# Planning for the Threat
# Hurricane Evacuation Decision Making


## 2016 CAFM Conference

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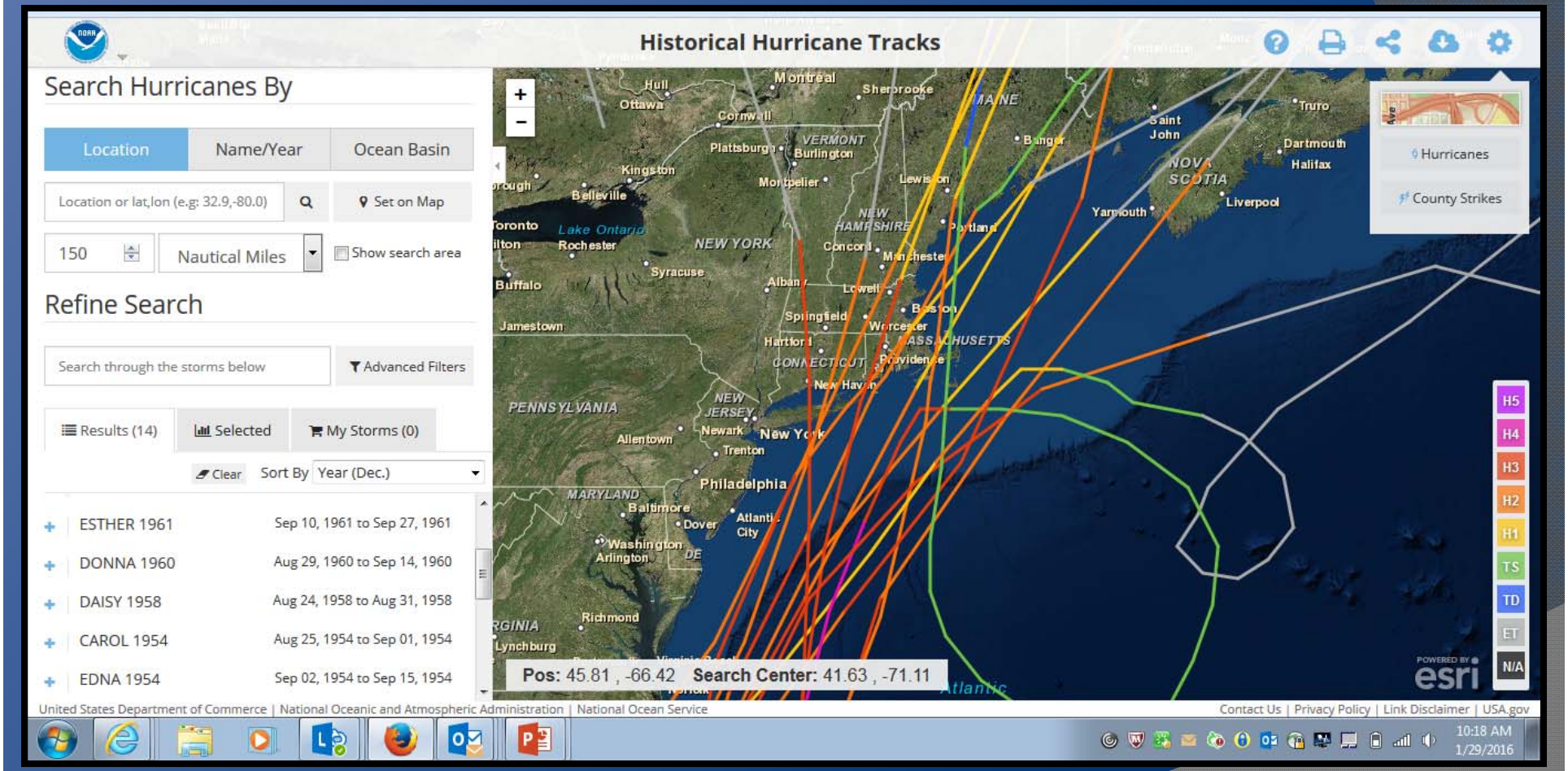
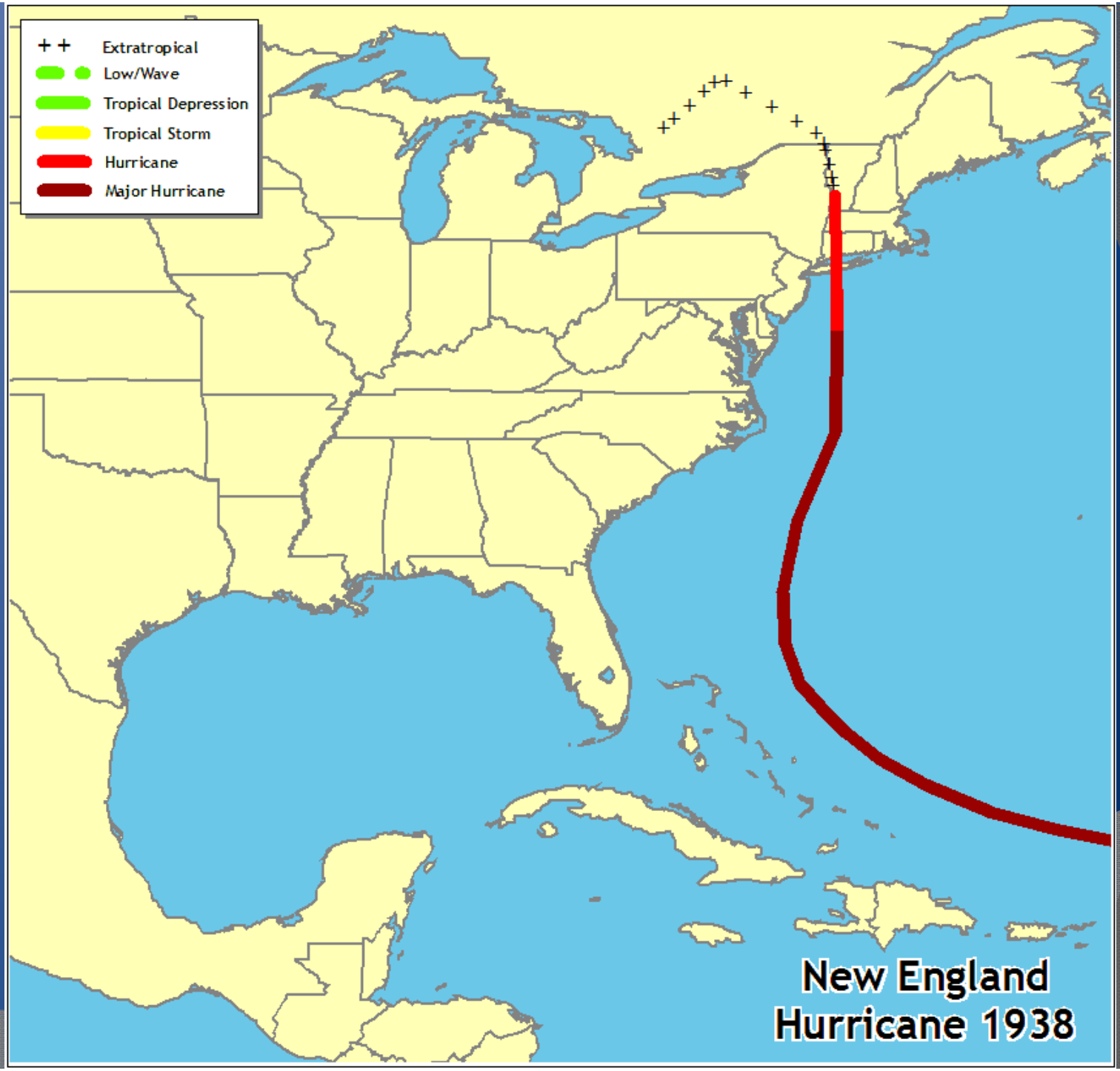
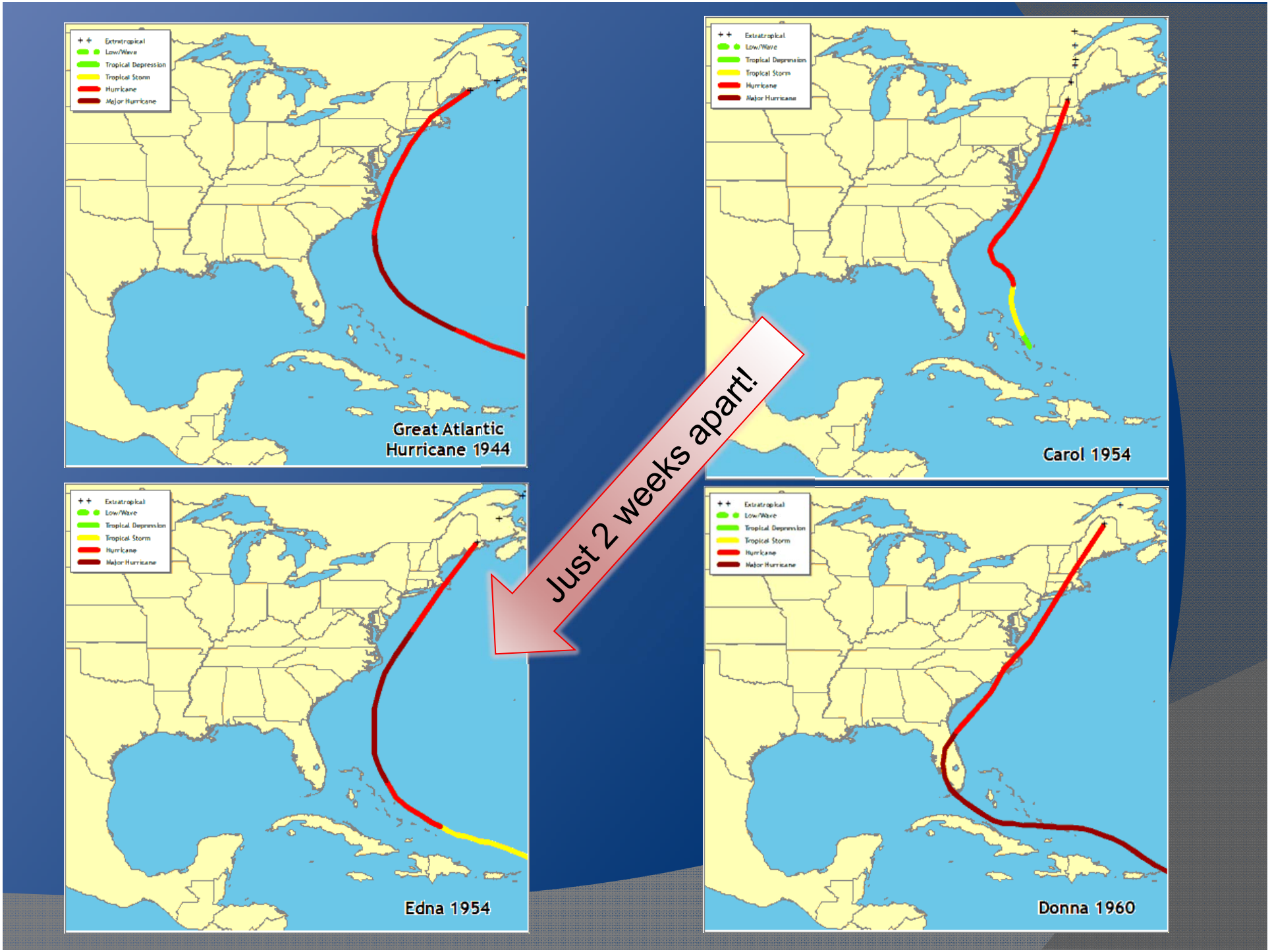
**FEMA Region I**
**Hurricane Program Manager**

