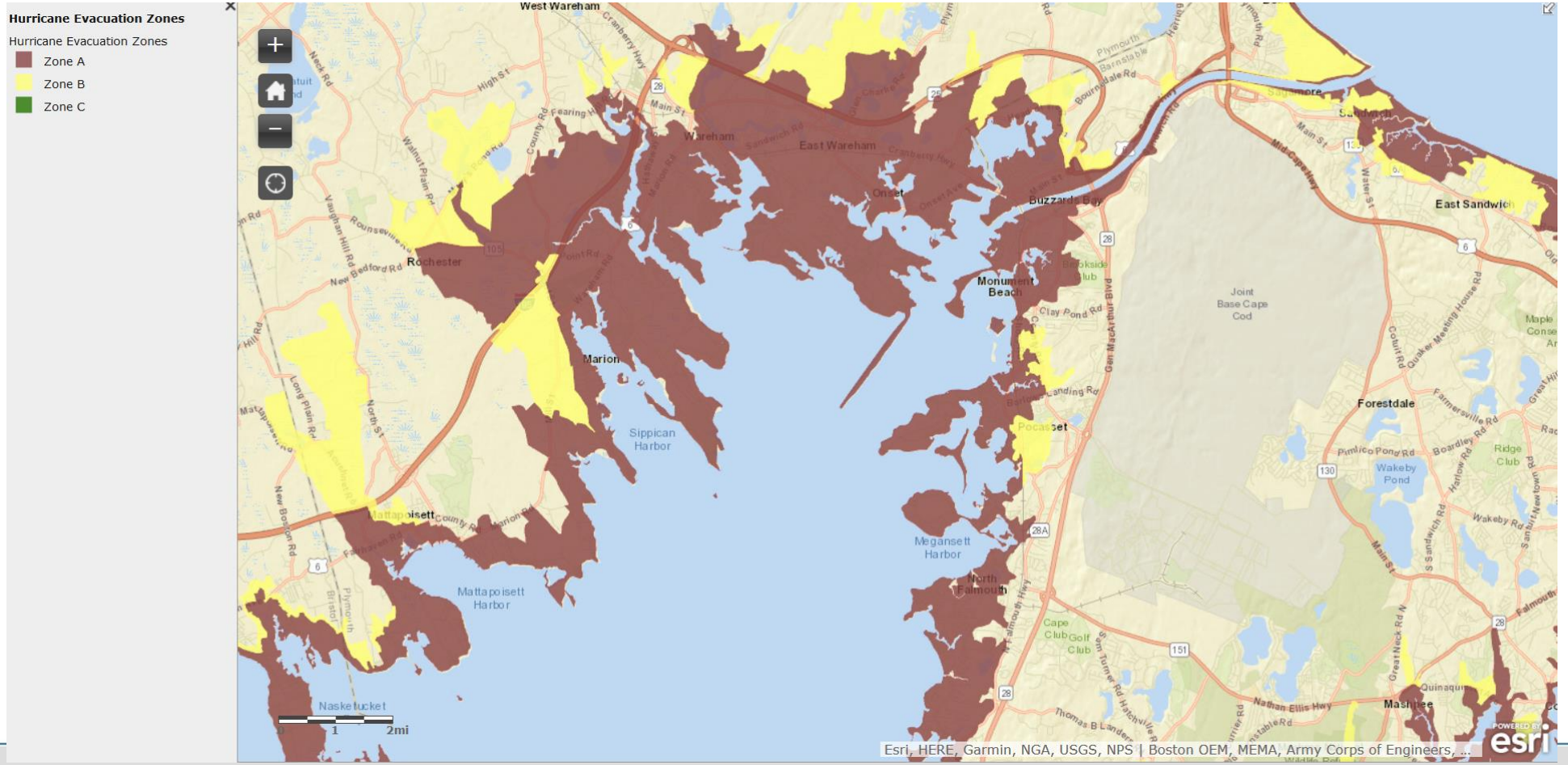
Hurricane Evacuation Zones

- **Zone A & B**
  - Include areas that, depending on predicted inundation, may flood first from storm surge during a tropical storm or hurricane. Areas in Zone A would flood before areas in Zone B
- **Zone C**
  - The cities of Boston and Cambridge have designated a third zone, Zone C, which may flood depending on the track and intensity of the storm
- **NOTE: Evacuation zones do not directly correspond to hurricane categories. Storm surge is not measured by the Saffir-Simpson scale, and storm surge threats can vary from storm to storm**

