AWR-362
Flooding Hazards: Science and Preparedness

Participant Guide

Version 1.0

FEMA

NATIONAL DISASTER PREPAREDNESS TRAINING CENTER

Copyright Information

Flooding Hazards: Science and Preparedness

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FEMA's National Training and Education Division (NTED) offers a full catalog of courses at no-cost to help build critical skills that responders need to function effectively in mass consequence events. Course subjects range from Weapons of Mass Destruction (WMD) terrorism, cybersecurity, and agro-terrorism to citizen preparedness and public works. NTED courses include multiple delivery methods: instructor led (direct deliveries), train-the-trainers (indirect deliveries), customized (conferences and seminars) and web-based. Instructor-led courses are offered in residence (i.e. at a training facility) or through mobile programs in which courses are brought to state and local jurisdictions that request the training. A full list of NTED courses can be found at http://www.firstrespondertraining.gov.

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Flooding Hazards: Science and Preparedness

Module 1: Welcome, Introduction, and Administration

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FEMA

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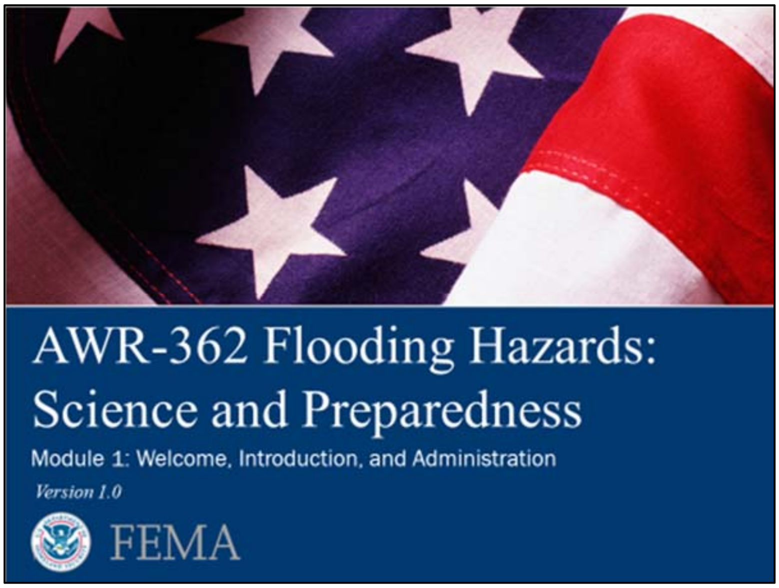
Module 1: Welcome, Introduction, and Administration – Administration Page



Slide 1-1. Welcome, Introduction, and Administration

Duration

50 minutes

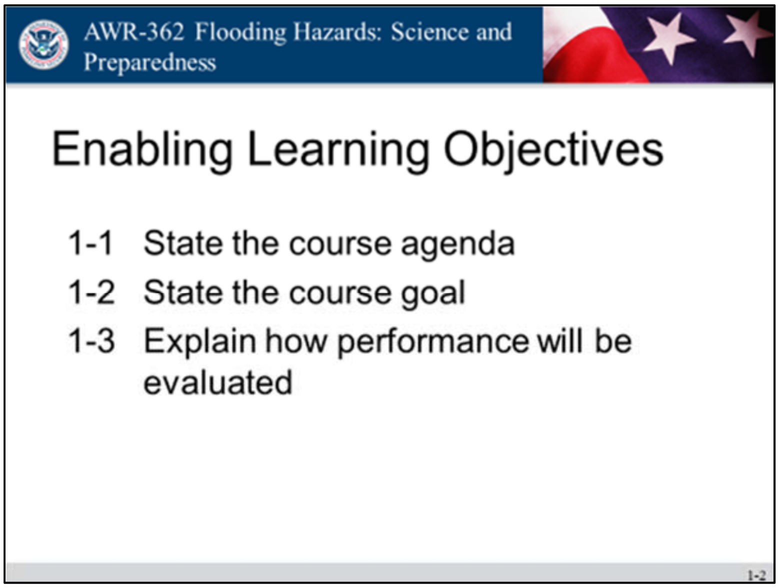
Scope Statement

In this module, the instructor will welcome participants to the course, explain how instruction will take place, and provide an agenda. The instructor will discuss the course purpose, goals, and objectives; describe the course content; and wrap up any administrative details that remain. The instructor will introduce him- or herself and lead a round of introductions among the participants. Finally, the instructor will assess the participants' existing comprehension of course materials by conducting a pre-test.

Terminal Learning Objective (TLO)

Participants will be able to state the course goals and its major objectives.

Enabling Learning Objectives (ELO)



Slide 1-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

1-1 State the course agenda;
1-2 State the course goal; and
1-3 Explain how performance will be evaluated.

Resources

- Instructor ID
- Instructor Guide (IG)
- Module 1 presentation slides
- Class roster
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- Correction tape dispensers (two)
- Letter-size manila envelopes (four: one each for the course registration forms, pre-tests, post-tests, and Level 1 evaluations)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handouts

- Pre-test answer sheet corresponding to pre-test version
- Post-test answer sheet corresponding to post-test version
- Level 1 evaluation forms (with extras as needed)

Instructor to Participant Ratio

2:40

Reference List

Not Applicable

Practical Exercise Statement

Not Applicable

Assessment Strategy

- Instructor observation of participant involvement in classroom discussion
- Instructor-led discussion to gauge participant grasp of the subject matter and to ensure participants understand both how performance will be evaluated and how evaluation will impact participant outcomes
- Instructor administration of objectives-based pre-test to assess the knowledge and experience participants bring to the class

Flooding Hazards: Science and Preparedness

Icon Map

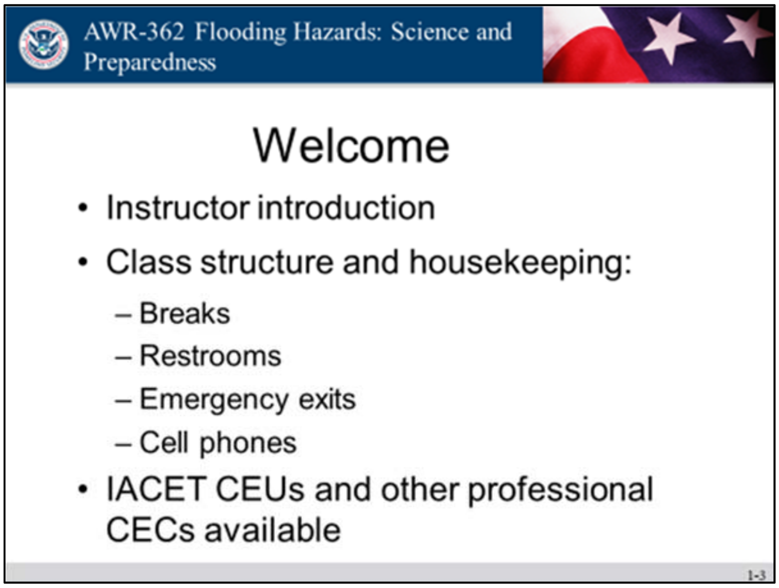
Knowledge Check: Used when it is time to assess participant understanding.

Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:

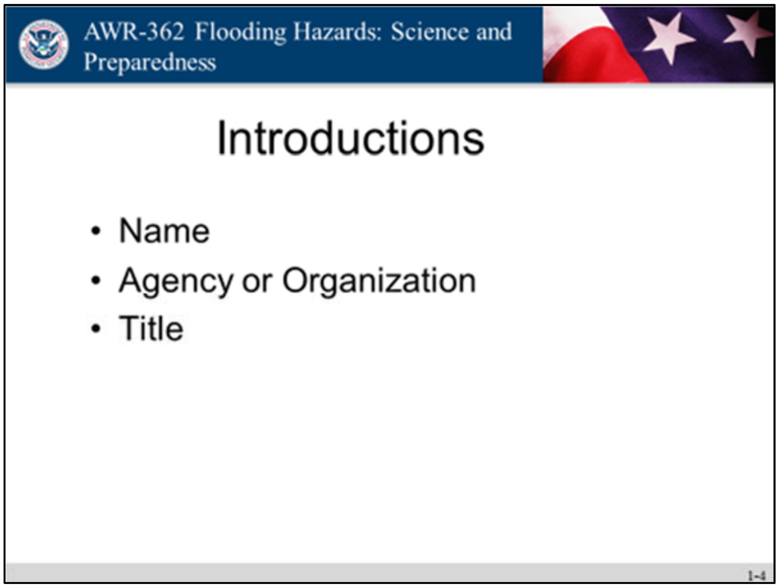


Slide 1-3. Welcome

The lead instructor will begin by welcoming participants and introducing the instructional team. The instructor will then review classroom protocols and standard classroom policies, such as breaks, restroom facilities, emergency exits, cell phone and Internet use.

Key Point: The National Disaster Preparedness Training Center (NDPTC) mission is as follows: Uniquely positioned geographically and culturally, the NDPTC works collaboratively to develop and deliver training and education in the areas of disaster preparedness, response, and recovery to governmental, private, tribal, and non-profit entities, and under-represented/under-served communities. It incorporates urban planning and environmental management, emphasizing community preparedness and addressing the needs of vulnerable at-risk populations.

Participant Notes:



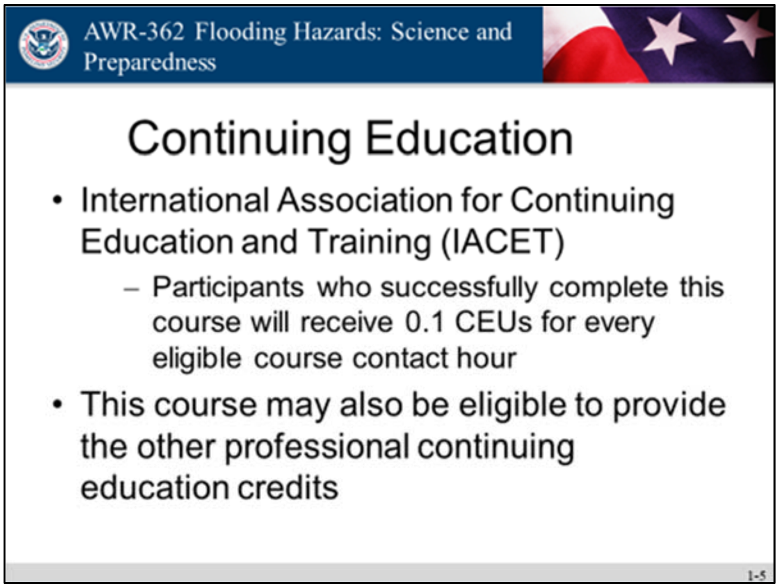
Slide 1-4. Introductions

The instructor will lead a round of participant self-introductions. Participants are asked to provide information designed to help the instructor learn names and understand the participants' backgrounds and motivations, including:

- Name;
- Organization or agency;
- Experience with disasters and leadership;
- Reasons for taking this course; and
- Expectations for the course.

Participants are encouraged to take an active role in the class discussions and group activities to demonstrate comprehension. Participant Guides are provided for participants to follow along with the course and to take any notes as needed.

Participant Notes:



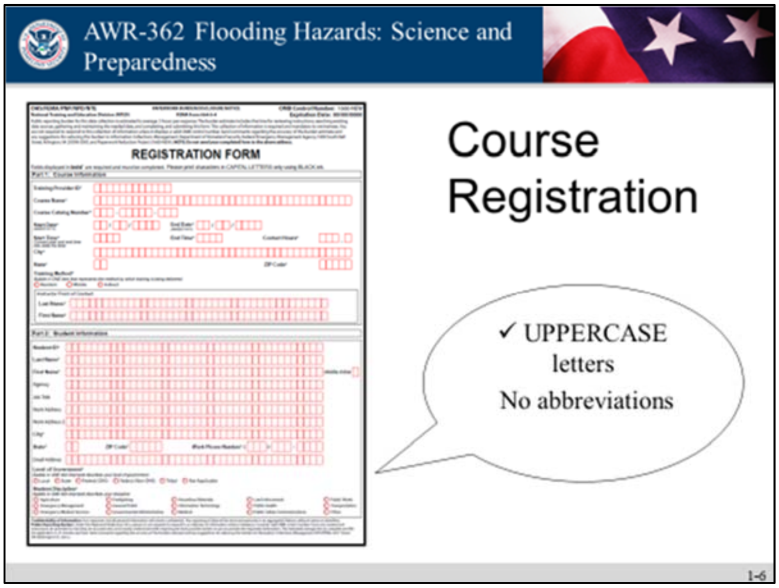
Slide 1-5. Continuing Education

This course may also be eligible to provide the following professional continuing education credits:

1. International Association of Emergency Managers (IAEM) – Training hours
2. Association of State Floodplain Managers (ASFPM) – Continuing Education Credits (CEC)
3. American Planning Association (APA) – Certification Maintenance (CM)
4. American Institute of Architects (AIA) – Continuing Education System (CES) Learning Units (LU)

Eligibility to receive credits from the designated professional organizations is dependent on the specific membership and/or qualification requirements as enforced by each individual organization. Submission processes enforced by each organization should be followed to successfully receive credits. For more information, visit the NDPTC website or contact NDPTC at 808-725-5220/ ndptc-training@lists.hawaii.edu.

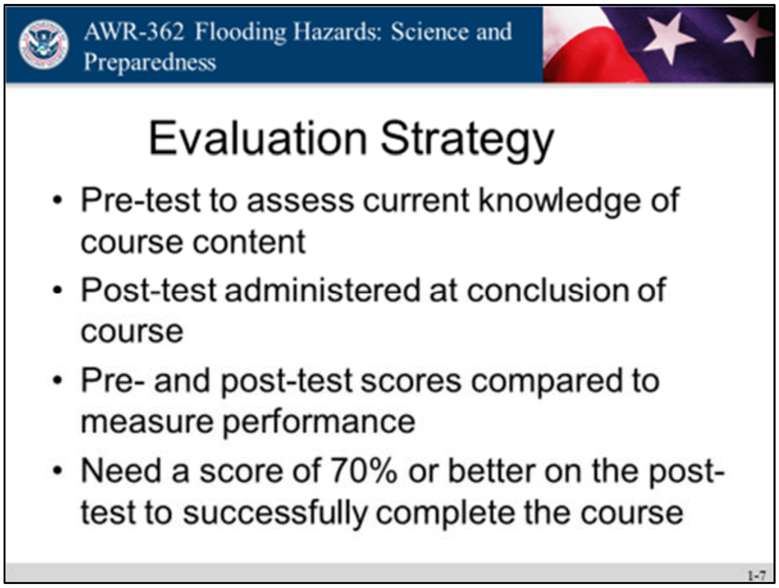
Participant Notes:



Slide 1-6. Course Registration

The instructor will distribute the course registration forms for those participants who have not already completed the online registration. The instructor will then collect the registration forms.

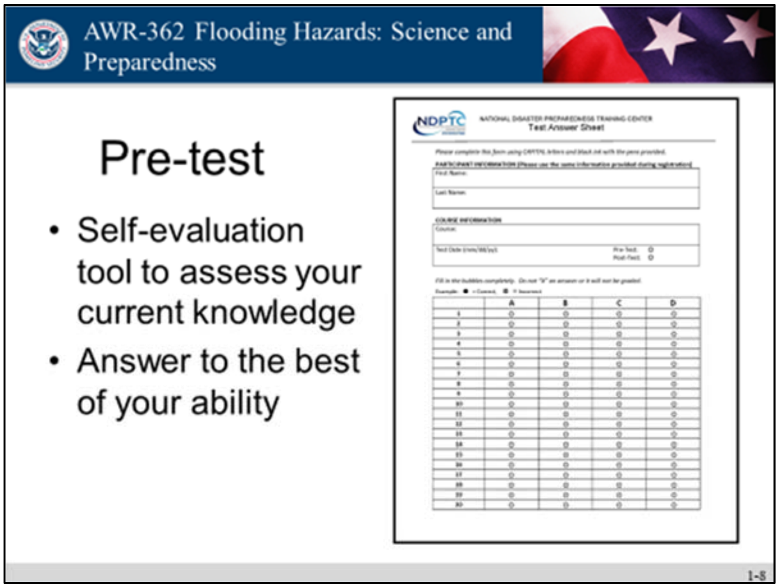
Participant Notes:



Slide 1-7. Evaluation Strategy

The evaluation strategy for this course follows FEMA's Responder Training Development Center (RTDC) guidance and uses resources, templates, and best practices that provide for instructional development and evaluation. Participants will be given two tests – a pre-test administered next, and a post-test at the end of the course. Each test includes one or more items designed to assess mastery of the module enabling learning objectives. Successful performance on the post-test (i.e., scoring 70 percent or better) will be recognized by issuance of a Certificate of Achievement. During the course, knowledge checks will offer participants an opportunity to reinforce new knowledge and get corrective feedback prior to the post-test.

Participant Notes:



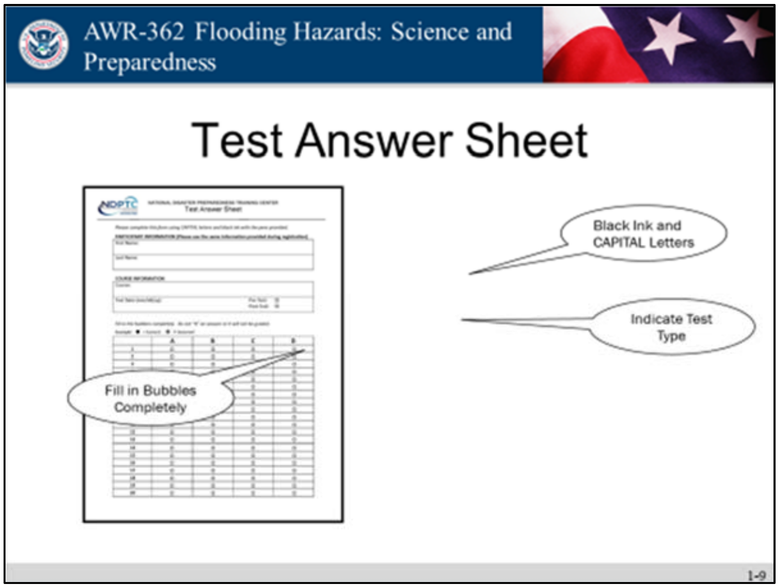
Slide 1-8. Pre-test

The instructor will inform the participants that, working independently, they will have 10 minutes to complete the pre-test.

Participants should follow these instructions as they take the pre-test and indicate their answers on the test answer sheet:

- Write legibly using uppercase letters.
- Use the same first name, last name, and date of birth provided on the participant registration form. This information is used to generate a unique participant identification number.
- Complete the Test Date field in the upper right-hand portion of the sheet by writing the day the test is actually administered.
- Write the test document ID number in the Test Doc ID field. The ID number is located in the test handout footer.
    - o The instructor should confirm that all participants are using the same test version.
- Fill-in the Pre-test answer bubble.
- Completely fill-in each bubble making certain the darkened bubble is correctly aligned to the selected answer letter on the test answer sheet.

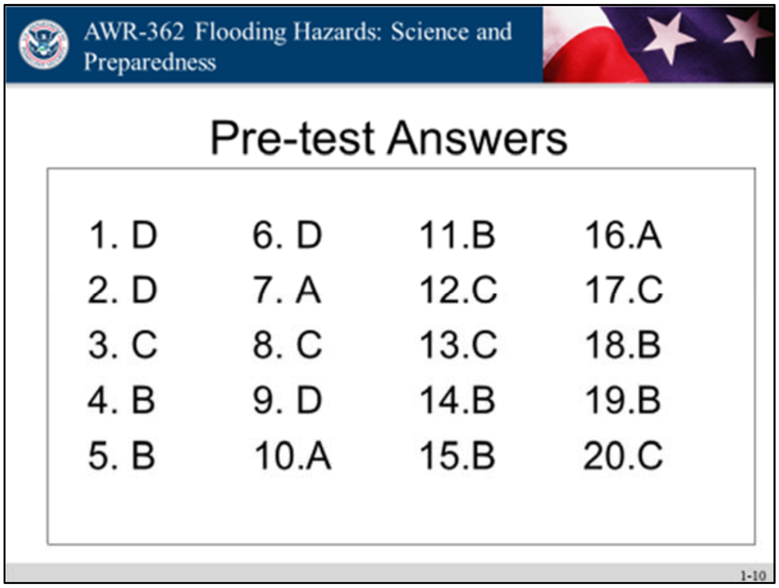
Participant Notes:



Slide 1-9. Test Answer Sheet

Participants will grade their own tests, taking care not to make grading marks in answer columns A through D. Participants may write the correct answer in the margins of the test answer sheet. On a separate piece of paper, participants may also write down test scores for personal reference, and take any notes as needed.

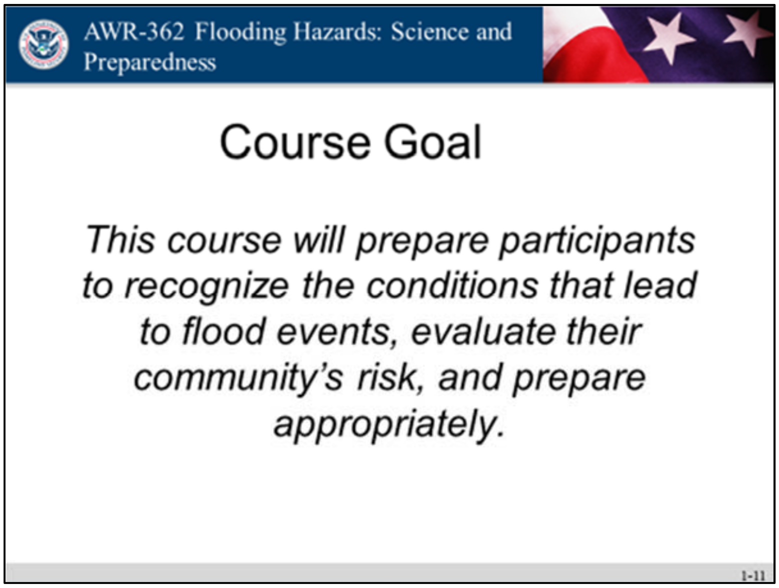
Participant Notes:



Slide 1-10. Pre-test Answers

Participants are encouraged to write down their pre-test score on the upper-right corner of the answer sheet. Instructors will come around and collect all testing materials.

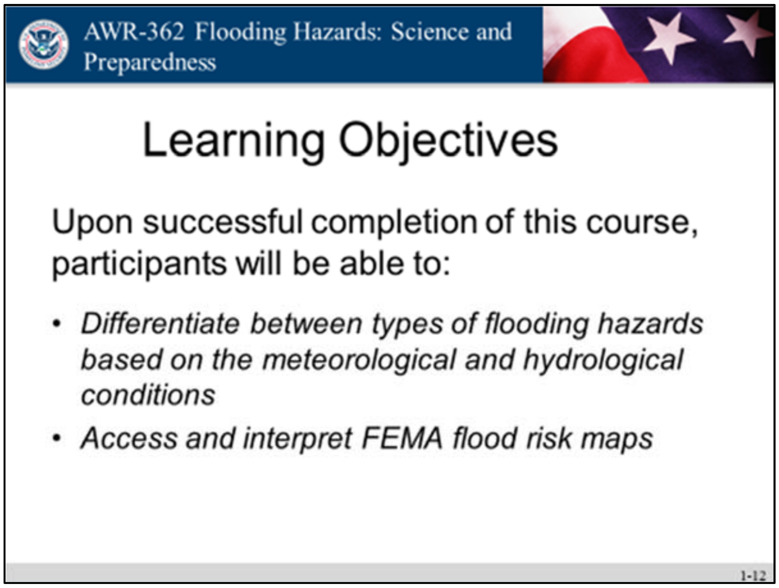
Participant Notes:



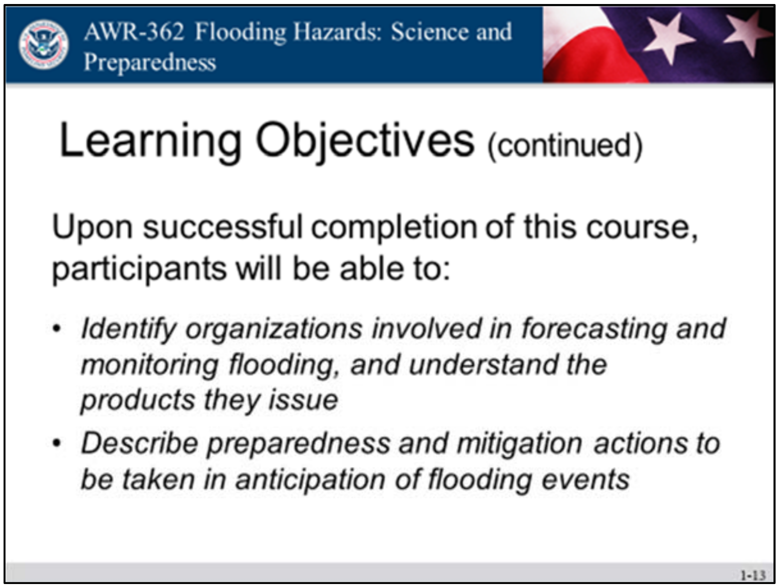
Slide 1-11. Course Goal

Upon successful completion of this course, participants will be prepared to recognize the conditions that lead to flood events, evaluate their community's risk, and prepare appropriately.

Participant Notes:



Slide 1-12. Learning Objectives



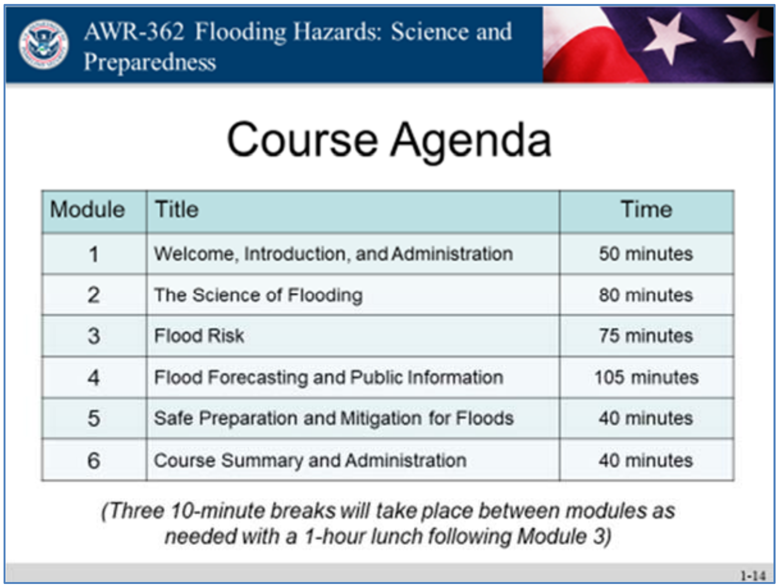
Slide 1-13. Learning Objectives (continued)

Participant Notes:

The learning objectives of this course are to teach participants to:

- Differentiate between types of flooding hazards based on the meteorological and hydrological conditions;
- Access and interpret FEMA flood risk maps;
- Identify organizations involved in forecasting and monitoring flooding, and understand the products they issue; and
- Describe preparedness and mitigation actions to be taken in anticipation of flooding events.

Participant Notes:



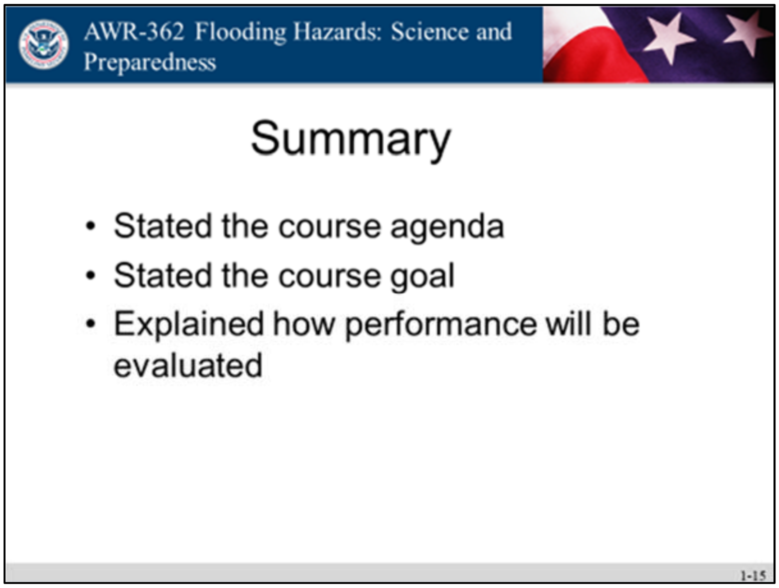
Slide 1-14. Course Agenda

To achieve the learning objectives, the course will be broken down into four modules of content, plus a module each for administration at the beginning and end:

1. Welcome, Introduction, and Administration;
2. The Science of Flooding;
3. Flood Risk;
4. Flood Forecasting and Public Information;
5. Safe Preparation and Mitigation for Floods; and
6. Course Summary and Administration.

One hour will be given for lunch and three 10-minute breaks will be taken as necessary.

Participant Notes:



Slide 1-15. Summary

This module welcomed participants to the course and outlined its goal, content, and evaluation strategy. Participants were apprised of the class schedule and introduced to module topics to be covered in the rest of the course.

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Module 2: The Science of Flooding

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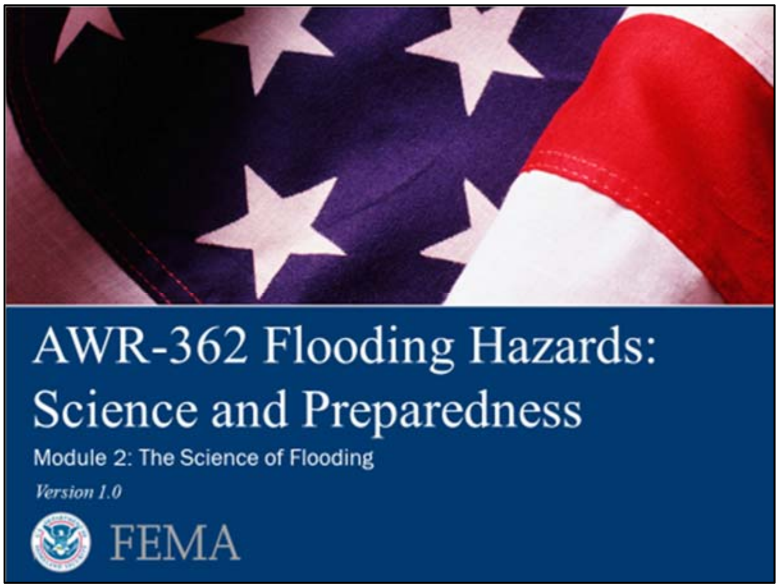
Module 2: The Science of Flooding – Administration Page



Slide 2-1. The Science of Flooding

Duration

80 minutes

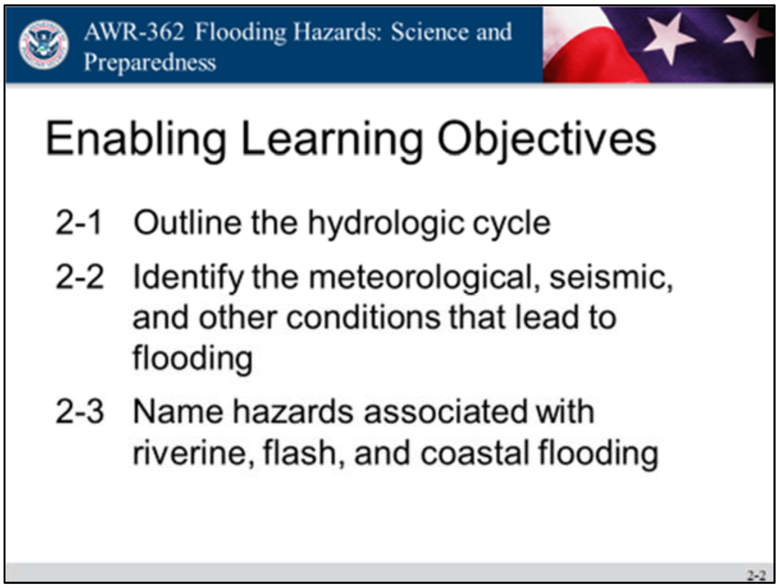
Scope Statement

This module begins with a brief discussion of the statistics that describe flooding across the United States. The instructor will use this discussion of climatology to emphasize the widespread and frequent threat that flooding poses. Three major categories of flood events will be described: riverine flooding, flash flooding, and coastal flooding. The overview of each type of flooding will include definition of terms, timeframe, potential causes, and specific hazards. A description of the hydrological cycle will highlight the connectedness of watersheds and remote sources of floodwaters.

Terminal Learning Objective (TLO)

Participants will be able to differentiate between different types of flooding hazards based on the meteorological and hydrological conditions.

Enabling Learning Objectives (ELO)



Slide 2-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

2-1 Outline the hydrologic cycle;
2-2 Identify the meteorological, seismic, and other conditions that lead to flooding; and
2-3 Name hazards associated with riverine, flash, and coastal flooding.

Resources

- Instructor Guide (IG)
- Module 2 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handout

Instructor to Participant Ratio

2:40

Reference List

American Meteorological Society. 2017. "Flood." Glossary of Meteorology. Retrieved 2017. http://glossary.ametsoc.org/?p=1&query=Flood

Brackenridge, G.R. 2011. "Global Active Archive of Large Flood Events." http://floodobservatory.colorado.edu/Archives/index.html

CIMMS. 2015. "Flooding Rains in Southern California." http://cimss.ssec.wisc.edu/goes/blog/archives/18971

Environmental Protection Agency (EPA). 2016. "Climate Change Indicators in the United States." https://www.epa.gov/climate-indicators

Federal Emergency Management Agency (FEMA). 2007. "Floodplain Management: Principles and Current Practices." https://training.fema.gov/hiedu/docs/fmc/chapter%202%20-%20types%20of%20floods%20and%20floodplains.pdf

FEMA. 2012. "Isaac's Storm Surge on Lake Pontchartrain." https://www.fema.gov/media-library/assets/images/65463

National Aeronautics and Space Administration (NASA). 2009. "A Tour of the Water Cycle." https://pmm.nasa.gov/education/videos/tour-water-cycle

National Oceanic and Atmospheric Administration (NOAA). 2010. "Isolated Severe Weather and an MCS in the Rio Grande Valley and Deep South Texas May 18, 2010." https://www.weather.gov/crp/may18mcs

NOAA. 2015. "Coastal Flooding in California." https://oceanservice.noaa.gov/news/dec15/california-flooding.html

NOAA. 2017. "2016 Annual Weather Highlights Severe Weather." Retrieved 2017. https://www.weather.gov/abq/climonhigh2016annual-severweather

NOAA. 2017. "Atmospheric River Information Page." Retrieved 2017. https://www.esrl.noaa.gov/psd/atmrivers/

NOAA. 2017. "Basic Weather Education." Retrieved 2017. https://www.weather.gov/crp/weather_education

NOAA. 2017. "Flood." NWS Glossary. Retrieved 2017. http://w1.weather.gov/glossary/index.php?word=flood

NOAA. 2017. "Flood Products -- What Do They Mean?" Retrieved 2017. https://www.weather.gov/bmx/outreach_flw

NOAA. 2017. "Ice Jams and Flooding." Retrieved 2017. http://www.weather.gov/media/dmx/Hydro/DMX_InfoSht_IceJamsAndFlooding.pdf

NOAA. 2017. "JetStream – An Online School For Weather." Retrieved 2017. http://www.srh.noaa.gov/jetstream/

NOAA. 2017. "National Tsunami Hazard Mitigation Program." Retrieved 2017. http://nws.weather.gov/nthmp/about_program.html

NOAA. 2017. "Natural Hazards Statistics." Retrieved 2017. http://www.nws.noaa.gov/om/hazstats.shtml

NOAA. 2017. "Severe Weather 101." Retrieved 2017. http://www.nssl.noaa.gov/education/svrwx101/

NOAA. 2017. "Storm Surge Overview." Retrieved 2017. http://www.nhc.noaa.gov/surge/

NOAA. 2017. "Tropical Cyclone Climatology." Retrieved 2017. http://www.nhc.noaa.gov/climo/

Reference List (continued)

NOAA. 2017. "Tsunami Strike Japan. Part 1: Destruction." Retrieved 2017. https://oceantoday.noaa.gov/tsunamistrikedestruction/

NOAA. 2017. "What are Tides." Retrieved 2017. https://oceanservice.noaa.gov/facts/tides.html

NOAA. 2017. "What is a Tsunami?" Retrieved 2017. https://oceanservice.noaa.gov/facts/tsunami.html

Tucson DOT. 2017. "5 feet of water in less than 2 minutes." https://twitter.com/Tucson_DOT/status/887066272210407425

University Corporation for Atmospheric Research (UCAR). 2006. "Clouds, Precipitation, & Water Vapor." http://www.meted.ucar.edu/npoess/microwave_topics/clouds_precip_water_vapor/index.htm

UCAR. 2011. "Introduction to Tropical Meteorology." http://www.goes-r.gov/users/comet/tropical/textbook_2nd_edition/index.htm

UCAR. 2015. "Introduction to Tropical Storm Surge." https://www.meted.ucar.edu/tropical/storm_surge/intro_surge/index.htm

U.S. Army. 2004. "Ice Jam Database." http://icejams.crrel.usace.army.mil/icejam/ijdatabase.html

U.S. Geological Survey (USGS) 2016. "Some Perspectives on Climate and Floods in the Southwestern U.S." https://geochange.er.usgs.gov/sw/changes/natural/floods/

U.S. Global Change Research Program. "National Climate Assessment." http://nca2014.globalchange.gov/

Practical Exercise Statement

Not Applicable

Assessment Strategy

- Instructor observation of participant involvement in classroom discussion
- Instructor-led discussion to gauge participant grasp of the subject matter

Flooding Hazards: Science and Preparedness

Icon Map

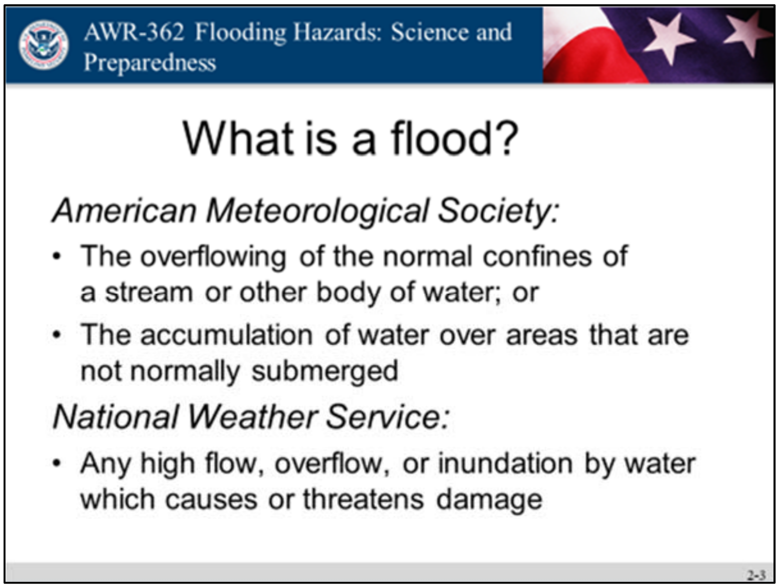
Knowledge Check: Used when it is time to assess participant understanding.

Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:



Slide 2-3. What is a flood?

While many weather events have specific criteria (for example a blizzard is defined as a snow event with visibilities less than one-fourth mile and winds greater than 35 mph for three hours; while hurricanes require sustained winds of 74 mph or higher, etc.), there is no set number that can be used in classifying an event as a “flood.” Various types of meteorological and non-meteorological causes to flooding exist.

If heavy rain hits a small part of a city and a few homes experience water in the basement – is that a flood? If upstream rainfall turns a river in the middle of a forest into a raging torrent, but the only damage is to some trees, is that a flood? Does there need to be an exact definition?

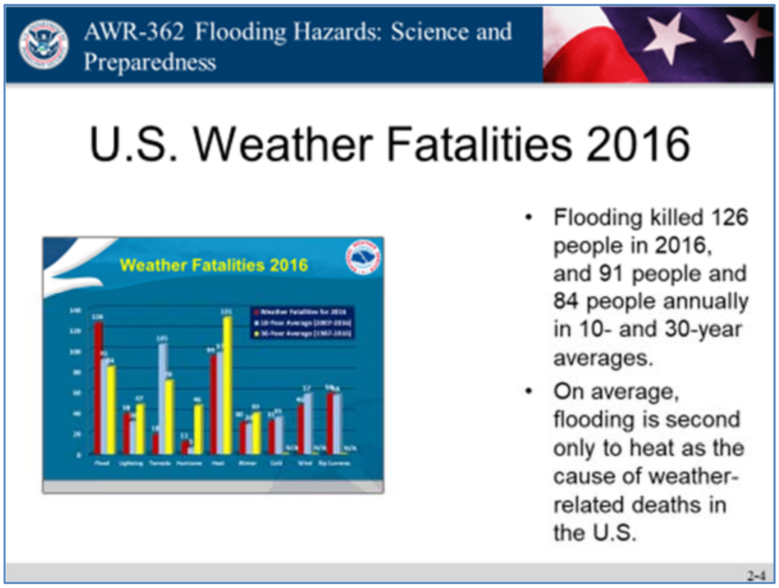
On the other hand, meteorology is a science. As such we need to have formal definitions established to enable discussions on the topic. The American Meteorological Society defines a flood as an event that causes the normal flow of water to exceed its banks, or simply when water accumulates in areas that are normally dry.

The National Weather Service considers water that causes (or just threatens) damage to be a flood event.

Participant Notes:

Key Point: One event can be considered a flood by some in the community and nothing more than a nuisance by others. Unlike other weather events, the fluid definitions should not impact response. However, as we will see in later modules, the struggle between the meteorological definitions of different flood types and the societal response can cause communication issues when explaining events to the public.

Participant Notes:



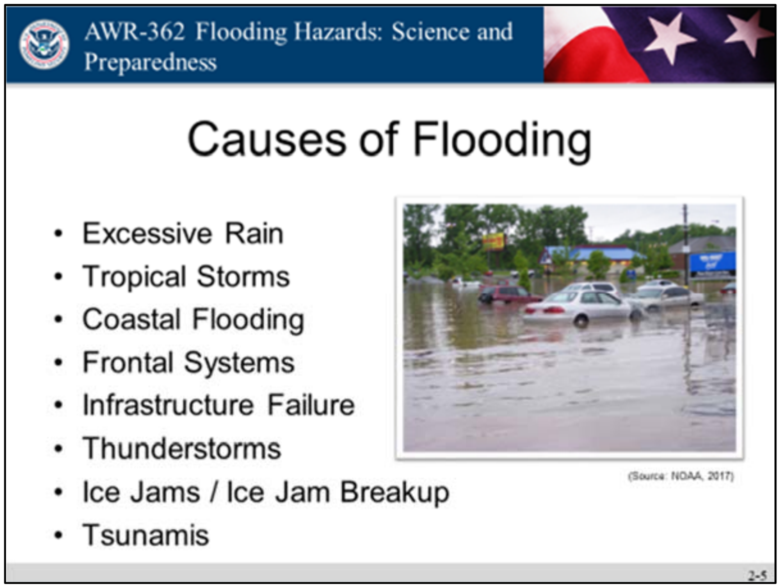
Slide 2-4. Weather Fatalities

The weather events of 2016 were particularly damaging in the United States. According to a review of some of the statistics as shown in this slide:

- 458 deaths were reported due to weather in 2016;
- 1,276 people were injured;
- $18 Billion in property damages were reported;
- Flooding deaths were above the 10-year and 30-year averages; and
- Many other weather causes had fatality rates under or near the long-term averages.

Flooding was the number one cause of death from weather in 2016, which is partially attributable to the devastating flooding that occurred in Baton Rouge, Louisiana, in August 2016 (that event will be presented as a case study later in this course). On average, flooding is a major threat to human life in the United States. Only heat killed more Americans on average over the last 30 years.

Participant Notes:



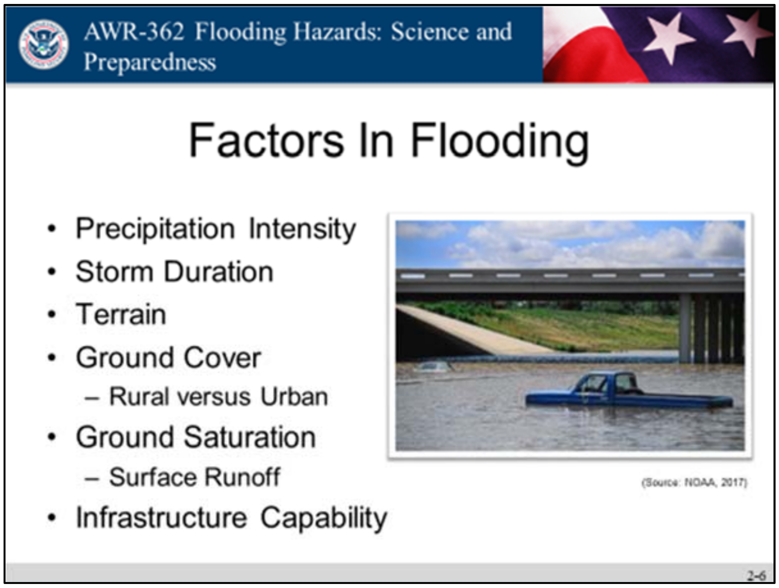
Slide 2-5. Causes of Flooding

Flooding originates from many different sources. While hurricanes only develop from tropical systems, and lightning only comes from a thunderstorm, floods have a variety of triggers. Many of them are weather related, and at some point, all are connected to the hydrological cycle.

Causes include:

- Excessive rain;
- Tropical storms;
- Coastal flooding;
- Frontal systems;
- Infrastructure failure;
- Thunderstorms;
- Ice jams or ice jam breakup; and/or
- Tsunamis.

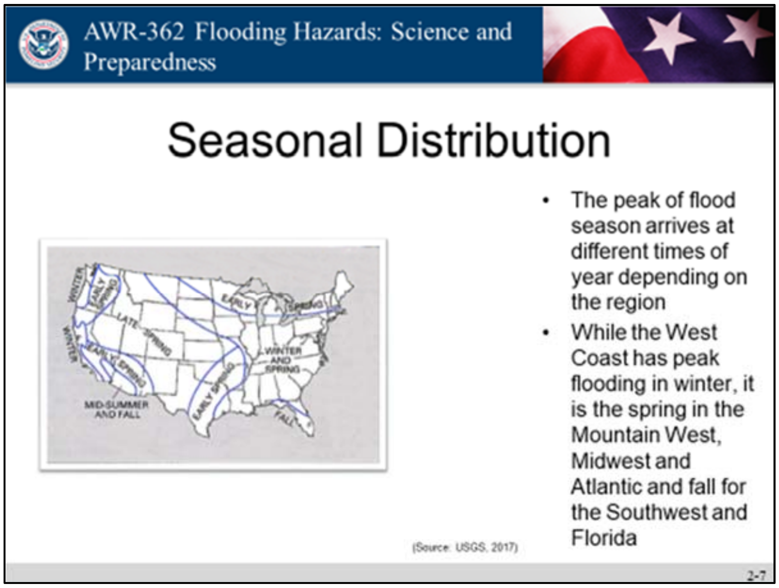
Participant Notes:



Slide 2-6. Factors in Flooding

Besides the trigger of the event, a flood often depends on many factors both natural and man-made. If a flood is due to rain, precipitation intensity and duration are important components. However, if you live in an area with good drainage, this may be less of a concern. Rural farmland has a much higher capacity to hold water than a covered parking lot downtown, so the same storm can be a nuisance in one area and cause widespread devastation in another. If an event occurs just as spring snow is melting and the ground cannot take any more water, the outcome will be far different than if it has been a few weeks since the last good rainfall. Moreover, one of the biggest components is the capability of the sewer system in the affected area. If the rain occurs over a community with older infrastructure and outdated mechanical components, the system may not be able to handle a downpour. The difference between pumps and levees that can withstand torrential rain and ones that break can make all the difference for lives and property.

Participant Notes:



Slide 2-7. Seasonal Distribution

The climate of the United States is characterized by a diversity of climatic regimes--humid coastal plains and arid desert basins, temperate woodlands and semiarid grasslands, tropical islands and subarctic interiors, and the complex microenvironments present throughout the major mountain ranges of the nation. Yet within these diverse climatic systems, each of the 50 states is subject to flooding on a periodic basis.

Floods are caused by weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin. The kinds of weather phenomena and events that cause floods include intense convective thunderstorms, tropical storms and hurricanes, cyclones and frontal passages, and rapid snowmelt.

These individual meteorological processes are part of a larger climatic framework that determines:

1. The seasonal availability and large-scale delivery pathways of atmospheric moisture;
2. The seasonal frequency, typical locations, and degree of persistence of the weather phenomena that release the delivered moisture; and
3. The seasonal variation of climate-related, land-surface conditions that affect flood runoff, such as antecedent soil moisture or snow cover.

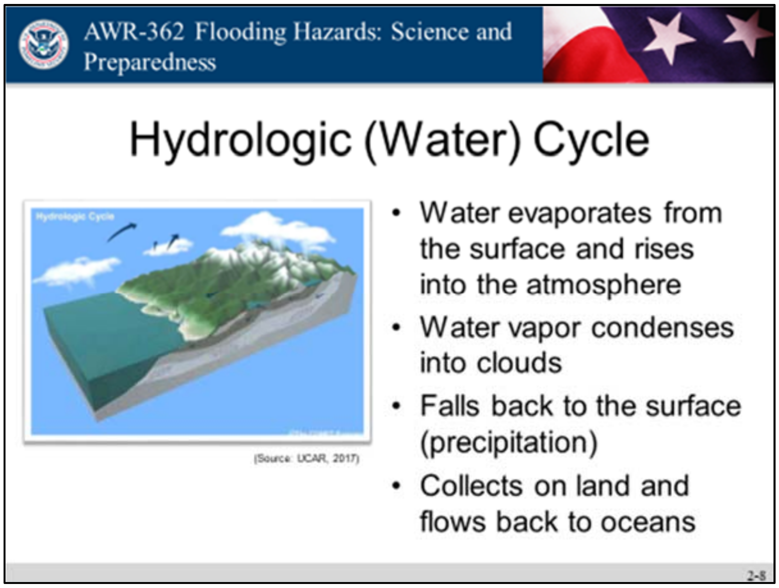
Although the public considers the southwestern U.S. to be dry and desert-like, floods are not uncommon in that area. Infamous summer

Participant Notes:

thunderstorms produce flash floods that suddenly fill dry washes and overwhelm the area.

Key Point: This map only shows the **peak** of flood season for each region. Flooding can happen at any time during the year!

Participant Notes:



Slide 2-8. Hydrologic (Water) Cycle

The **hydrologic cycle**, or the natural water cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor, and ice, with these processes happening in the blink of an eye and over millions of years.

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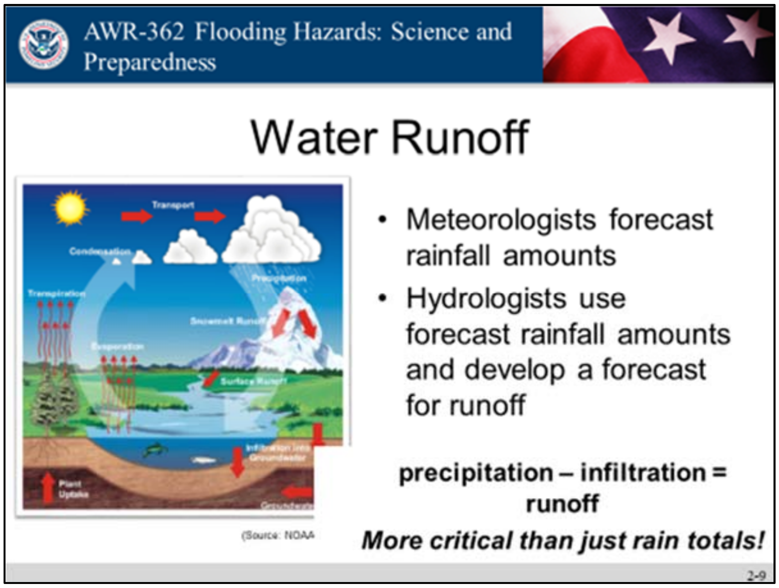

Slide 2-9. Water Runoff

When rain falls to the ground, the water can:

1. Evaporate as a gas back into the atmosphere;
2. Soak into the ground as groundwater; and/or
3. Run off into streams and rivers or as a flood.

When the ground is saturated (cannot absorb any more water) and the atmosphere cannot evaporate water fast enough, the remaining water runs off. Rivers and lakes are the results of runoff. There is some evaporation from the surfaces of rivers and lakes into the atmosphere, but for the most part, water in rivers and lakes returns to the oceans.

Evaporation of surface water into the atmosphere begins the hydrologic cycle over again. Some of the water percolates into the soil and into the ground water only to be drawn into plants again for transpiration (the release of water as a gas from the leaves of plants) to take place.

When there is so much runoff generated by precipitation that the water cannot be held by existing bodies of water on land such as lakes, reservoirs, and waterways, a flood occurs.

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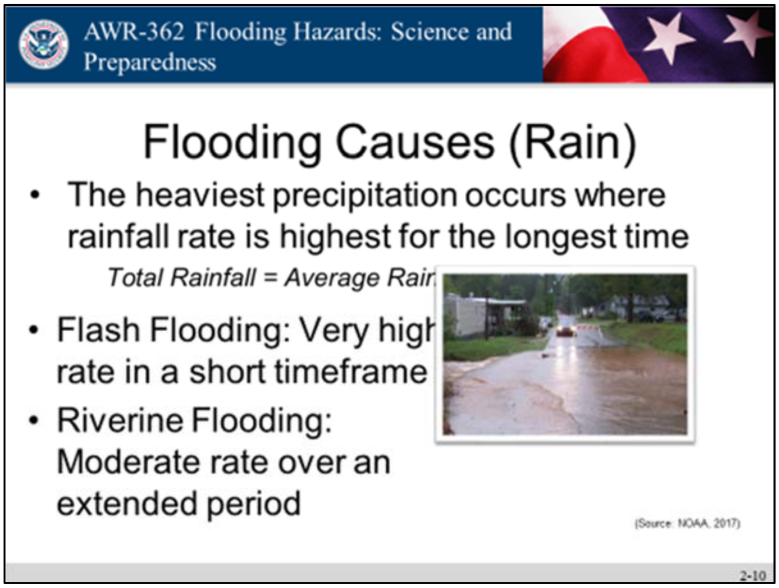

Slide 2-10. Flooding Causes (Rain)

Flooding from precipitation is a product of the rain rate (how fast the water falls) and rain duration (how long the water falls for). A very heavy downpour does not need much time to create a flash flood. On the other hand, rain that is more moderate can still cause a disaster if it continues for several days on end.

Densely populated areas are at a high risk for flash floods. The construction of buildings, highways, driveways, and parking lots increases runoff by reducing the amount of rain absorbed by the ground. This runoff increases the flash flood potential.

Sometimes, streams through cities and towns flow underground into storm drains. During heavy rain, the storm drains can become overwhelmed and flood roads and buildings. Low spots, such as underpasses, underground parking garages, and basements can become death traps.

Areas near rivers are at risk from both river flooding and flash floods. Often embankments, known as levees, are built along rivers to prevent high water from flooding the bordering land. In 1993, many levees failed along the Mississippi River, resulting in devastating flash floods.

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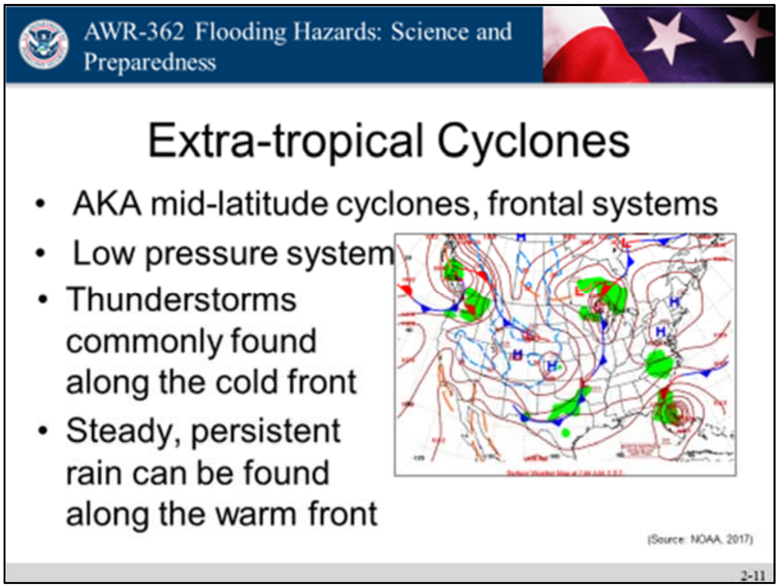

Slide 2-11. Extra-tropical Cyclones

An **extra-tropical cyclone** is a storm system that primarily gets its energy from the horizontal temperature contrasts that exist in the atmosphere. Extra-tropical cyclones (also known as "mid-latitude," "frontal" or "baroclinic" storms) are low-pressure systems with associated cold fronts, warm fronts, and occluded fronts. Much of the United States exists in the "middle" latitudes (and not the low latitudes of the tropics, nor the high latitudes of the Arctic), so the source of much of our stormy weather is mid-latitude cyclones.

The **cold front** is where convection (thunderstorms) often forms in a typical setup; this area is where concerns for flash flooding is concentrated.

Along the **warm front**, steady "non-convective" rainfall is usually located along and just to the north. In a slow-moving system, that rainfall will not be as intense as the downpours in a thunderstorm, but it can be persistent and repeatedly bring rain to the same area. This can cause river and urban flooding.

The map from October 6, 2016, shows several extra-tropical cyclones and their associated fronts across the United States and Canada. The red lines with a half circle are warm fronts, with the circles pointed in the direction the front is moving. The blue lines with triangles are cold fronts, with the triangles pointed in the direction the front is moving.

Participant Notes:

Participant Note: Blue “H” letters showing high-pressure systems are usually an indication of pleasant, non-threatening weather. The red “L” letters are low-pressure systems, typically a source of inclement weather.

Notice the tropical cyclone – Hurricane Matthew – impacting the Florida coast. Tropical cyclones are a major flood threat and will be discussed later in this module. Note here that they do not have fronts that meet in the area of low pressure, as you will find in extra-tropical cyclone systems.

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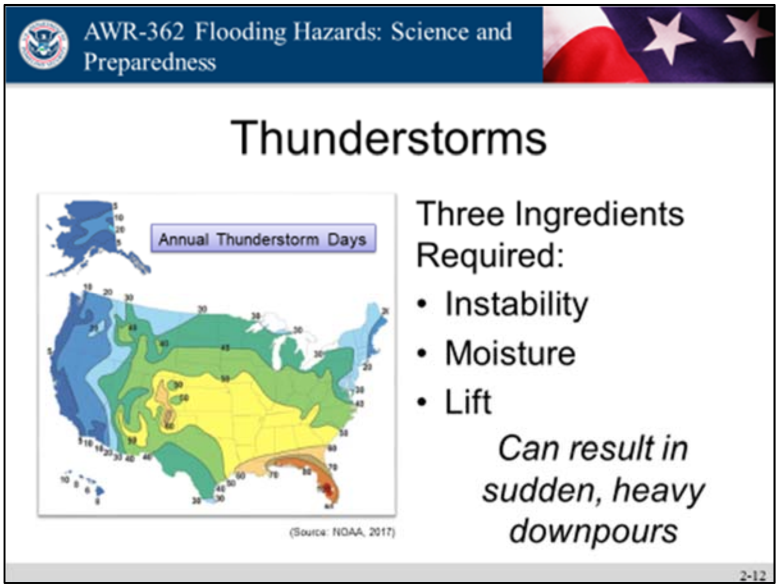

Slide 2-12. Thunderstorms

It is estimated that there are as many as 40,000 thunderstorm occurrences each day worldwide. This translates into an astounding 14.6 million occurrences around the world annually, and the United States certainly experiences its share.

The map shows the average number of thunderstorm days each year throughout the U.S. The most frequent occurrence is in the southeastern states, with Florida having the highest number of “thunder days” (80 to 100+ days per year).

It is in this part of the country that warm, moist air from the Gulf of Mexico and Atlantic Ocean is most readily available to fuel thunderstorm development.

All thunderstorms require three ingredients for their formation:

- Moisture;
- Instability; and
- A lifting mechanism.

Sources of Moisture

Typical sources of moisture for thunderstorms are the oceans. However, water temperature plays a large role in how much moisture the atmosphere takes up.

Participant Notes:

In the southeastern U.S., warm water from the two moisture sources (Atlantic Ocean and Gulf of Mexico) helps explain why there is much more precipitation in that region as compared to the same latitude in Southern California, which is adjacent to the relatively cold Eastern Pacific Ocean.

Instability

Air is unstable if it continues to rise when given a nudge upward (or continues to sink if given a nudge downward). An unstable air mass contains warm moist air near the surface and cold dry air aloft.

In these situations, if a bubble or parcel of air is forced upward it will continue to rise on its own. As this parcel rises, it cools. Some of the water vapor will condense forming the familiar tall cumulonimbus cloud that is the thunderstorm.

Sources of Lift (upward)

Typically, for a thunderstorm to develop there needs to be a trigger that initiates the upward motion. This upward nudge is a direct result of air density.

Some of the sun's heating of the earth's surface transfers to the air, resulting in different air densities. The propensity for air to rise increases with decreasing density. This difference in air density is the main source for lift and is accomplished by several methods.

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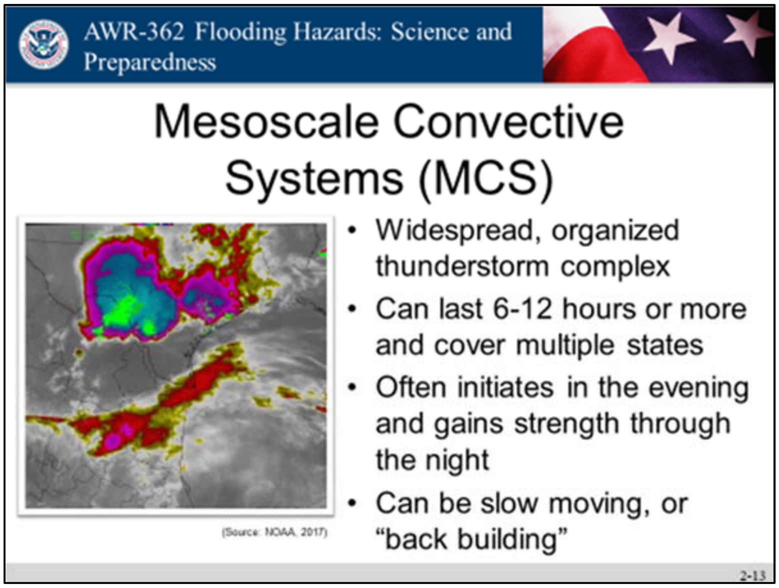

Slide 2-13. Mesoscale Convective System (MCS)

A Mesoscale Convective System (MCS) is an organized collection of thunderstorms that act as a system. An MCS can spread across an entire state and last more than 12 hours. On radar, one of these large storms might appear as a solid line, a broken line, or a cluster of cells.

Because of their long duration, large size, and intense rainfall, MCSs are a major flooding threat. As they strengthen through the night, communities may be asleep when flooding danger looms.

Shown in the loop is satellite imagery of a Mesoscale Convective System (MCS) over Texas. Lightning strike data is overlaid on top of the satellite map in green.

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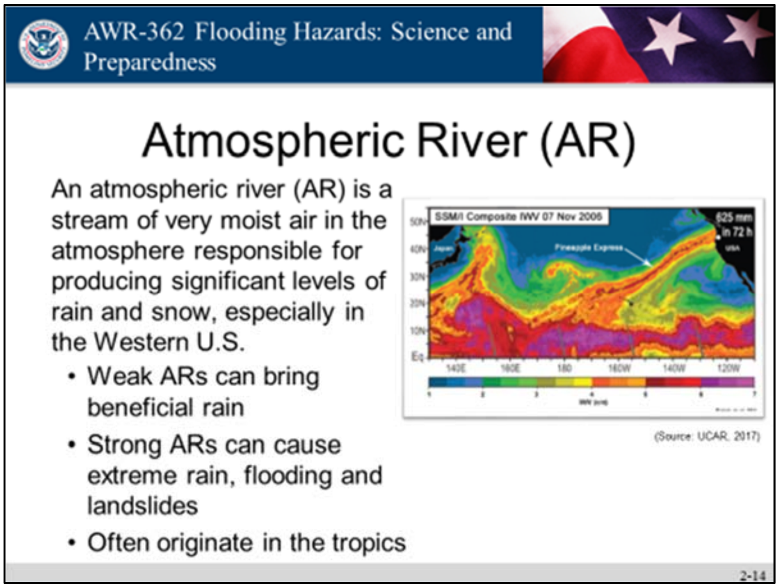

Slide 2-14. Atmospheric River (AR)

Atmospheric Rivers (ARs) are relatively narrow regions in the atmosphere that are responsible for most of the horizontal transport of water vapor outside of the tropics. While ARs come in many shapes and sizes, those that contain the largest amounts of water vapor, the strongest winds, and stall over watersheds vulnerable to flooding, can create extreme rainfall and floods. These events can disrupt travel, induce mudslides, and cause catastrophic damage to life and property. However, not all ARs cause damage – most are weak, and simply provide beneficial rain or snow that is crucial to water supply.

Example: A well-known type of strong AR that can hit the U.S. west coast is the "Pineapple Express," due to its apparent origin in the tropics near Hawaii.

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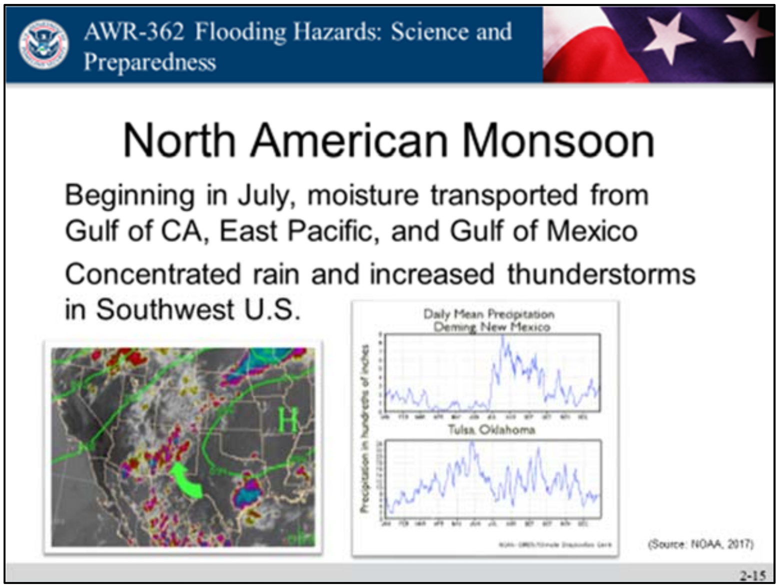

Slide 2-15. North American Monsoon

The North American Monsoon is not as strong or persistent as its Indian counterpart is, mainly because the Mexican Plateau is not as high or as large as the Tibetan Plateau in Asia. However, the North American Monsoon shares most of the basic characteristics of its Indian counterpart. There is a shift in wind patterns in summer that occurs as Mexico and the southwest U.S. warm under intense solar heating. As this happens, the flow reverses from originating in dry land areas to moist ocean areas. In the North American Monsoon, the low-level flow transports moisture primarily from the Gulf of California and eastern Pacific. Upper-level flow also transports moisture into the region, mainly from the Gulf of Mexico by easterly winds aloft.

Once the forests of the Sierra Madre Occidental turn green from the initial monsoon rains, evaporation and plant transpiration can add additional moisture to the atmosphere that will then flow into Arizona. Finally, if the southern plains of the U.S. are unusually wet and green during the early summer months, that area can also serve as a moisture source.

This combination causes a distinct rainy season over large portions of western North America, which can develop quickly and sometimes dramatically.

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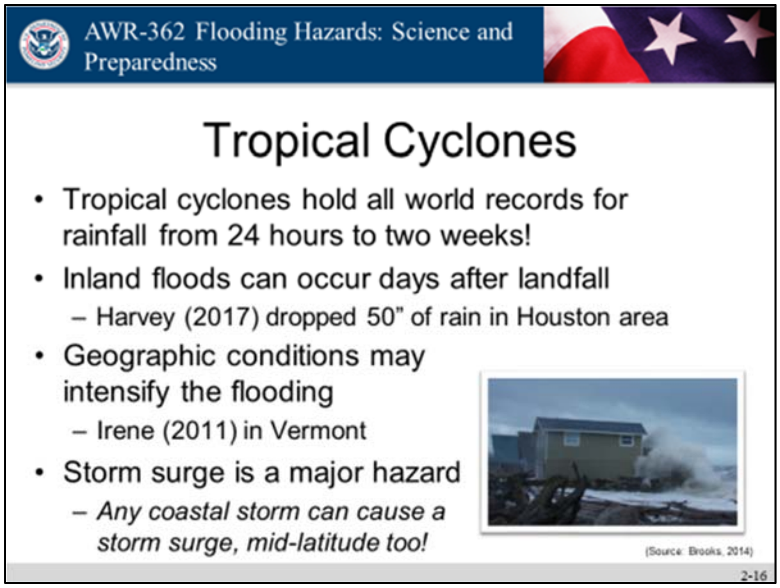

Slide 2-16. Tropical Cyclones

A **tropical cyclone** is a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters and has a closed low-level circulation. Tropical cyclones rotate counterclockwise in the Northern Hemisphere.

Tropical cyclone classifications are as follows:

- **Tropical Depression:** A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.
- **Tropical Storm:** A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- **Hurricane:** A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones. These correspond to a Category 1 or 2 on the Saffir-Simpson Hurricane Wind Scale.
- **Major Hurricane:** A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4, or 5 on the Saffir-Simpson Hurricane Wind Scale.

The United States can experience tropical cyclones anywhere along the coasts of the Atlantic and Gulf of Mexico, as well as in the state of Hawaii and territories of Guam and the Commonwealth of the Northern Mariana Islands in the Pacific. The season for tropical cyclones is typically from June to October when oceans are warmest, but in the Western Pacific, they can occur all year.

Participant Notes:

In addition to the threat of coastal flooding from storm surge, rain bands can drop extreme amounts of rainfall over an extended timeframe, oftentimes far inland from the coast.

A tropical system does not have to be a hurricane to produce dangerous floods. For example, in 1994 Tropical Storm Alberto dropped 21 inches of rain in Georgia. In 1979, Tropical Storm Claudette dumped 45 inches of rain in Alvin, Texas. In 2017, Hurricane Harvey resulted in more than four feet of rain, most of which fell after it was downgraded to a tropical storm.

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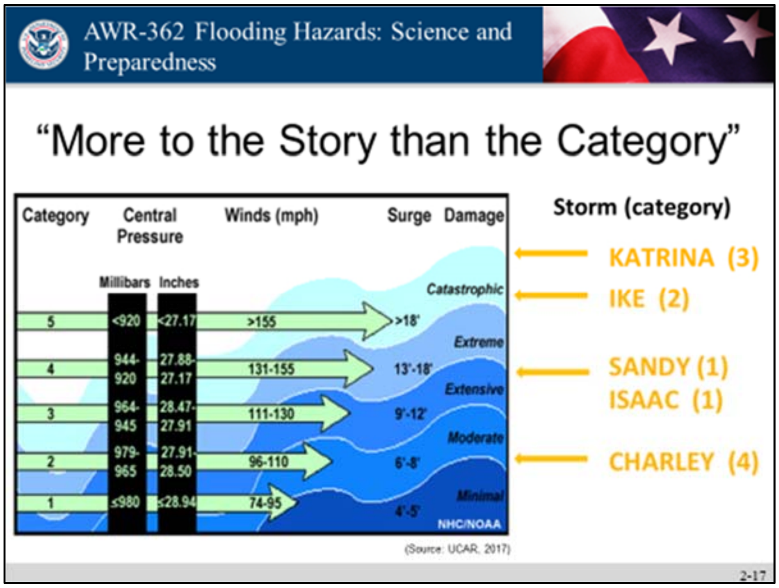

Slide 2-17. "More to the Story than the Category"

Along the coast, storm surge is often the greatest threat to life and property from a hurricane. In the past, large death tolls have resulted from the rise of the ocean associated with many of the major hurricanes that have made landfall.

> e.g. **Example:** Hurricane Katrina (2005) is a prime example of the damage and devastation that storm surge can cause. At least 1,500 persons lost their lives during Katrina, and many of those deaths occurred as a direct or indirect result of storm surge.

Tropical cyclones produce a storm surge by pushing water toward the shore with the force of winds moving cyclonically around the storm. The impact on surge by the low pressure associated with intense storms is minimal in comparison to the force of wind forcing water toward the shore.

The maximum potential storm surge for a particular location depends on a number of different factors. Storm surge is a very complex phenomenon because it is sensitive to the slightest changes in storm intensity, forward speed, size, angle of approach to the coast, central pressure, and the shape and characteristics of coastal features such as bays and estuaries. Other factors that can influence storm surge are the width and slope of the continental shelf. A shallow slope will potentially produce a greater storm surge than a steep shelf. For example, a Category 4 storm hitting the Louisiana coastline, which has a very wide and shallow continental shelf, may produce a 20-foot storm surge, while the same hurricane in a

Participant Notes:

place like Miami Beach, Florida, where the continental shelf drops off very quickly, might only see an eight- or nine-foot surge!

Key Point: “There is more to the story than the category.” A hurricane is far too complex of a system to be fully described by a simple category. With so many variables in the system, a single scale cannot cover all of the impacts.

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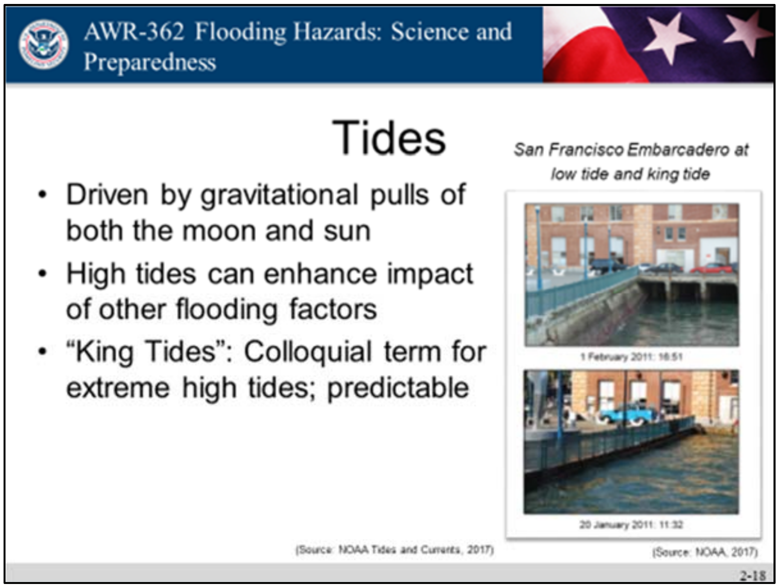

Slide 2-18. Tides

Tides are one of the most reliable phenomena in the world. As the sun rises in the east and the stars come out at night, we are confident that the ocean waters will regularly rise and fall along our shores.