# Hurricane History of New England



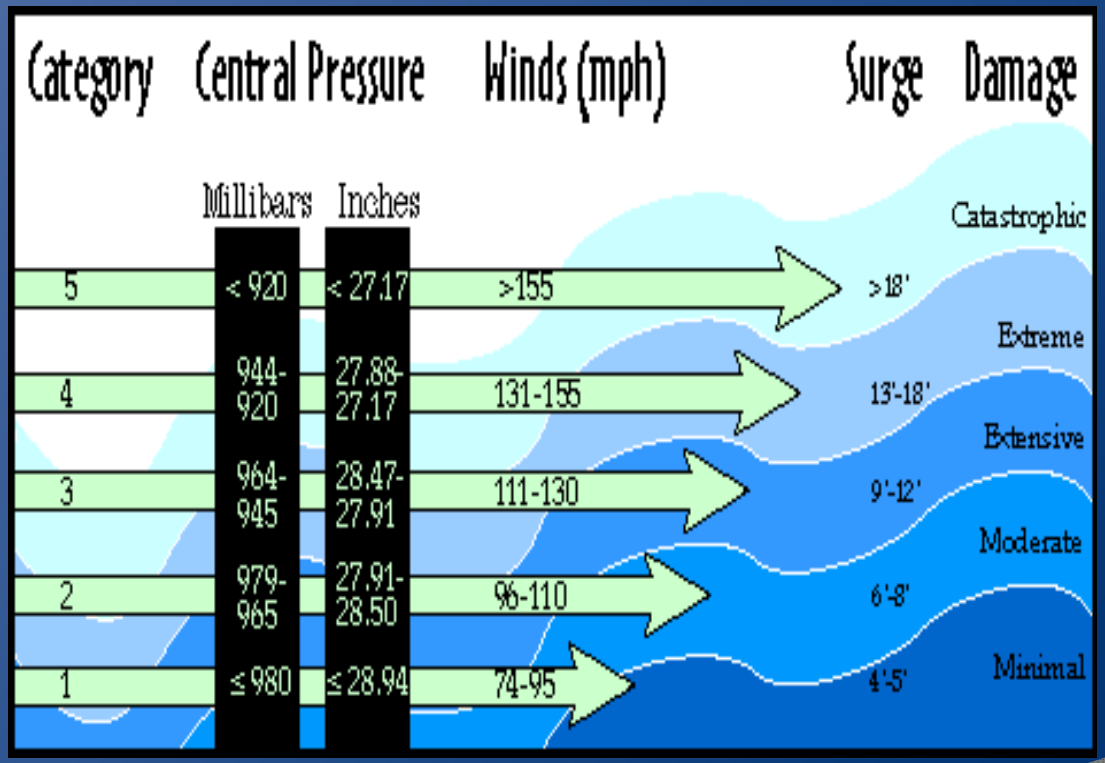

## The map shows only Cat 2 and above hurricanes!


Extratropical
Low/Wave
Tropical Depression
Tropical Storm
Hurricane
Major Hurricane
New England
Hurricane 1938


Extratropical
Low/Wave
Tropical Depression
Tropical Storm
Hurricane
Major Hurricane
Great Atlantic Hurricane 1944
Carol 1954
Just 2 weeks apart!
Edna 1954
Donna 1960

# Hold on! What about TS, Cat 1, Cat 2…
# 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)

# Decision Making in the Face of Uncertainty

## Key Questions:

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

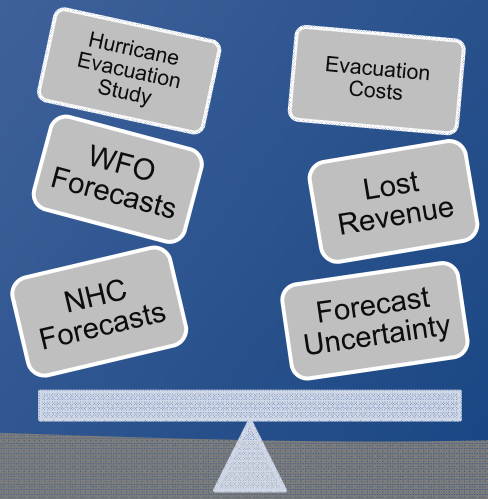
**How much coastal flooding and where?**

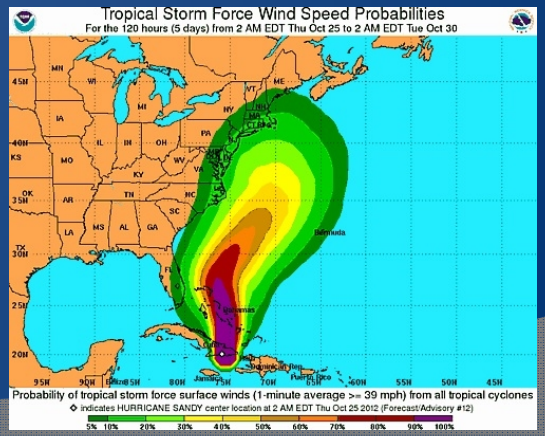
**What about wind and inland flooding from rain?**

**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**

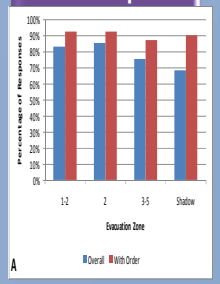
- SLOSH Model Development
- Surge MOMS

**Vulnerability Analysis**

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

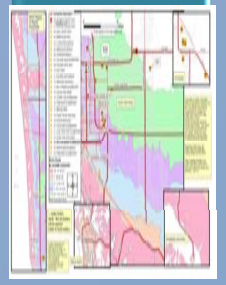
**Behavioral Analysis**

- Public Survey
- Analysis of Survey Responses
- Results for Input



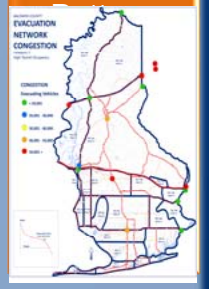

**Shelter Analysis**

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



**Transportation Analysis**

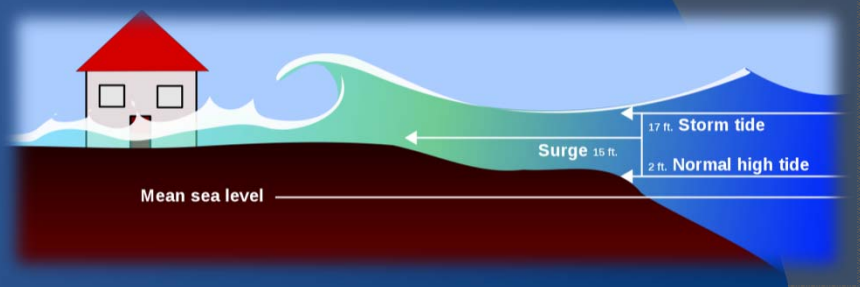
- Analysis of Traffic Volumes, Evac. Routes, and Destinations
- Traffic