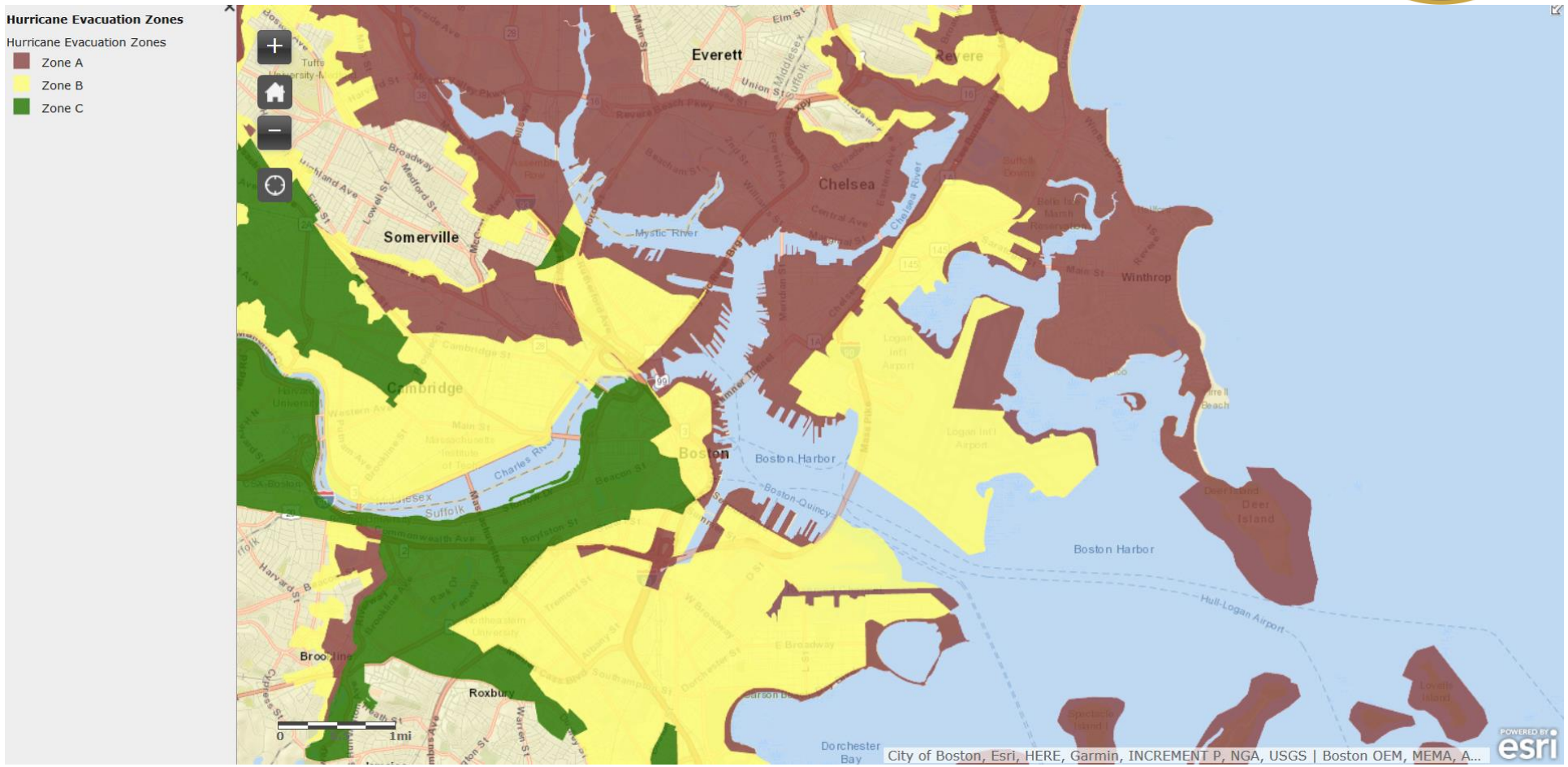
Hurricane Evacuation Zones

- **Where to find the Hurricane Evacuation Interactive Map:**

Hurricane Evacuation Zones

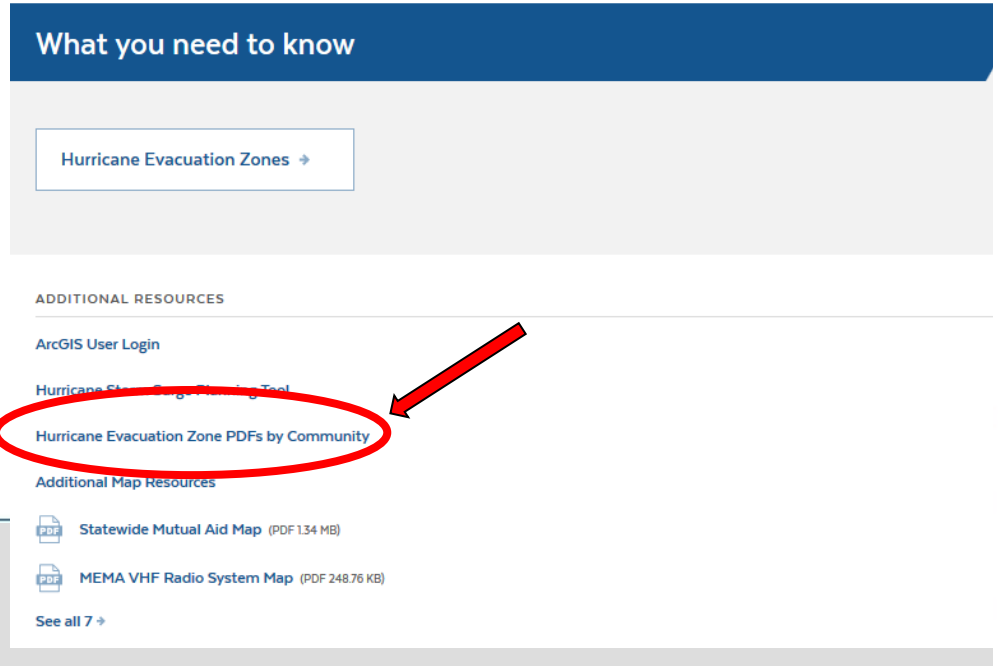


Hurricane Evacuation Zones



Hurricane Evacuation Zones

- **Where to find the Hurricane Inundation Community Maps:**
  - MEMA Website
  - Map Resources
  - Hurricane Evacuation Zones



Hurricane Evacuation Zones

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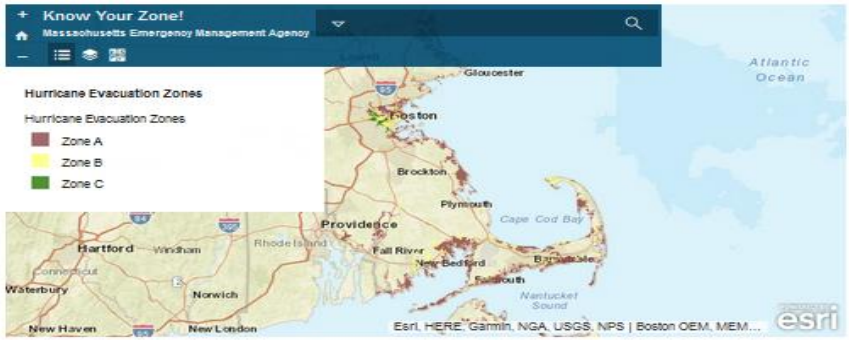