Tides are long-period waves that move through the oceans in response to the forces exerted by the moon and sun. Tides originate in the oceans and progress toward the coastlines where they appear as the regular rise and fall of the sea surface.

When the highest part, or crest, of the wave reaches a particular location, high tide occurs; low tide corresponds to the lowest part of the wave, or its trough. The tidal range is the difference in height between the high tide and the low tide.

A **King Tide** is a non-scientific term the media often uses to describe exceptionally high tides. Because king tides tend to occur when the forces of the sun and moon align, they happen during specific (and varying) seasons around the country.

e.g. **Example:** The King Tide Photo Initiative encourages the public to visually document the impact of rising seas, as exemplified during current king tide events. Photos on the right side of this slide show water levels along the Embarcadero in San

Participant Notes:

Francisco, California, during relatively normal tides (top) and during an extreme high tide or “king tide” (bottom).

e.g. **Example:** Tides build on other flood phenomena. In 2012, the surge of Hurricane Sandy very nearly came ashore as high tide peaked at the Battery in Manhattan. The superposition of these two sources of flooding increased the damage potential by raising water levels more than the storm surge alone.

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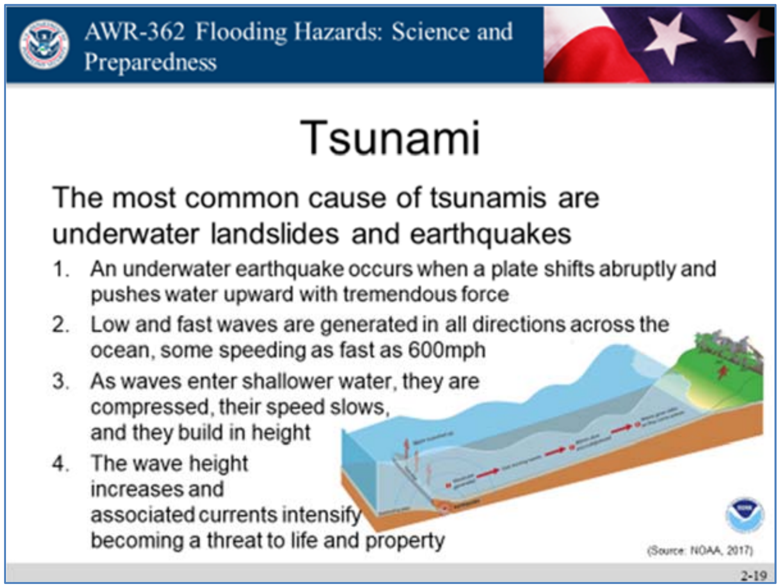

Slide 2-19. Tsunami

Tsunamis are giant waves caused by earthquakes, landslides, or volcanic eruptions under the sea. Out in the depths of the ocean, tsunami waves do not dramatically increase in height. However, as the waves travel inland, they build up to higher and higher heights as the depth of the ocean decreases. The speed of tsunami waves depends on ocean depth rather than the distance from the source of the wave. Tsunami waves may travel as fast as jet planes over deep waters, only slowing down when reaching shallow waters.

Participant Note: While tsunamis are often referred to as tidal waves, oceanographers discourage the use of this name because tides have nothing to do with these giant waves.

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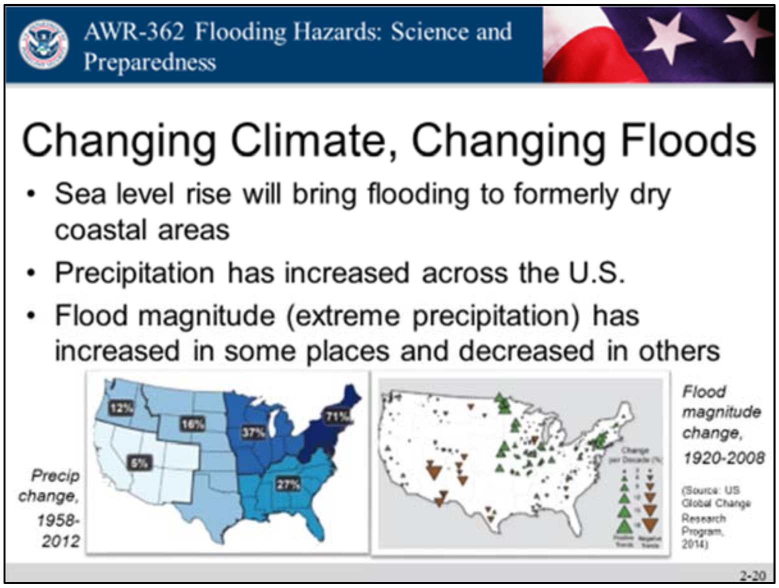

Slide 2-20. Changing Climate, Changing Floods

Climate change is not a direct cause of flooding; however, the rising sea levels that result from warmer ocean waters and melting glaciers will enhance any coastal flooding.

Also, consider that sea level rise is not uniform. While most of the United States will see some sort of sea level rise, the largest impacts will occur in the northeast U.S. along with the western Gulf of Mexico coast.

Some areas will actually experience a decrease in relative sea level. That has less to do with the actual water level than it does the rising ground elevation in the northwest U.S. and Alaska.

Heavy downpours are increasing nationally, especially over the last three to five decades, with the largest increases in the Midwest and Northeast. Climate scientists project increases in extreme precipitation for all U.S. regions in the future.

Across most of the United States, the heaviest rainfall events have become more substantial and more frequent. The amount of rain falling on the heaviest rain days has also increased over the past few decades. Since 1991, the amount of rain falling in very heavy precipitation events has been significantly above average. This increase has been greatest in the Northeast, Midwest, and upper Great Plains – more than 30 percent above the 1901-1960 average. Flooding events have also increased in the Midwest and Northeast where the largest increases in heavy rain

Participant Notes:

amounts have occurred. Projections of future climate over the U.S. suggest that the recent trend toward increased heavy precipitation events will continue. These projections hold even in regions where total precipitation is projected to decrease, such as the Southwest.

Warmer air can contain more water vapor than cooler air. Global analyses show that the amount of water vapor in the atmosphere has in fact increased over both land and oceans. Climate change also alters dynamical characteristics of the atmosphere that in turn affect weather patterns and storms. In the mid-latitudes, where most of the continental U.S. is located, there is an upward trend in extreme precipitation near fronts associated with mid-latitude storms. Locally, natural variations can also be important.

There are significant trends in the magnitude of river flooding in many parts of the United States. River flood magnitudes (from the 1920s through 2008) have decreased in the Southwest and increased in the eastern Great Plains, parts of the Midwest, and from the northern Appalachians into New England.

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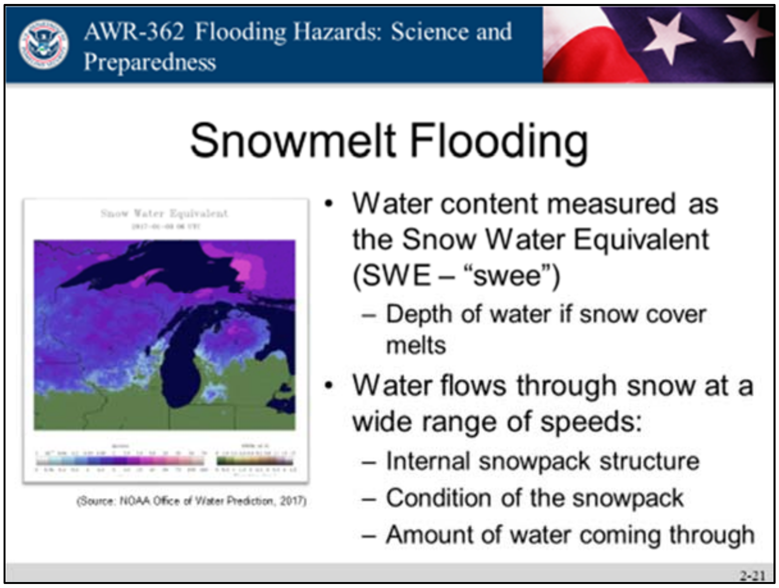

Slide 2-21. Snowmelt Flooding

Snowfall during the fall and winter seasons supplies the majority of water to most mountainous regions. Topography, winter weather patterns, and a host of other factors can combine to produce snow packs with an excess of 50 inches of water equivalent each year.

During peak periods, the location of melting snow can have as much impact on the potential for high water as the amount of snow itself. Even though flooding caused by snowmelt alone is rare, other factors combined with snowmelt can create out-of-bank flows very easily. Quick, low elevation snowmelt affected by wide temperature variations can cause flooding easily and with little warning.

When the snow melts, it adds water to the ground that drains away in the same way as water from rainfall. On average, one inch of fresh snowfall contains slightly less than a tenth of an inch of water. As snow accumulates and compacts during winter, the ratio of snow to water decreases. Thus, 10 inches of snow remaining on the ground into early spring may contain as much as five inches of water.

The National Operational Hydrologic Remote Sensing Center produces daily maps of estimated snow cover, snow depth, and snow water equivalent (SWE). Participants can also find resources for monitoring snow depth and density, as well as other hydrologic measurements at the U.S. Department of Agriculture's Natural Resources Conservation Service – National Water and Climate Center. In addition, many volunteer snow observers in the Community Collaborative Rain, Hail and Snow (CoCoRAHS) network measure the SWE on a daily basis.

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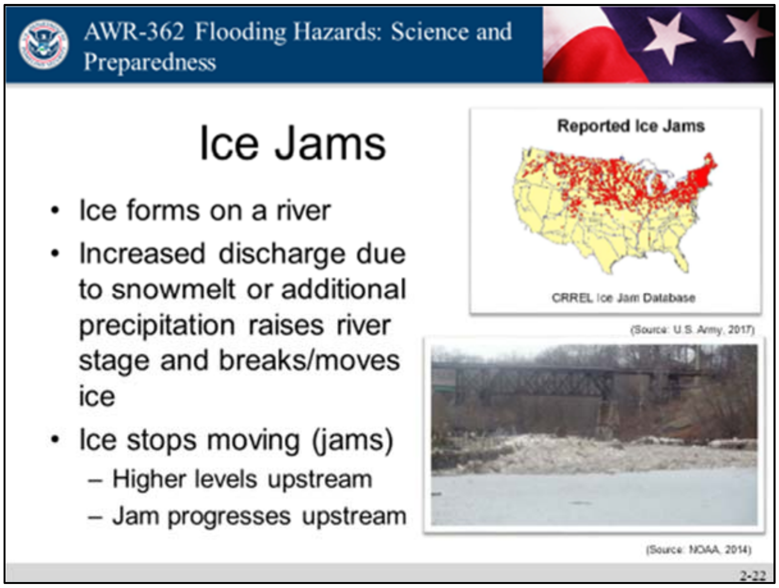

Slide 2-22. Ice Jams

Pieces of floating ice carried with a stream's current can accumulate at any obstruction to the stream flow. These ice jams can develop near river bends, mouths of tributaries, points where the river slope decreases, downstream of dams and upstream of bridges or obstructions. The water trapped behind the jam may cause flooding upstream. If the obstruction suddenly breaks, then flash flooding may occur downstream.

An ice jam can occur anytime from early winter to late spring in cold climates depending upon changes in temperatures that can cause alternate freezing and melting of water surfaces. The most likely times are freeze-up jams in early winter and break-up jams early spring. Freeze-up jams typically result in minimal if any flooding. Break-up jams usually cause the most damage and flooding. In addition to flooding, break-up ice jams can cause significant property damage. They can push entire houses off their foundations and rip wooden decks from homes.

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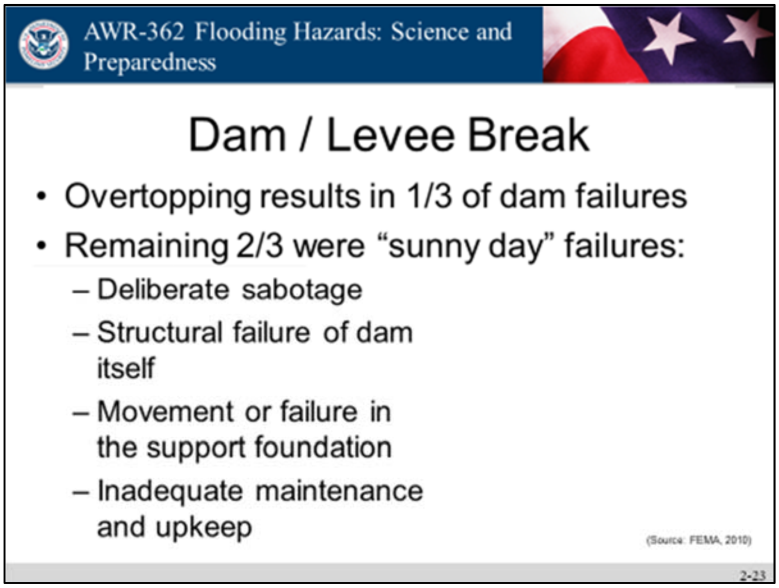

Slide 2-23. Dam / Levee Break

Dam failure can often be traced either to a poor decision made during design and construction or to inadequate maintenance or operational mismanagement. Failure may also result from natural hazards, such as earthquakes, or from flow volumes that exceed the dam's capacity. Damage from dam failure is especially severe because of the high velocity of floodwater. Breaching often occurs within hours after the first visible signs of dam failure, leaving little or no time for evacuation.

Some of the most significant losses due to the failure of flood control structures can be attributed to the construction of inadequate dams and levees, or to a flood that exceeds the design protection level. Many private or locally built levees and dams provide only limited flood protection or are poorly designed and maintained. Many were built with no design standards. Levee overtopping or failure typically occurs from floods beyond their capacity to handle, often with spectacular and tragic results.

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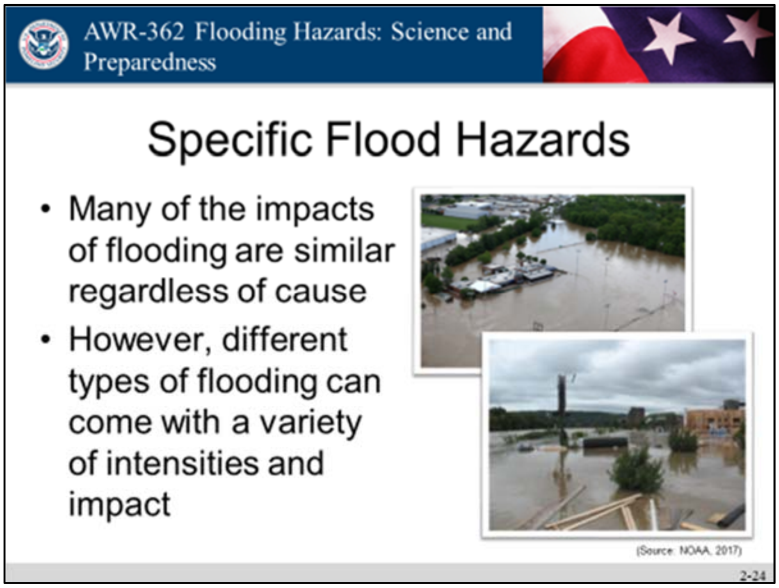

Slide 2-24. Specific Flood Hazards

So far, we have seen that flooding can be caused by a multitude of triggers, from heavy precipitation, to the break of an ice jam, or the failure of man-made structures.

Regardless of the cause, we generally break flooding up into three different categories depending on how fast and where it occurs, and each category has its own characteristics and hazards. The three categories are:

1. Riverine flooding;
2. Flash flooding; and
3. Coastal flooding.

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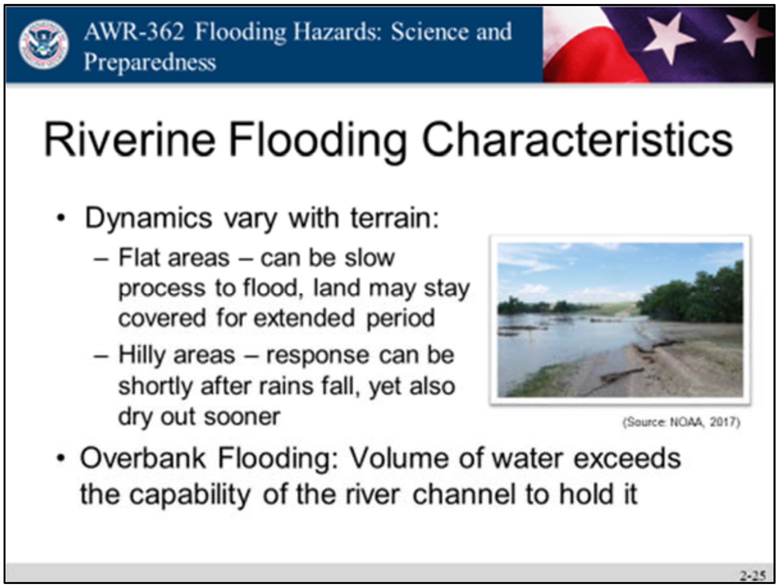

Slide 2-25. Riverine Flooding Characteristics

The dynamics of riverine flooding vary with terrain. In relatively flat areas, land may remain covered with shallow, slow-moving floodwater for days or even weeks. In hilly and mountainous areas, floods may come minutes after a heavy rain.

Overbank flooding of rivers and streams – the increase in the volume of water within a river channel and the overflow of water from the channel onto the adjacent floodplain – represents the classic flooding event that most people associate with the term “flood.” In fact, this is also the most common type of flood event. Hundreds of riverine floods, great and small, occur annually in the United States.

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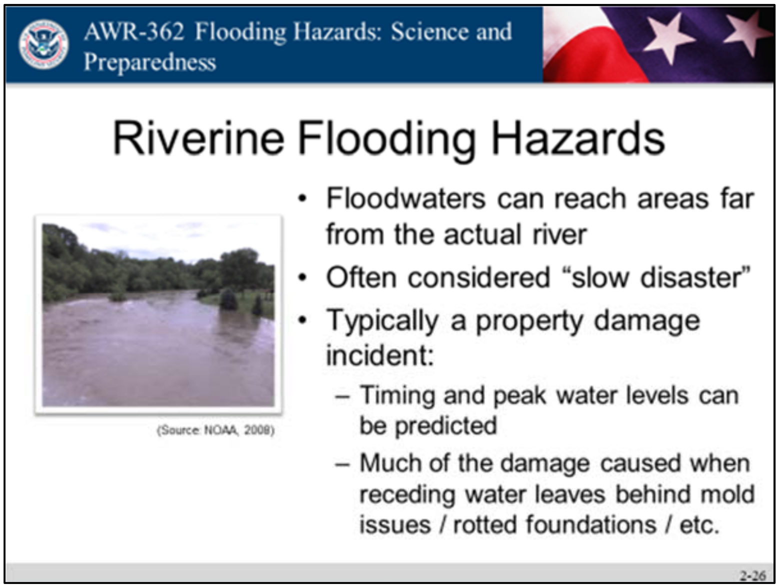

Slide 2-26. Riverine Flooding Hazards

Riverine floodplains range from narrow, confined channels (as in steep river valleys in hilly and mountainous areas) to wide, flat areas (as in much of the Midwest and in many coastal areas). In the steep narrow valleys, flooding usually occurs quickly and is of short duration, but is likely to be rapid and deep. In relatively flat floodplains, areas may remain inundated for days or even weeks, but floodwaters are typically slow moving and shallow.

Along major rivers with very large drainage basins, the timing and elevations of flood peaks can be predicted far in advance and with considerable accuracy. In very small basins, flooding may be more difficult to predict to provide useful warning time. Generally, the smaller the drainage basin, the more difficult it is to forecast the flood.

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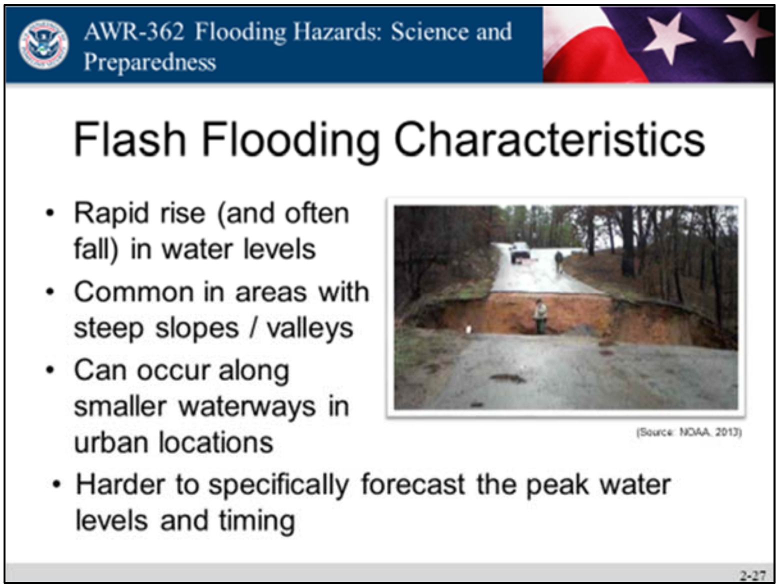

Slide 2-27. Flash Flooding Characteristics

Flash floods are characterized by a rapid rise in water, high velocities, and large amounts of debris. Major factors in flash flooding are the intensity and duration of rainfall and the steepness of watershed and stream gradients. Flash flooding occurs in all of the states and territories of the U.S., most commonly in steeply sloping valleys in mountainous areas, but can also occur along small waterways in urban environments. Dam failure, release of ice jams, and collapse of debris dams can also cause flash floods.

Because they happen very suddenly, flash floods can be hard to predict and occur with little or no warning, making them extremely dangerous.

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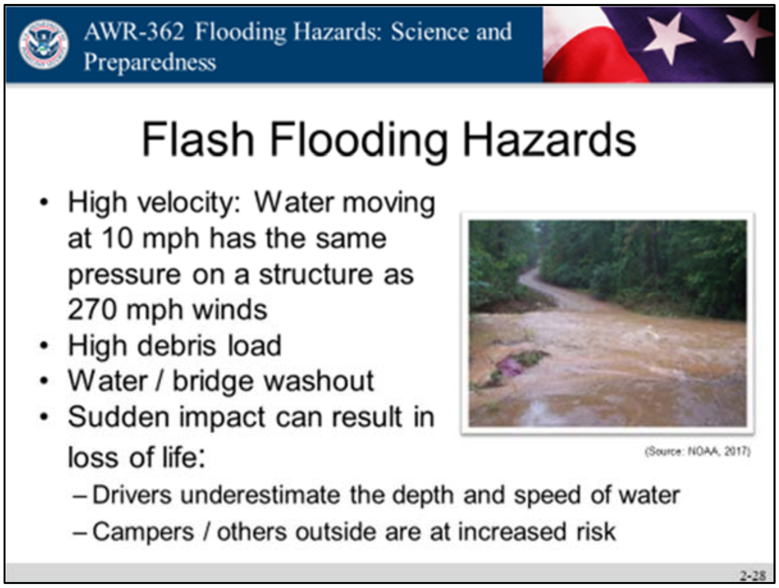

Slide 2-28. Flash Flooding Hazards

The damage caused by flash floods can be more severe than ordinary riverine floods because of the speed with which flooding occurs (possibly hindering evacuation or protection of property), the high velocity of water, and the debris load. Channel velocities of nine feet per second, typically realized in flash floods, can move a 90-pound rock. Major flash floods like the one that occurred in the Big Thompson Canyon in Colorado in 1976, where velocities exceeded 30 feet per second, moved boulders weighing 250 tons.

The density of water enables it to pack a destructive punch. Water moving at 10 miles per hour exerts the same pressure on a structure as wind gusts at 270 miles per hour.

Sudden destruction of structures and the washout of access roads may result in loss of life. A high percentage of flood-related deaths result from motorists underestimating the depth and velocity of floodwaters and attempting to cross swollen streams.

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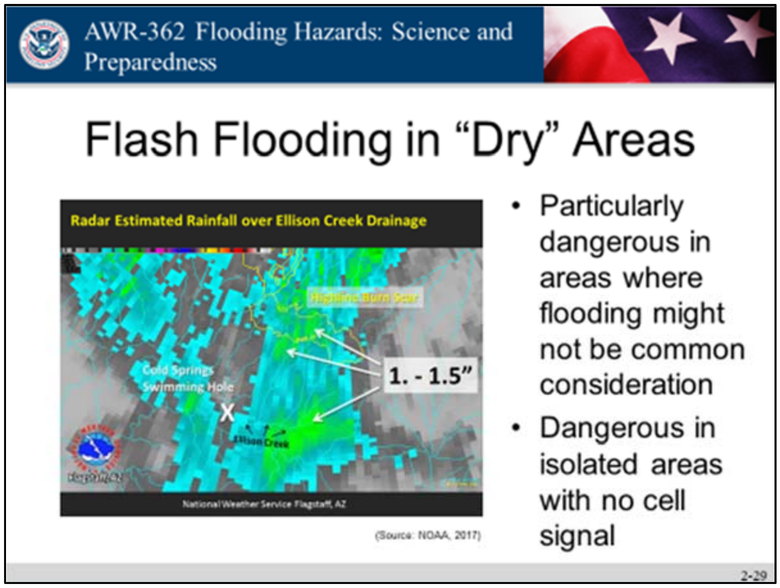


Slide 2-29. Flash Flooding in “Dry” Areas

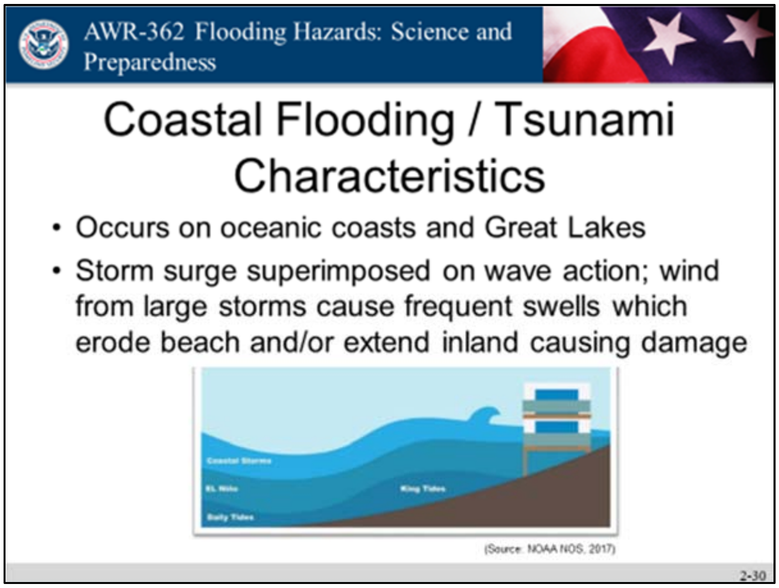
In July 2017, a Flash Flood Warning was issued for Gila County, Arizona. Slow moving thunderstorms dropped a quick 1 to 1.5 inches of rain over mountainous terrain that had recently gone through extensive wildfires.

The terrain and lack of ground brush caused a wall of debris and water to rush down the mountain. At the same time, people were gathering at a popular swimming hole at the Tonto National Forest.

This location is outside of cell phone coverage areas, so while they were swimming on an otherwise dry day, the torrent of water and debris rushed through the area.

Ten members of an extended family perished in the ensuing flood.

Participant Notes:



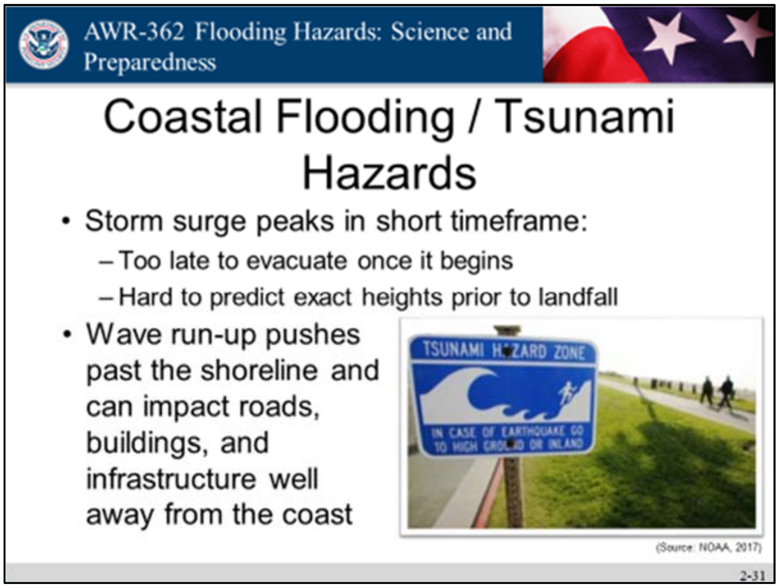
Slide 2-30. Coastal Flooding / Tsunami Characteristics

Coastal flooding and erosion are serious problems along much of the nation’s coasts, although the frequency and magnitude of flooding and the severity of the erosion vary considerably. They result from storm surges and wave actions. Coastal communities must contend with many flooding threats superimposed upon each other. High or king tides, sea level rise from El Nino, storm surge from tropical or mid-latitude storms, high surf, and tsunamis can happen in any combination.

Components of wave action include wave set-up and wave run-up. **Wave set-up** is the super elevation of the water surface over normal surge elevation due to wave action alone. **Wave run-up** is the action of a wave after it breaks and the water “runs up” the shoreline or other obstacle, flooding areas not reached by the storm surge itself. Where vertical obstructions such as seawalls are present, wave run-up refers to the upward movement of the water.

As waves move toward the shore, they encounter several obstacles. The first obstacle is the sloping bottom near the shoreline. When waves reach a water depth equal to about 1.3 times the wave height, the wave breaks. Breaking waves dissipate their energy by generating turbulence in the water. As the turbulent water travels forward, it expends most of its remaining energy as it rushes up the beach slope. The beach adjusts to changes in wave energy by changing its profile. Beach material is moved either seaward, creating an offshore berm, or landward, building up the beach. The beach is constantly adjusting to both wave energy and water level.

Participant Notes:



Slide 2-31. Coastal Flooding / Tsunami Hazards

One of the major hazards associated with land falling hurricanes is storm surge. Storm surge is the abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

Storm surge results mainly from the force of hurricane winds shoving the ocean water up over the coast, although low pressure in the eye also contributes a small amount.

Breaking waves at the shoreline become very destructive, causing damage to natural and man-made structures by hydrodynamic pressure, battering solid objects and scouring sand from around foundations.

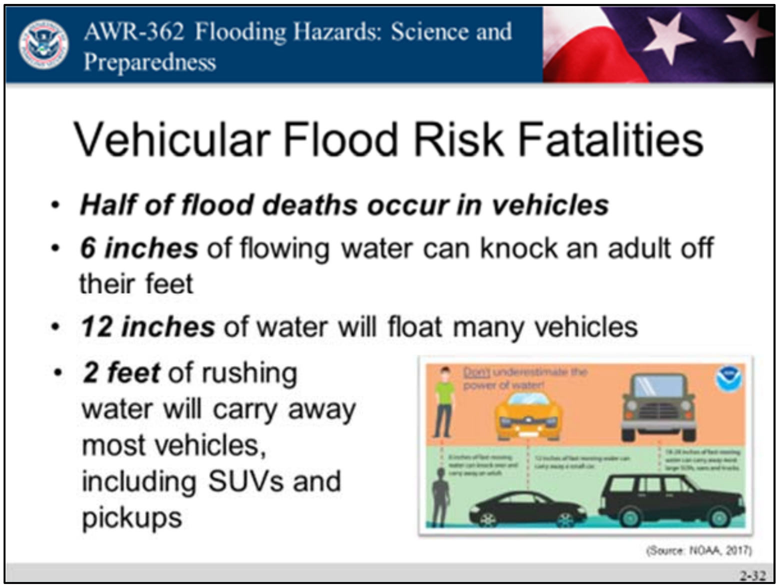
When working with storm surge products, you are likely to encounter the terms storm surge and storm tide. Here are their definitions:

- **Storm surge** is the abnormal rise of water generated by a storm, over and above the predicted astronomical tide.
- **Storm tide** is the water level height during a storm due to the combination of storm surge and the astronomical tide.

Participant Notes:

Participant Note: Social science research has shown that the public better understands, and responds more appropriately, when forecast products use the general term “storm surge” instead of “storm tide” or “storm surge and tide.” Consequently, most meteorologists use the term storm surge to refer to the combined effects of surge and tide. The National Hurricane Center and local forecast office products already use this terminology.

Participant Notes:



Slide 2-32. Vehicular Flood Risk Fatalities

Some hazards are common to all floods, regardless of the speed of their onset, their cause, or their location. Half of all flood deaths occur in a vehicle, which is why the National Weather Service widely distributes graphics and text products that include the phrase “Turn Around Don’t Drown.” There are many reasons that a flood victim may enter the water; though it is usually with the goal of reaching their destination safely, most flood victims underestimate the power of floodwaters.

- Just **six inches** of flowing water can knock an adult off their feet.
- **12 inches**, or **one foot**, of water will float many vehicles.
- **Two feet** of rushing water will carry away most vehicles, including sport utility vehicles and pickup trucks.

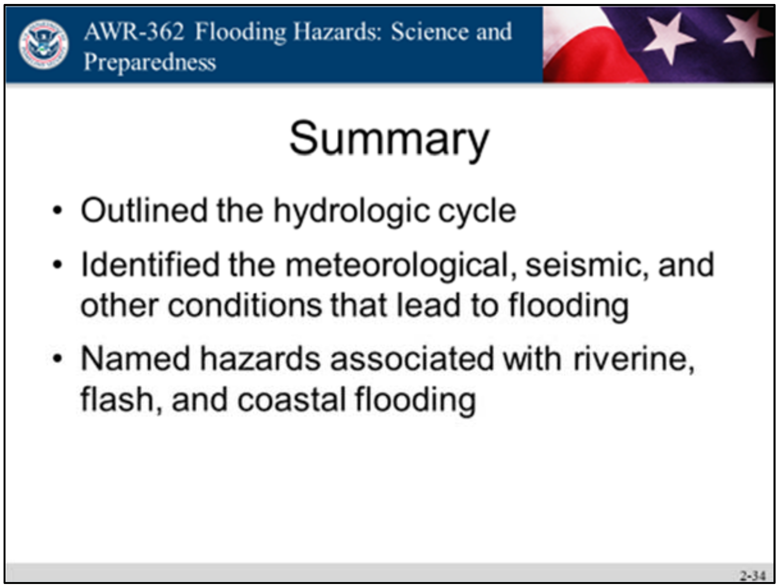
Outreach and public education can reduce the number of drownings in and out of vehicles during floods. It may seem like common sense not to enter floodwaters, but it is in fact quite common. Adults often enter floodwaters to assist or rescue others, or to reach a destination such as a house or car. Children often approach floodwaters out of curiosity, or to play in the water.

Participant Notes:

Slide 2-33. Don't Wade In There, Either

Anticipating the hazards of floodwaters before a disaster happens is part of preparedness. First responders may have no choice but to assist or rescue members of the public during a flood event, but remember, there is no way to make entering floodwaters safe. Floodwaters are usually turbid, obscuring the true depth as well as objects that can cut and injure. Infectious diseases that cause gastrointestinal illness or infect open wounds or sensitive areas such as the eyes are almost always present due to overwhelmed sewer systems and waste treatment plants. Animals do not like to be flooded, either! Snakes, insects, reptiles, and other animals that you might not normally encounter may make their way into floodwaters in search of dry ground. Finally, the damage to infrastructure can cause ongoing safety hazards in flooded areas: releases of industrial materials can lead to chemical contamination, and downed power lines can electrocute those in contact with the water.

Participant Notes:



Slide 2-34. Summary

This module:

- Outlined the hydrologic cycle;
- Identified the meteorological, seismic, and other conditions that lead to flooding; and
- Named hazards associated with riverine, flash, and coastal flooding

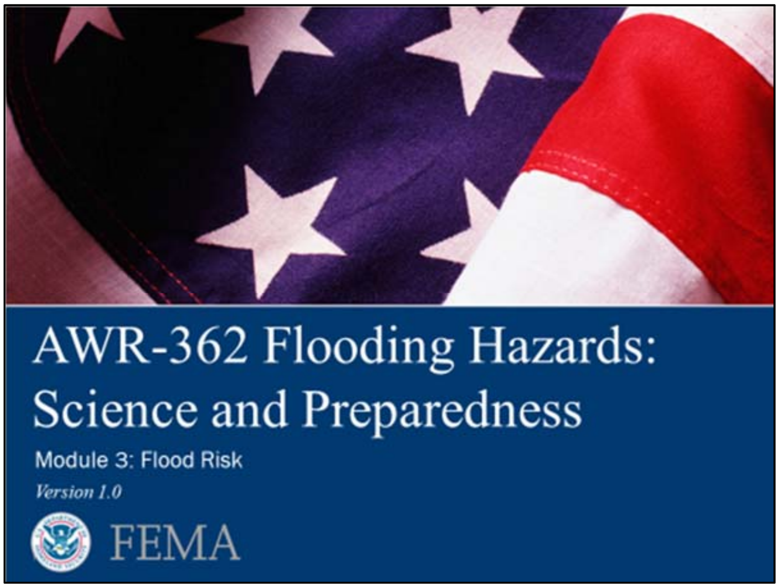
AWR-362
Flooding Hazards: Science and Preparedness

Module 3: Flood Risk

Version 1.0

FEMA

Module 3: Flood Risk – Administration Page



Slide 3-1. Flood Risk

Duration

75 minutes

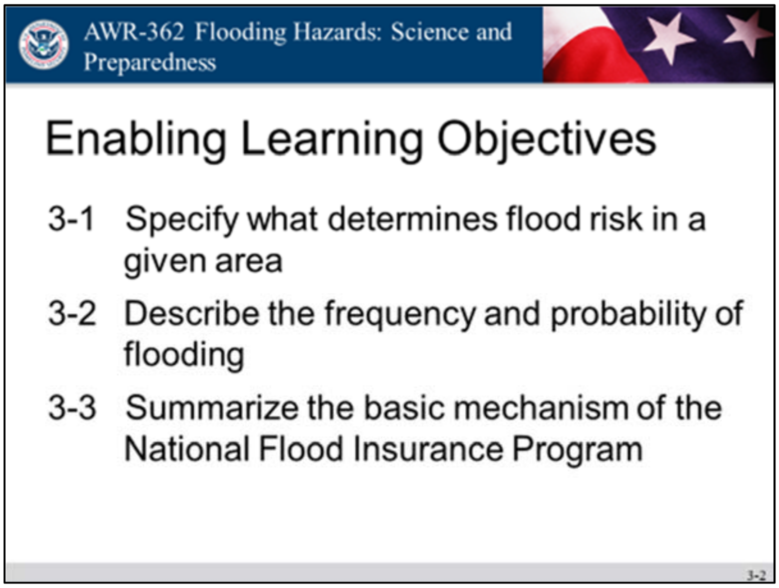
Scope Statement

Many factors determine a community's flood risk: proximity to waterways, land use, soil type, climate, and topography. This module introduces participants to the ways in which these factors are combined to determine their flood risk, and how this affects the cost and availability of flood insurance. A discussion of using historical data to determine the return period of flood events, and how these might be affected by climate change is also included.

