

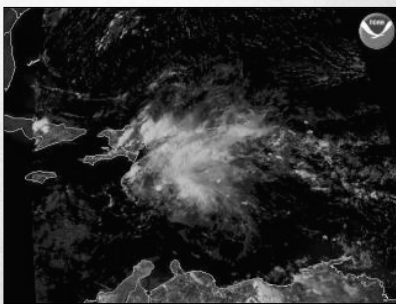
**Coastal Resiliency:
Planning for Natural
Variability and Recovering
from Extreme Events**

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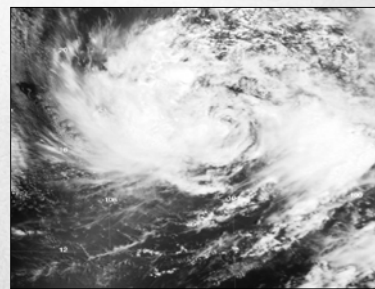
Coastal Hazards

- Major Coastal Hazards
 - Hurricanes
 - Storm Surge
 - Flash Flooding
 - Tornadoes
- Other Potential Hazards
 - Shoreline Erosion
 - Sea Level Rise
 - Chronic Pollution

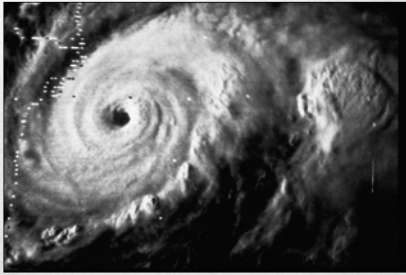
Tropical Depression



Tropical Storm



Hurricane



Saffir-Simpson Scale

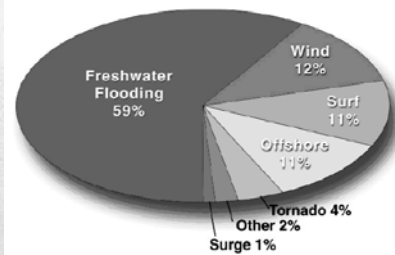
- Category 1 (Sustained winds 74-95 MPH)
 - Minimal damage primarily to trees and foliage
- Category 2 (Sustained winds 96-110 MPH)
 - Moderate damage
- Category 3 (Sustained winds 111-130 MPH)
 - Extensive damage
- Category 4 (Sustained winds 131-155 MPH)
 - Extreme damage
- Category 5 (Sustained winds over 155 MPH)
 - Catastrophic damage

How Hurricanes Form

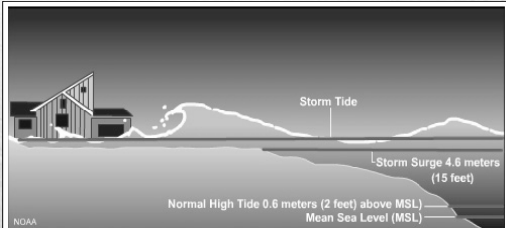
- A disturbance gathers heat and energy through contact with warm ocean waters.
- Moisture evaporating from sea surface powers storm like a giant heat engine.
- Seedling storm forms a wind pattern near the ocean surface that spirals air inward.

Leading Causes of Death

Leading Causes of Tropical Cyclone Deaths in the U.S. 1970-1999



Storm Surge

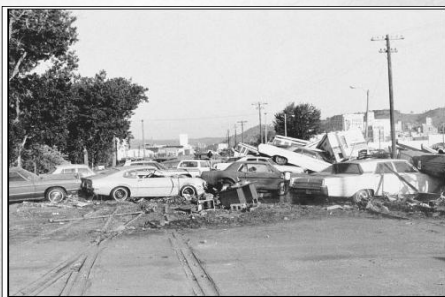


Storm surge is a large dome of water, often 50 to 100 miles wide, that sweeps across the coastline where a hurricane makes landfall. The storm tide is the combination of the storm surge and the astronomical tide.

Flooding

- Hurricanes and tropical storms can cause significant inland flooding.
- According to the National Hurricane Center, 50% of deaths associated with tropical cyclones over the last 30 years are a result of inland flooding.

Flash Floods

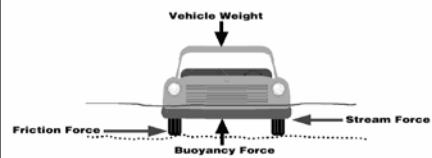


Primary Concern

Forces on Vehicles Crossing Streams

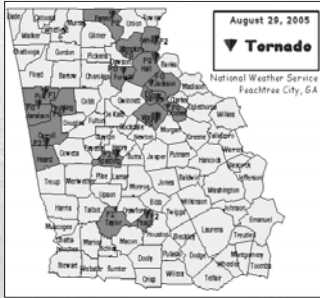
The car will float downstream when:

$$\text{Stream Force} > \text{Friction Force}$$



Source: Steve Waters—Senior Hydrologist, Maricopa County Arizona Flood Control District

Tornadoes



Hurricane Katrina spawned at least 18 tornadoes in Georgia.

Hazard or Disaster?

- Hurricanes, floods, earthquakes, and similar events are part of nature.
- A disaster only occurs when a natural hazard event collides with the human environment.

What is Vulnerable in a Disaster?

- Key Infrastructure
 - Transportation Routes
 - Telecommunication Systems
 - Food and Water Supplies
 - Power Grid

What else is Vulnerable?