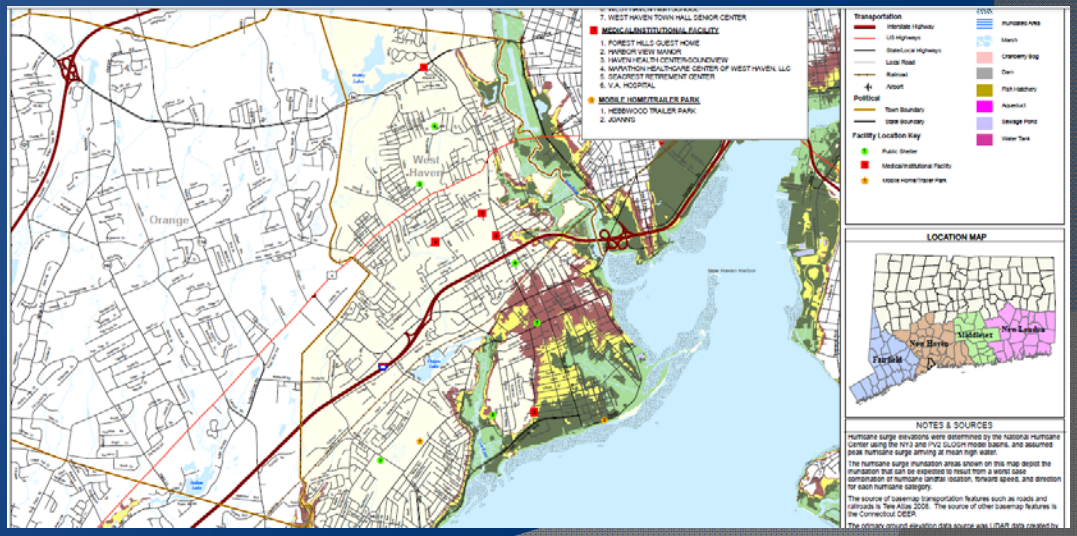

## Critical Information for Planning and Response…

# 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



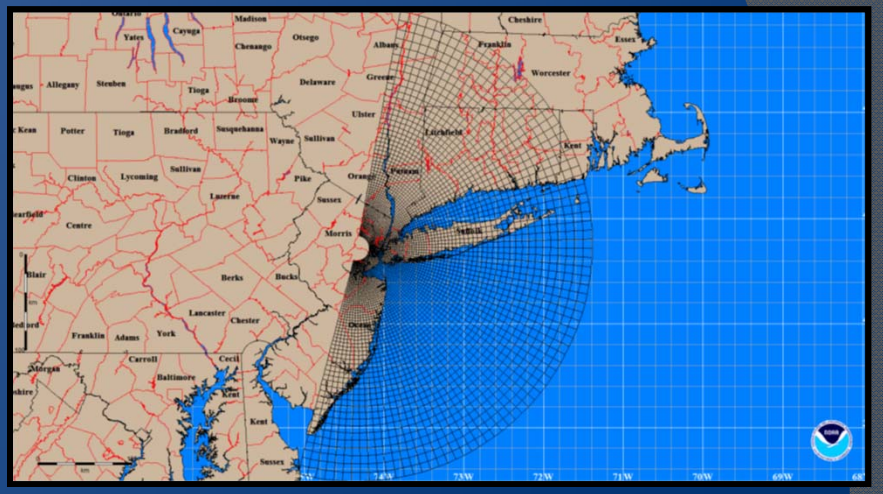

Analysis: **Hazard** Vulnerability Behavioral Shelter Transportation
Products: Surge Maps Evacuation Zones Planning Data Clearance times

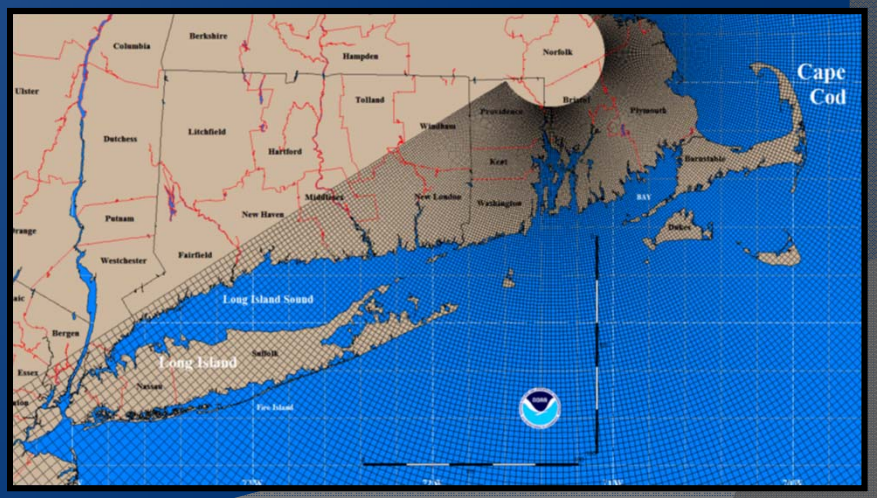
# What are the zones based on?

**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**



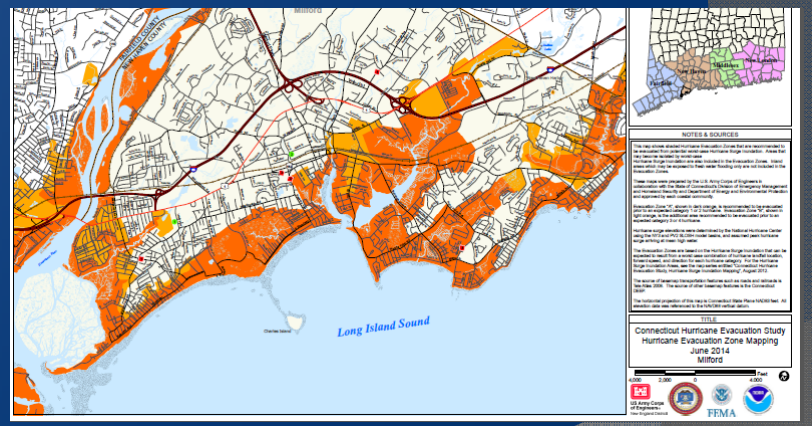




Analysis: Hazard Vulnerability Behavioral Shelter Transportation
Products: Surge Maps Evacuation Zones Planning Data Clearance times

# 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

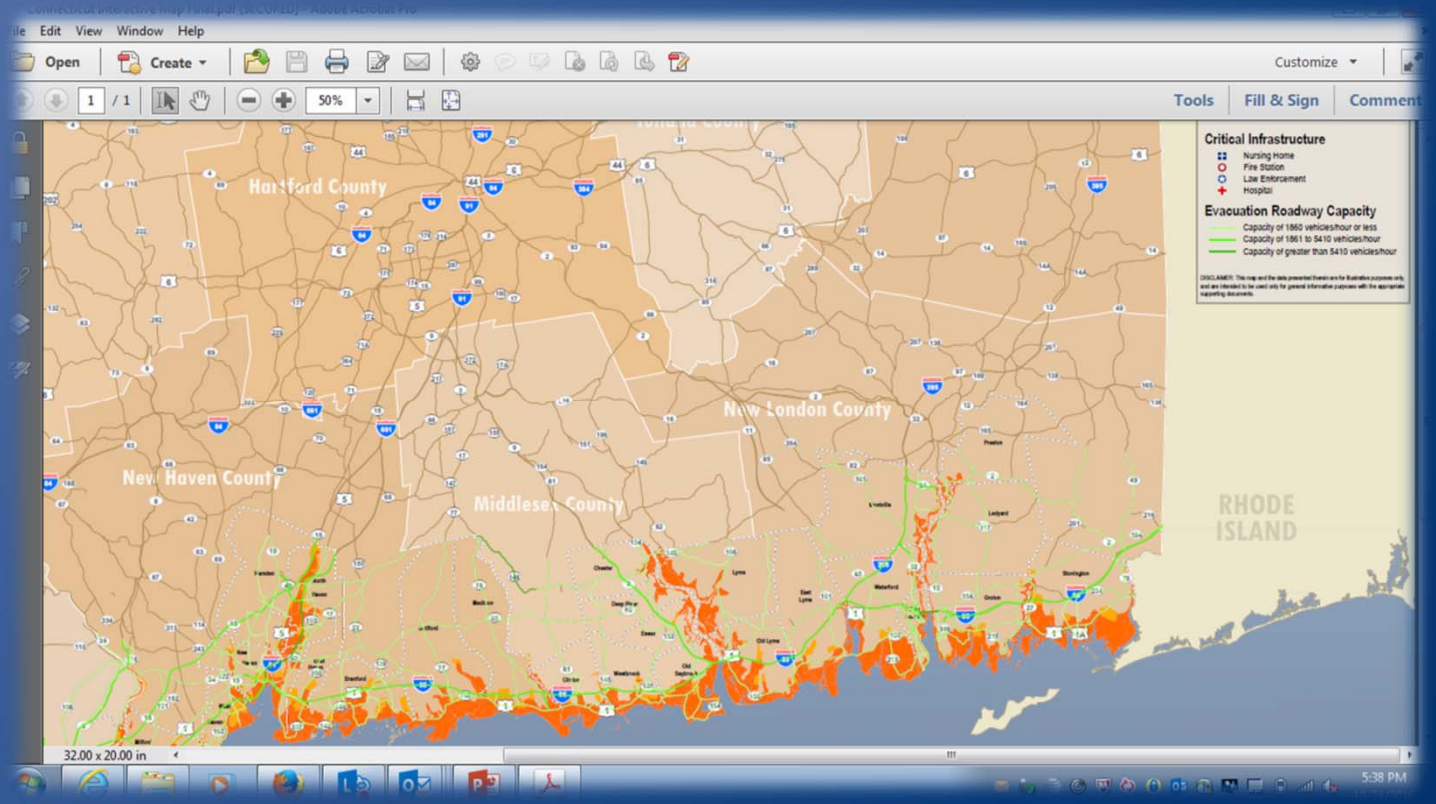
- Citizens residing in surge prone areas
- Critical facilities
- Mobile/Manufactured home communities
- Vulnerable shelters
- Colleges/Universities