About the Hurricane Evacuation Zones

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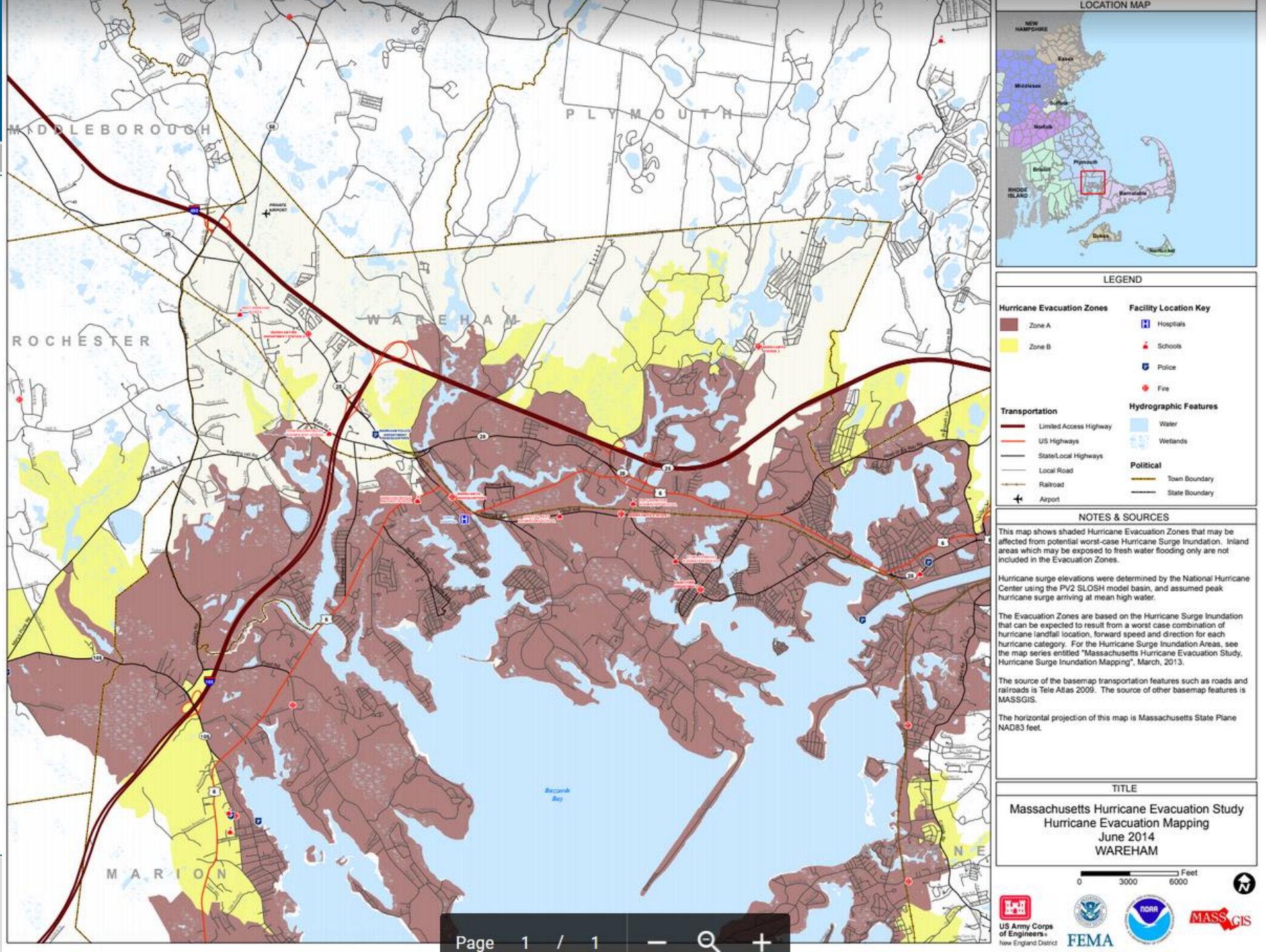
Zone C – The cities of Boston and Cambridge have designated a third zone, Zone C, which may flood depending on the track and intensity of the storm.


MIDDLEBOROUGH
PLYMOUTH
WAREHAM
ROCHESTER
MARION
Buzzards Bay
LOCATION MAP
NEW HAMPSHIRE
RHODE ISLAND
LEGEND
Hurricane Evacuation Zones
Zone A
Zone B
Facility Location Key
Hospitals
Schools
Police
Fire
Transportation
Limited Access Highway
US Highways
State/Local Highways
Local Road
Railroad
Airport
Hydrographic Features
Water
Wetlands
Political
Town Boundary
State Boundary
NOTES & SOURCES
This map shows shaded Hurricane Evacuation Zones that may be affected from potential worst-case Hurricane Surge Inundation. Inland areas which may be exposed to fresh water flooding only are not included in the Evacuation Zones.
Hurricane surge elevations were determined by the National Hurricane Center using the PV2 SLOSH model basin, and assumed peak hurricane surge arriving at mean high water.
The Evacuation Zones are based on the Hurricane Surge Inundation that can be expected to result from a worst case combination of hurricane landfall location, forward speed and direction for each hurricane category. For the Hurricane Surge Inundation Areas, see the map series entitled "Massachusetts Hurricane Evacuation Study, Hurricane Surge Inundation Mapping", March, 2013.
The source of the basemap transportation features such as roads and railroads is Tele Atlas 2009. The source of other basemap features is MASSGIS.
The horizontal projection of this map is Massachusetts State Plane NAD83 feet.
TITLE
Massachusetts Hurricane Evacuation Study
Hurricane Evacuation Mapping
June 2014
WAREHAM
Feet
0
3000
6000
US Army Corps of Engineers
New England District
FEMA
NOAA
MASSGIS
Page 1 / 1

Recommendations for Communities

- **Identify one or more Point of Distribution (POD) sites**
  - Develop plans to staff & operate them
- **Determine sources for critical commodities**
  - Food & Water
- **Have a debris management plan**