Terminal Learning Objective (TLO)

Participants will be able to access and interpret FEMA flood risk maps for their area.

Enabling Learning Objectives (ELO)



Slide 3-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

3-1 Specify what determines flood risk in a given area;

3-2 Describe the frequency and probability of flooding; and

3-3 Summarize the basic mechanism of the National Flood Insurance Program.

Resources

- Instructor Guide (IG)
- Module 3 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handout

Instructor to Participant Ratio

2:40

Reference List

Alberta WaterPortal. 2013. “How Wildfires Impact a Watershed.” Accessed 09/05/2017. http://albertawater.com/how-wildfires-impact-a-watershed

American Institutes for Research. 2005. “A Chronology of Major Events Affecting the National Flood Insurance Program.” *The American Institutes for Research, The Pacific Institute for Research and Evaluation,* Deloitte & Touche LLP. 12/2005. Accessed 09/05/2017. https://www.fema.gov/media-library-data/20130726-1602-20490-7283/nfip_eval_chronology.pdf

Beall, Barbara B. (Undated.) “Wetland Words and What They Mean: Soil-Related Words.” NYS Wetlands Forum. Accessed 09/05/2017. http://www.wetlandsforum.org/faqsoils.htm

Botts, H. et al. 2017. “2017 Storm Surge Report.” CoreLogic, 06/2017. Accessed 09/05/2017. http://www.corelogic.com/about-us/researchtrends/storm-surge-report.aspx#

Dunn, Terry. 2017. “Floodplain: Definition, Development & Features.” Study.com, 2017. Accessed 09/05/2017. http://study.com/academy/lesson/floodplain-definition-development-features.html

Federal Emergency Management Agency (FEMA). 2007. “Managing Floodplain Development Through the NFIP.” Accessed 09/05/2017. https://www.fema.gov/media-library/assets/documents/6029

FEMA. 2014. “Floodplain Management Guidebook.” Accessed 09/05/2017. https://www.fema.gov/media-library/assets/documents/15477

FEMA. 2015. “IS-1102: Theory of Elevation Rating.” Emergency Management Institute. Accessed 09/05/2017. https://training.fema.gov/is/courseoverview.aspx?code=IS-1102

FEMA. 2015. “IS-1109: Understanding Basement Coverage.” *Emergency Management Institute.* Accessed 09/05/2017. https://training.fema.gov/is/courseoverview.aspx?code=IS-1109

FEMA. 2017. “The Benefits of Flood Insurance Versus Disaster Assistance.” *National Flood Insurance Program.* Accessed 09/05/2017. https://www.fema.gov/media-library-data/20130726-1643-20490-9801/f_217_benefits_30nov2012_web.pdf

FEMA. 2017. “Flood Map Definition.” Accessed 09/05/2017. https://www.fema.gov/national-flood-insurance-program/definitions

FEMA. 2017. “Floodway.” Accessed 09/05/2017. https://www.fema.gov/floodway

FEMA. 2017. “Flood Zones.” Accessed 09/05/2017. https://www.fema.gov/flood-zones

National Oceanic and Atmospheric Administration (NOAA). (2017.) “What is hydrography?” National Ocean Service*.* Accessed 09/05/2017. https://oceanservice.noaa.gov/facts/hydrography.html

Oleson, Timothy. 2015. “The ‘100-year flood’ fallacy: Return periods misleading in communication of flood risk.” Earth Magazine, *American Geosciences Institute.* 01/11/2015. Accessed 09/05/2017. https://www.earthmagazine.org/article/100-year-flood-fallacy-return-periods-misleading-communication-flood-risk

Soil Science Society of America. (Undated.) “Wetland Soils.” Accessed 09/05/2017. http://soils4teachers.org/wetlands

U.S. Department of Agriculture. (Undated.) “Soil Classification.” Natural Resources Conservation Service. Accessed 09/05/2017. https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/class/

Reference List (continued)

U.S. Department of Agriculture. “CFR §761.2” (Title 7 – Agriculture; Subtitle B Regulations of The Department of Agriculture; Chapter VII Farm Service Agency, Department of Agriculture; Subchapter D Special Programs; Part 761 General Program Administration; Subpart A General Provisions)

U.S. Geological Survey. (USGS.) 2016. “Floods: Recurrence Intervals and 100-year floods.” Accessed 09/05/2017. https://water.usgs.gov/edu/100yearflood.html

U.S. Postal Service. “39 CFR §776.3” (Title 39 - Postal Service; Chapter I - United States Postal Service; Subchapter K - Environmental Regulations; Part 776 - Floodplain And Wetland Procedures; Subpart A - General Provisions)

University Corporation for Atmospheric Research (UCAR).2015. “Overview of Watershed and Channel Sedimentation.” *MetEd,* COMET-UCAR, 01/27/2015. Accessed 09/05/2017. https://www.meted.ucar.edu/training_module.php?id=1123&tab=05

Practical Exercise Statement

Not Applicable

Assessment Strategy

- Instructor-led discussion to gauge participant grasp of the subject matter
- Instructor observation of participant involvement in classroom discussion

Flooding Hazards: Science and Preparedness

Icon Map

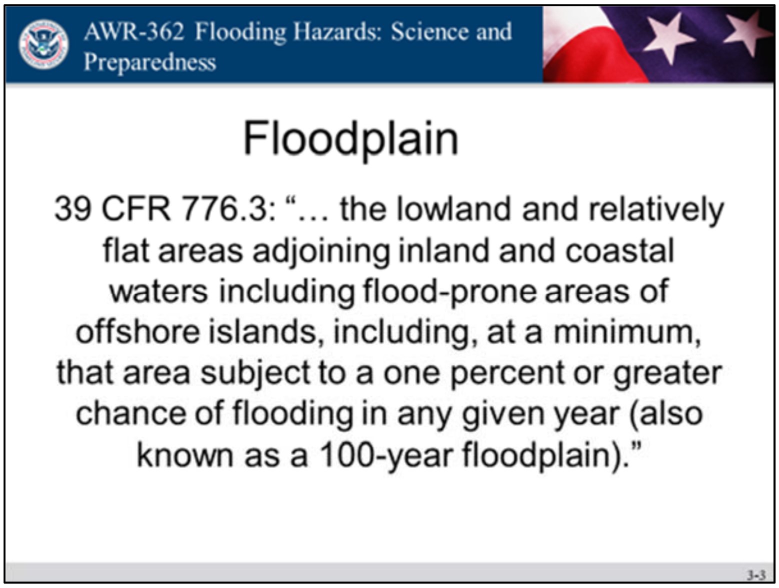
Knowledge Check: Used when it is time to assess participant understanding.

Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

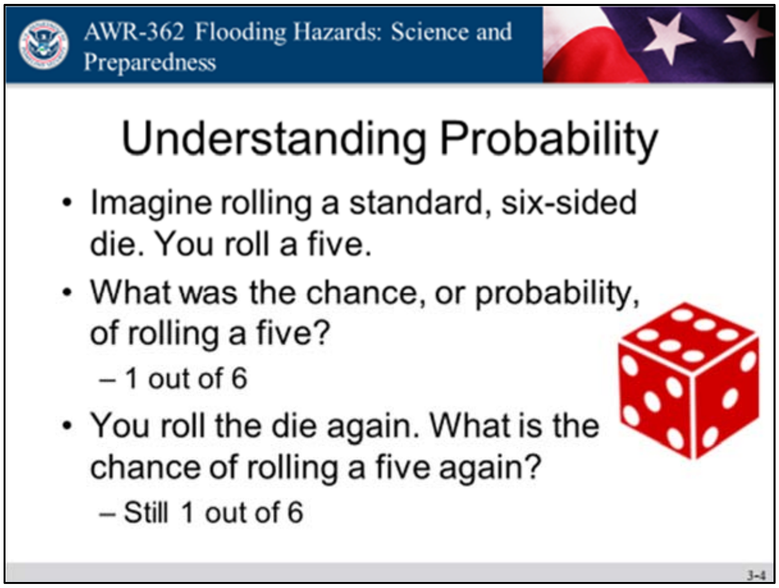
Participant Notes:



Slide 3-3. Floodplain

Managing flood risk begins with identifying the floodplain. Floodplain management in the United States involves enforcing a set of rules put in place by the local jurisdiction to meet the needs of the National Flood Insurance Program (NFIP). The NFIP defines the **floodplain** as "the lowland and relatively flat areas adjoining inland and coastal waters including flood-prone areas of offshore islands, including, at a minimum, that area subject to a one percent or greater chance of flooding in any given year (also known as a 100-year floodplain)." In plain English, the floodplain is the area around inland or coastal waters that a 100-year flood would inundate. The NFIP further divides the floodplain into different areas. We will learn about how the floodplain subdivisions are mapped and used to express risk and determine insurance eligibility in the next few slides. First, we need to learn exactly what the term "100-year flood" means.

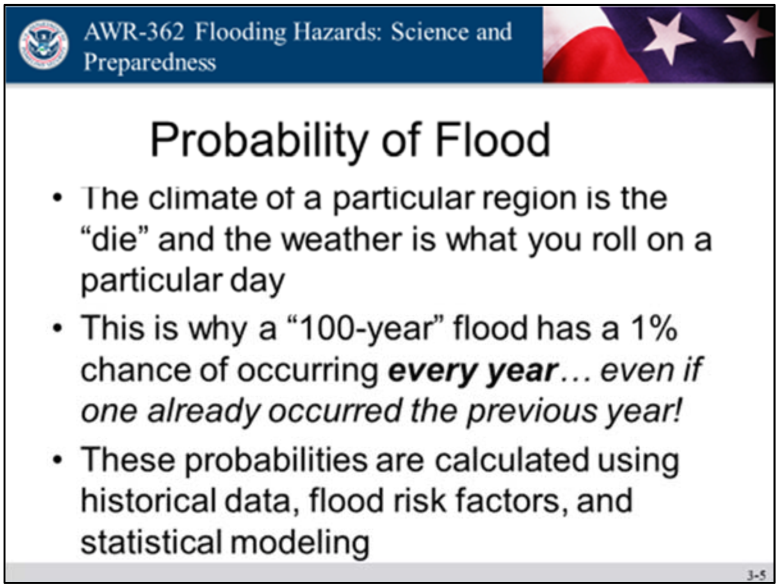
Participant Notes:



Slide 3-4. Understanding Probability

To understand what a “100-year” or “1 percent” flood means, we first have to think about probability. To help us think about probability, let’s do a thought experiment: Imagine you have one fair, six-sided die. Imagine you roll the die. What is the probability of rolling a five? There are six sides, and five is on one of them, so the probability is one out of six, or about 17 percent. Now – imagine picking up the die and rolling it again. What is the probability of rolling a five again? The die has not changed – the fact that you rolled a five before cannot effect your second roll. The probability is the same – still one out of six.

Participant Notes:

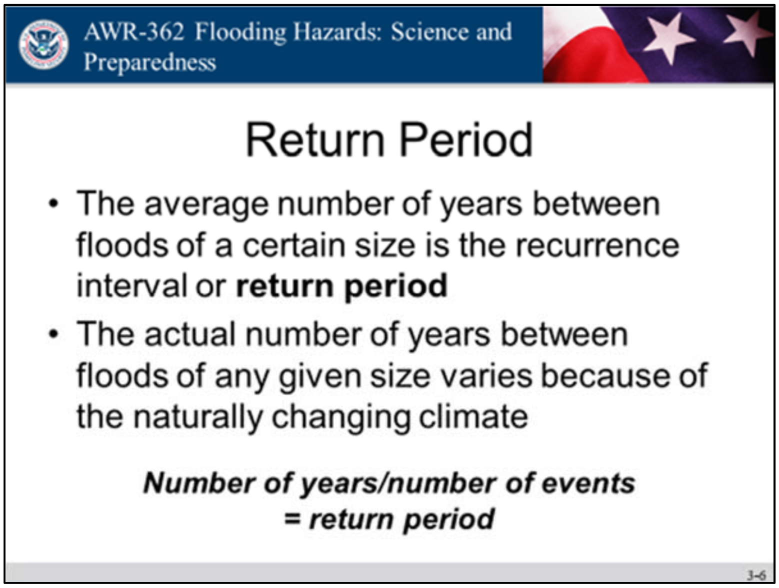


Slide 3-5. Probability of Flood

When we consider weather and climate, climate is like the die on the previous slide and weather is a particular roll of that die. Climate sets the probabilities, but you can still be “unlucky” and get an extreme weather event two years in a row. The fact that an extreme precipitation event happens one year does not lessen the chances of it happening the next year.

The term “100-year-flood” has been used over time to make the statistical, annual probability of flooding in the floodplain easier for the general public to understand. Unfortunately, over time, the statistical basis has been underemphasized, and the term became a “mental marker” for communities who experienced extreme flooding. A member of the public might come to believe that if a “100-year” flood occurred, they had 99 years until the next flood of a similar magnitude would occur.

Participant Notes:



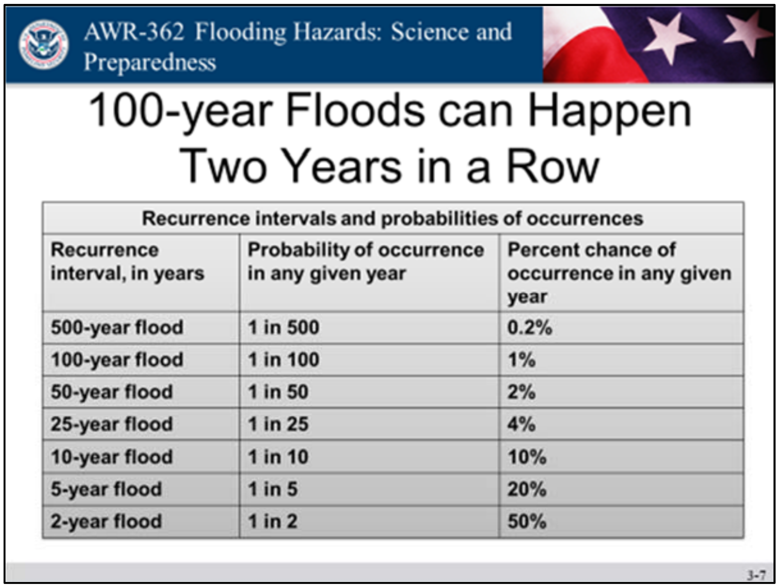
Slide 3-6. Return Period

What the “100 year” in the term “100-year flood” is actually referring to is a **return period**, or recurrence interval. The return period is an average rate of occurrence, which, ideally, would be determined by data taken over millennia in a stable climate. Since scientists do not have this kind of data, they work with the historical record, indicators of weather in the geologic record, computer simulations, and statistical methods to estimate the return period of precipitation events.

In the most basic terms, the return period is the number of years divided by the number of events. The recurrence interval is based on the probability that the given event will be equalled or exceeded in any given year. For example, assume there is a 1 in 50 chance that 6.60 inches of rain will fall in a certain area in a 24-hour period during any given year. Thus, a rainfall total of 6.60 inches in a consecutive 24-hour period is said to have a 50-year recurrence interval (USGS).

Participants can find a Flood Return Period Calculator online via the National Weather Service at https://www.weather.gov/epz/wxcalc_floodperiod.

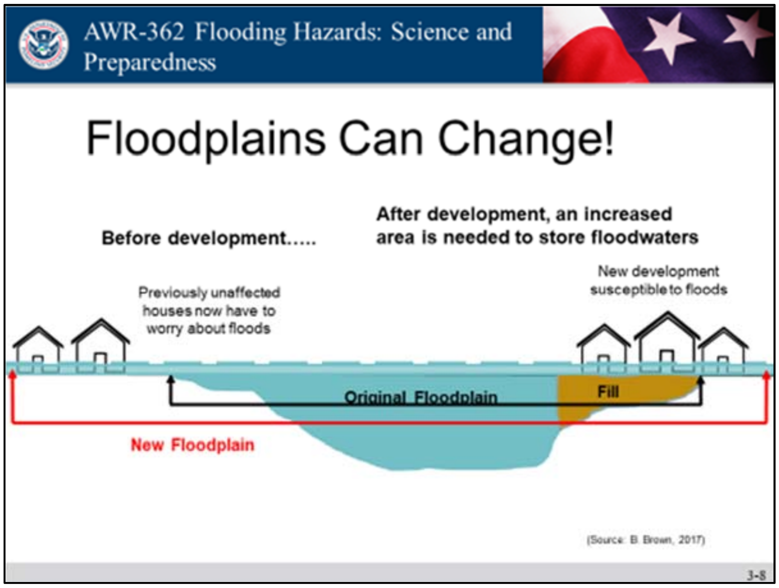
Participant Notes:



Slide 3-7. 100-Year Floods Can Happen Two Years in a Row

This table gives the equivalent annual percent chance and probability of occurrence in a given year for various return periods. For example, a 25-year flood has a 1 in 25 probability of occurring in any given year, for a 4% annual percent chance.

Participant Notes:



Slide 3-8. Floodplains Can Change!

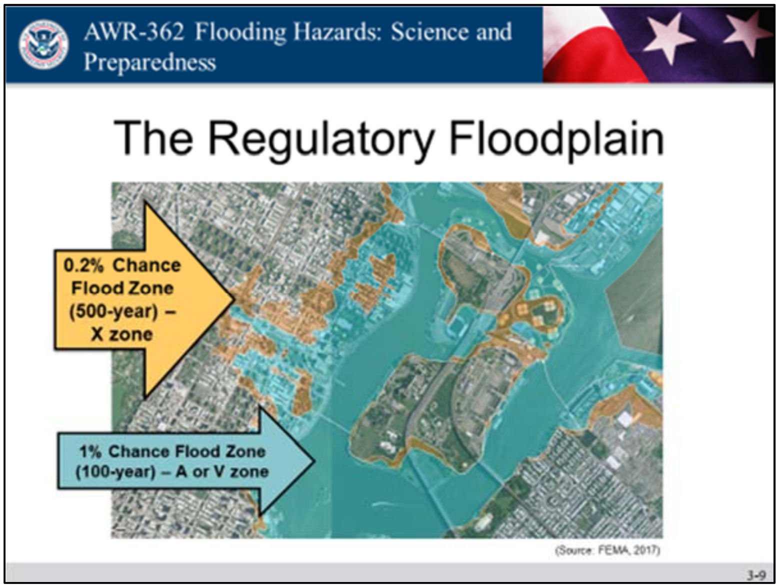
Floodplains – both natural and as mapped on flood insurance rate maps (FIRMs) – may change over time, either by natural processes (for example, river sediments feeding deltas, or sand being carried from one beach to another by tidal movement) or by human involvement, as shown in this graphic. The resulting change can affect properties that previously were not mapped in the floodplain.

FEMA has regulations regarding the use of fill in the regulatory floodplain:

> *"Earthen fill is sometimes placed in a Special Flood Hazard Area (SFHA) to reduce flood risk to the filled area. The placement of fill is considered development and will require a permit under applicable Federal, state and local laws, ordinances, and regulations. Fill is prohibited within the floodway unless it has been demonstrated that it will not result in any increase in flood levels. Some communities limit the use of fill in the flood fringe to protect storage capacity or require compensatory storage. The use of fill is prohibited for structural support of buildings in V Zones* (www.fema.gov)."

Mapped floodplains are based on our best knowledge of flooding in the area, but if we learn more about the probability of flooding in a particular location, the 100-year floodplain may change. As more data is collected, or when a river basin is altered in a way that affects the flow of water in the river, scientists re-evaluate the frequency of flooding. Dams and urban development are examples of some man-made changes in a basin that affect floods.

Participant Notes:

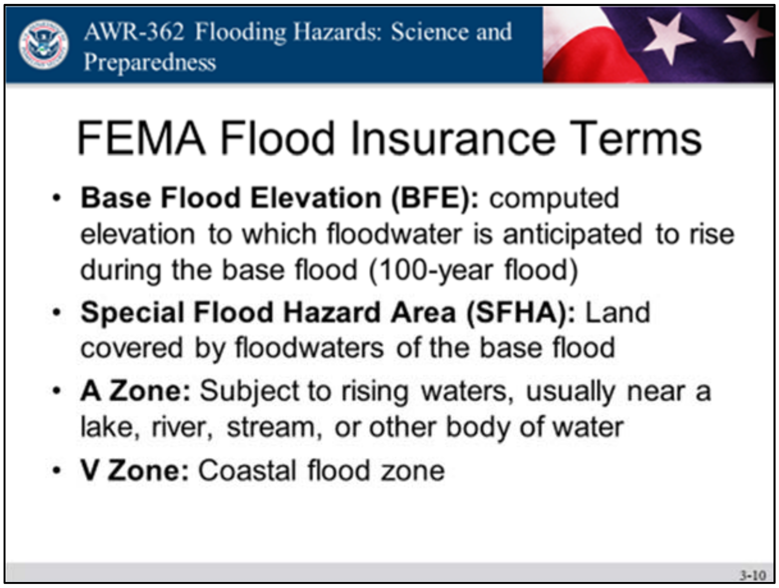


Slide 3-9. The Regulatory Floodplain

This slide shows an example of a FEMA Flood Insurance Rate Map, which insurance companies use to set flood insurance rates and determine eligibility. Importantly, FIRMs are publicly available and anyone can use them to determine where their local floodplain extends. Caution should be used when drawing conclusions from FIRMs, though, because, as discussed above, floodplains can easily change.

The teal overlay indicates the area that a 1% or 100-year flood would inundate. The yellow/orange overlay extends further – it shows the 0.2% flood area. It covers a larger area because a smaller probability indicates a more extreme flood. The floodplain boundaries delineate subdivisions of the floodplain such as the A, V, and X zones, which we will define next.

Participant Notes:



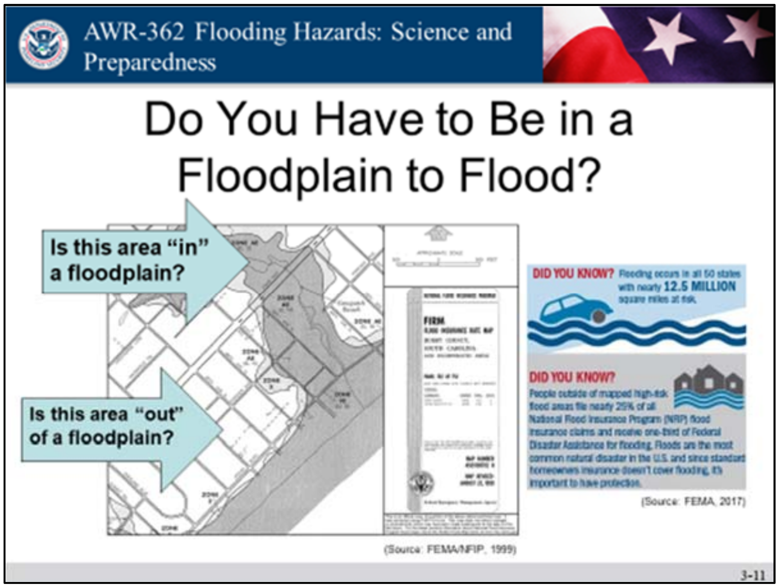
Slide 3-10. FEMA Flood Insurance Terms

Some terms need to be defined to understand what a FIRM shows. Now that we know what a 1% and 0.2% floodplain are and how they look on a map, we next need to define:

- **Base flood elevation (BFE):** this is the computed elevation to which floodwater is anticipated to rise during the base flood (a 100-year flood).
- **Special Flood Hazard Area (SFHA):** the land area covered by the floodwaters of the base flood.
- **A Zone:** subject to rising waters, usually near a lake, river, stream, or other body of water during the base flood; areas with a 1% annual chance of flooding (26% cumulative chance over a 30-year mortgage).
- **V Zone:** Analogous to the A Zone for coastal areas.

Because this is an awareness-level course, we will focus on risk analysis and hazard mitigation for A and V zones. Participants should note that the NFIP breaks each of these zones into further subdivisions. In addition, there are other zones with lower flood risk, such as **X Zone**, which denotes low- to moderate-risk areas sometimes within the 500-year floodplain.

Participant Notes:



Slide 3-11. Do You Have to Be in a Floodplain to Flood?

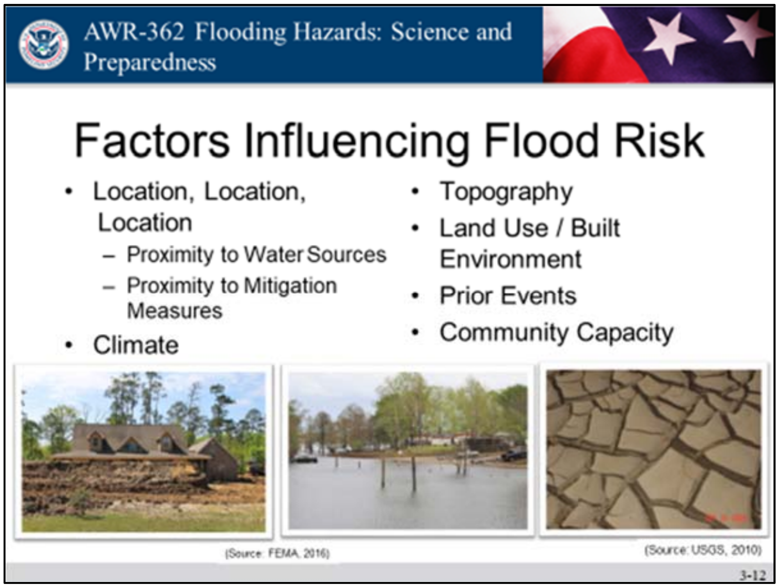
Do you have to be in a floodplain to flood? Short answer: **No!** Nearly a quarter of all claims submitted to the NFIP are for properties outside of a mapped high-risk zone (A and V zones).

This slide shows another example of a Flood Insurance Rate Map (FIRM) that lays out where the regulatory flood plain lies in a community.

There are four main types of flood zones delineated by the FIRM:

- Special Flood Hazard Areas (SFHA), High Risk – A zones;
- Coastal Special Flood Hazard Areas (SFHA), High Risk – V zones;
- Moderate- to Low-Risk Areas – B, C, and X zones; and
- Undetermined Risk Areas – D zones.

Participant Notes:



Slide 3-12. Factors Influencing Flood Risk

Many factors influence any given location's flood risk. These risk factors combine to produce events that are ultimately counted in the statistics and used in model simulations to determine return period. We will discuss each of these factors in the following slides.

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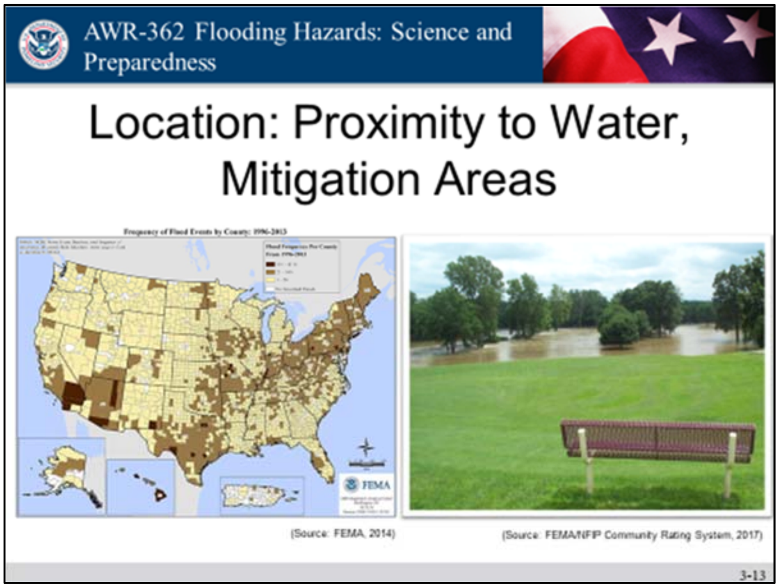


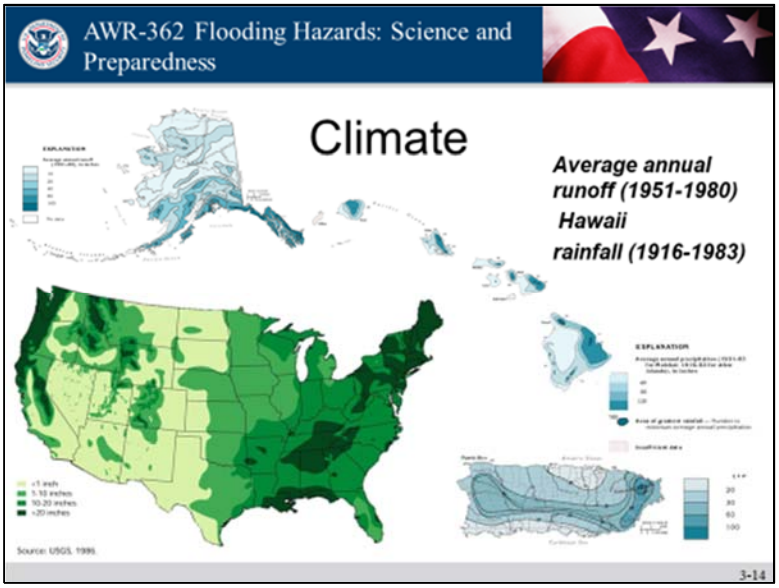
Slide 3-13. Location: Proximity to Water, Mitigation Areas

Probably the most direct factor is the proximity to a water body that is subject to flooding. The type of water body will also affect the type of flooding. For example, coastal areas are subject to flooding with wave action; river floods are subject to water speed; the Great Lakes are subject to their own tidal influence.

Understanding where mitigation areas exist is important, too – levees, dams, and seawalls provide additional flood protection when they work as intended, but can contribute to a flooding disaster if they fail. An open space such as a park or promenade may have been designed to absorb floodwaters – a sure sign that an area is prone to flooding.

e.g. **Example:** Levees constructed along the Mississippi River and Lake Pontchartrain were intended to protect the citizens of New Orleans from floods. When Hurricane Katrina hit New Orleans in 2005, many of the levees held and did their job. Property owners behind the 17th Street Canal levee, however, found themselves unprotected when the levee broke.

Participant Notes:

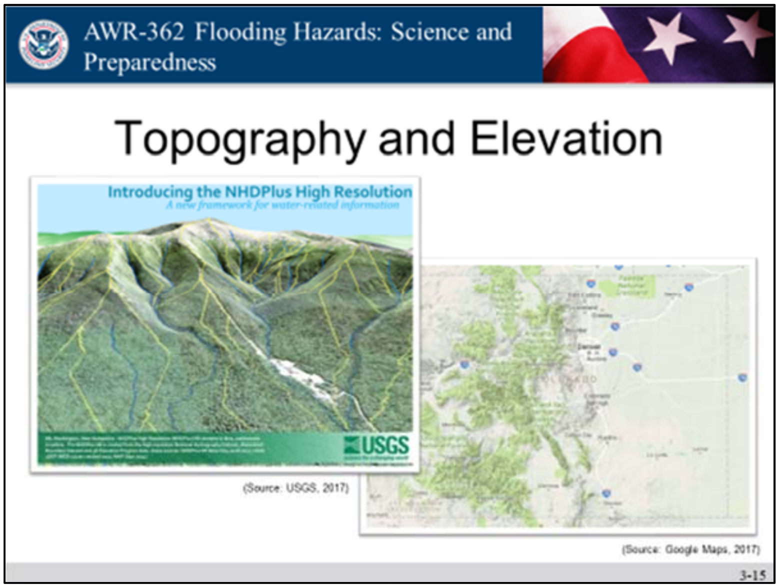


Slide 3-14. Climate

As discussed earlier in this module, climate determines the likelihood of extreme precipitation events over the long term for any given location. The map shown in the slide is an example of how climate can inform flood mitigation efforts. It shows the long-term average runoff for the United States (except Hawaii; here we show rainfall rather than runoff for that state). This can give planners an idea of the capacity needed when building sewers, culverts, etc. We see that the rainy Pacific Northwest receives a large amount of runoff, as does the subtropical Gulf of Mexico, whereas the plains states and the desert southwest can expect comparatively little runoff on average.

When climate changes, we can no longer expect past averages to reflect our future risk. Climate estimates must be continuously updated and scrutinized for changes or trends that might indicate that our expectations must be adjusted. This is a highly technical process, and best done by climate scientists. Most states in the nation have a state climatologist, an excellent resource for current and future climate estimates.

Participant Notes:



Slide 3-15. Topography and Elevation

The type and shape of the land around your community is another factor that affects your flood risk.

Water obeys the laws of gravity and tries to get to the lowest point possible. The area from the high point near your community to the low point where the water collects to go off to a common outlet is a ***watershed***.

If your community is at the base of a mountain, you are more susceptible to flooding from water sources that travel down the mountain through the watershed, enroute to the closest drainage area that takes the water to the ocean/gulf/bay.

Communities at high elevations are not immune to floods – they still pose risk as water passes through the system, and can create flooding hazards (such as mudslides) depending on community design and construction.

Some features shown on topographic maps that can affect flood risk include:

- Railroad beds (raised beds may act as a levee); and
- Strip mines (removing vegetation from land cover increases the speed and volume of floodwaters).

Soil types are also a consideration when discussing flood risk. Some soils are “thirsty” and hold water well; others are dry and resist absorbing water.

Participant Notes:

Slide 3-16. Land Use / Built Environment

The way communities build and use the land directly affects their flood risk.

Areas that are more densely populated require more infrastructure to serve the population. Roads and streets (impervious or pervious surfaces), storm water systems (open ditches, pipes, culverts, etc.), water and sewer lines, and protection measures are just a few parts of infrastructure that support a densely populated area.

Each of these have flood risk:

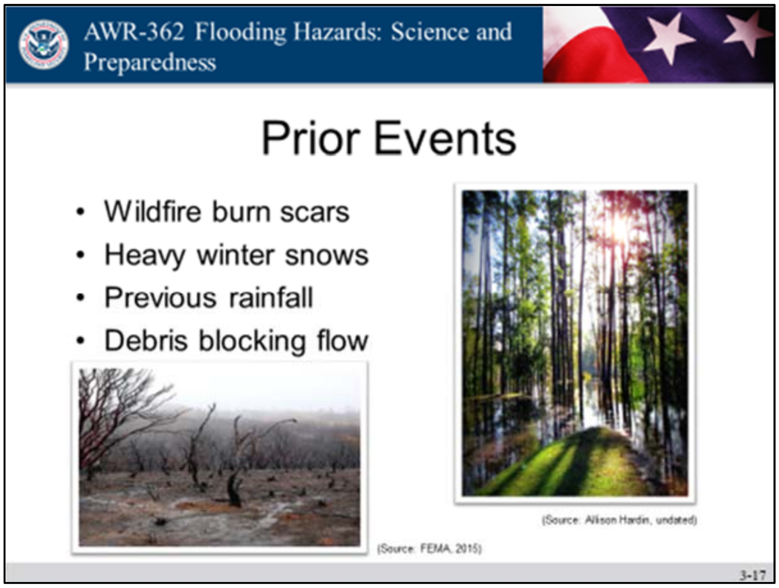
- Streets of asphalt or concrete serve as “speedways” for water delivery. Water runs over these impervious surfaces much faster than it does over grass or pervious surfaces, such as gravel. As water speeds up, so does the potential for flooding.
- Storm water systems are designed to handle runoff from streets, roads, parking lots, and other surfaces. The system should have mechanisms built in to filter sediment and pollutants before the stormwater is discharged into a receiving body of water. These mechanisms – culverts, riprap, sand traps, etc. – have the potential to clog up if not routinely cleaned. A clogged filtering mechanism can act as a dam, causing flooding upstream.
- Water and sewer lines are typically placed underground near roadways, at times along and across ditches that hold storm water. Water and sewer line work in some dense areas involves going beneath the road via manholes. During floods, these service corridors can flood and cause damage to the water and sewer system, which impacts public health.

Participant Notes:

- Protection measures installed by communities to hold water away from the built environment are often used as a long-term solution. If not designed well or inadequately constructed, the long-term protection may be affected by repeat storms.

Of course, any infrastructure must also be maintained properly in order to function correctly. To avoid inadvertently creating a flooding hazard, community capacity must exist. **Community capacity** refers to the manpower, equipment, and other resources beyond infrastructure.

Participant Notes:



Slide 3-17. Prior Events

No flood happens in a vacuum. A community must always be aware of current conditions created by prior environmental events, which may influence future flooding.

Burn scars from wildfires become devoid of trees and brush, unable to hold soil in place when it rains. Erosion and debris can increase the destruction of a flood, damaging or destroying culverts, bridges, roadways, and buildings miles away from the burn scar. Because burn scars cannot absorb rainwater as efficiently as foliated areas, they are also at increased danger of flash flooding.