### 3.0 Vulnerability Analysis

Table 3-7: Critical Facilities: Fire Stations – Fairfield County

| Community | Zone[1] | Asset | Address | Zip |
|---|---|---|---|---|
| Bridgeport | A | BRIDGEPORT FIRE DEPT - ENGINE COMPANY 7 AND LADDER 11 | 245 OCEAN TERRACE | 06605 |
| | A | BRIDGEPORT FIRE DEPT - RESCUE SQUAD 5 - HEADQUARTERS | 30 CONGRESS ST | 06604 |
| | B | BRIDGEPORT FIRE DEPT - ENGINE COMPANY 3 AND 4 | 233 WOOD AVE | 06605 |
| | B | BRIDGEPORT FIRE DEPT - ENGINE AND LADDER 6 | 1035 CENTRAL AVE | 06607 |
| | Inland | BRIDGEPORT FIRE DEPT - ENGINE COMPANY 12 | 265 BEECHMONT AVE | 06606 |
| | Inland | BRIDGEPORT FIRE DEPT - ENGINE COMPANY 15 | 104 EVERS ST | 06610 |
| | Inland | BRIDGEPORT FIRE DEPT - ENGINE COMPANY 16 | 3115 MADISON AVE | 06606 |
| | Inland | BRIDGEPORT FIRE DEPT - ENGINE COMPANY AND LADDER 10 | 950 BOSTON AVE | 06610 |
| Darien | Inland | DARIEN VOLUNTEER FIRE DEPT | 848 POST RD | 06820 |
| | Inland | NOROTON FIRE DEPT | 1873 POST RD | 06820 |
| | Inland | NOROTON HEIGHTS FIRE DEPT | 209 NOROTON AVE | 06820 |
| Fairfield | A | REGIONAL FIRE SCHOOL | 205 ONE ROD HWY | 06824 |
| | A | FAIRFIELD FIRE DEPT STATION 1 - HEADQUARTERS | 140 REEF RD | 06824 |
| | A | FAIRFIELD FIRE DEPT STATION 4 | 69 MAIN ST | 06890 |
| | A | SOUTHPORT VOLUNTEER FIRE DEPT | 69 MAIN ST | 06890 |
| | Inland | FAIRFIELD FIRE DEPT STATION 5 | 3965 CONGRESS ST | 06824 |
| | Inland | FAIRFIELD FIRE DEPT STATION 2 | 600 JENNINGS RD | 06824 |
| | Inland | FAIRFIELD FIRE DEPT STATION 3 | 400 JACKMAN AVE | 06825 |
| Greenwich | A | GREENWICH FIRE DEPT STATION 5 - SOUND BEACH | 207 SOUND BEACH AVE | 06870 |

# Vulnerability Analysis




## Critical Facility Maps

# Hurricane Behavioral Analysis

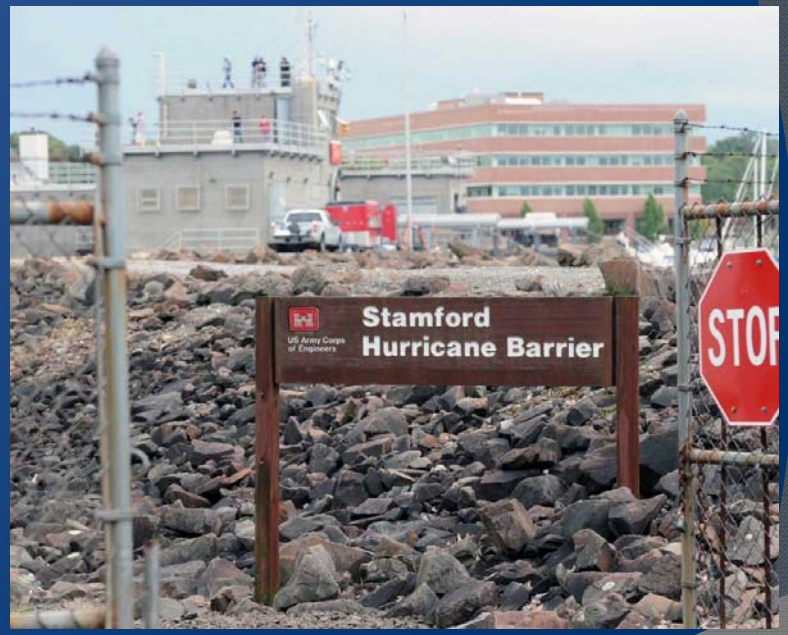
- Attitudes about risk from hurricane hazards – Primarily storm surge
- Evacuation intentions and past experiences
- Evacuation destinations
- Evacuation routes
- Sources of forecast information

**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 |
| 42% | 22% | 13% | 57% | 42% | 25% | 72% | 63% | 36% |

**Table 4-3:** Perceived Vulnerability – Believe Home would not be Safe

| 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 |
| 42% | 32% | 28% | 56% | 48% | 32% | 66% | 59% | 46% |



# Hurricane Behavioral Analysis

- **600 total surveys in state**
- **300 in Surge Inundation Zones 1 and 2 (Combined)**
- **200 in Surge Inundation Zones 3 and 4 (Combined)**
- **100 in non-surge areas of adjacent coastal communities**

# Some Key Findings

- Serious under-concern about surge
- Evacuation intent over-stated
- Evacuation intent highest (and better predictor of actual behavior)
  - For major storms
  - For mandatory or ordered evacuations
  - For households with children
  - With recent real hurricane experience
- Often get “False Experience” effect
  - Earl/Irene/Sandy?

# Shelter Analysis

## Understanding Shelter Need

**Key Sheltering Information:**

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

### 5.0 Shelter Analysis

Table 5-3: Public Sheltering Demand and Sheltering Capacity – New Haven County

| Community | Scenario A Low Occ | Scenario A High Occ | Scenario B Low Occ | Scenario B High Occ | Shelter Capacities* |
|---|---|---|---|---|---|
| Branford | 806 | 832 | 992 | 1,023 | 70 |
| East Haven | 750 | 761 | 968 | 978 | 175 |
| Guilford | 395 | 413 | 574 | 594 | 35 |
| Hamden | 613 | 618 | 1,202 | 1,209 | 5,145 |
| Madison | 344 | 385 | 487 | 530 | 105 |
| Milford | 1,224 | 1,255 | 1,652 | 1,689 | 4,962 |
| New Haven | 1,892 | 1,914 | 3,254 | 3,282 | 400 |
| North Haven | 266 | 271 | 511 | 517 | 50 |
| West Haven | 1,026 | 1,032 | 1,567 | 1,576 | 105 |
| **Totals** | **7,316** | **7,481** | **11,207** | **11,398** | **11,047** |