- Community Networks
 - Neighborhood Associations
 - Schools
 - Businesses
 - Church groups

Traditional Approach



Alternative Approach



Photo Credit: Carole Y. Swinehart, Michigan Sea Grant Extension

Resilience

“An ability to recover from or adjust easily to misfortune or change.”

Merriam-Webster's Online Dictionary

“Measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between population or state variables.”

C.S. Holling, Resilience and Stability of Ecological Systems, *Annual Review of Ecology and Systematics*. (1973).

Example - Forests



Johnson wildfire in an aspen grove on the Fishlake National Forest in southern Utah.



The area burned by the Johnson wildfire, a year after the fire (2005), Fishlake National Forest, Utah.



Aspen sprouting in an area in the Johnson wildfire, two years after the fire (2006), Fishlake National Forest, Utah.

Photo Credits: B. Campbell, U.S. FWS.

Social-Ecological Resiliency

“Capacity of linked social-ecological systems to absorb recurrent disturbances such as hurricanes or floods so as to retain essential structures, processes, and feedbacks.”

Can be measured by:

- Degree to which system is capable of self-organization (versus lack of organization or organization forced by external factors) and
- Degree to which the system can build capacity for learning and adaptation.

Adger, et. al, Social-Ecological Resilience to Coastal Disasters, *Science* (2005).

Hurricane Katrina



Bay St. Louis, Mississippi post-Katrina
Photo Credit: NOAA

New Orleans



Resilient Cities

- New development would be guided away from high hazard areas and vulnerable existing development relocated.
- Buildings would be constructed or retrofitted to meet code standards.
- Natural environment would be conserved.
- Organizations would be prepared, linked with effective communication networks, and have experience working together.

David R. Godschalk, *Urban Hazard Mitigation: Creating Resilient Cities*, *Natural Hazards Review*, Vol 4., No. 3, pp. 136 - 143 (2003).

Berkeley, California



Loma Prieta, California, Earthquake October 17, 1989. San Francisco. Photo Credit: USGS

Latimer Hall, University of California at Berkeley after seismic retrofit.



Tulsa, Oklahoma



Characteristics of Resilient Systems

- Redundant
- Diverse
- Efficient
- Autonomous
- Strong
- Interdependent
- Adaptable
- Collaborative

Resiliency & Hurricanes

- Before the Hurricane Season
 - Determine safe evacuation routes
 - Make emergency plans for pets
 - Learn location of shelters
- Know difference between watch and warning

Retrofit Your Home

- Protect and Reinforce:
 - Windows and Doors
 - Install impact-resistant shutters
 - Use laminated window systems
 - Install metal doors
 - Roof and Walls
 - Brace gabled roofs
 - Garage Door(s)
- At a minimum, abide by all local building codes.

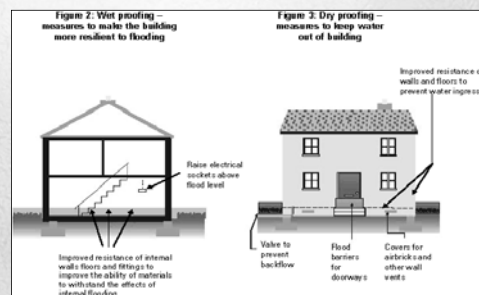
Resiliency & Floods

- Determine your risk!
 - Know your proximity to streams
 - Know the type of soil in the area
 - Clay soils increase risk because they absorb less water.
 - Know your flood elevation
 - FEMA's Flood Hazard maps at <http://www.fema.gov/mit/tsd> .

Take Action

- Before
 - Know your risk
 - Purchase flood insurance
 - Develop an evacuation plan with alternate routes.
- During
 - If advised to do so, evacuate immediately
 - Do not attempt to drive through a flooding road.
 - Stay out of flood waters. Moving swiftly, even 6 inches of water can knock you off your feet.

Reduce your Future Risk



Resiliency & TORNADOS

- Consider constructing a tornado safe room in or adjacent to your home.
- Have a plan of where to go during a tornado threat—a nearby pre-identified safe structure within walking distance.

Cautionary Note



Banda Aceh, Indonesia.
Photo Credit: Chris Rainier, National Geographic

Additional Resources

- C.S. Holling, Resilience and Stability of Ecological Systems, Annual Review of Ecology and Systematics, Vol. 4 (1973).
<http://forest.mtu.edu/info/ecologyseries/Hollings%201973%20resilience.pdf>
- Robert Strauss, After Forest Fires, Resiliency and Growth, New York Times, May 27, 2007.
<http://www.nytimes.com/2007/05/27/nyregion/nyregionspecial2/27mainj.html>
- Flooding History, City of Tulsa, Oklahoma,
<http://www.cityoftulsa.org/CityServices/FloodControl/History.asp>
- Adger, et. al. Social-Ecological Resilience to Coastal Disasters, Science, Vol. 309 (2005), pp. 1036-1039.
<http://www.sciencemag.org/cgi/content/full/309/5737/1036>
- Storm Surge Student Activity and Teacher Resource,
<http://www.climate.noaa.gov/education/hurricanes/stormsurge.pdf>

Websites

- <http://www.nhc.noaa.gov>
- <http://www.floodsmart.gov>
- <http://www.redcross.org>
- <http://www.fema.gov/hfip>
- <http://www.nws.noaa.gov/nwr/>
- <http://www.fhway.dot.gov/trafficinfo/index/htm>
- Bathymetric Maps are available at
<http://www.ngdc.noaa.gov/mgg/coastal/coastal.html>
- Topographic Maps are available at
<http://store.usgs.gov/>

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