Debris itself can be an additional risk factor for flooding as it can act like an ice jam (discussed in Module 2) and back up water, or collapse and release stored water.

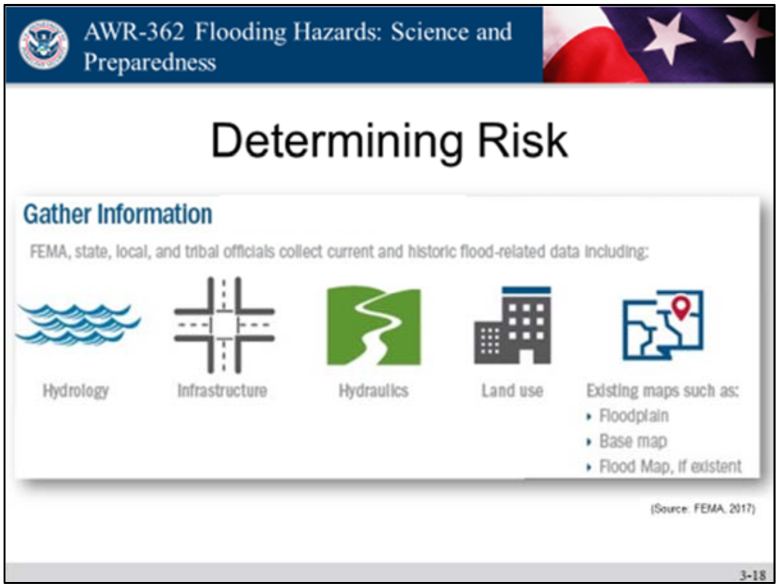
Heavy winter snows can result in greater than normal snowmelt in the springtime, which can be accelerated by spring rains falling on and melting snow.

Previous rainfall can saturate the soil such that rain from succeeding storms cannot be absorbed into the ground. If your community has experienced multiple rainfall events, the ground in your area can only hold so much water at a time. In coastal communities, for example, a tropical storm will have a much bigger effect on the area if there were multiple rainstorms. Such storms may have shortened the amount of time the ground had available to process the rainwater through the water system

Participant Notes:

(evaporation, absorption by vegetation, and recharging groundwater/ aquifers). Conversely, in an arid region with very dry and hydrophobic soils, the lack of a rainfall to soften the ground can result in rainfall traveling over the ground as if it were concrete.

Participant Notes:



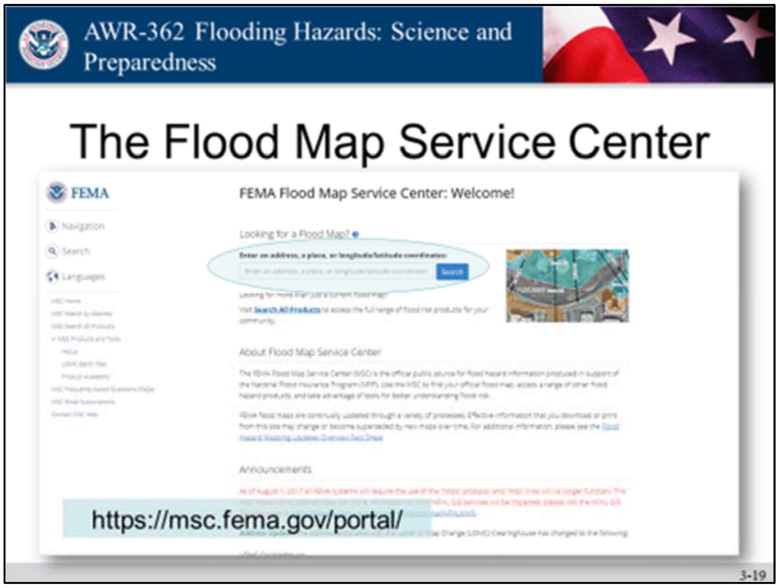
Slide 3-18. Determining Risk

All of the factors just discussed combine to determine a community's flood risk. In *Understanding Your Risks*, FEMA identifies a four-step process to risk assessment:

1. Identify hazards – which hazards might impact your community?
2. Profile hazard events – how bad can it get?
3. Inventory assets – which community assets will be affected by the hazards?
4. Estimate losses – what are the costs associated with the impacts?

The hazard assessment is conducted first because the community needs to understand what hazards are present and what areas may be impacted by a hazard before it can consider what assets (buildings, structures, services, and people) are exposed and sensitive to the hazard(s). The outcome of considering hazards and vulnerability measures the potential loss of life, personal injury, economic injury, service impacts, and property damage resulting from natural hazards.

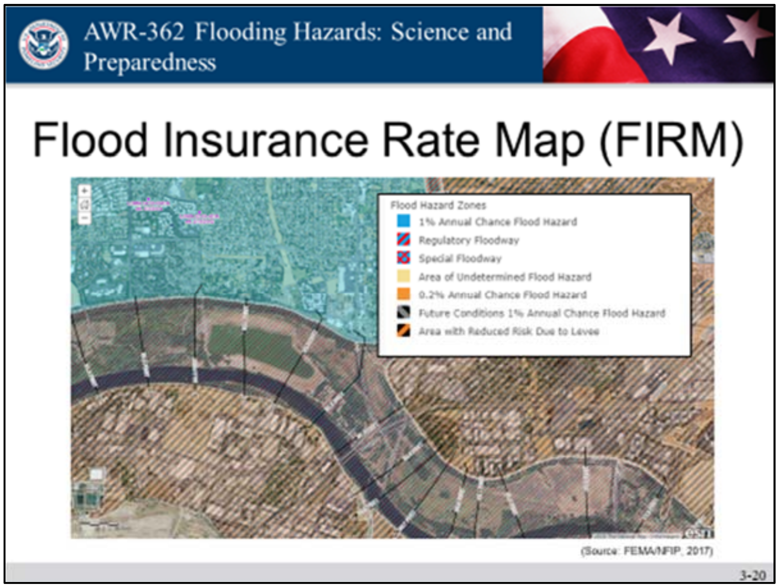
Participant Notes:



Slide 3-19. The Flood Map Service Center

The result of the science and statistics that go into determining flood risk is available to the public. The FEMA Flood Map Service Center is an online portal that allows the user to input their location and obtain the FIRM for a desired area. The Map Service Center offers both static and interactive maps, which can be used in geographical information systems software.

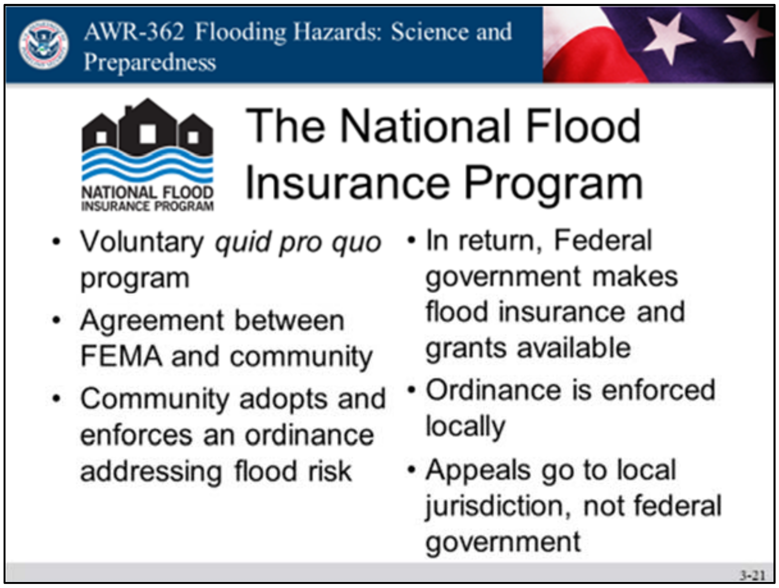
Participant Notes:



Slide 3-20. Flood Insurance Rate Map (FIRM)

Shown on the slide is an example of the interactive FIRM for a location in Sacramento, California. Using the legend, participants can identify areas in the regulatory floodway (Sacramento River and adjacent land). Bordering the floodway to the north is an area of 1% annual chance of flooding in teal, and to the south and northeast are areas hatched with orange, indicating areas with reduced risk due to levees. The legend indicates other categories that might be seen on a FIRM: special floodway, area of undetermined flood hazard, 0.2% annual chance of flood hazard, and future conditions 1% annual flood hazard.

Participant Notes:



Slide 3-21. The National Flood Insurance Program

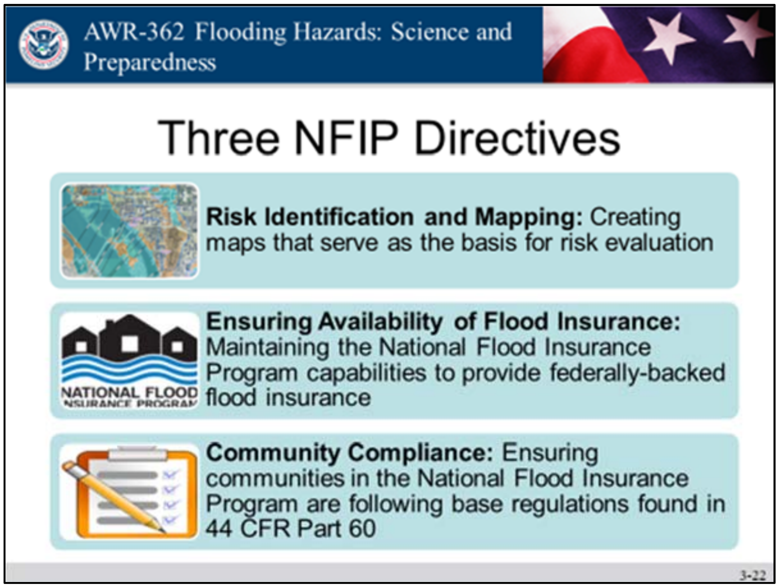
The goal of the National Flood Insurance Program is to reduce the impact of flooding on private and public structures. It does so by providing affordable insurance to property owners and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on new and improved structures. Overall, the program reduces the socio-economic impact of disasters by promoting the purchase and retention of risk insurance in general, and flood insurance specifically.

The program is voluntary, and requires communities to apply to join the program. In exchange for adopting and enforcing the minimum requirements of 44.CFR.60 (the Code of Federal Regulations) and its subsets, residents of the community may apply for and receive federally-backed flood insurance (which is less expensive than private flood insurance, when private flood insurance is offered at all).

The ordinance adopted by the community becomes local law, and must be enforced by the local jurisdiction, or by a contractor on their behalf. Any appeals to the ordinance go through the local ordinance appeal process and do not go to federal courts. Once the community adopts the FIRM and its ordinance, it is not a "FEMA rule," it becomes a local one.

The NFIP is administered by FEMA, which is part of the Department of Homeland Security (DHS).

Participant Notes:



Slide 3-22. Three NFIP Directives

FEMA's written resources explain the following about the three directives of the NFIP:

Risk Identification and Mapping
Through FEMA's flood hazard mapping program, Risk Mapping, Assessment and Planning (MAP), FEMA identifies flood hazards, assesses flood risks, and partners with states and communities to provide accurate flood hazard and risk data to guide them to mitigation actions. Flood hazard mapping is an important part of the National Flood Insurance Program (NFIP), as it is the basis of the NFIP regulations and flood insurance requirements. FEMA maintains and updates data through Flood Insurance Rate Maps (FIRMs) and risk assessments. FIRMs include statistical information such as data for river flow, storm tides, hydrologic/hydraulic analyses and rainfall and topographic surveys. FEMA uses the best available technical data to create the flood hazard maps that outline your community's flood risk areas (https://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping).

Ensuring Availability of Flood Insurance
In order to help alleviate the financial devastation caused by flooding, Congress created the National Flood Insurance Program (NFIP) in 1968. The NFIP, overseen by the Federal Emergency Management Agency (FEMA), enables homeowners, business owners, and renters in participating communities to purchase federally backed flood insurance. This insurance is designed to provide an alternative to disaster assistance to meet the escalating costs of repairing flood damage to buildings and their contents.

Participant Notes:

You can get flood insurance:

- *If you live or own a business in a high-risk area (or Special Flood Hazard Area, known as an SFHA).*
- *If you live or own a business in a moderate- to low-risk area—and possibly at a lower cost.*
- *If your home or business has been flooded before.*
- *If your mortgage company does not require it.*

(https://www.fema.gov/media-library-data/1427811288492-36fb55e74d14c318db2996580527d131/Flood_Insurance_How_It_Works.pdf)

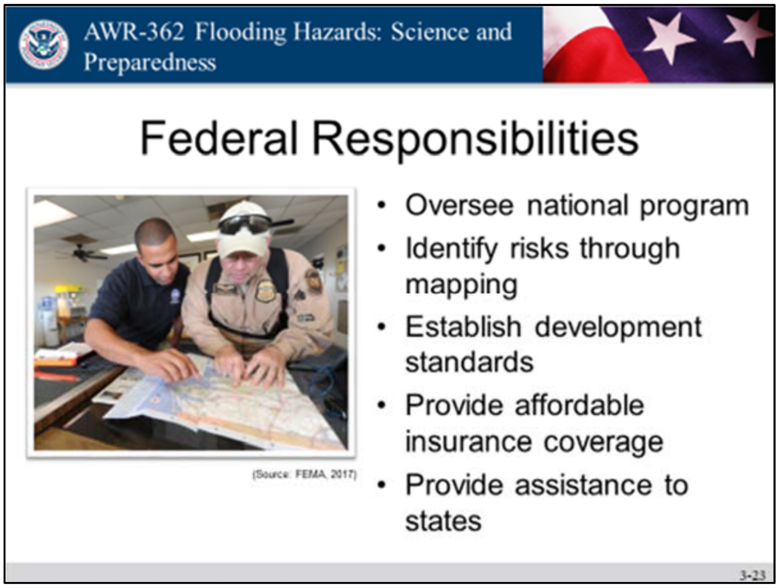
Community Compliance

The National Flood Insurance Act of 1968 prohibits the Federal Emergency Management Agency (FEMA) from providing flood insurance in a community unless that community adopts and enforces floodplain management regulations that meet minimum National Flood Insurance Program (NFIP) criteria.

When administrative problems or potential violations are identified in a community, FEMA is committed to working with that community and providing technical assistance to help them bring their floodplain management programs into compliance with NFIP requirements. In those cases where the community does not take action to become compliant, FEMA implements its Community Compliance Program.

The Community Compliance Program builds on the basic probation and suspension procedures in Section 59.24 (b) and (c) and provides an orderly sequence of enforcement options of varying severity. If all attempts at obtaining community compliance are to no avail, communities will become subject to suspension from the NFIP. The availability of two separate sets of enforcement options -- one for communities and one for individuals and structures -- helps FEMA ensure that NFIP enforcement actions are targeted to the responsible party (https://www.fema.gov/community-compliance-program).

Participant Notes:



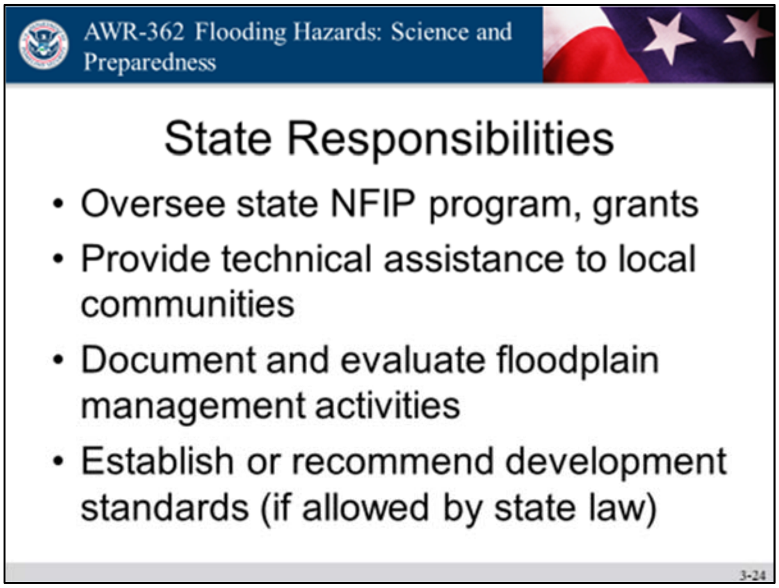
Slide 3-23. Federal Responsibilities

The following descriptions of the Federal, state, and local responsibilities in the NFIP are taken from the second chapter of the FEMA publication "SI/SD Desk Reference" entitled "The NFIP: Roles and Responsibilities" (https://www.fema.gov/media-library-data/20130726-1734-25045-8378/p758_ch2_r2.pdf).

FEMA is charged with managing the NFIP. Regional offices serve as points of contact for state officers, and provide input on mapping, standards, and compliance actions by the states. The federal offices participate in discussions with Congress and the Executive Branch on issues relating to flood insurance rates and developing national standards.

Federal flood insurance is designed to provide an alternative to disaster assistance and disaster loans for home and business owners. Disaster assistance rarely comes close to covering all of the costs to repair and clean up. While available to qualified victims, disaster loans do not significantly ease the financial burden due to repayment terms. It is important to remember that disaster assistance is available only after floods have been declared major disasters by the President of the United States. In contrast, flood insurance claims will be paid any time damage from a qualifying flood event occurs.

Participant Notes:



Slide 3-24. State Responsibilities

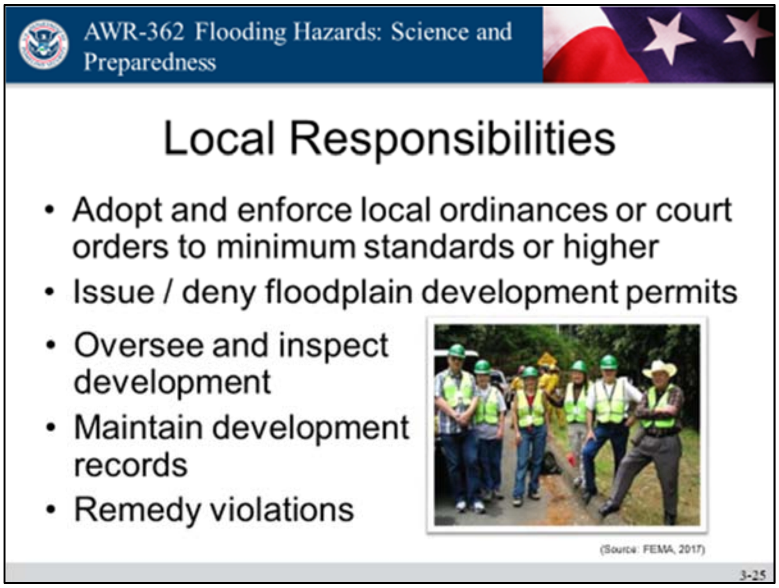
Each state's governor has designated an NFIP State Coordinating Agency. This agency is specifically charged with being a link between Federal, state, and local governments. The NFIP State Coordinator stays current on NFIP issues and can advise communities on specific provisions and any state requirements.

While the explicit role of the NFIP State Coordinator may vary among states, the NFIP regulations [44 CFR § 60.25] outline the following key responsibilities:

- Encourage and provide assistance for communities to qualify for participation in the NFIP;
- Guide and assist communities to develop, implement, and maintain floodplain management regulations;
- Provide technical assistance to communities; and
- Participate in training opportunities.

Some states have their own floodplain management statutes and regulations, and some administer regulatory programs pertaining to flood hazards. State requirements related to work on existing buildings must be satisfied in addition to local requirements.

Participant Notes:



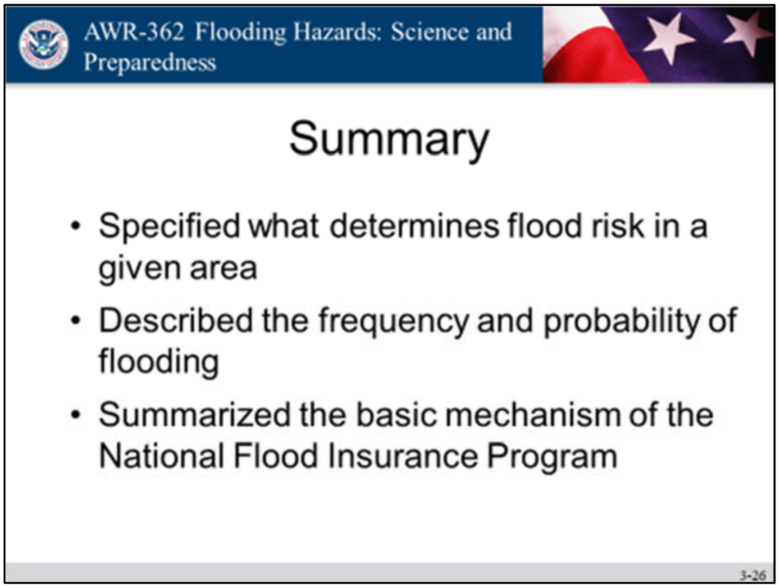
Slide 3-25. Local Responsibilities

The NFIP regulations outline responsibilities that communities must accept in order to become and remain eligible to participate in the NFIP.

The key responsibilities listed in the CFR include:

- Designate an agency that is charged with the responsibility to administer floodplain management requirements;
- Determine whether proposed development activities are located in SFHAs;
- Review development proposals to ensure compliance with the requirements of applicable floodplain management regulations and building codes;
- Require that new subdivisions and development proposals with more than 50 lots or larger than five acres include BFEs;
- Issue or deny permits for floodplain development;
- Inspect all development in SFHAs to ensure compliance;
- Maintain records of issued permits, elevation data, inspections, and enforcement actions;
- Assist in the preparation and revision of floodplain maps; and
- Help residents obtain information on flood hazards, floodplain map data, and compliant construction measures.

Participant Notes:



Slide 3-26. Summary

In this module, we learned about the factors that influence flood risk, defined return period, and summarized the basic mechanism of the National Flood Insurance Program.

AWR-362
Flooding Hazards: Science and Preparedness

Module 4: Flood Forecasting and Public Information

Version 1.0

FEMA

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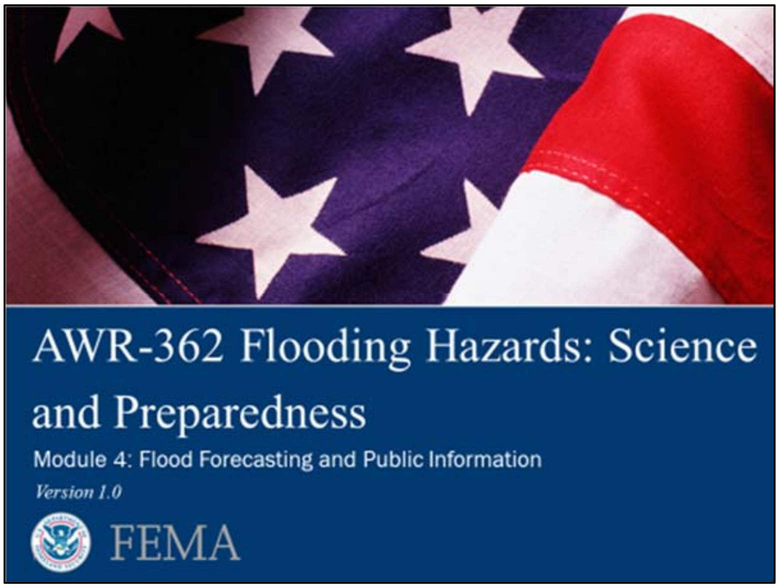
Module 4: Flood Forecasting and Public Information – Administration Page



Slide 4-1. Flood Forecasting and Public Information

Duration

105 minutes

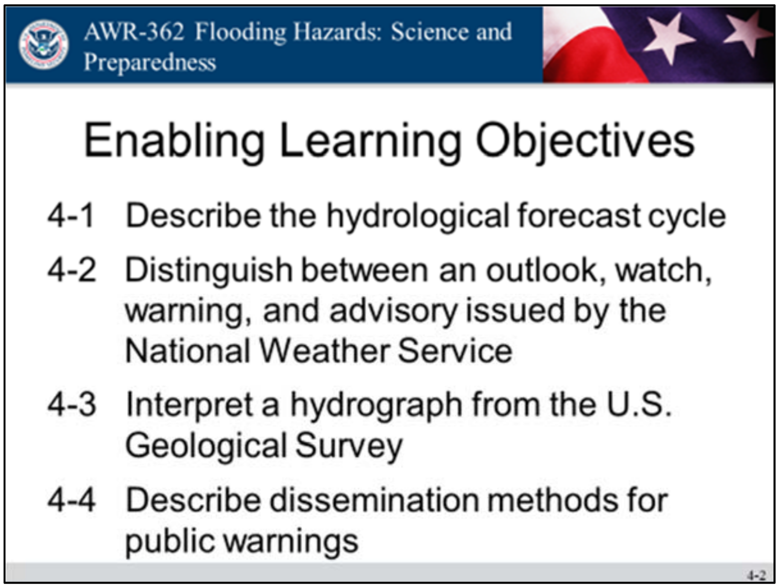
Scope Statement

This module introduces participants to the government agencies that forecast weather and other events that contribute to flooding, monitor the nation's rivers and streams, and issue public warnings. Participants will learn where to find various forecast and warning products, how to interpret them, how they are distributed to the public, and their relative urgency.

Terminal Learning Objective (TLO)

Participants will be able to identify organizations involved in forecasting and monitoring flooding, and understand the products they issue.

Enabling Learning Objectives (ELO)



Slide 4-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

4-1 Describe the hydrological forecast cycle;
4-2 Distinguish between an outlook, watch, warning, and advisory issued by the National Weather Service;
4-3 Interpret a hydrograph from the U.S. Geological Survey; and
4-4 Describe dissemination methods for public warnings.

Resources

- Instructor Guide (IG)
- Module 4 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handout

Instructor to Participant Ratio

2:40

Reference List

Federal Emergency Management Agency (FEMA). 2016. “Disaster Reporter Data.” https://www.fema.gov/disaster-reporter-data

National Oceanic and Atmospheric Administration (NOAA). 2011. “Weather Forecast Office Hydrologic Products Specifications.” http://www.nws.noaa.gov/directives/sym/pd01009022curr.pdf

NOAA. 2014. “WPC Center Overview.” http://www.wpc.ncep.noaa.gov/html/WPC_Overview_2014.pdf

NOAA. 2015. “An Overview of Operations at the West Gulf River Forecast Center.” http://ispuw.uta.edu/nsf/downloads/2015_Workshop/Greg_Waller1.pdf

NOAA. 2016. “August 2016 Record Flooding.” http://www.weather.gov/lix/August2016flood

NOAA. 2017. “Advanced Hydrologic Prediction System.” Retrieved 2017. https://water.weather.gov/ahps/

NOAA. 2017. “Lansing Record Rainfall and Flood, August 10, 2015.” https://www.weather.gov/grr/LansingRecordRainfall10Aug2015

NOAA. 2017. “National Weather Service Organization.” Retrieved 2017. https://www.weather.gov/organization/

NOAA. 2017. “NEXRAD and TDWR Radar Locations.” Retrieved 2017. https://www.roc.noaa.gov/WSR88D/Maps.aspx

NOAA. 2017. “Radar Operations Center Applications Branch.” Retrieved 2017. https://www.roc.noaa.gov/WSR88D/Applications/Applications.aspx

NOAA. 2017. “Storm Surge Overview.” Retrieved 2017. http://www.nhc.noaa.gov/surge/

Practical Exercise Statement

Using the 2016 floods in Baton Rouge, LA, as a case study, the practical exercise consists of receiving and interpreting a series of escalating watches/warnings in a flood scenario. This exercise allows participants to interpret flood insurance risk maps (FIRMs), read and interpret the language and graphics of forecasts from the National Weather Service, recognize outlooks, watches, and warnings, and read a hydrograph.

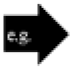
Assessment Strategy

- Instructor observation of participant involvement in classroom discussion
- Instructor-led discussion to gauge participant grasp of the subject matter
- Instructor observation of participant involvement in practical exercise

Flooding Hazards: Science and Preparedness

Icon Map

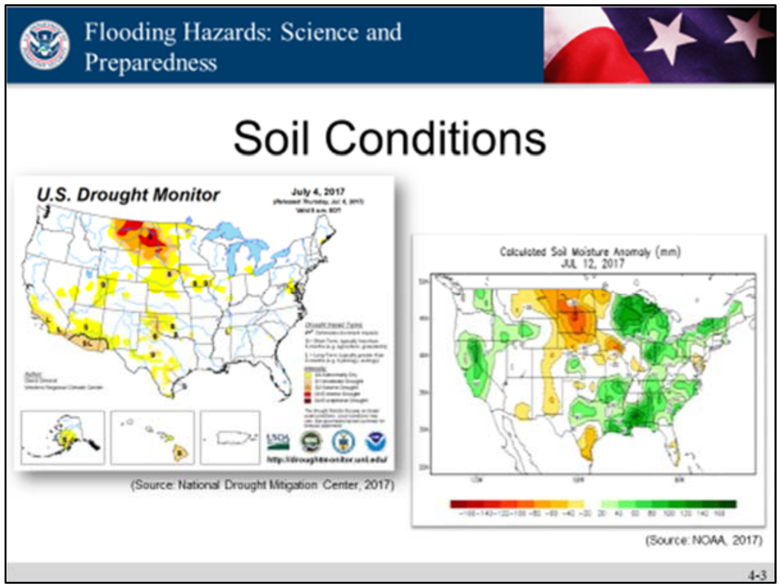

Knowledge Check: Used when it is time to assess participant understanding.


Example: Used when there is a descriptive illustration to show or explain.


Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.


Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:



Slide 4-3. Soil Conditions

The United States maintains numerous networks that continuously measure soil moisture and soil temperature. NOAA operates the Climate Reference Network (CRN) that has 114 stations at 107 locations across the contiguous U.S. and 16 in Alaska, Hawaii, and Canada. The Natural Resources Conservation Service (NRCS) has managed the Soil Climate Analysis Network (SCAN) since 1991 and has 200 stations across the U.S. and in Puerto Rico and U.S. Virgin Islands. Many states, including Oklahoma, Nebraska, and parts of Texas, operate mesonet systems that provide extensive measurements within their states.

Another system used to gauge ground conditions is the U.S. Drought Monitor, shown on the left. This system, established in 1999, is a weekly map of drought conditions that is produced jointly by the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture, and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln. The NDMC hosts and maintains the U.S. Drought Monitor website.

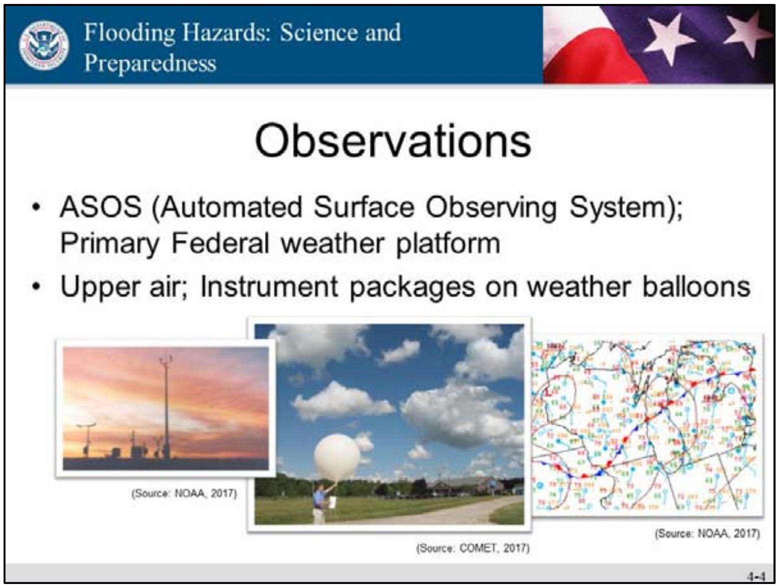
U.S. Drought Monitor maps come out every Thursday morning at 8:30 Eastern Time, based on data through 7am Eastern Standard Time (8am Eastern Daylight Time) the preceding Tuesday.

Participant Notes:

The map is based on measurements of climatic, hydrologic, and soil conditions as well as reported impacts and observations from more than 350 contributors around the country. Eleven climatologists from the partner organizations take turns serving as the lead author each week. The authors examine all the data and use their best judgment to reconcile any differences in what different sources are saying.

e.g. **Example:** The image on the right shows whether soil moisture on the observation date was drier than normal (red), near normal (white), or wetter than normal (green). That information can be useful for runoff forecasting and used when considering winter snowmelt.

Participant Notes:



Slide 4-4. Observations

The Automated Surface Observing System (ASOS) is a collection of weather instruments installed at over 900 airports around the country. Supported by the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of the Defense (DoD), this network of automatic weather sensors collects important data on the changing weather conditions at the ground level around the country around the clock.

ASOS stations collect various types of data including the following:

- Sky conditions (cloud height/amount);
- Surface visibility and obstructions;
- Type of, intensity, and/or accumulated precipitation;
- Sea-level pressure;
- Temperature and dew point temperature;
- Wind direction and speed including gusts; and
- Significant weather changes.

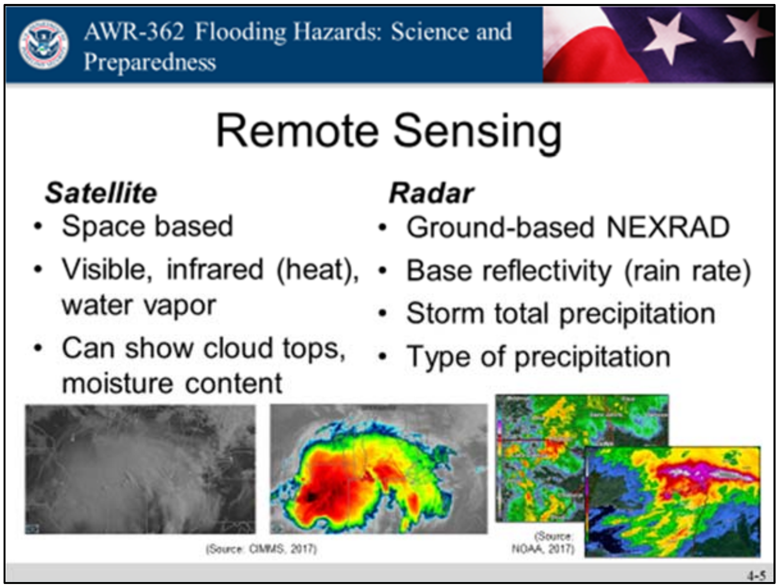
Because of the limited point data that ASOS provides, human observations (e.g., sky conditions) can also be a useful supplement. Some states have also installed Automated Weather Observing System (AWOS) mesonets that provide greater spatial resolution of surface weather data. In addition to the land-based ASOS stations, the NOAA National Data Buoy Center http://www.ndbc.noaa.gov also maintains a network of sea-based weather sensors (buoys), which collect crucial weather and ocean data along the U.S. coastlines including the Great Lakes.

Participant Notes:

Given that the atmosphere is three-dimensional, in addition to surface weather observations, it is also important to observe atmospheric variables in the upper atmosphere. Meteorologists use weather balloons launched around the world at coordinated times (00Z and 12Z) to observe the state of the atmosphere above ground. Data is collected via a radiosonde that is attached to the weather balloon, and transmitted back to the ground via a transmitter. Important data such as barometric pressure, altitude, position, wind direction/magnitude, air temperature, and relative humidity are collected by these systems.

Participant Note: “Z” time refers to “Zulu” time, also known as “Universal Time Coordinated” (UTC) and “Greenwich Mean Time” (GMT). 12Z is 7am Eastern Standard Time, 8am Eastern Daylight Time; 12Z is 4am Pacific Standard Time or 5am Pacific Daylight Time. Find a conversion table at: https://www.ready.noaa.gov/READYtime.php.

Participant Notes:



Slide 4-5. Remote Sensing

The main meteorological satellite used for observations and forecasting is known as the “geostationary satellite.” Orbiting at an altitude of 22,236 miles (35,786 km), this type of satellite is able to travel at the same radial velocity as the earth, completing one orbit at the same time as the planet. As a result, geostationary satellites remain fixed at a location above the earth’s equator, standing constant watch over half of the earth’s surface. Because the relative position is fixed, these satellites can take a snapshot of the cloud patterns every few minutes, which can be useful to understand the changing weather. The U.S. operates two main Geostationary Operational Environmental Satellites (GOES) called GOES-EAST and GOES-WEST, giving each half of the country and nearby oceans overlapping coverage.

e.g. **Example:** This particular set of imagery tracks a Mesoscale Convective System (MCS) moving through the southern Great Lakes in July 2017.

Multiple instruments on board weather satellites give us different views of the atmosphere from above. **Visible (VIS)** satellite imagery measures the same wavelengths of light as our eyes see, so they appear as if an image has been taken with a camera from space. Because there is no visible light at night, visible satellite imagery is only available during the day.

Participant Notes:

Infrared (IR), on the other hand, detects heat – much like night vision technology. Because the atmosphere cools with height, cold, towering cloud tops can be distinguished from the relatively warm ground in infrared imagery.

Water vapor (WV) imagery is a special type of infrared detection that identifies water vapor in the atmosphere, showing us where concentrations of moisture are when clouds are not evident.