# Shelter Analysis

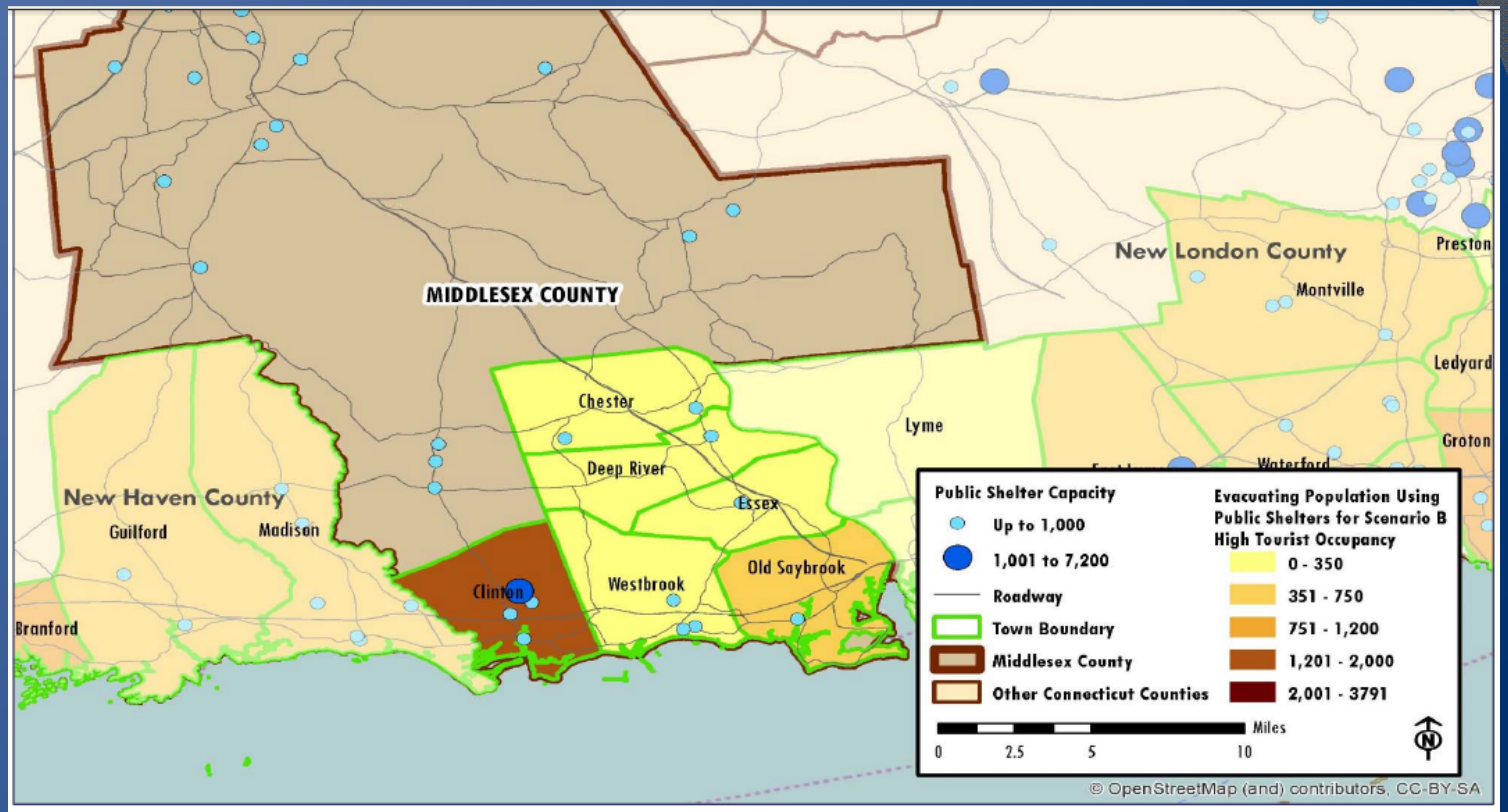
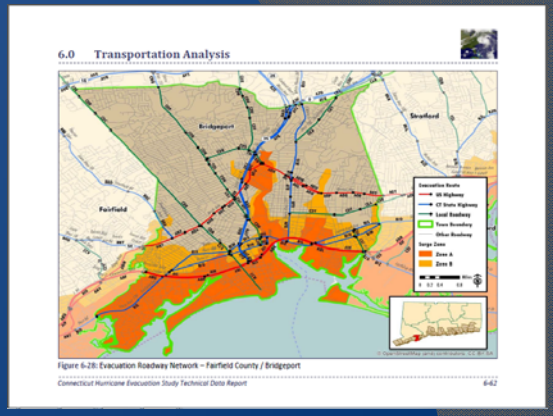



**Figure 5-3:** Estimated Evacuating Population Using Shelters for Scenario B High Tourist Occupancy – Middlesex County

## Shelter Capacity/Demand Maps

# Transportation Analysis

**Understand traffic congestion potential based upon evacuation decisions**

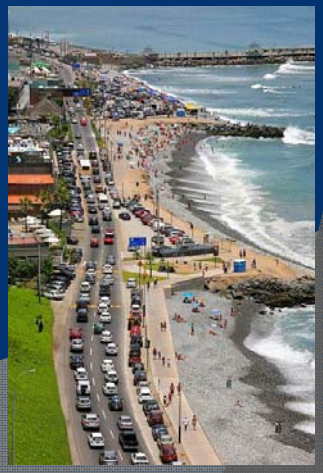



- Traffic Patterns (bottle necks)
- Evacuating Vehicles

## Clearance Time tables

Variables of:

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



# Evacuation Clearance Times - Example

Timeline

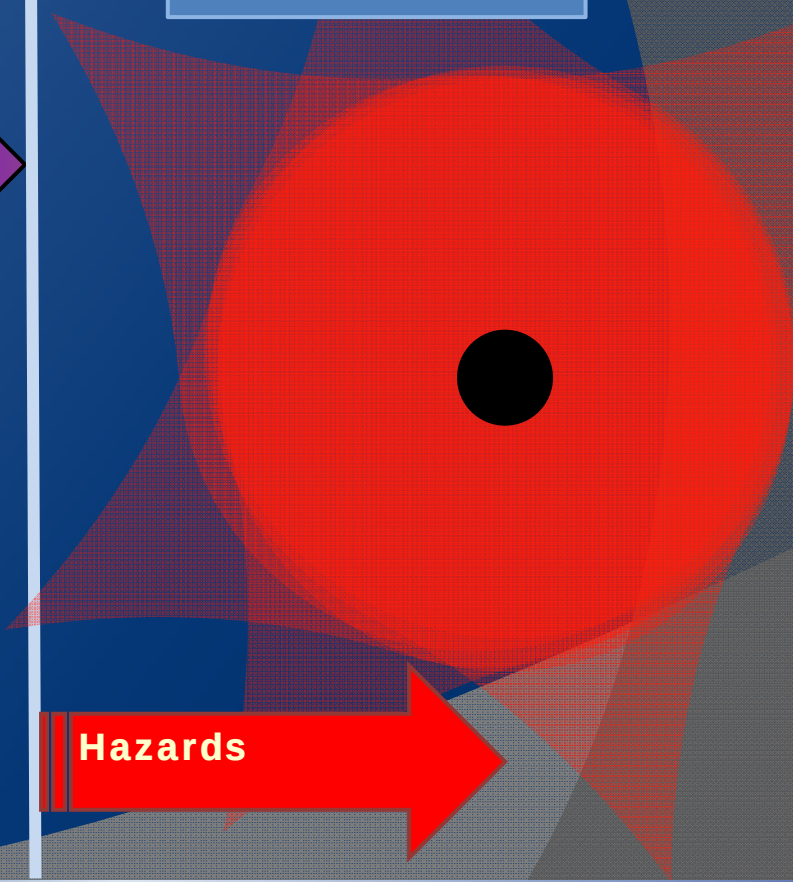
H= -48 H= -36 H= -24 H= -18 H= -12 H= -6 H=0 H=+6 H=+12 H=+18 H=+26

Evacuation Start Time

Forecasted Onset of TS winds or surge

Clearance Time = 48hrs

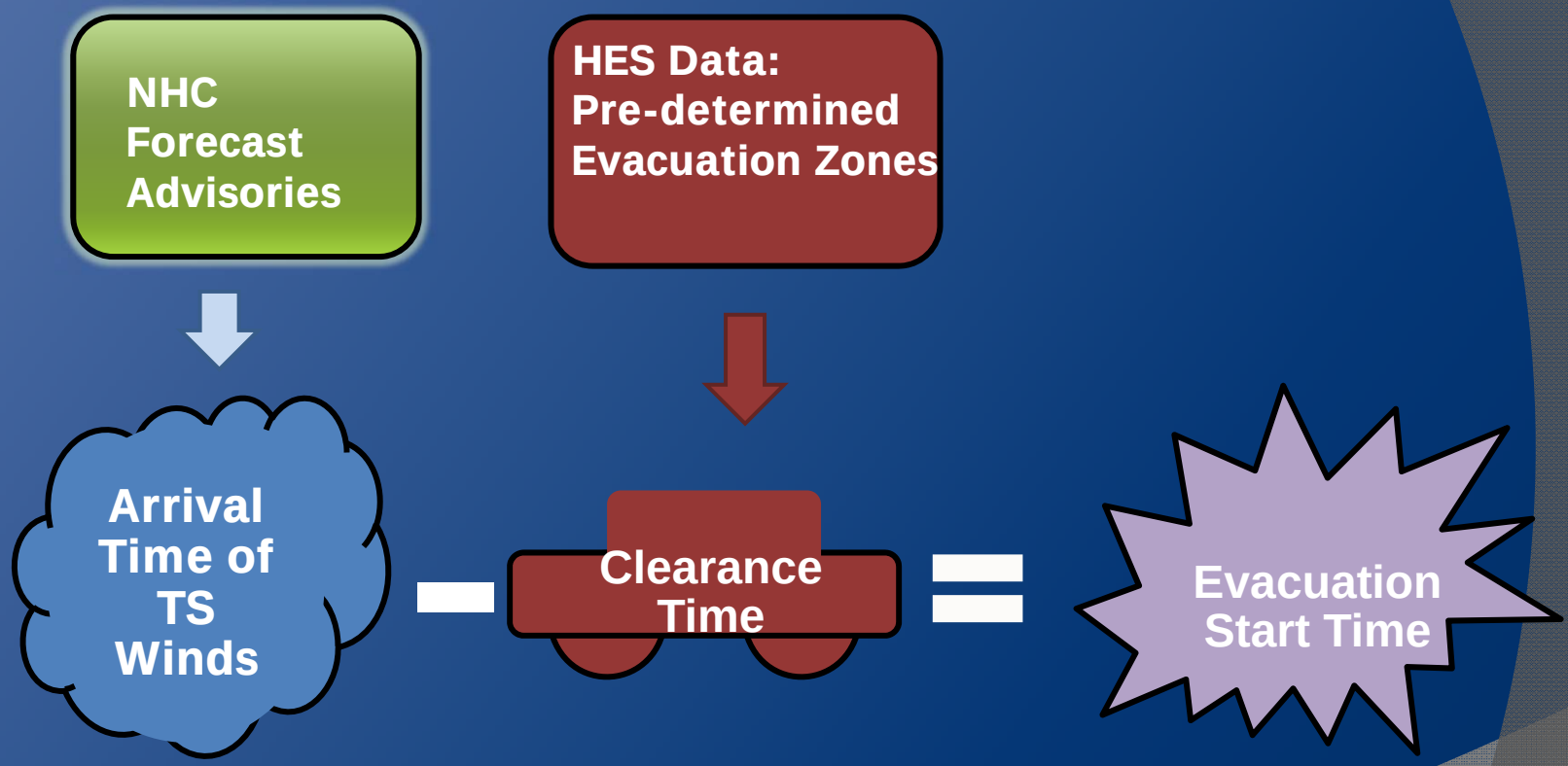
Begins when the first evacuating vehicle enters the road network, ends when the last vehicle reaches an assumed point of safety