Recommendations for Communities

- **Identify people with access and functional needs; critical transportation needs**
- **Develop critical transportation needs plan**
  - MEMA Website: www.mass.gov/mema/
- **Develop plan to notify the public of evacuation orders; provide critical information**
- **Assess and bolster shelter plans**
  - Personnel
  - Supplies
  - Food/ Water
  - People with access and functional needs

Hurricane Working Groups

- **Hurricane Season Planning & Pre-Landfall Coordination**
  - Air Operations
  - Communications
  - Debris Management
  - Energy & Utilities
  - Evacuation & Transportation
  - Fuel Planning

Hurricane Working Groups

- **Hurricane Season Planning & Pre-Landfall Coordination**
  - Mass Care & Sheltering
  - Mass Feeding & Commodities
  - Search & Rescue
  - State Staging
  - Rapid Impact Assessments
  - Distribution of Critical Commodities

What to expect from MEMA

- Situational Awareness Statements (SAS)
- Conference calls
- Emergency alerting; Wireless Emergency Alerts and the Emergency Alert System
- Pre-landfall evacuation support
- Pre-landfall staging of resources
- Post-landfall coordination

MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY
HURRICANE DECISION SUPPORT TEAM
SITUATIONAL AWARENESS STATEMENT

Tropical Storm Jose – 9/14/2017, 9:00 PM Update

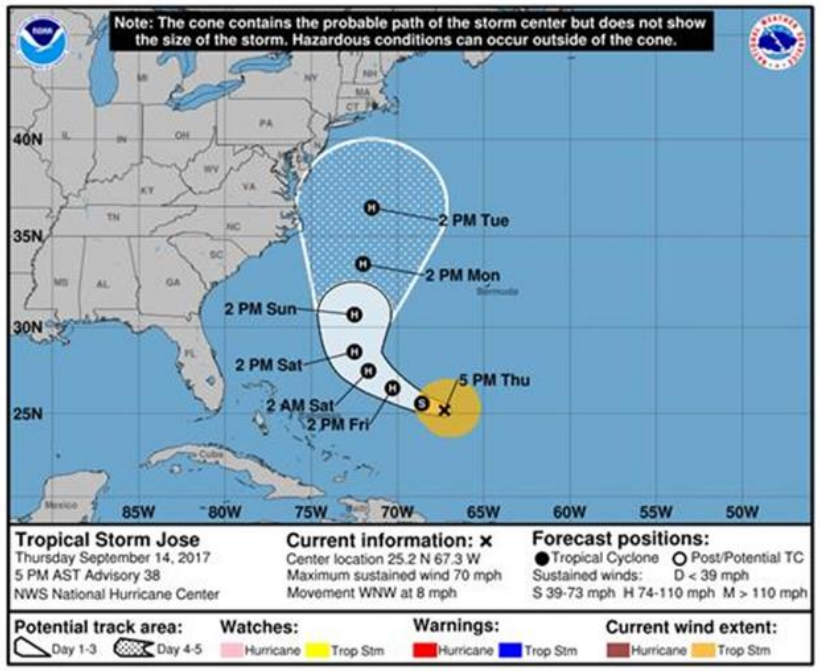
Situation

As of 5:00 PM today, Tropical Storm Jose was located 405 miles east-northeast of the Southeastern Bahamas and moving to the west-northwest at 8 MPH. This motion is expected to continue through Friday, followed by a turn to the northwest on Saturday. Maximum sustained winds are at 70 MPH. Tropical storm force winds extend outward from the center of the storm up to 140 miles. TS Jose is expected to re-intensify and become a hurricane again this weekend, and remain as a hurricane at least into early next week.

Jose will make its closest approach to Southern New England late Tuesday into Wednesday.

While there is still a lot of uncertainty in Jose's track and forecast, it is likely that in the next 24-36 hours, Massachusetts will fall within the National Hurricane Center's 5-day so-called "cone of uncertainty. The cone represents the probable track of the center of the storm, and the width of the cone is set so that two-thirds of historical official forecast errors over a 5-year sample fall within the cone. At this point, it appears that the actual storm track could be anywhere from a pass off of the coast of Southern New England, to direct landfall. If the storm tracks along the eastern edge of the cone of uncertainty, staying well offshore, impacts in Massachusetts could be similar to a strong nor'easter with the southeast areas of the state experiencing wind gusts of 50-60 mph. A track farther to the west with the hurricane making landfall in southern New England, or passing close by, would cause more significant impacts (stronger winds, more substantial beach erosion and coastal flooding, heavy rainfall, etc.)

National Hurricane Center Forecast Track:



2018 Hurricane Season Preparation