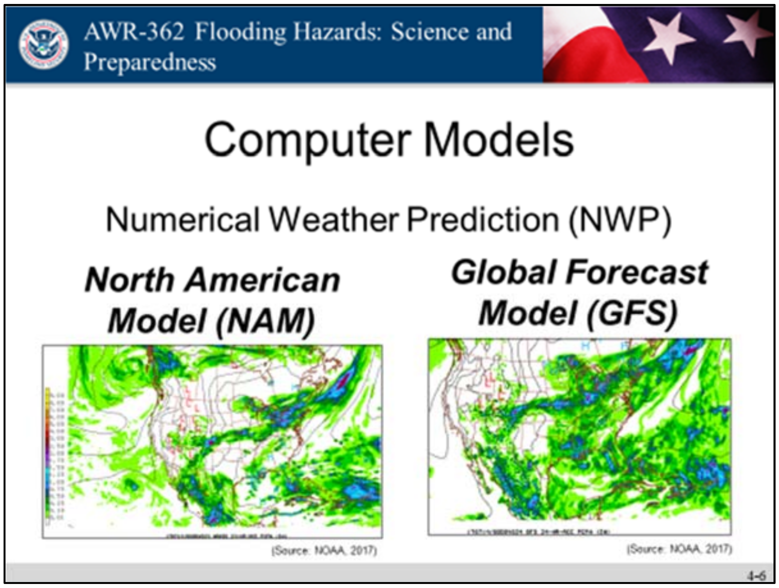
Radar is the other indispensable tool in meteorologists' remote sensing arsenal. Radar sends electromagnetic waves into the atmosphere and detects how much energy it receives back from those waves bouncing off objects. Weather radar is calibrated to detect precipitation. While radar can be space- and aircraft-based, the most important radar products are from ground-based networks.

Here in the United States, the workhorse network is called the NEXRAD WSR-88D, which stands for NEXt-generation RADar Weather Surveillance Radar 1988 Doppler. The Doppler Effect measures the change in frequency of energy as the source moves toward or away from the observer – this effect is responsible for the change in pitch of an ambulance siren as it drives past you. With Doppler, as well as other innovations, WSR-88D radars allow meteorologists to determine the amount and type of precipitation in storms, as well as the movement of storms.

Participant Note: Radar and satellite technology are some of the most advanced innovations that meteorologists have at their disposal. Though imagery is popular on TV newscasts and freely available for the most part, remember that you should leave the interpretation of these complex products to experts.

Key Point: Even though radar is an indispensable tool in severe weather detection, it is not without its limitations. There are gaps in coverage, particularly in the mountainous regions of the western U.S. Given that radar beams angle slightly above the horizon, and the earth curves away from the radar site, it is difficult to detect the precipitation and wind occurring at the base of thunderstorms where tornadoes affect people. Finally, radar ranges do not extend far beyond the U.S. coastline, so storm systems such as tropical cyclones are not detectable by radar until they approach land.

Participant Notes:



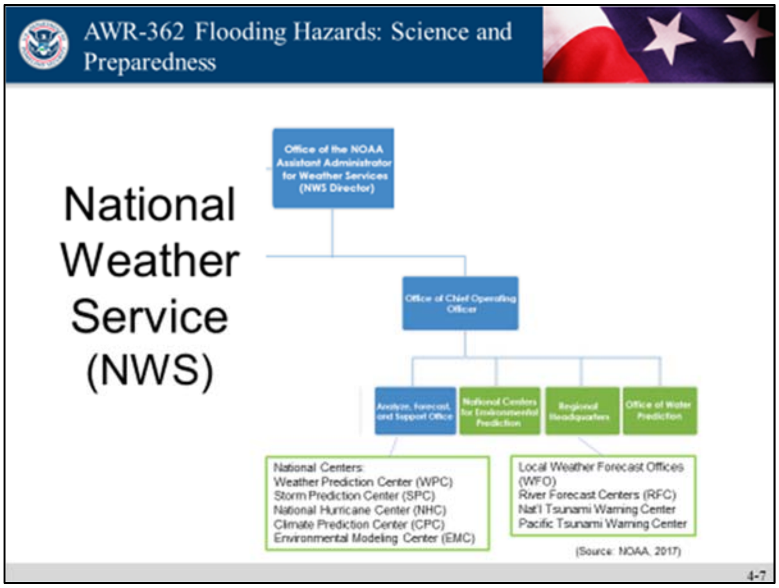
Slide 4-6. Computer Models

Numerical weather prediction (NWP) is performed using some of the world's most powerful computers. These computers consist of hundreds and thousands of parallel processors, each sharing the task of performing numerous calculations based on the differential equations that describe the atmosphere at grid points on the earth. Because models require so much computer power, many are only run two to four times per day. They also cannot represent every point on the globe. Models rely on all the same observations that forecasters use – since we cannot perfectly observe the atmosphere, models are imperfect as well.

Numerical Weather Prediction models are incredibly complex. Specialized training and education, as well as on-the-job experience, is required for forecasters to understand the behavior of models and differentiate from other models. Though they provide an amazing window into the future, models are far from infallible. It is the forecaster's job to consider possible model errors. The public is discouraged from trying to make their own interpretations of model output.

The left image is an example of the North American Model (NAM) prediction for surface pressure and 24-hour precipitation valid from 00Z July 13, 2017, through 00Z July 14, 2017. That would be 8pm EDT July 12th through 8pm EDT July 13th. The image on the right is the same forecast for the same period, made by the Global Forecast System (GFS). Note that while they show broad similarities, they disagree on the details of the forecast.

Participant Notes:



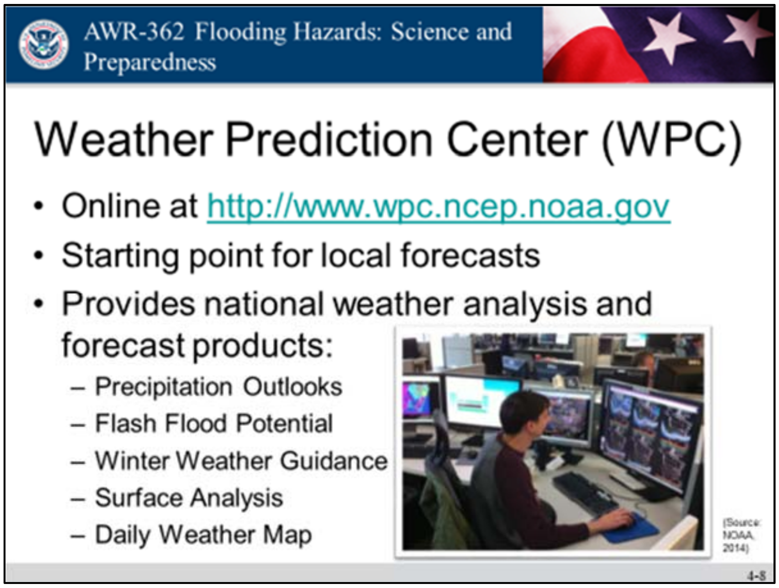
Slide 4-7. National Weather Service (NWS)

Founded in 1870 as the Weather Bureau, today the National Weather Service (NWS) is part of the National Oceanic and Atmospheric Administration (NOAA), which is located within the U.S. Department of Commerce.

By law, the NWS provides official weather forecasts and warnings (excerpted from 15 USC 313 “The Organic Act”):

Sec. 313. Duties of Secretary of Commerce
The Secretary of Commerce shall have charge of the forecasting of weather, issue of storm warnings, display of weather and flood signals for the benefit of agriculture, commerce, and navigation, gauging and reporting of rivers, maintenance and operation of seacoast telegraph lines and collection and transmission of marine intelligence for the benefit of commerce and navigation, reporting of temperature and rain-fall conditions for the cotton interests, display of frost and cold-wave signals, distribution of meteorological information in the interests of agriculture and commerce, and taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties.

Participant Notes:



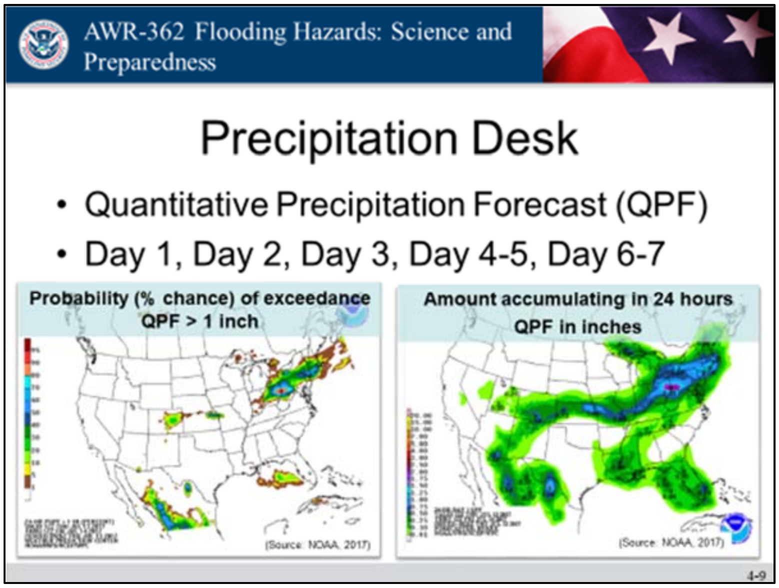
Slide 4-8. Weather Prediction Center (WPC)

The Weather Prediction Center (WPC) is one of nine centers of the National Centers for Environmental Prediction (NCEP). WPC is a leader in the collaborative weather forecast process, delivering responsive, accurate, and reliable national forecasts and analyses. WPC serves as a center of excellence in quantitative precipitation forecasting, medium-range forecasting (three to eight days), the interpretation of numerical weather prediction models, and in surface analysis. WPC's vision is to be America's center for high-impact precipitation events and forecast guidance out to 14 days for a Weather Ready Nation.

Originally created in 1942 as the Weather Bureau Analysis Center, the center was renamed the Weather Prediction Center (WPC) on March 5, 2013 (the unit's 71st birthday.) The new name better reflects the diverse mission of the organization and provides a clearer name for the center.

This diverse mission includes quantitative precipitation forecasts, short- and medium-range forecast graphics and discussions, winter weather products, surface analyses and more. NWS Weather Forecast Offices and River Forecast Centers, private sector forecasters, the media, the academic community, and the general public all rely on products produced by the center.

Participant Notes:



Slide 4-9. Precipitation Desk

Quantitative Precipitation Forecasts (QPF)

The QPF (“precipitation”) desk of the WPC prepares and issues forecasts of accumulating (quantitative) precipitation, heavy rain, heavy snow, and highlights areas with the potential for flash flooding. The basic QPF products are primarily directed to the NWS forecast offices but are available on the Internet for public use. Through a continuous watch for excessive rainfall, heavy snow, and winter storms, this desk ensures that the highest quality forecast products are constantly available.

The QPF desk is co-located with the National Environmental Satellite Data and Information Service (NESDIS), and together they comprise the National Precipitation Prediction Unit (NPPU). NESDIS meteorologists prepare estimates of rainfall and current trends based on satellite data, and the QPF short-term forecaster combines the satellite estimate with numerous other guidance sources as part of the input for individual six-hourly forecasts that cover the next 12 hours.

Precipitation forecasts can come in two different forms. The first is probability of QPF exceedance (PQPF); that is, the percent chance that rainfall accumulation within a given time period will exceed a given threshold. The left-hand image shows PQPF of one inch or greater over 24 hours. Rather than a chance of exceedance, one can also view forecasts of the specific amount forecast to accumulate, the QPF. The right-hand image shows the amount in inches that is forecast to accumulate over 24 hours for the same period as the PQPF image.

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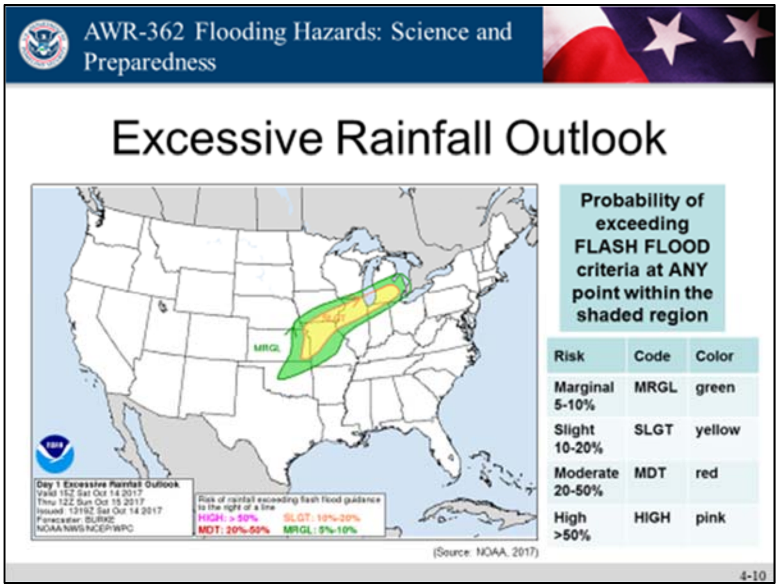

Slide 4-10. Excessive Rainfall Outlook

In Excessive Rainfall Outlooks, the Weather Prediction Center (WPC) forecasts the probability that rainfall will exceed flash flood guidance (FFG) at any point. Guidance**,** in this case, refers to a criteria or threshold. FFG indicates the amount of rain that is estimated to result in rivers or streams overrunning their banks in a given time period. WPC makes these outlooks one, two, and three days in advance.

WPC expresses the risk of excessive rainfall both probabilistically and categorically. On an excessive rainfall outlook, the risk categories and corresponding percent chances of flash flooding are as follows:

- **Marginal (MRGL)** – 5-10% (shaded green)
- **Slight (SLGT)** – 10-20% (shaded yellow)
- **Moderate (MDT)** – 20-50% (shaded red)
- **High (HIGH)** – greater than 50% (shaded magenta/pink)

Flash floods are rare events at any one specific location, and, therefore, the point probability of a flash flood is low even when forecasters are confident that flash flooding will occur within the region. When forecasters declare risk areas by placing a contour on an Excessive Rainfall Graphic, they are expecting at least some flash flooding to occur and the possibility of very organized heavy rainfall and flash flooding affecting numerous locations. In an ideal case, as confidence of the threat increases (usually as lead-time, or time to the event, decreases) the category may be updated from Slight to Moderate to High. In other cases, risk areas may be introduced quite suddenly and with short lead-time, owing to the difficult nature of flash flood forecasting.

Participant Notes:

Participant Note: The National Weather Service changed the probabilities/percentages for each risk category discussed above in 2017. Previously, the categories corresponded to lower probabilities for flash flooding. This means some areas that would have been at marginal risk (between 2% and 5%) before will now not be indicated in the outlook. ***Be aware that outlooks issued before 2017 will look the same but the shading will correspond to different, lower probabilities.*** Detailed explanation of the excessive rainfall outlook product and the schedule for its release every day can be found at http://www.wpc.ncep.noaa.gov/html/fam2.shtml#excessrain

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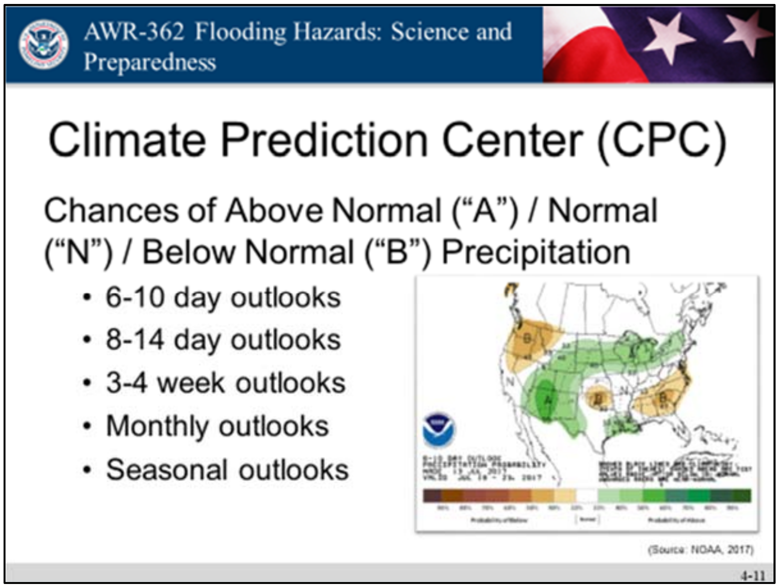

Slide 4-11. Climate Prediction Center (CPC)

The Climate Prediction Center (CPC) is responsible for issuing seasonal climate outlook maps for one to thirteen months in the future. In addition, the CPC issues extended range outlook maps for 6-10 and 8-14 days as well as several special outlooks, such as degree day, drought and soil moisture, and a forecast for daily ultraviolet (UV) radiation index.

Many of the outlook maps have an accompanying technical discussion. The CPC's outlook and forecast products complement the short-range weather forecasts issued by other components of the National Weather Service (e.g. local Weather Forecast Offices, and National Centers for Environmental Prediction). These weather and climate products comprise the National Weather Service's Suite of Forecast Products.

Shown here is one of CPC's flood-relevant products, the 6-10 day precipitation outlook. Note that the forecast is only for "above normal," "normal," and "below normal." The technology to predict specific amounts more than a few days in advance does not exist. This does mean, though, that you need to know what "normal" is for your location and the season in order to interpret this product.

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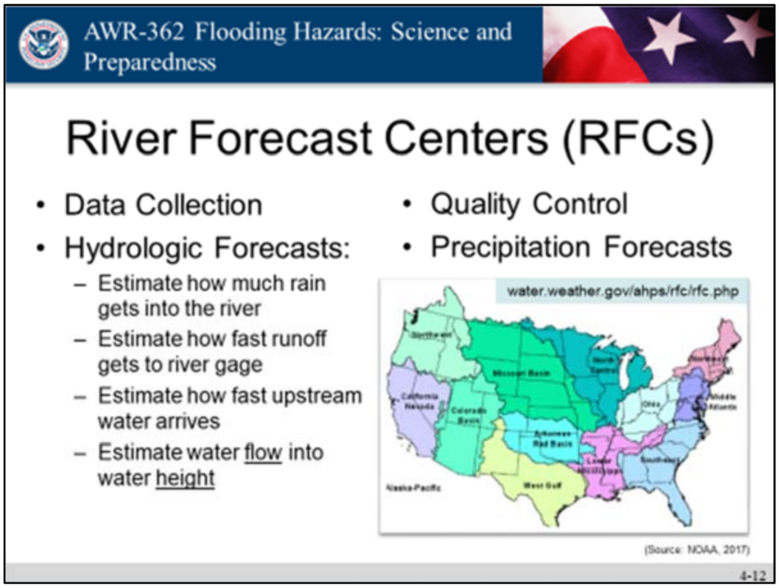


Slide 4-12. River Forecast Centers (RFCs)

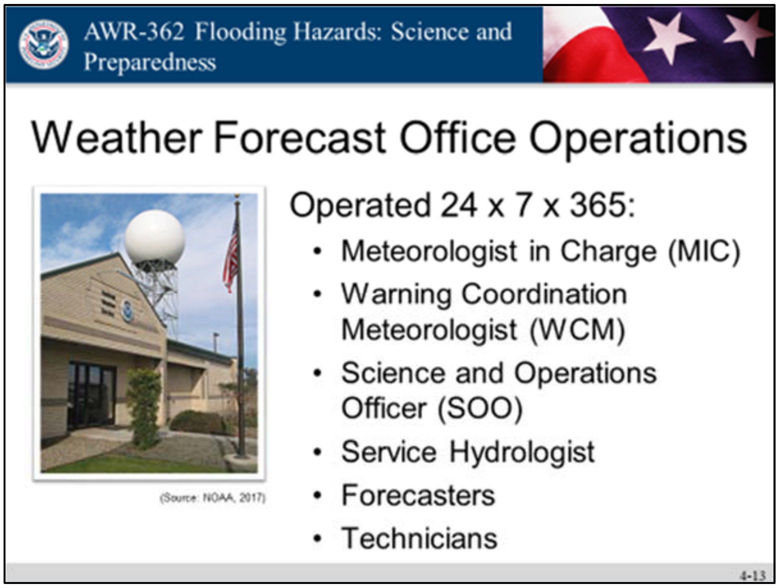
River Forecast Centers (RFC) produce water forecasts and information to support the NWS, customers, and partners, using the best scientific principles to integrate and model water, weather, and climate information.

RFCs provide river forecasts and hydrologic guidance to its users, which consist of Weather Forecast Offices (WFOs), National Weather Service centers, other RFCs, and primary cooperating agencies. These partners use the forecasts and guidance for the protection of life and property associated with flooding, and to provide water resource information to support commerce and economic decisions. RFC operations are oriented toward providing hydrologic forecasts and guidance to both WFOs and selected water-related cooperators.

RFCs routinely issue Flash Flood Guidance (FFG) throughout the day for every county in their area. The river forecast centers determine one-, three- and six-hour flash flood guidance values for all counties, and 12- and 24-hour values for parts of the eastern United States. The NWS Weather Forecast Offices use this guidance when issuing flash flood watches and warnings to the public. The WPC also uses the FFG in producing the Excessive Rainfall Outlook, as discussed above

Flash Flood Guidance estimates the average number of inches of rainfall for given durations required to produce flash flooding in the indicated county. These estimates are based on current soil moisture conditions. Note, in urban areas, that less rainfall is required to produce flash flooding.

Participant Notes:



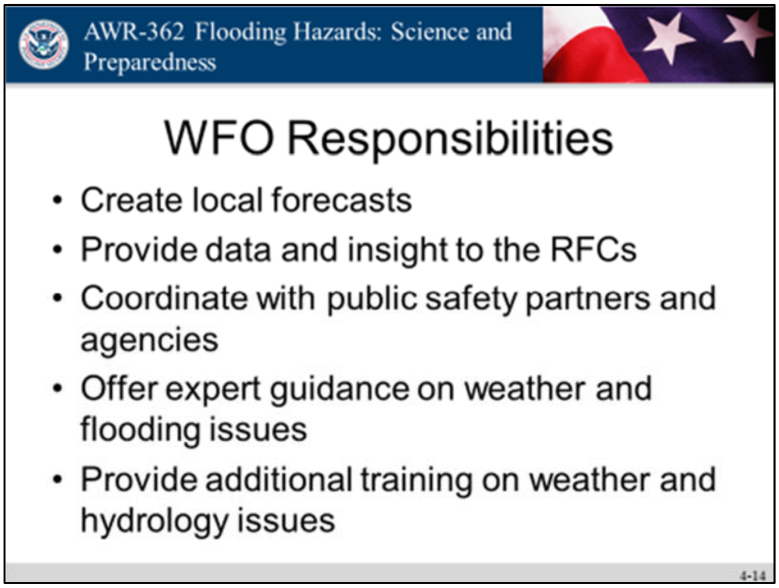
Slide 4-13. Weather Forecast Office Operations

The local Weather Forecast Office operates around the clock producing forecasts and taking observations.

Typical personnel that partner agencies interested in flooding might interact with include:

- **Meteorologist-In-Charge (MIC)** – the top position in the office; manages personnel, acts as a senior forecaster.
- **Warning Coordination Meteorologist (WCM)** – serves as a senior forecaster, evaluates WFO products and services, spearheads preparedness and outreach programs.
- **Science and Operations Officer (SOO)** – implements new technology and data, responsible for training and scientific research.
- **Service Hydrologist** – runs the office’s hydrology program, provides training on flood guidance.
- **Forecasters** (lead, general, and intern)
- **Technicians**

Participant Notes:

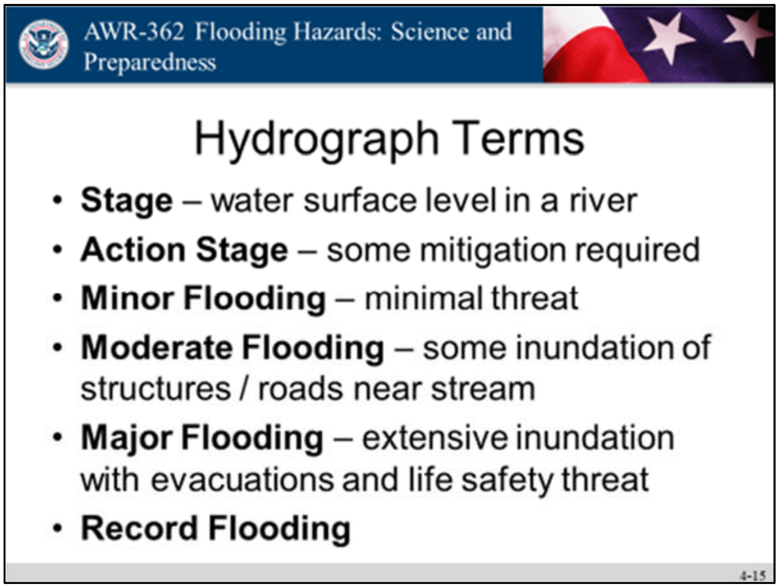


Slide 4-14. WFO Responsibilities

The NWS WFO is responsible for:

- Creating local forecasts (including warnings);
- Providing data and insight to the RFCs (from a local perspective);
- Coordinating with public safety partner agencies;
- Offering expert guidance on weather and flooding issues; and
- Providing additional training on weather and hydrology issues.

Participant Notes:



Slide 4-15. Hydrograph Terms

The Advanced Hydrologic Prediction Service (AHPS) is a new and essential component of NOAA's Climate, Water, and Weather Services. AHPS is a web-based suite of accurate and information-rich forecast products. They display the magnitude and uncertainty of occurrence of floods or droughts, from hours to days and months, in advance. These graphical products are useful information and planning tools for many economic and emergency managers. These new products will enable government agencies, private institutions, and individuals to make informed decisions about risk-based policies and actions to mitigate the dangers posed by floods and droughts.

Gauge height (also known as stage) is the height of the water in the stream above a reference point. Gauge height refers to the elevation of the water surface in the specific pool at the stream gauging station, not along the entire stream. Gauge height also does not refer to the depth of the stream. Measurements of gauge height are continually recorded by equipment inside a gauge house on the streambank.

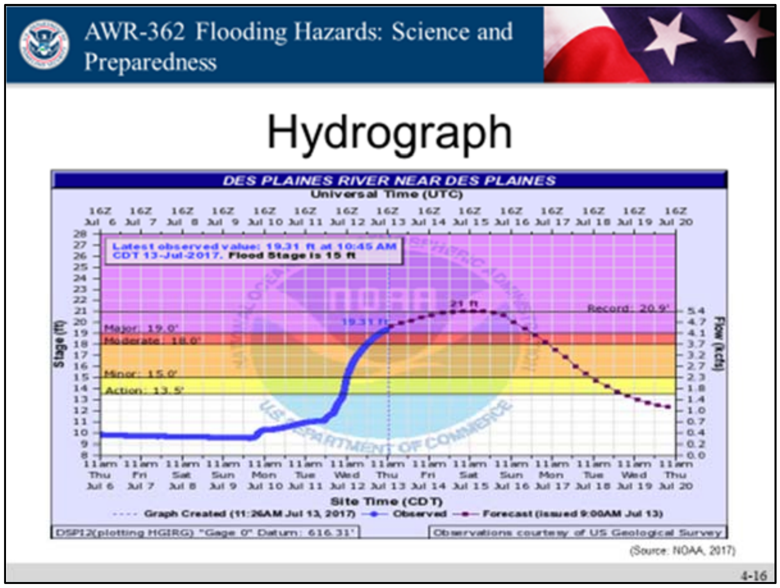
The following terminology is used when describing floods:

- **Action Stage -** the stage which, when reached by a rising stream, lake, or reservoir represents the level where the NWS or a partner/user needs to take some type of mitigation action in preparation for possible significant hydrologic activity. The appropriate action is usually defined in a weather forecast office (WFO) hydrologic service manual. Action stage can be the same as forecast issuance stage (see forecast issuance stage).

Participant Notes:

- **Minor flooding -** minimal or no property damage, but possibly some public threat.
- **Moderate Flooding -** some inundation of structures and roads near stream; some evacuations of people and/or transfer of property to higher elevations.
- **Major Flooding -** extensive inundation of structures and roads; significant evacuations of people and/or transfer of property to higher elevations.
- **Record Flooding -** flooding which equals or exceeds the highest stage or discharge at a given site during the period of record keeping.

Participant Notes:



Slide 4-16. Hydrograph

The United States Geological Survey (USGS) maintains a network of river observation gauges throughout the United States. Monitoring sites typically make measurements in 15- to 60-minute intervals and store the data onsite. The data is then transmitted to USGS offices every one to four hours, depending on the data relay technique used.

Recording and transmission times may be more frequent during critical events. Data from current sites are relayed to USGS offices via satellite, telephone, and/or radio telemetry and are available for viewing within minutes of arrival.

To provide streamflow information to meet national needs, the information obtained from these stream gauges needs to be consistent, obtained using standard techniques and technology, and be subject to the same quality assurance and quality control. The USGS plan provides for a unified network to meet national, regional, state, tribal, and local needs of streamflow information. The USGS stream gauging network is currently funded in partnership with over 850 Federal, state, tribal, and local agencies in combination with USGS Cooperative Matching Funds where applicable.

A hydrograph shows how the river level changes over time at a specific location. Forecast hydrographs are displayed when flooding is expected, otherwise the hydrograph for the past few days is provided, if the data are available. At key river gauges, such as along navigable rivers, daily forecast hydrographs are provided whether or not flooding is anticipated. In cold regions, the hydrograph may seasonally show the effects of the

Participant Notes:

formation of an ice cover. Gauges may either malfunction due to cold weather and/or show sporadic readings due to formation of ice cover on a river or movement of ice. The amount of ice effects can be determined at a site by comparing the gauge forecasts (which is based on open water flow) to the observed stages.

In this hydrograph, the observation was made at 10:45am CDT on July 13, 2017. It shows an observation of 19.31 feet, with a flood stage of 15 feet. It is currently in the “major flood” category, which starts at 19 feet. The forecast is to reach 21 feet Friday, with the record flood of 20.9 feet. It will go back down below flood stage, assuming no additional precipitation, next Wednesday.

Participant Note: Any time a forecast uses estimates or assumptions, uncertainty is introduced. Hydrologic forecasts are no different. Because observations of stream and river flow are only taken at a few points, many factors can affect the accuracy of a gauge. Some information from private entities is not always available, therefore, in addition to other challenges, hydrologic forecasts can never be perfect.

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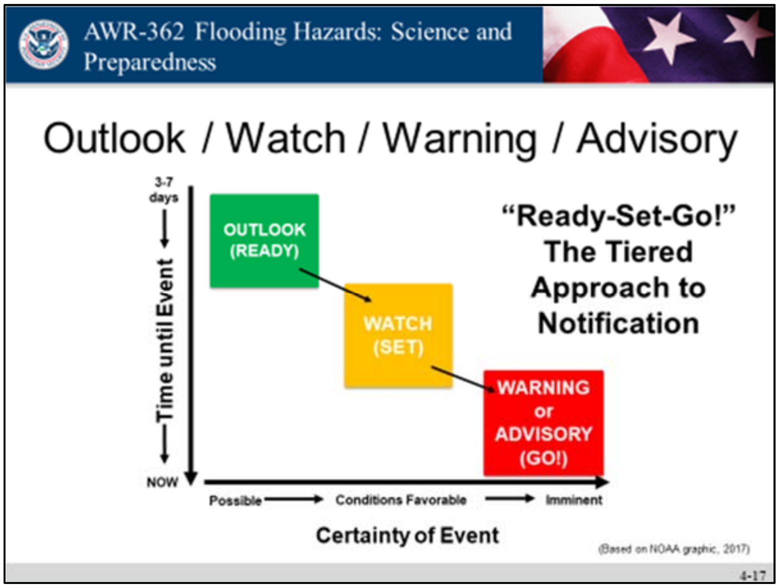

Slide 4-17. Outlook / Watch / Warning / Advisory

The NWS Glossary provides the following definitions:

- **Outlook –** indicates a hazardous weather or hydrologic event may develop. It is used to provide information to those needing considerable lead time to prepare for the event.

- **Watch –** indicates the risk of a hazardous weather or hydrologic event has increased significantly, but its timing, occurrence, and/or location is uncertain. It is used to provide enough lead time for those needing to set plans in motion.

- **Warning –** is issued when a hazardous weather or hydrologic event is occurring, is imminent, or has a high probability of occurring. It is used for conditions posing a threat to life and/or property.

- **Advisory –** highlights special weather conditions that are less serious than a warning. They are for events that may cause significant inconvenience, and if caution is not exercised, could lead to situations that may threaten life and/or property.

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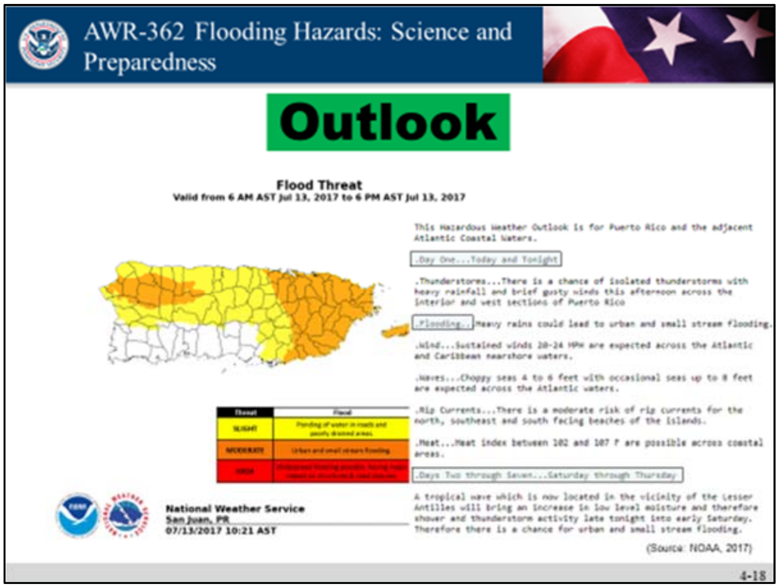

Slide 4-18. Outlook

The Hazardous Weather Outlook (HWO) is a narrative statement produced by the National Weather Service, frequently issued on a routine basis, to provide information regarding the potential of significant weather expected during the next one to seven days. The information is provided with no technical meteorological terms, and instead uses common English to inform users of the primary threats possible over the next week.

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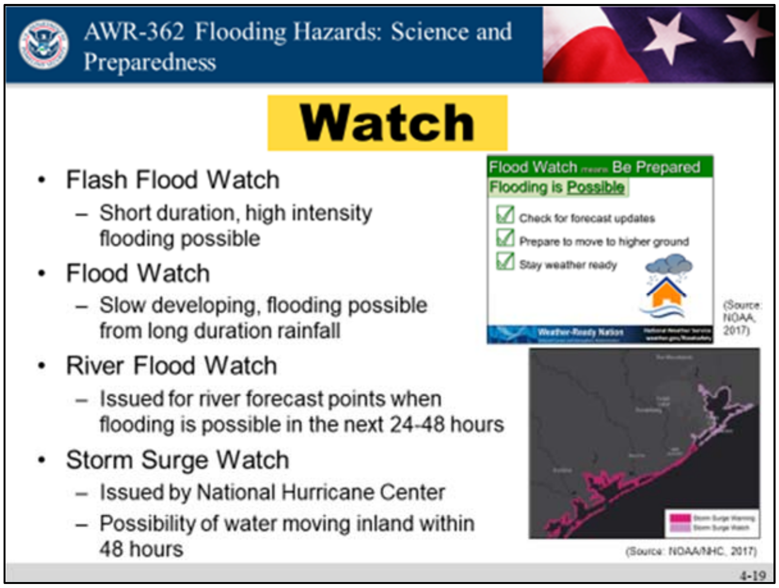

Slide 4-19. Watch

Watch products associated with flooding are typically issued from hours to a day or more before the event. The confidence level for an event to occur when a Watch is issued is 50-80 percent. When a Watch is issued, you should begin to gather more information about the situation and determine what actions you will need to take should a warning be issued.

The NWS issues a **Flash Flood Watch** to indicate current or developing conditions that are favorable for flash flooding. The occurrence is neither certain nor imminent. A watch is typically issued within several hours to days ahead of the onset of possible flash flooding.

The NWS issues a **Flood Watch** to indicate current or developing conditions that are favorable for flooding. The occurrence is neither certain nor imminent. A watch is typically issued within several hours to days ahead of the onset of possible flooding. In situations where a river or stream is expected to be the main source of the flooding, forecast confidence may allow for a **River Flood Watch** to be issued several days in advance.

A **Storm Surge Watch** is defined as the possibility of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 48 hours, in association with a tropical, subtropical, or post-tropical cyclone. The watch may be issued earlier when other conditions, such as the onset of tropical storm-force winds, are expected to limit the time available to take protective actions for surge (e.g., evacuations). The watch may also be issued for locations

Participant Notes:

not expected to receive life-threatening inundation, but which could potentially be isolated by inundation in adjacent areas. Storm surge watches are issued by the National Hurricane Center, and may be issued by the Central Pacific Hurricane Center in the future once the product is tested in Hawaii.

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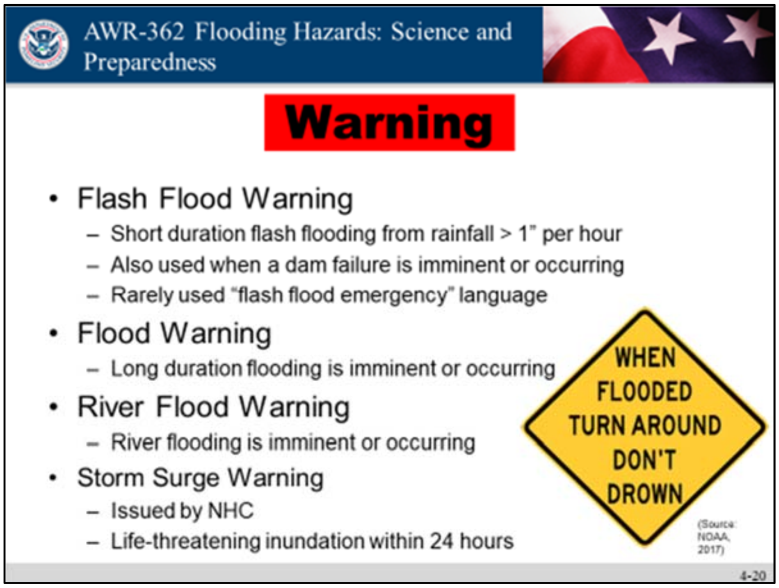


Slide 4-20. Warning

Warnings are issued when confidence is greater than 80 percent that an event will occur. Depending on the type of event, these may be issued anywhere from hours before an event to a day or two in advance.