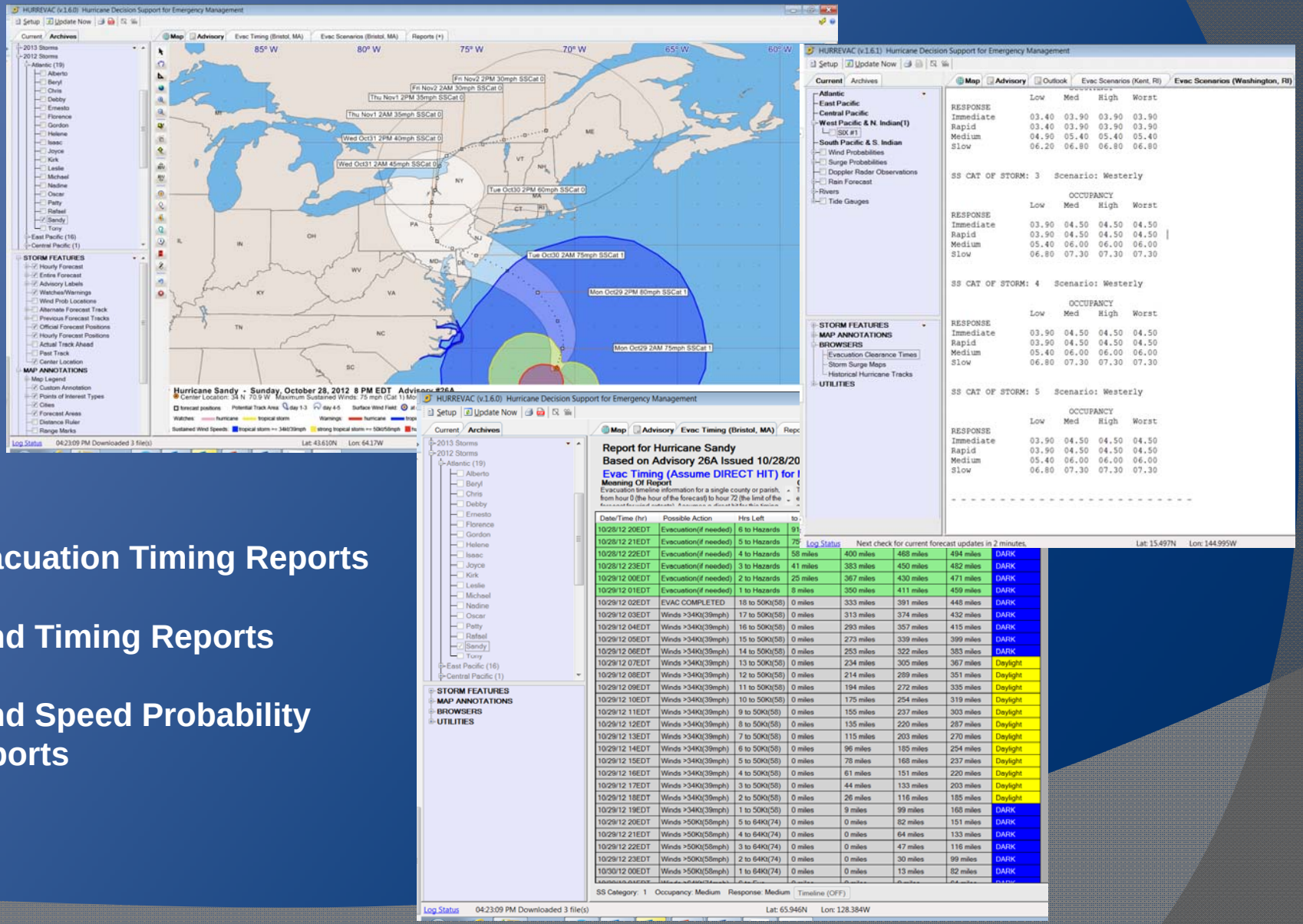

Analysis: Hazard Vulnerability Behavioral Shelter **Transportation**

Products: Surge Maps Evacuation Zones Planning Data Clearance times

# Evacuation Decision Calculation



# HES in HURREVAC




**Evacuation Timing Reports**

**Wind Timing Reports**

**Wind Speed Probability Reports**

# The Hurricane Evacuation Study:


**Informs** your **plans** with data from the 5 analysis

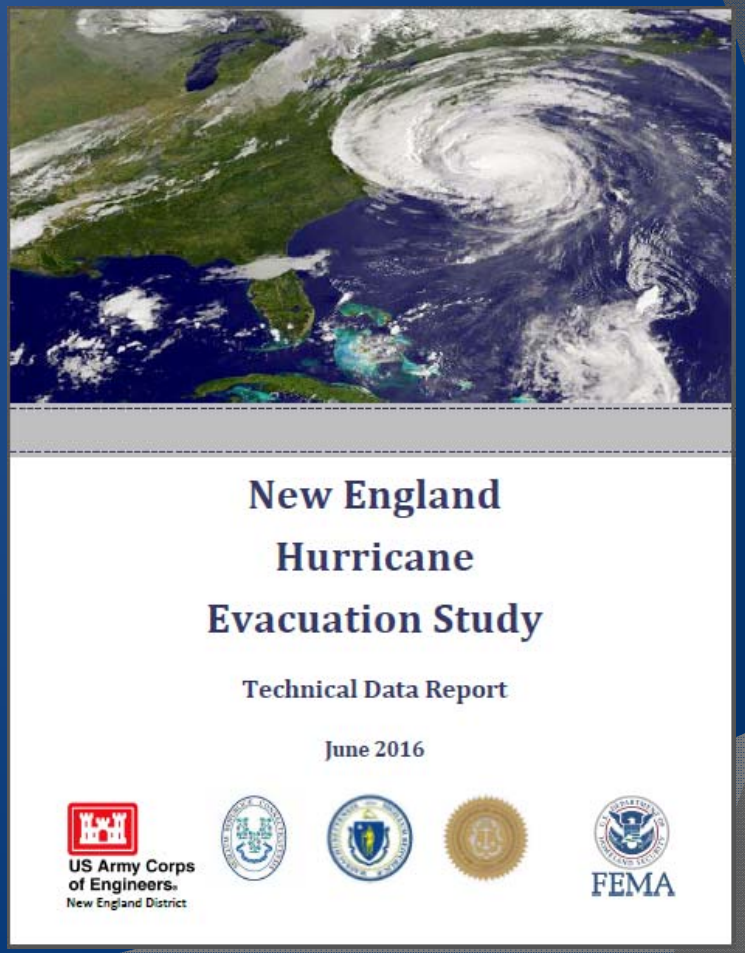
**Supports** your **response** operations by providing:

- 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

# Technical Data Reports

**Detailed reports of the following analyses:**

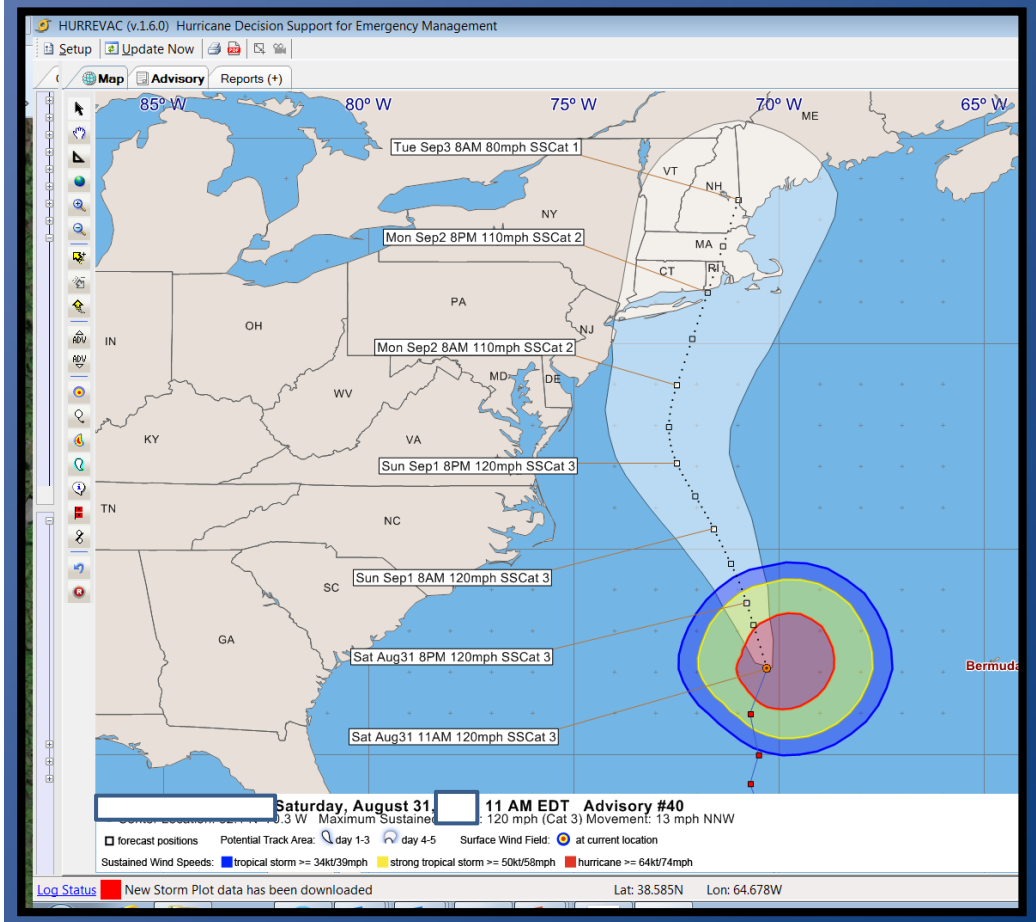
- **Hazards Analysis**
- **Vulnerability Analysis**
- **Behavioral Surveys**
- **Shelter Analysis**
- **Transportation Analysis**




Analysis: Hazard Vulnerability Behavioral Shelter Transportation

Products: Surge Maps Evacuation Zones Planning Data Clearance times

# Hurricane Scenario




**Advisory 40**

**Issued at 11AM**

**Saturday August 31st**

**Cat 3**

**Moving 13mph**

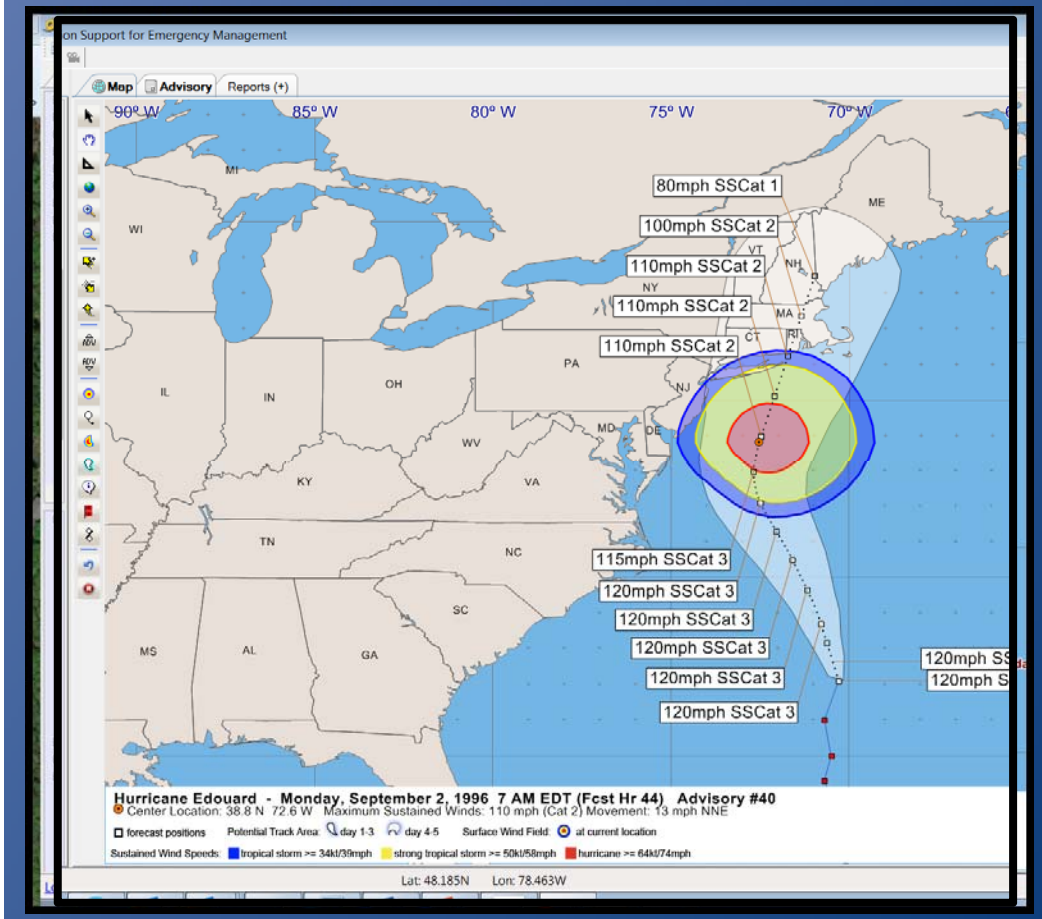
**Center located off the coast of GA/SC**

**Assume an 17 hour CT (worst case)**

**Ex. Stamford**

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

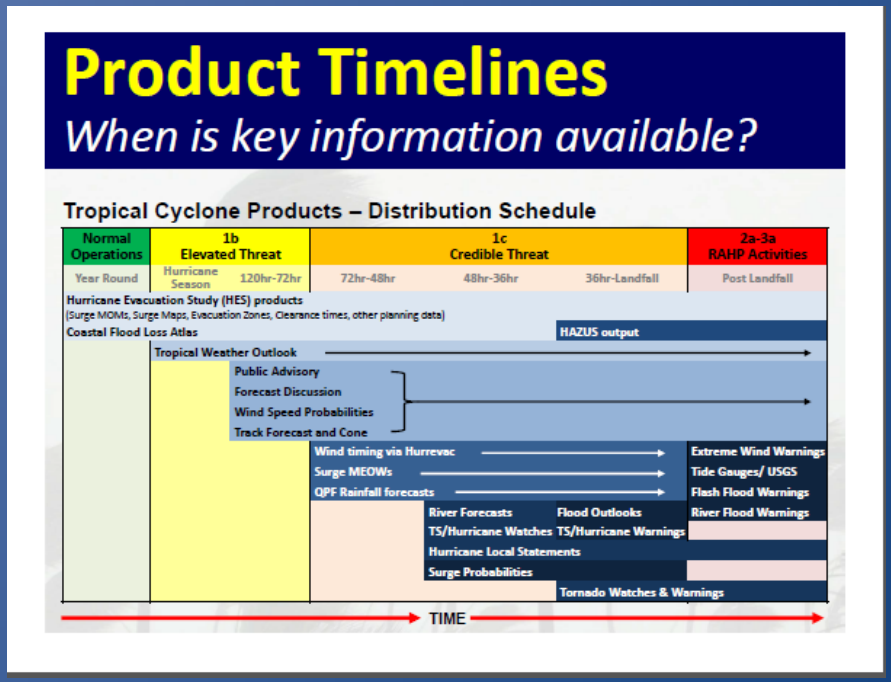
# This was Hurricane Edouard 1996

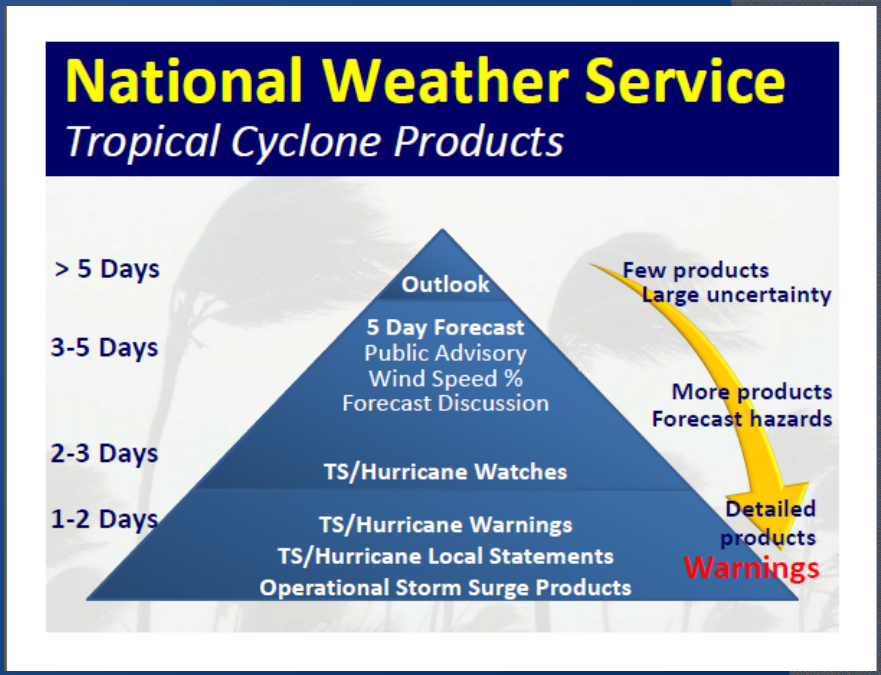



**In this scenario, given a 17 hour Clearance Time, evacuations would have to begin Sunday PM in order to be complete before the onset of TS force winds.**