The NWS issues a **Flash Flood Warning** to inform the public, emergency management, and other cooperating agencies that flash flooding is in progress, imminent, or highly likely. Flash Flood Warnings are urgent messages as dangerous flooding can develop very rapidly, with a serious threat to life and/or property. Flash Flood Warnings are usually issued minutes to hours in advance of the onset of flooding.

A **Flash Flood Emergency** is the most extreme variety of a Flash Flood Warning. Examples of situations which warrant the inclusion of flash flood emergency language in flash flood warnings may include but are not limited to:

- Emergency manager(s) of the affected county(s) or the state emergency management association declare a state of emergency and have confirmed that rapidly rising floodwaters are placing or will place people in life-threatening situations. The state of emergency for the affected areas may have been previously relayed by the emergency manager(s) or the state emergency management association through the WFO in a Non-Weather Emergency Message. These might include a Civil Emergency Message (CEM), Evacuate Immediate (EVI), or Local Area Emergency (LAE).

Participant Notes:

- Water has rapidly risen or will rapidly rise to levels where people who are ordinarily in safe locations during previous flash flood events are now placed in life-threatening situations. For example, people in homes that might see waters rapidly rise up to their front yards or steps during typical flash flood situations would experience waters that are several feet above floor level such that rescue is necessary and/or their entire home is threatened.

- Multiple swift water rescue teams have been or are being deployed in response to flash flooding of an exceptional magnitude.

- Stream gauges, where available, indicate floodwaters have risen rapidly to at least major levels or, if gauges are not available, floodwaters have risen to levels rarely if ever seen.

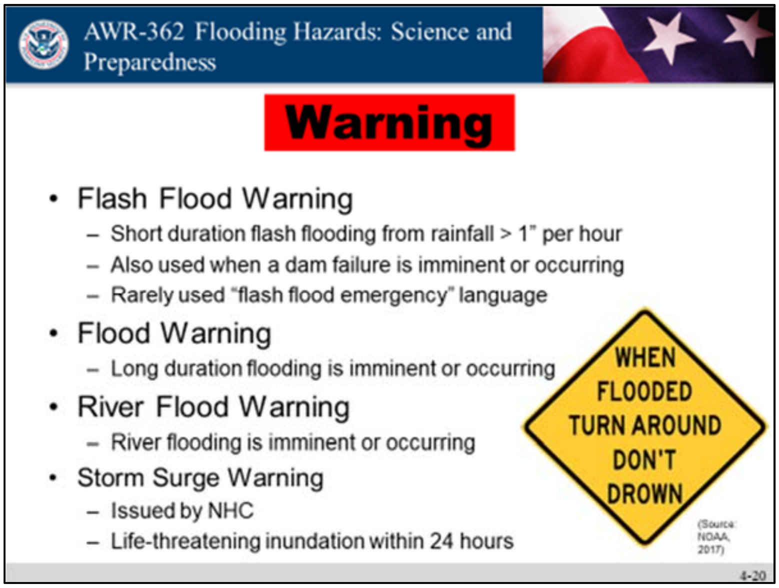
- Total failure of a major high hazard dam that would have a catastrophic impact on downstream communities.

In situations where a robust emergency management structure does not exist or external communications are not possible, a WFO may include flash flood emergency language in a flash flood warning without pre-coordinating with emergency managers when the above or similar criteria are met.

The NWS issues a **Flood Warning** to inform the public of flooding that poses a serious threat to life and/or property. A Flood Warning may be issued hours to days in advance of the onset of flooding based on forecast conditions. Floods occurring along a river usually contain river stage (level) forecasts and utilize the **River Flood Warning** product.

A **Storm Surge Warning** is defined as the danger of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 36 hours, in association with a tropical, subtropical, or post-tropical cyclone. The warning may be issued earlier when other conditions, such as the onset of tropical storm-force winds, are expected to limit the time available to take protective actions for surge (e.g., evacuations). Storm surge warnings are issued by the National Hurricane Center and may be issued by the Central Pacific Hurricane Center in the future once the product is tested in Hawaii.

Participant Notes:



Slide 4-21. Advisory

Advisories are issued when confidence is greater than 80 percent that an event will occur, but will not seriously threaten life and/or property. Depending on the type of event, these may be issued anywhere from hours before an event to days in advance of an event.

The NWS issues a Flood Advisory when a flood event warrants notification but is less urgent than a warning. Advisories are issued for conditions that could cause significant inconvenience, and if caution is not exercised, could lead to situations that may threaten life and/or property.

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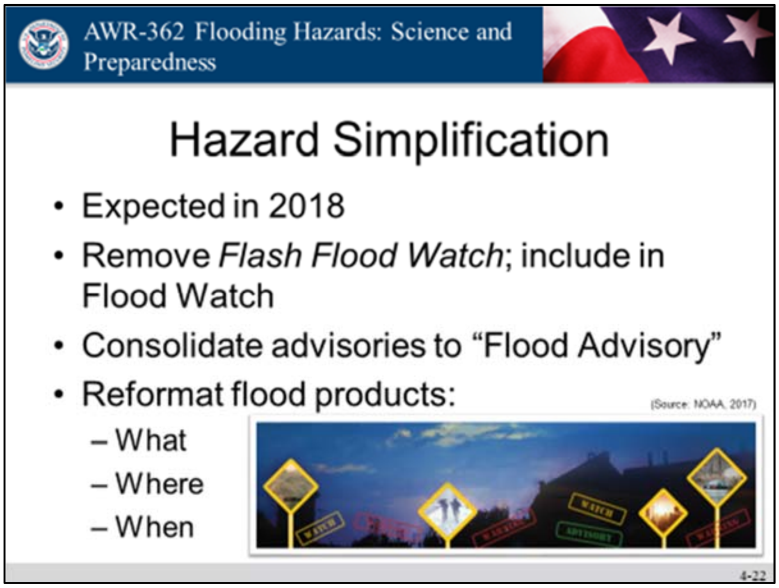


Slide 4-22. Hazard Simplifcation

The NWS is striving to support a “Weather-Ready Nation” by ensuring citizens are aware of and prepared for the variety of weather- and water-based hazards we experience across the country every day. One factor in supporting this awareness and preparedness is to make sure NWS messaging is as clear and focused as possible.

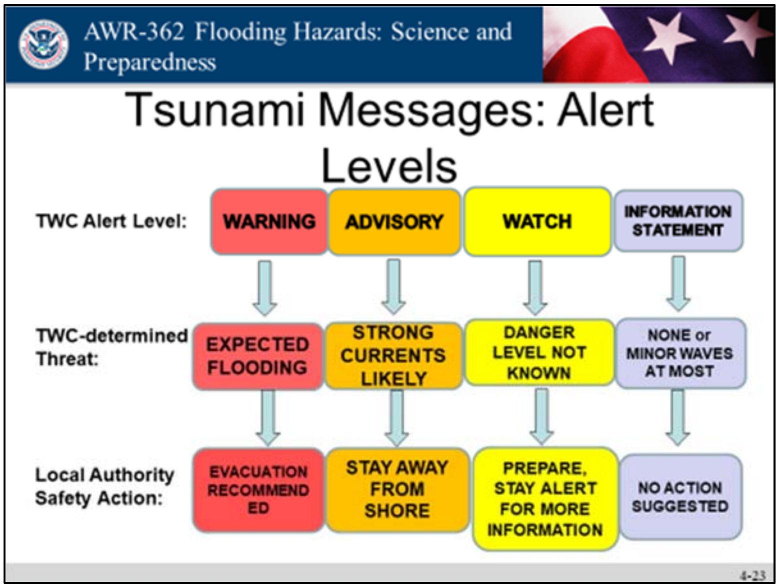
The NWS recently compiled the feedback of online surveys, focus groups, social scientists, meteorologists, emergency managers, and other stakeholders to begin a process called **hazard simplification.** Though some suggested a completely revamped hazard alerting system, the majority favored minor changes to streamline the Watch-Warning-Advisory (WWA) system.

The main results for hydrologic hazards are:

- All localized flood advisory names such as “urban and small stream flood advisory” will be discontinued and the same information will be conveyed under the overarching title of “Flood Advisory.”
- In situations where a Flash Flood Watch would currently be issued, a Flood Watch will be issued in the future, expanding the definition of a Flood Watch and eliminating the Flash Flood Watch.
- Text products will be reformatted to emphasize the “where, what, when” of flooding events.

These changes are expected in 2018. Similar changes for winter weather WWA products have already been implemented

Participant Notes:



Slide 4-23. Tsunami Messages: Alert Levels

The **National Tsunami Warning Center (NTWC)** and **Pacific Tsunami Warning Center (PTWC)** issue alert messages related to tsunamis.

The P/NTWC issues a **Tsunami Warning** when a potential tsunami with significant widespread inundation is imminent or expected. Warnings alert the public that widespread, dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after arrival of the initial wave. Warnings may be updated, adjusted geographically, downgraded, or canceled. To provide the earliest possible alert, initial warnings are normally based only on seismic information.

The P/NTWC issues a **Tsunami Advisory** when a tsunami with the potential to generate strong currents or waves dangerous to those in or very near the water is imminent, expected, or occurring. The threat may continue for several hours after initial arrival, but significant inundation is not expected for areas under an advisory.

The P/NTWC issues a **Tsunami Watch** to alert emergency management officials and the public of an event that may later impact the watch area. The watch area may be upgraded to a warning or canceled based on updated information and analysis. Therefore, emergency management officials and the public should prepare to take action. Watches are normally issued based on seismic information without confirmation that a destructive tsunami is underway.

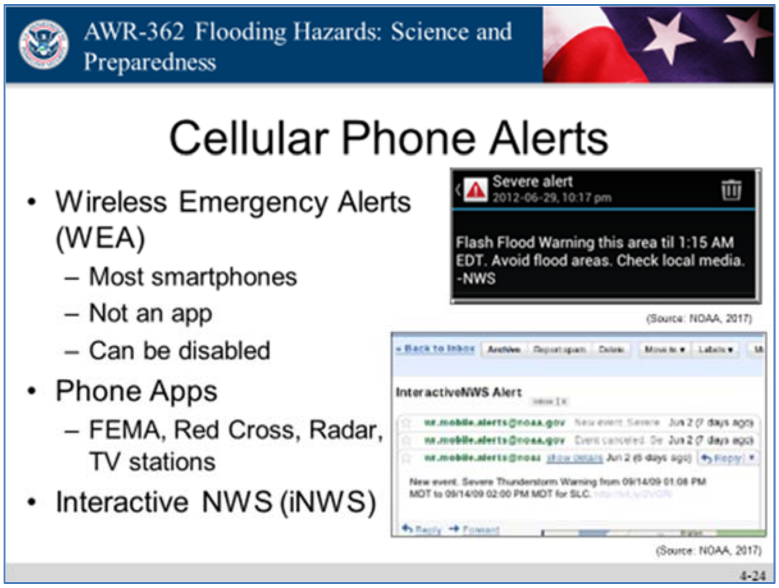
Participant Notes:

A **Tsunami Information Statement** informs the public that an earthquake has occurred and advises regarding its potential to generate a tsunami. In most cases, there is no threat of a destructive tsunami. The information is used to prevent unnecessary evacuations as the earthquake may have been strongly felt in coastal areas.

A cancellation indicates the end of the damaging tsunami threat. A cancellation is usually issued after an evaluation of sea level data confirms that a destructive tsunami will not impact the warned area. A cancellation will also be issued following a destructive tsunami when sea level readings indicate that the tsunami is below destructive levels and subsiding in most locations that can be monitored.

Participant Note: The Watch-Warning-Advisory structure is generally the same in terms of certainty, urgency, and threat level as NWS products, even though tsunamis are not meteorological phenomena, and they are generally disseminated through the NWS.

Participant Notes:



Slide 4-24. Cellular Phone Alerts

Even the best warning will not be effective if the message is not received by its intended target – the public. As a result, varieties of paths exist to get data and alerts from the National Weather Service to its partners and customers.

“Wireless Emergency Alerts (WEA),” also known as the “Commercial Mobile Alert System” or “Personal Localized Alerting Network,” are a free service for wireless customers developed in 2012 through a partnership between the Federal Communications Commission, the wireless industry, and FEMA. A special text message-like alert with audible alarm is delivered to WEA-capable cell phones when there is an imminent threat nearby, including “Presidential Alerts,” “Imminent Threat Alerts,” and “AMBER Alerts.” These alerts are delivered separately from text messages and are location dependent.

Other emergency alert products include:

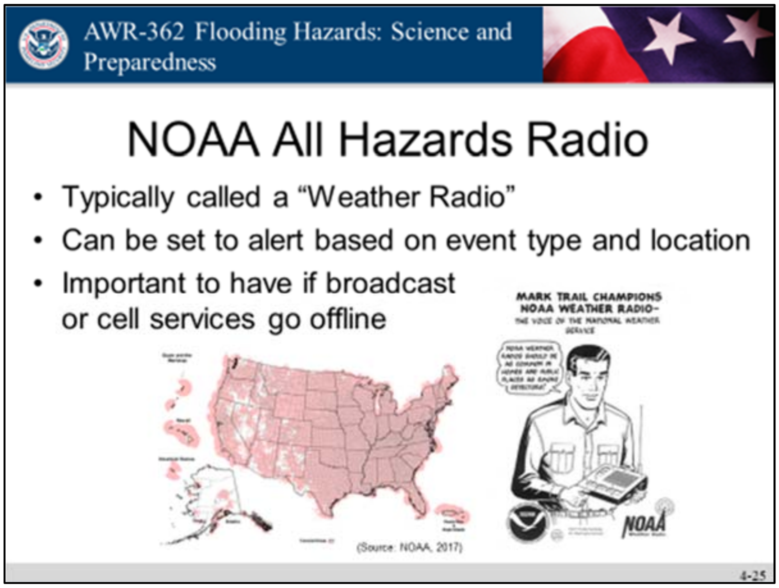
- The FEMA app has a disaster reporter function with crowdsourcing. For more information on this, visit: http://www.fema.gov/smartphone-app.
- NWSChat is an instant messaging, decision support tool available for NWS partners, such as emergency managers and the media: https://nwschat.weather.gov/
- For information on the Integrated Public Alert & Warning System, visit: http://www.fema.gov/integrated-public-alert-warning-system.

Participant Notes:

- Some private applications can provide useful platforms for visualizing NWS radar data. Many disaster relief non-governmental organizations also have useful mobile phone apps. InteractiveNWS (iNWS) is the NWS' mobile alerting platform available for NWS partners: https://inws.ncep.noaa.gov/

Participant Note: For more about social media, please refer to the National Disaster Preparedness Training Center's FEMA-certified course, "PER-304 Social Media for Natural Disaster Response and Recovery."

Participant Notes:



Slide 4-25. NOAA All Hazards Radio

The “NOAA Weather Radio” is a continuous broadcast of weather forecasts and advisories originating from local NWS offices. Newer radios offer Specific Area Message Encoding (SAME) capability, which allow users to filter alerts based on the most relevant geographic area of interest. The weather radio is designed to play a continuous broadcast of the latest weather forecasts, or to be set on standby and to activate when an alert is received. It can be a life-saving tool.

Non-weather emergencies can also be broadcast via the “Emergency Alert System” (EAS). Implemented in 1997, the EAS was designed to allow the President to reach the public within 10 minutes in the event of an emergency. The EAS is a part of the FEMA Integrated Public Alert and Warning System and is coordinated by the Federal Communications Commission.

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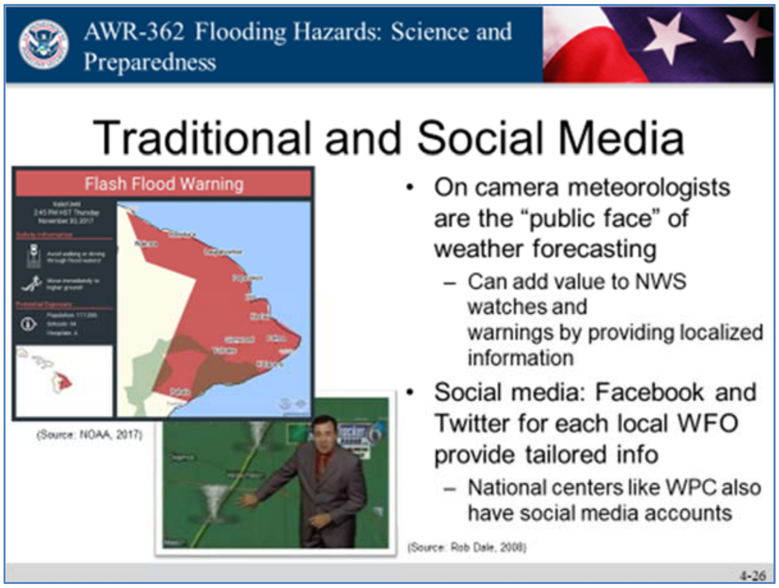
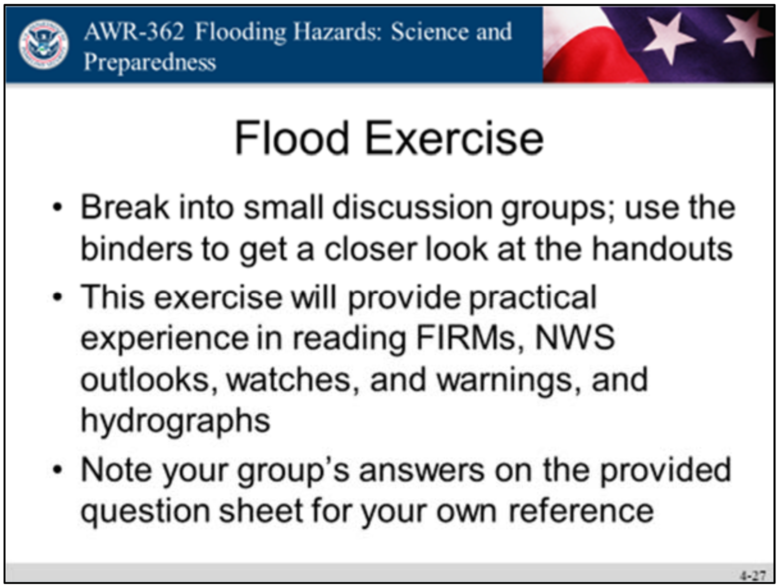


Slide 4-26. Television / Radio

Television is one of the primary methods in which the public receives weather warnings. Most national and local news stations employ meteorologists on their staff whose sole purpose is to watch and broadcast the weather. While news stations are required to relay NWS alerts, they are also able to add value to forecasts and warnings by providing their own interpretations that make complex weather situations more easily understandable to the public.

Social media is a highly responsive method by which to receive and provide specific, locally tailored messages. Most National Weather Service offices have their own Facebook and Twitter accounts by which they publish weather information, which can range from a weekend forecast and weather trivia, to time-sensitive emergency information. Each office is responsible for their social media products, so the style and information provided will vary from office to office, thus we do not provide an exhaustive guide here. It is best to refer to your local WFO for their social media handles and familiarize yourself with their social media products.

Participant Notes:

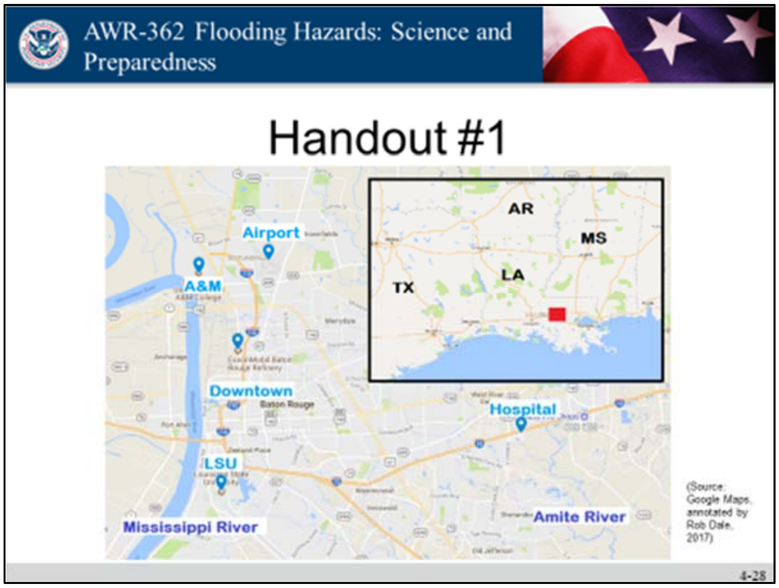


Slide 4-27. Flood Exercise

Module 4 Activity
Flooding: Understanding Risk, Forecasts, and Warnings

This exercise provides an opportunity for participants to work together in groups to understand and appreciate different decisions and courses of action that they may need to make in a flooding situation.

Participant Notes:



Slide 4-28. Handout #1

This image of the East Baton Rouge (Louisiana) Parish covers the city of Baton Rouge along with surrounding areas.

Major transportation routes include the East/West Interstate 12, which merges with I-10 West of the city. To the East, I-10 travels to New Orleans.

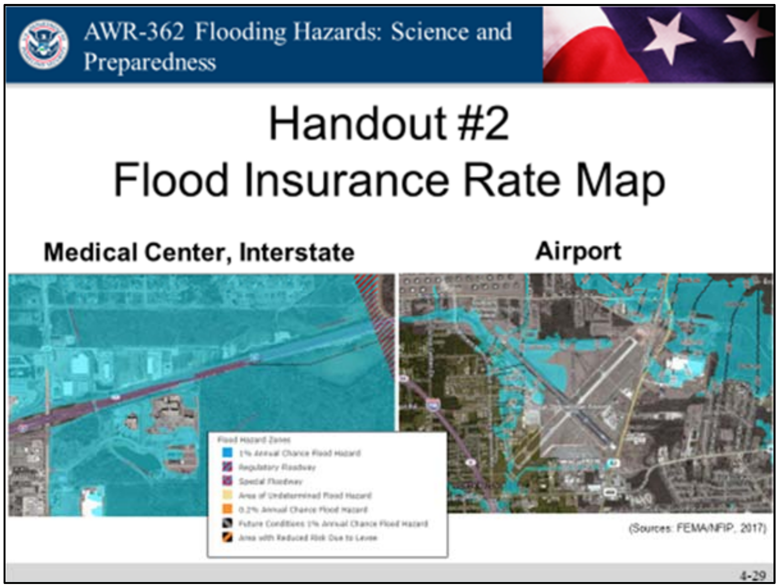
Interstate 55 runs North and South and extends to New Orleans.

Notice the city of Baton Rouge is on the banks of the Mississippi River. The area along the river includes prominent locations, such as:

- Louisiana State University;
- Exxon-Mobile Refinery;
- Southern University A&M College; and
- Downtown Baton Rouge.

Note that the highlighted hospital lies close to the Amite River to the East.

Participant Notes:



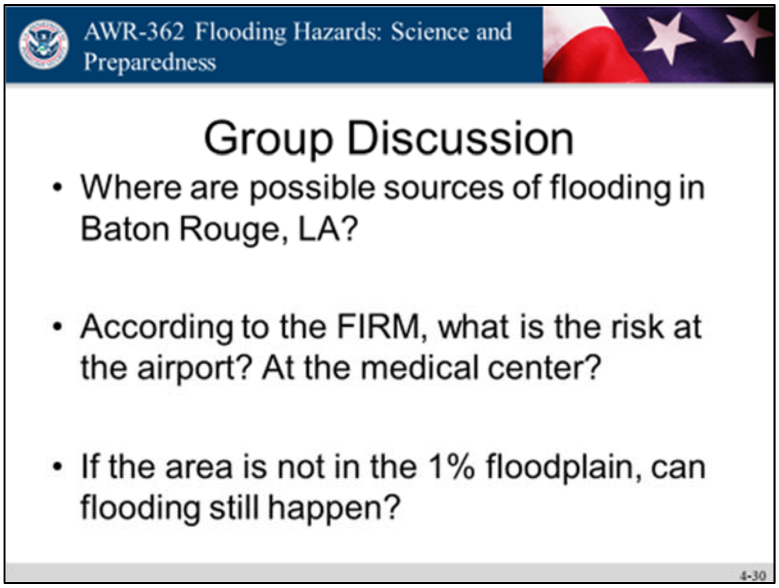
Slide 4-29. Handout #2 – Flood Insurance Rate Map

The most widely distributed flood map product in the United States is the Flood Insurance Rate Map (FIRM) of the National Flood Insurance Program (NFIP). Module 3 explained the basics of interpreting FEMA flood maps.

This map shows in blue where the 1% annual chance of flooding exists. Notice that threat extends through much of the city, and even impacts the airport. On the South side, Interstate 10 and Interstate 12 are in the flood zone.

Flooding is also possible along the banks of the Mississippi River, but we will see in this exercise that the threat came from elsewhere due to extensive flood control measures on the Mississippi.

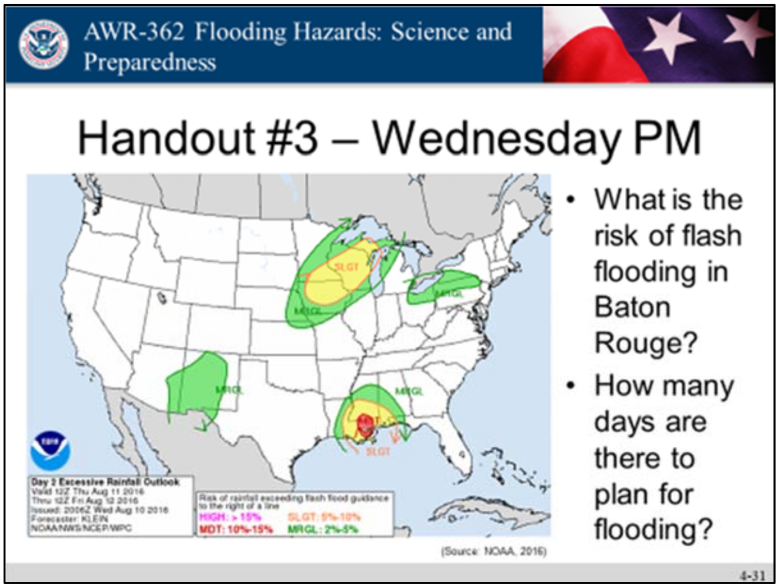
Participant Notes:



Slide 4-30. Group Discussion

- What are your possible sources of flooding in Baton Rouge, LA?
- According to the FIRM, what is the risk at the airport? At the medical center?
- If an area is not in the 1% floodplain, can flooding still happen?

Participant Notes:



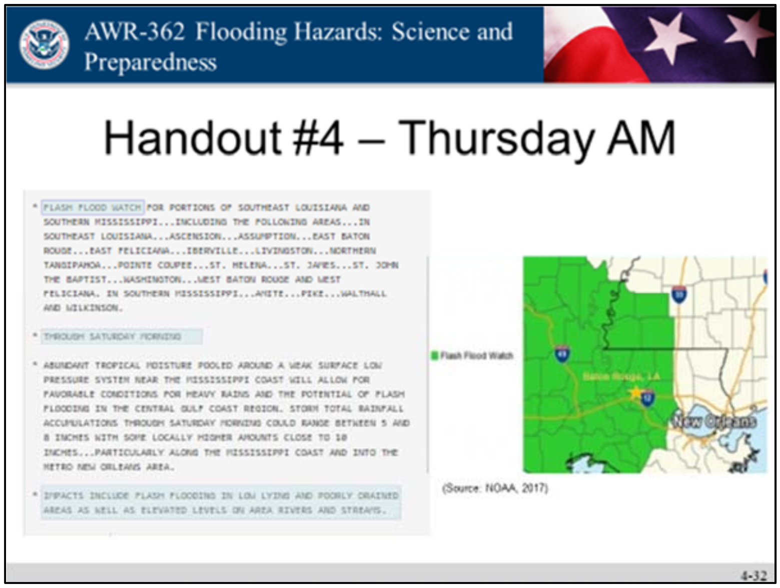
Slide 4-31. Handout #3 – Wednesday PM

The event is expected to begin on Friday.

The graphic published Wednesday afternoon is the WPC risk of rainfall exceeding flash flood guidance on Friday.

- What is the risk of flash flooding in Baton Rouge?
- How many days are there to plan for flooding?

Participant Notes:

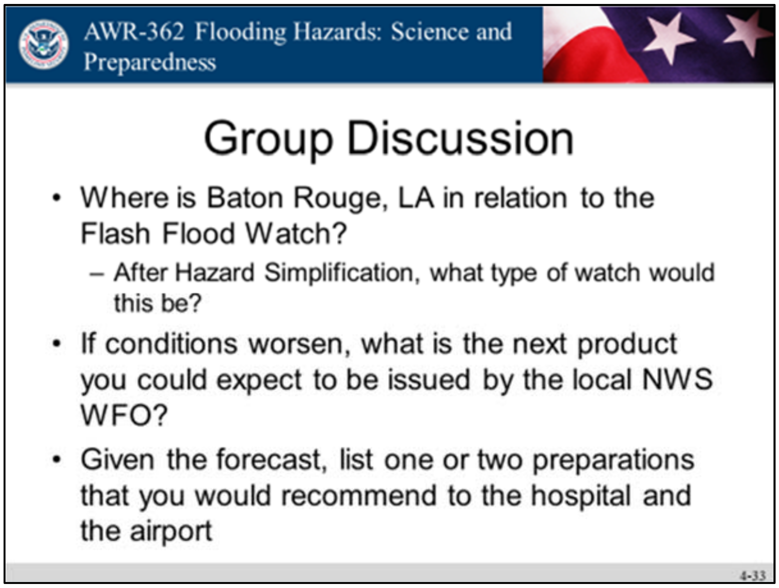


Slide 4-32. Handout #4 – Thursday AM

The event is expected to begin tomorrow.

Thursday Morning: A Flash Flood Watch has been issued, per the graphic on the left.

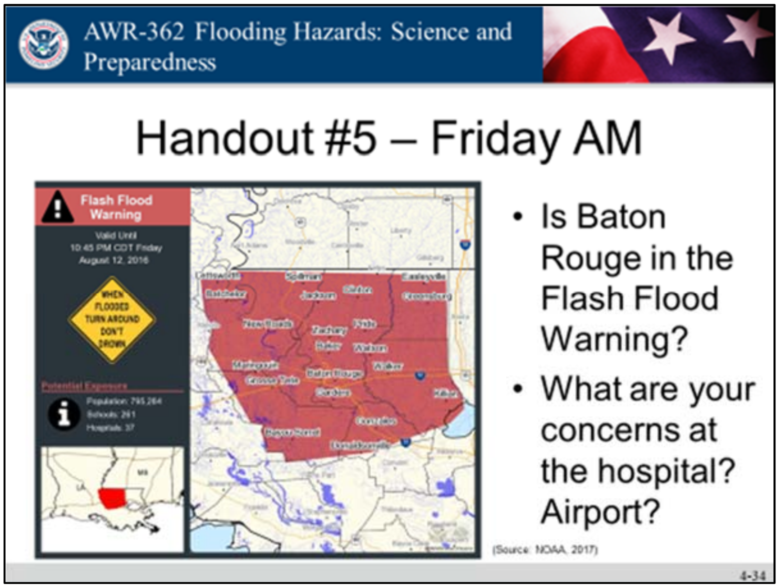
Participant Notes:



Slide 4-33. Group Discussion

- Where is Baton Rouge, LA in relation to the Flash Flood Watch?
  - After Hazard Simplification, what type of watch would this be?
- If conditions worsen, what is the next product you could expect to be issued by the local NWS WFO?
- Given the forecast, list one or two preparations that you would recommend to the hospital and the airport.

Participant Notes:

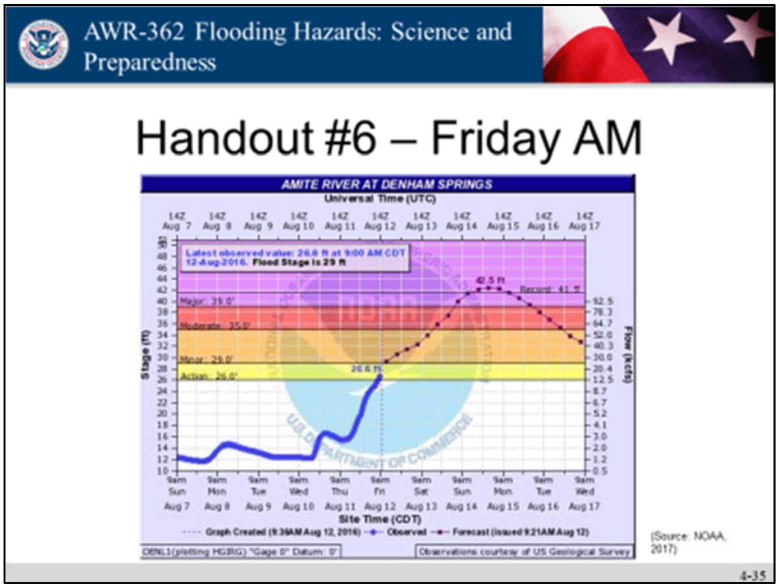


Slide 4-34. Handout #5 – Friday AM

The rainfall has begun.

Friday Morning: A Flash Flood Warning was issued that is in effect until 10:45pm Friday night, as indicated by the graphic on the left. In addition, GIS information is now available on the population, number of schools, and hospitals that are in the warned area.

Participant Notes:

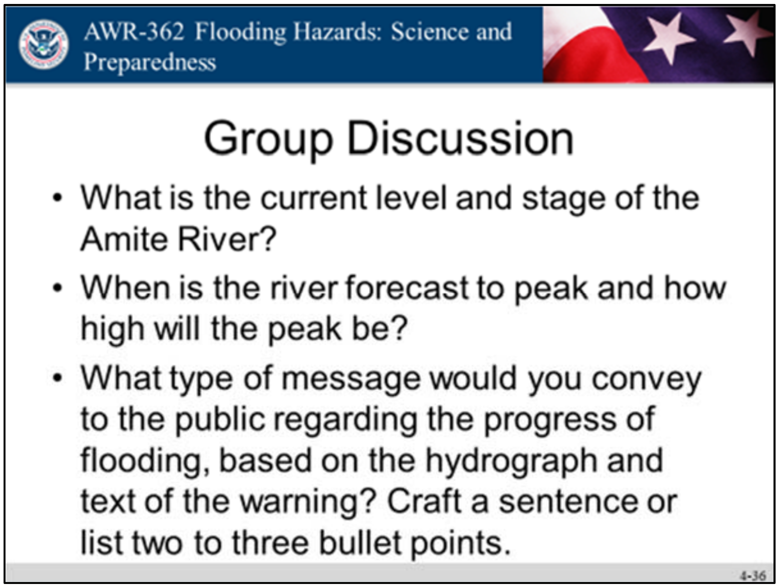


Slide 4-35. Handout #6 – Friday AM

The Amite River at Denham Springs is located east of Baton Rouge.

- Is Baton Rouge in the Flash Flood Warning?
- What are your concerns at the hospital? Airport?

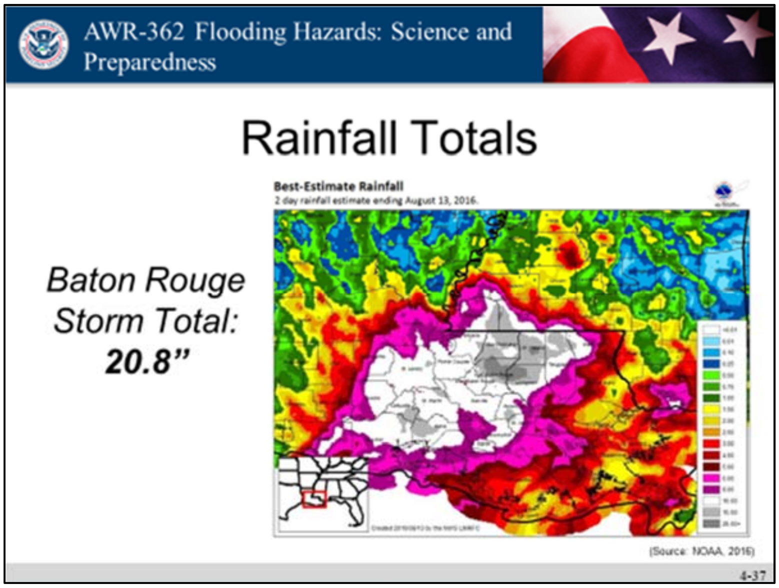
Participant Notes:



Slide 4-36. Group Discussion

- What is the current level and stage of the Amite River?
- When is the river forecast to peak and how high will the peak be?
- What type of message would you convey to the public regarding the progress of flooding, based on the hydrograph and text of the warning? Craft a sentence or list two to three bullet points.

Participant Notes:



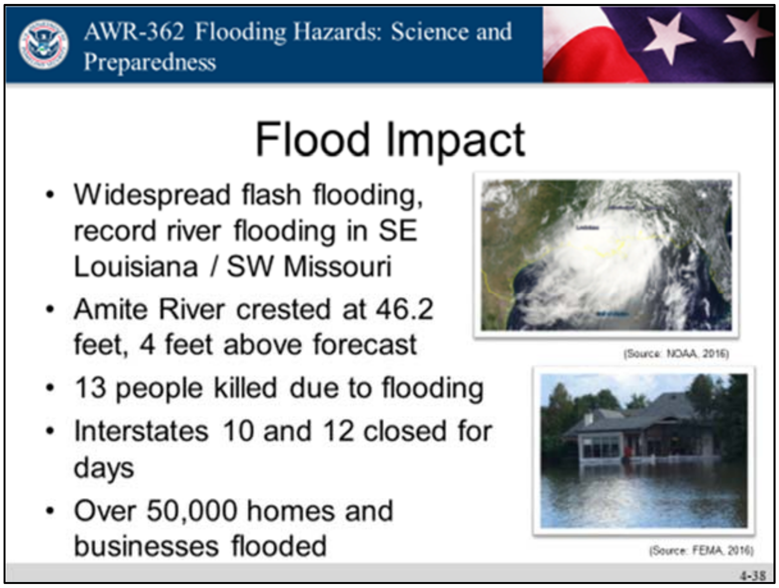
Slide 4-37. Rainfall Totals

The map shows a combination of radar estimated rainfall totals and actual rain gauge observations.