**This would leave 27 hours from the issuance of this advisory to make an evacuation decision, notify the public, and mobilize response assets.**

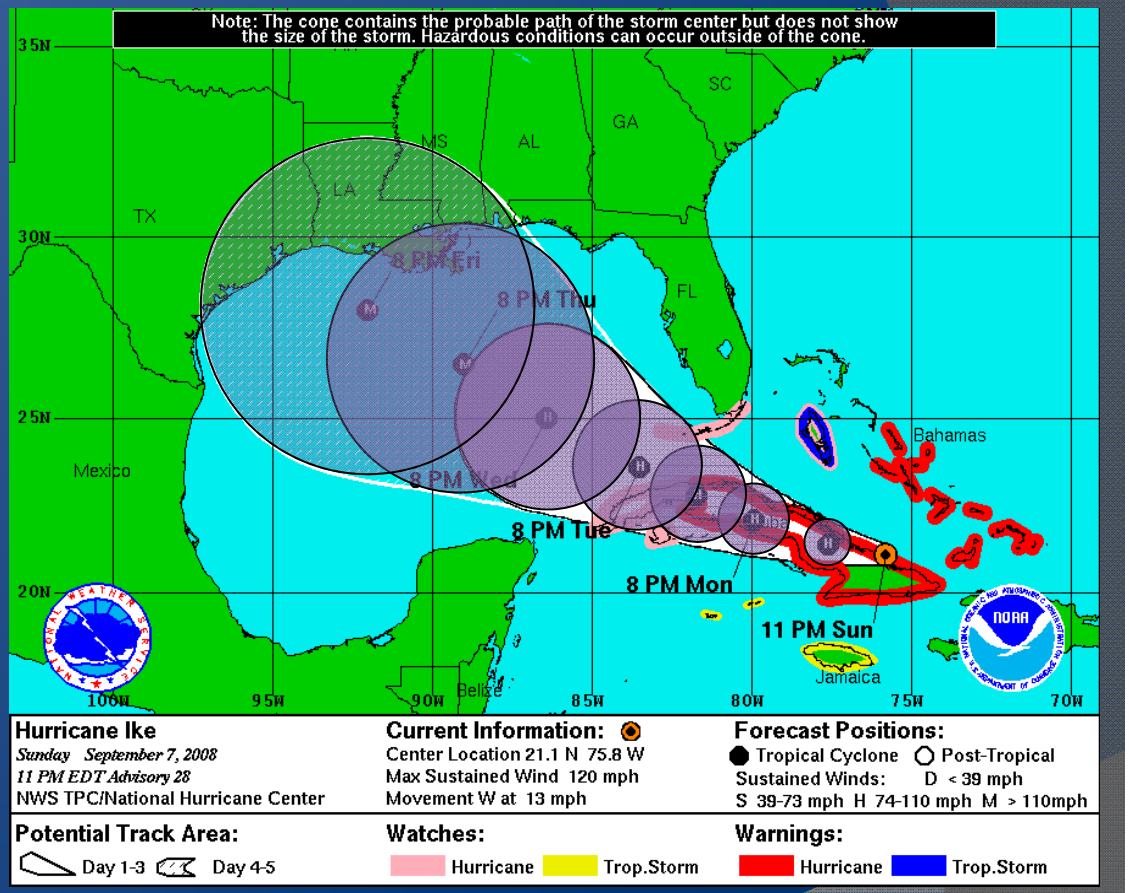
# Key forecast products, clearance times and local planning factors guide Evacuation Decision Making and other Response Actions



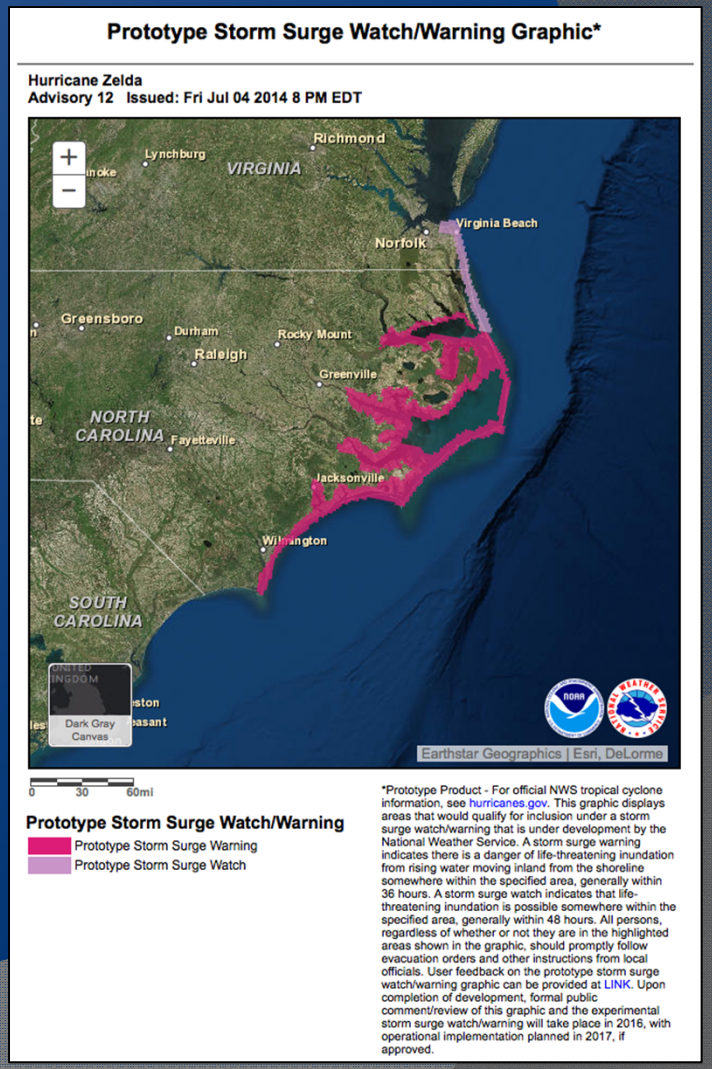
# NHC Forecast Cone

- Represents the probable track of the *center* of the tropical cyclone
- Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- Size of the circles determined so that, say, the actual storm position at 48 h will be within the 48-h circle 67% of the time

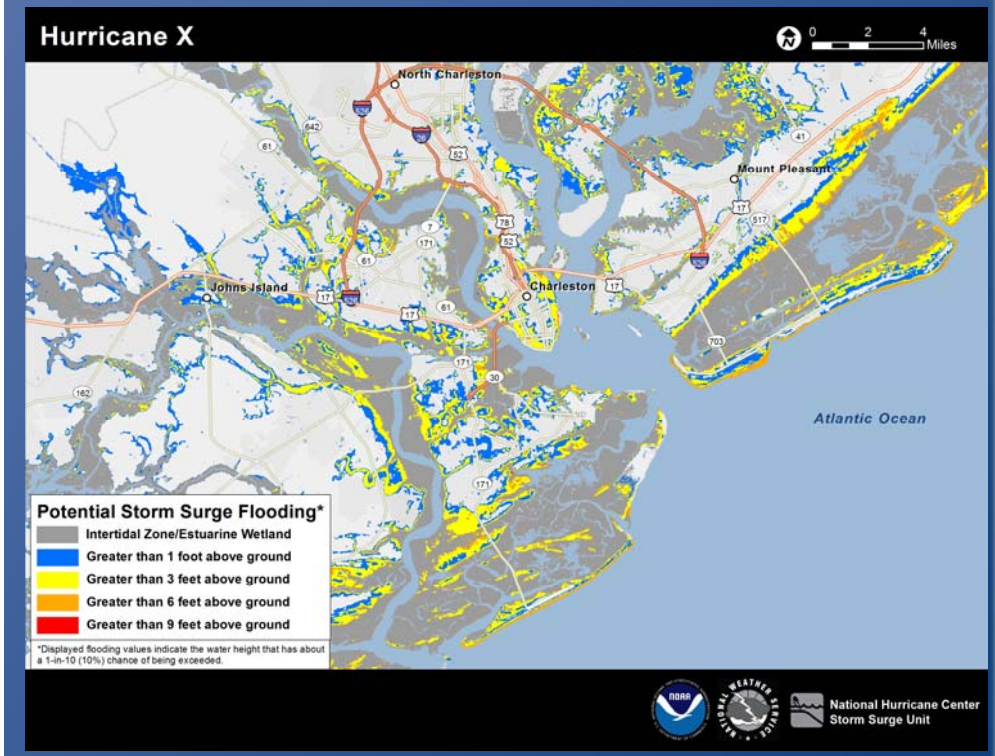


# Prototype Storm Surge Watch/Warning Graphic

- Intended for general public to enhance the response to instructions from local officials.
- Highlights areas that have a significant risk of life-threatening inundation by storm surge.
- Introduces the concept of a storm surge watch/warning.
- Issued 48 hours before the arrival of life-threatening surge (or other hazards that would impede evacuation).
- Issued in collaboration with local NWS Offices.



# Potential Storm Surge Flooding Map




Factors the map takes into account:

» Flooding due to storm surge from the ocean, including adjoining tidal rivers, sounds, and bays
» Tides
» Land elevation
» Uncertainties in the track, landfall location, intensity, and size of the cyclone

Factors the map does not take into account:
» Wave action
» Freshwater flooding from rainfall
» Flooding inside levees and overtopping

# Questions?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