The Baton Rouge airport received nearly two feet of rain into the middle part of the following week!

The Amite River at Denham Springs was forecast to reach a maximum stage of 42.5 feet, but instead crested at 46.2 feet, breaking the old 1983 record by almost 5 feet!

Participant Notes:



Slide 4-38. Flood Impact

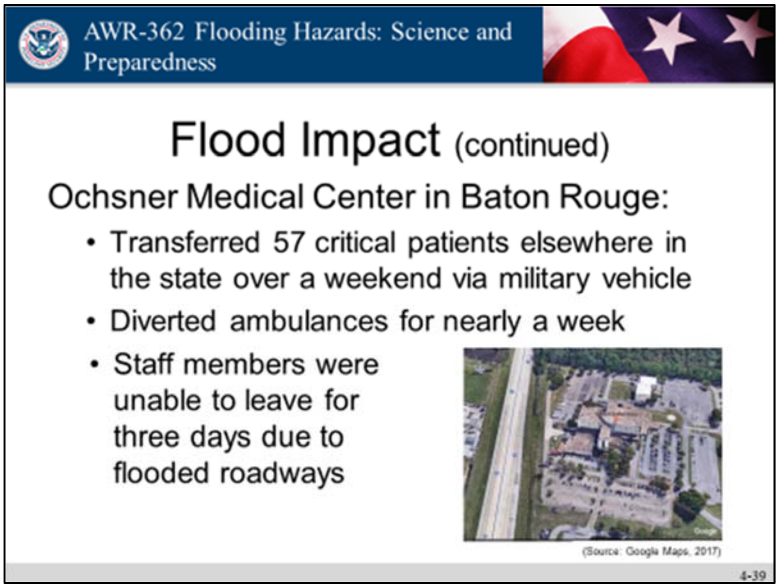
The following was reported by the New Orleans/Baton Rouge Weather Forecast Office regarding the 2016 flood event (http://www.weather.gov/lix/August2016flood):

A slow moving upper level low pressure system with a pool of very deep tropical moisture brought very heavy rainfall of 20 to 30 inches to parts of Southeast Louisiana and Southwest Mississippi from August 11th through August 13th. These very heavy rainfall totals led to widespread flash flooding and record river flooding across multiple parishes in Southeast Louisiana and Southwest Mississippi.

Record flooding was observed in Amite/Comite River Basin, Tickfaw River Basin, Natalbany River Basin, and the Tangipahoa River Basin. The flooding led to interstate closures on both Interstate 10 and 12 for several days, and flooded thousands of homes and businesses across portions of the Baton Rouge and Hammond Metropolitan Areas. A final tally of the number of homes and businesses flooded has not been compiled, but estimates range from 50,000 to 75,000 structures flooded from this event. The most widespread flooding impacted large portions of highly populated East Baton Rouge, Livingston, Ascension, and Tangipahoa Parishes.

The event also resulted in numerous water rescues and unfortunately there were 13 people killed from the flooding in the state. 12 of those deaths occurred in the Baton Rouge and Hammond areas.

Participant Notes:



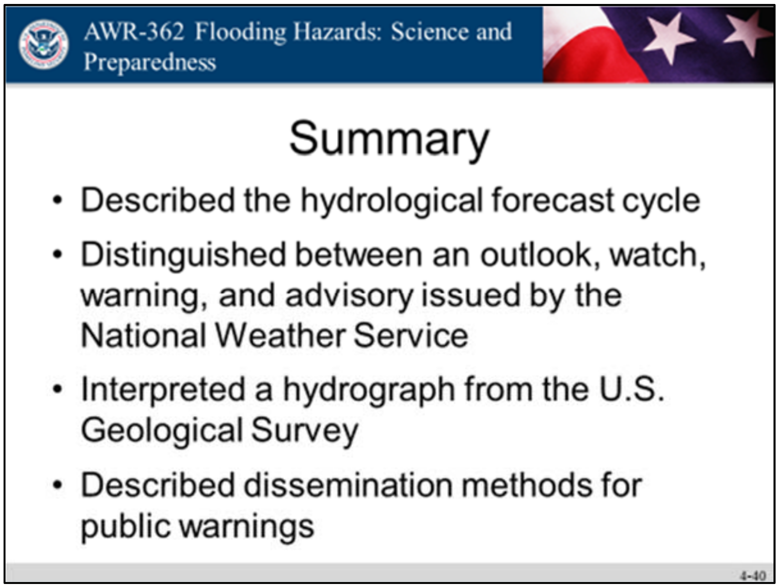
Slide 4-39. Flood Impact (Continued)

The Ochsner Medical Center – Baton Rouge was concerned about a loss of electricity. As a result, they transferred their critically ill patients to affiliated hospitals across the state on Sunday – two days into the rainfall event. Roads surrounding the facility were flooded so high that the hospital had to work with state officials to use military-style transport vehicles to move the patients.

Ambulances were not able to access the campus until Monday. They still did not have sufficient resources and personnel to accept incoming patients until later in the week.

Around 60 staff members slept on the hospital grounds and rotated shifts because they were unable to leave, and incoming employees could not make it to the hospital. In addition, many personnel had to attend to flooding issues at their home so were not available to come to work.

Participant Notes:



Slide 4-40. Summary

In the module, participants:

- Described the hydrological forecast cycle;
- Distinguished between an outlook, watch, warning, and advisory issued by the National Weather service;
- Interpreted a hydrograph from the U.S. Geological Survey; and
- Described dissemination methods for public warning.

AWR-362
Flooding Hazards: Science and Preparedness

Module 5: Safe Preparation and Mitigation for Floods

Version 1.0

FEMA

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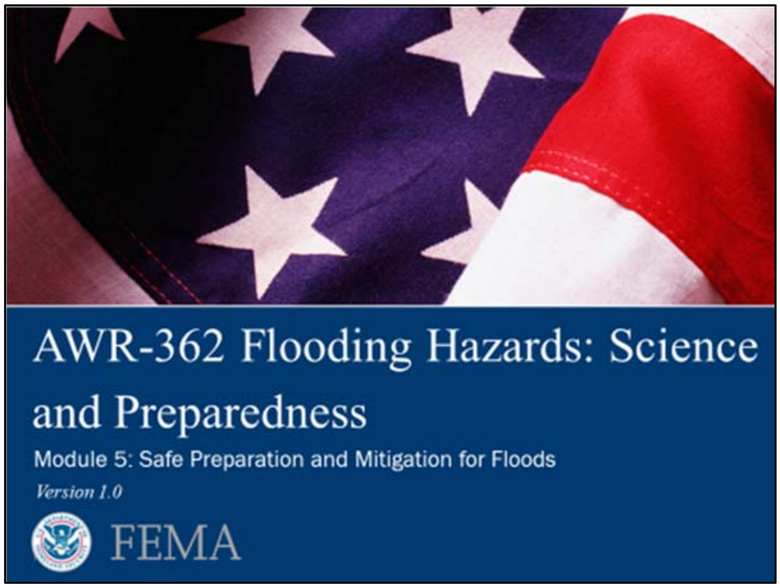
Module 5: Safe Preparation and Mitigation for Floods – Administration Page



Slide 5-1. Safe Preparation and Mitigation for Floods

Duration

40 minutes

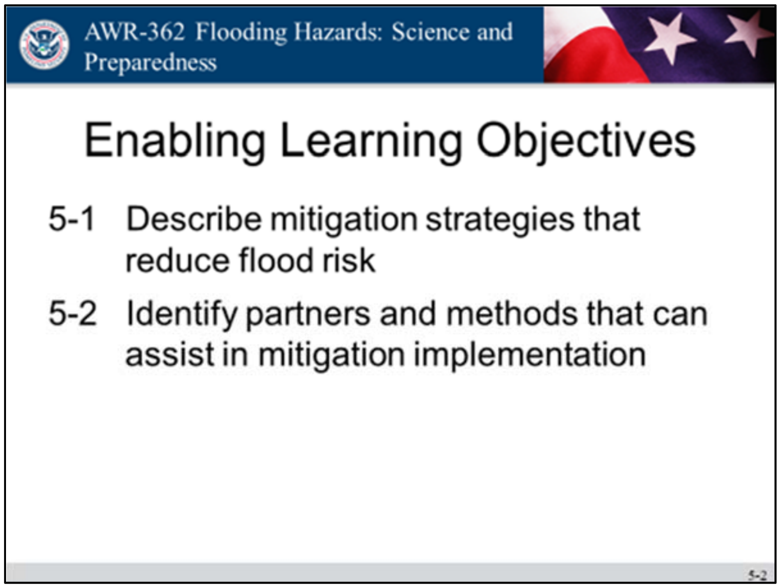
Scope Statement

Many factors determine a community's flood risk: proximity to waterways, land use, soil type, climate, and topography. This module introduces participants to the ways in which these factors are combined to determine their flood risk, and how this affects the cost and availability of flood insurance. A discussion of using historical data to determine the return period of flood events, and how these might be affected by climate change is also included.

Terminal Learning Objective (TLO)

Participants will be able to describe preparedness and mitigation actions to be taken in anticipation of flood events.

Enabling Learning Objectives



Slide 5-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

5-1 Describe mitigation strategies that reduce flood risk; and

5-2 Identify partners and methods that can assist in mitigation implementation.

Resources

- Instructor Guide (IG)
- Module 5 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handout

Instructor to Participant Ratio

2:40

Reference List

Federal Emergency Management Agency (FEMA). (Undated.) "Evacuation." Accessed 09/06/2017. https://www.ready.gov/evacuating-yourself-and-your-family

FEMA. 2007. "Chapter 5- Barriers." In *Selecting Appropriate Mitigation Measures for Floodprone Structures (FEMA 551).* Accessed 09/06/2017. https://www.fema.gov/media-library-data/20130726-1608-20490-6445/fema551_ch_05.pdf

FEMA. 2013. "Chapter 4 - Other Flood Protection Measures." In *Floodproofing Non-Residential Structures* (*FEMA P-936*). Accessed 09/06/2017. https://www.fema.gov/media-library-data/2c435971150193efc6a6ba08f2403863/P-936_sec4_508.pdf

FEMA. 2014. "How to Prepare for a Flood." Accessed 09/06/2017. https://www.fema.gov/media-librarydata/14090028528883c5d1f64f12df02aa801901cc7c311ca/how_to_prepare_flood_033014_508.pdf

FEMA 2015. "Communications Toolkit: Materials for your Outreach and Promotion." *Emergency Management Institute*. Accessed 09/07/2017. https://www.fema.gov/media-librarydata/14450302263097c7bb723c93678b3edf4d69e986862de/20151016_AP_Comm_Toolkit_Sept2015_508.pdf

FEMA. 2016. "U.S. Army Corps of Engineers – Coastal Partner." Accessed 09/06/2017. https://www.fema.gov/us-army-corps-engineers-coastal-partner

FEMA. 2017. "Floodproofing." Accessed 09/06/2017. https://www.fema.gov/floodproofing

FEMA. 2017. "Grants." Accessed 09/06/2017. https://www.fema.gov/grants

FEMA. 2017. "The National Flood Insurance Program Community Status Book." Accessed 09/06/2017. https://www.fema.gov/national-flood-insurance-program-community-status-book

Glick, P. et al. 2014. "Natural Defenses from Hurricanes and Floods: Protecting America's Communities and Ecosystems in an Era of Extreme Weather." *National Wildlife Federation*. Accessed 09/06/2017. http://www.nwf.org/~/media/PDFs/Global-Warming/2014/Natural-Defenses-Final-Embargoed-Until-102114-10amET.pdf

Horry County. 2017. "Know Your Zone." *Horry County Government.* Accessed 09/06/2017. http://www.horrycounty.org/Departments/EmergencyManagement/Hurricanes/KnowYourZone

National Governor's Association. 2014. "Governor's Guide to Mass Evacuation." *NGA Center for Best Practices.* Accessed 09/06/2017. https://www.nga.org/files/live/sites/NGA/files/pdf/GovGuideMassEvacuation.pdf

National Oceanic and Atmospheric Administration (NOAA). (2017.) "How Do Coral Reefs Protect Life and Property?" *National Ocean Service.* Accessed 09/06/2017. https://oceanservice.noaa.gov/facts/coral_protect.html

National Research Council of the National Academies. 2013. "Levees and the National Flood Insurance Program: Improving Policies and Practices." *Water Science and Technology Board, Division of Earth and Life Sciences.* Accessed 09/06/2017. https://www.nap.edu/read/18309/chapter/1

Naturally Resilient Communities. (Undated.) "Planning Approaches to Reduce Natural Hazards." Accessed 09/06/2017. http://nrcsolutions.org/mapping-planning-regulation-planning-approaches-to-reduce-natural-hazards/

Reference List (continued)

Oregon Health Authority. 2014. "Risk Communication Toolkit for Flooding." *Public Health Division - Health Security, Preparedness and Response.* Accessed 09/06/2017. http://www.oregon.gov/oha/PH/PREPAREDNESS/PARTNERS/Documents/Risk%20Comm%20Toolkit%20for%20Flooding_Oct2014_V3.pdf

Pilon, Paul J. (ed.) 2002. "Guidelines for Reducing Flood Losses." United Nations Office for Disaster Risk Reduction. Accessed 09/06/2017. https://www.unisdr.org/we/inform/publications/558

The Economist. 2016. "Flood Mitigation Resources." *Flood Economics,* The Economist Intelligence Unit. Accessed 09/06/2017. http://floodeconomics.com/flood-mitigation-resources/

Traver, R. et al. 2014. "Call for a National Flood Risk Management Strategy." American Society of Civil Engineers Publications. Accessed 09/06/2017. https://www.floods.org/ace-files/documentlibrary/Publications/ASCE_Call_for_National_Flood_Risk_Management_Strategy.pdf

U.S. Army Corps of Engineers. (Undated.) "Mission Overview." Accessed 09/06/2017. http://www.usace.army.mil/Missions/

U.S. Army Corps of Engineers. 2016. "Flood Risk Communication Toolbox." Accessed 09/06/2017. http://www.corpsriskanalysisgateway.us/riskcom-toolbox.cfm

U.S. Department of Housing and Urban Development. 2017. "Community Development Block Grant Disaster Recovery Program." *HUD Exchange.* Accessed 09/06/2017. https://www.hudexchange.info/programs/cdbg-dr/

Wikipedia Contributors. 2017. "Coastal Management." Wikipedia The Free Encyclopedia. 08/31/2017. Accessed 09/06/2017. https://en.wikipedia.org/w/index.php?title=Coastal_management&oldid=798155622

Wright, James M. 2002. "Floodplain Management: Principles and Current Practices." *Emergency Management Institute.* Accessed 09/06/2017. https://training.fema.gov/hiedu/aemrc/courses/coursetreat/fm.aspx

Practical Exercise Statement

Not Applicable

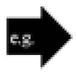
Assessment Strategy

- Instructor-led discussion to gauge participant grasp of the subject matter
- Instructor observation of participant involvement in classroom discussion

Flooding Hazards: Science and Preparedness

Icon Map

Knowledge Check: Used when it is time to assess participant understanding.

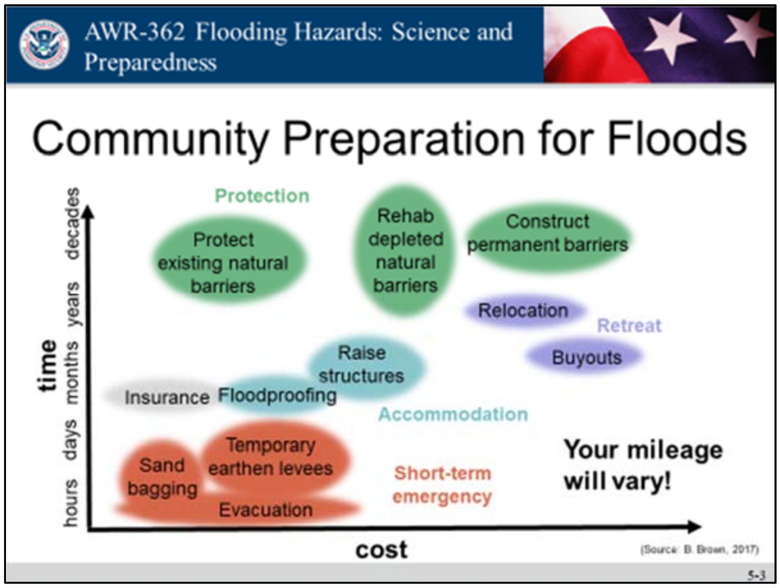


Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:



Slide 5-3. Community Preparation for Floods

Preparing for floods in your community can take many forms, all of which have a time and cost associated with them, as well as benefits and drawbacks. In an emergency, quick action must be taken. When mitigation is built in to a community's planning process, measures that are more comprehensive can be implemented to enhance flood protection. Strategies such as constructing permanent barriers (seawalls, levees) can require more time and money than rehabilitating barrier wetlands, but a healthy wetland system may end up providing better protection in the long run. Some mitigation options will be a good fit for your community's risk management program; some will not. Your experience will vary based on the type of mitigation desired and the time and money available. Mitigation strategies fall into various categories, which will be discussed in the next slides.

Slide 5-4. Short-term Mitigation Strategies

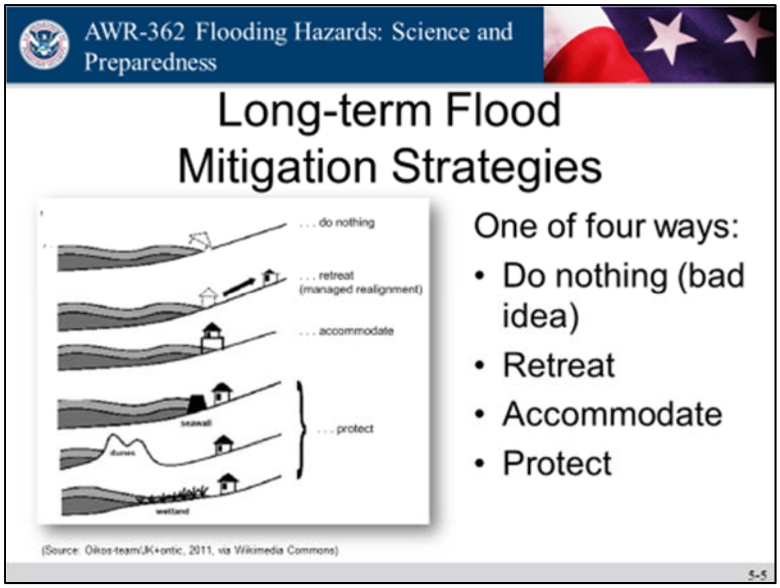
Short-term strategies for addressing flood risk include mitigation options such as sandbagging, building earthen dams using fill dirt, and evacuation. Each implementation has it's own time frame and expense. For instance, if you do not have a fill dirt resource nearby, you will have to factor in the cost of acqusition into your plan for building an earthen dam.

When considering sandbags, remember:

- Sandbags will not seal out water. Sandbags deteriorate when exposed to continued wetting and drying for several months.
- If bags are placed too early, they may not be effective when needed.
- Sandbags are for small water flow protection – up to two feet.
- Protection from larger flow requires a more permanent flood prevention system. Be sure to consult with your local environmental protection department before disposing of used sandbags.
- Sandbags that are exposed to contaminated floodwaters may pose an environmental hazard and require special handling.

Other resources that act as sandbags but do not require sand include water-filled protection measures, quick-set-up dam systems, pre-fit flood gates, sand-less bags, and other flood protection measures. These can be scaled from individual- to community-sized use.

e.g. **Example:** The leftmost photograph on this slide shows an "EvacuSpot" sculpture in New Orleans, LA, which indicates bus pick-up points for those who are unfamiliar with the city and its evacuations plans, and do not have their own transportation, such as tourists.



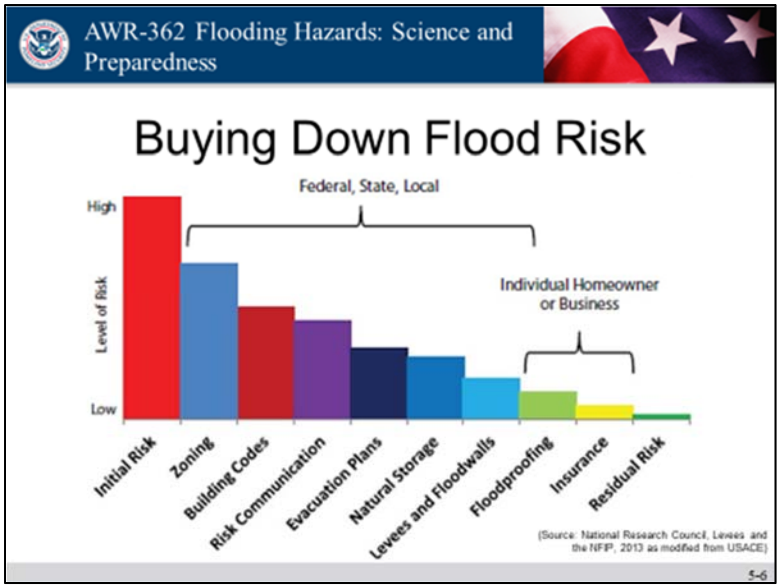
Slide 5-5. Long-term Flood Mitigation Strategies

Flood mitigation activities can be sorted into three main categories: retreat, accommodate, and protect.

Retreat involves homeowners or communities relocating to avoid the source of flooding in the first place. Individual homeowners can make the decision to move out of a floodplain on their own, but communities can also encourage relocation through buyouts or mass relocation.

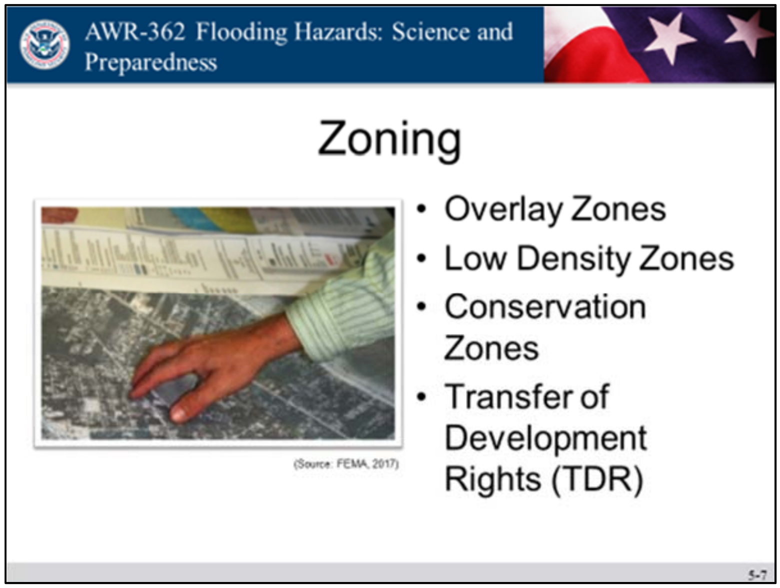
When implementing accommodation, structures remain in their original location, but are retrofitted to become impervious to floodwaters, either by elevating or floodproofing the structure.

Protection, as with accommodation, leaves structures and communities in place, but mitigates floods with barriers rather than modifying the structure itself. Barriers can include seawalls, levees, wetlands, dunes, etc. Details of these mitigation strategies will be expanded on in the remainder of this module.



Slide 5-6. Buying Down Flood Risk

Communities achieve effective storm damage risk reduction when property owners and all levels of government take preventive actions to reduce storm damages and consequences. From the initial risk of a completely vulnerable community, each action incrementally decreases the risk from flooding. Keep in mind, though, the risk can never be brought to zero. Each mitigation action will be presented in the next slides.



Slide 5-7. Zoning

Zoning is a legislative process through which the local governing body (under power delegated by the state zoning enabling law) determines regulations regarding land use, including the height and spacing of buildings, by zone or district in their jurisdiction.

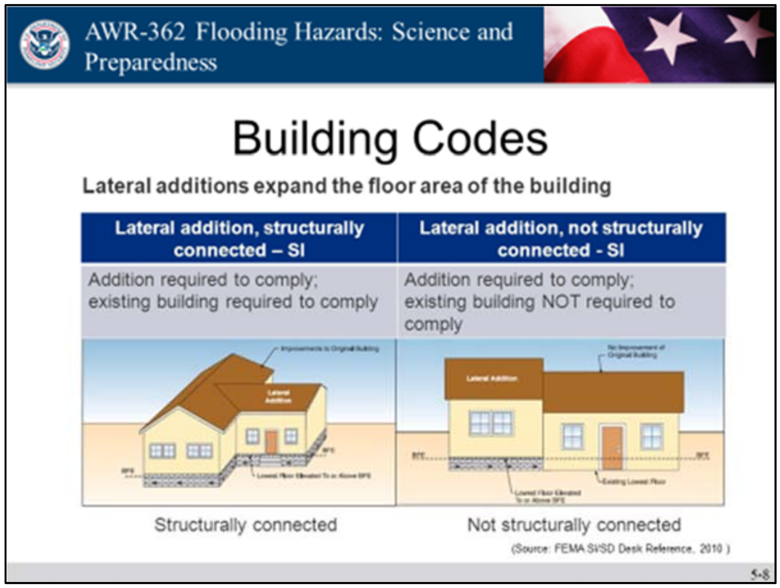
Some zoning tools to reduce flood risk include:

1. ***Overlay Zones:*** These zones coexist with other zones, operating like a transparency overlaying existing land use controls. Examples include floodplain and historic districts; within these areas, development is regulated by the standard zoning ordinance and the unique requirements of the overlay zone.
2. ***Low Density Zones:*** This is an option that is popular in rural areas; the number of residential or commercial units allowed on a piece of property is limited to a low number per acre, and as such results in considerable open space reserved.
3. ***Conservation Zones:*** If low density zones will not work in your area, conservation zones might. The goal of conservation zones is to protect a sensitive area (like a floodway, wetland, or fragile watershed) that would otherwise be developed. Often developers are given density in less sensitive areas in exchange for keeping the sensitive area conserved.
4. ***Transfer of Development Rights (TDR):*** These programs treat development as commodity separate from land itself. The government awards development rights based on value or acreage of land, and establishes sending and receiving areas for these rights. The sending areas contain land the government, for various reasons, seeks to protect. In these zones, landowners do not have enough rights to develop their land, but they can sell

rights to developers in receiving areas. With these rights, projects can take on higher densities than would otherwise be permissible. In addition to density, TDR programs can be used to affect the type of uses if the rights are for specific kinds of development, as opposed to one general-purpose right.

While zoning is the most common form of land-use control available to local government, it has a number of drawbacks for flood mitigation purposes:

1. Zoning, like building codes, primarily affects new structures rather than existing buildings. As a result, it is ineffective in making present development more hazard resilient.
2. Zoning regulations must preserve some economically viable use of the land for the landowner; otherwise, the regulations may qualify as an unconstitutional taking. This issue generally prevents any attempt at a blanket prohibition of development in hazardous areas.
3. Zoning is subject to changes in the courts' views and in the political climate. The courts and public opinion tend to sway between regarding property as an individual or as a community resource. Communities that issue variances, special use permits, or rezoning, or fail to enforce existing codes, seriously weaken the effectiveness of codes which prevent hazardous building practices.
4. The zoning code may also be swayed by other community priorities. For example, zoning that lowers density may increase the cost of providing services for governments that are seeking the economic benefits of growth. On the other hand, zoning that raises densities may increase the number of people at risk in hazard areas.

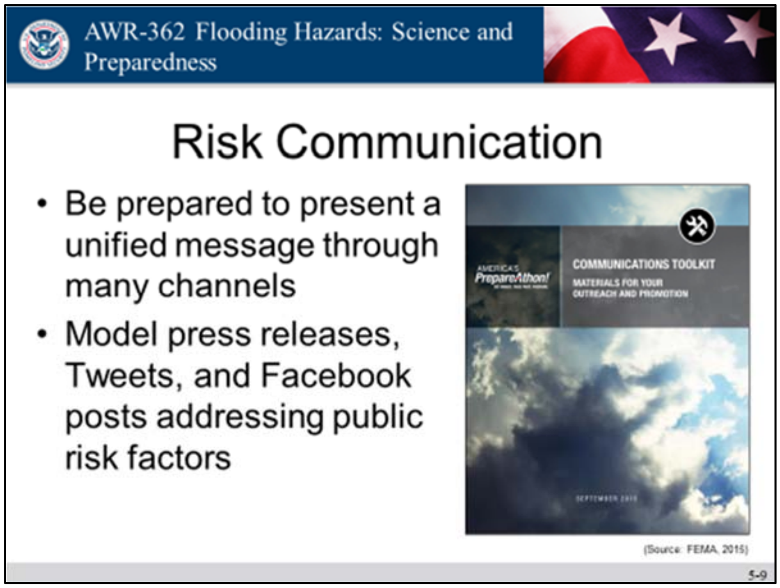


Slide 5-8. Building Codes

Rather than legislate where development occurs through zoning, communities can choose instead, or in addition, to legislate *how* it is built through building codes. This can encourage flood resilience even when the floodplain is densely occupied.

The National Flood Insurance Program (NFIP) reduces building damage and other community losses during flood events through community adoption and enforcement of its requirements. FEMA has long known that building codes also improve building performance during flood events.

The NFIP performance statement for flood-resistant construction at 44 CFR § 60.3(a)(3*) requires communities to review all permit applications to determine whether proposed building sites will be reasonably safe from flooding. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii)be constructed by methods and practices that minimize flood damages, and A-2 (iv)be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding (https://www.fema.gov/media-library/assets/documents/12442).*

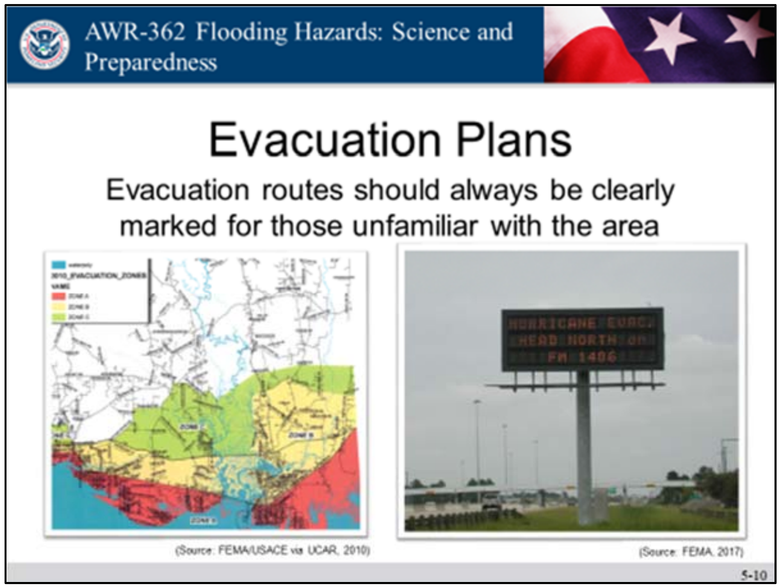


Slide 5-9. Risk Communication

You can live in a floodplain and not know it. In a world of easy exchange between communities, states, and countries, your community could be adding new members all the time who are not aware of the flood risks and hazards. Record events or changing floodplains can surprise even long-term residents.

Local officials are the first line for keeping everyone in their community up to date and properly informed when it comes to flooding. To do this, preparation is required to educate and prepare citizens during periods of quiescent weather, and alert them during flooding disasters. Officials should have templates and models of effective messaging for many situations, ready to go out in many forms: social media, television, public press release, etc.

Participant Note: Social science shows that repetition in messaging is the key to motivating the public to prepare.

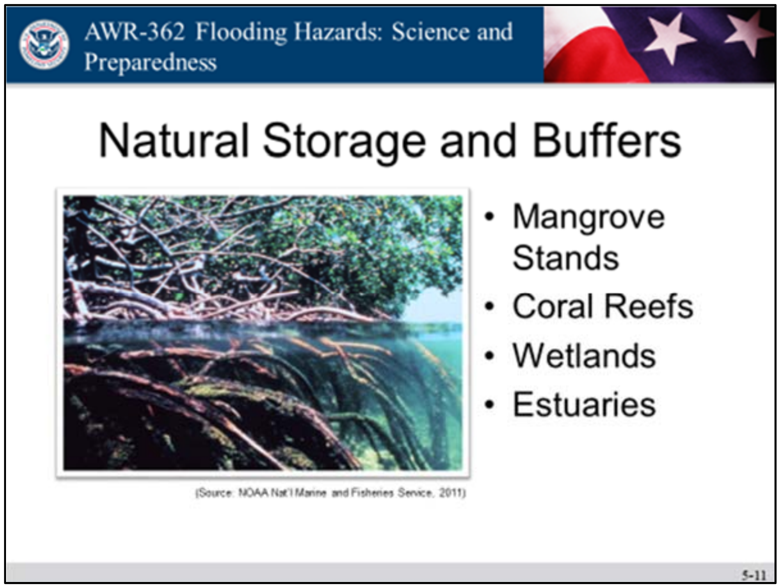


Slide 5-10. Evacuation Plans

The most effective evacuation plans are based on the range of likely risks to infrastructure, communities, and businesses. In addition, they are designed to implement time-phased evacuations with the goal of moving the most vulnerable populations out of harm's way first.

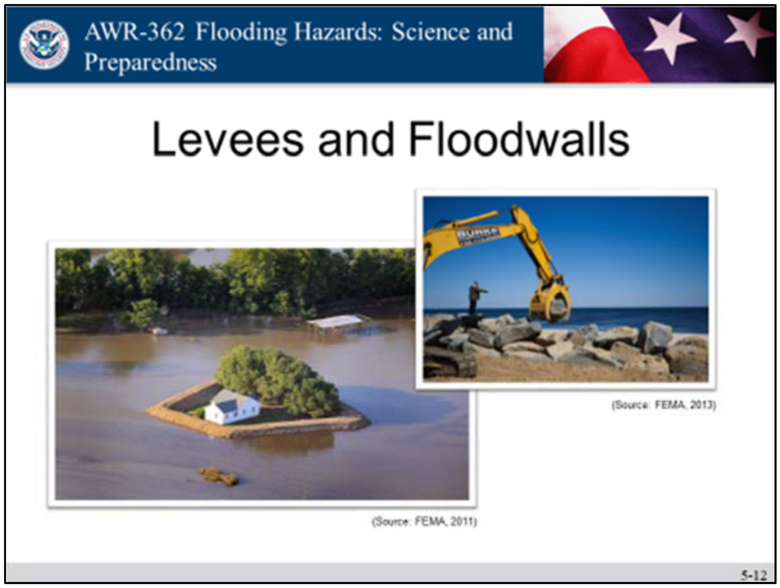
Evacuation plans must be publicized, readily available to the public, and easy to understand. Best practices include signage that indicates in which evacuation zone your street is located (for example, made part of the street sign or bolted to directional signage) to keep the message in mind daily.

Evacuation routes should be planned with the aid of your flood maps, to ensure the routes do not cross roads that are in the regulatory flood zone.



Slide 5-11. Natural Storage and Buffers

Natural storage and buffers make use of environmental benefits that already exist in your community and region. They generally require legislative protection and require maintenance. Some natural functions that benefit floodplain management include reefs, mangroves, barrier islands, wetlands, dunes, and many more. Many of these natural barriers act by preventing erosion, absorbing wave energy, and provide natural storage for floodwaters. In addition to natural flood risk reduction, barriers and storage such as healthy reefs can be an economic boon by attracting eco-tourism and encouraging healthy fisheries.

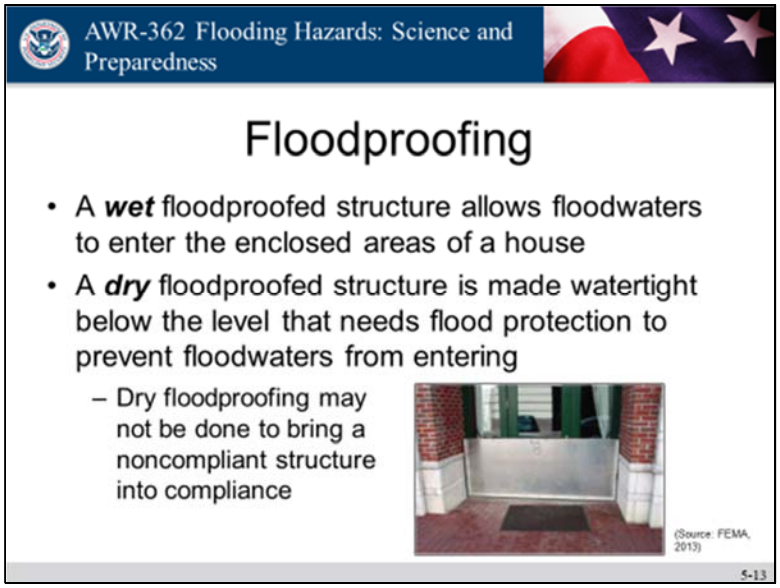


Slide 5-12. Levees and Floodwalls

Levees and Dikes: The terms “levee” and “dike” are often used synonymously. Levees are earthen embankments used to protect low-lying lands from flooding. Dikes are usually an earthen or rock structure built partially across a river for the purpose of maintaining the depth and location of a navigation channel.

Floodwall: A floodwall is a reinforced concrete wall that acts as a barrier against floodwaters. Floodwalls are usually built in lieu of levees where the space between land and the floodplain is limited.

Both levees and floodwalls require extensive engineering. Additionally, the design will need to involve the Army Corps of Engineers, which has jurisdiction over U.S. waters under the Clean Water Act.

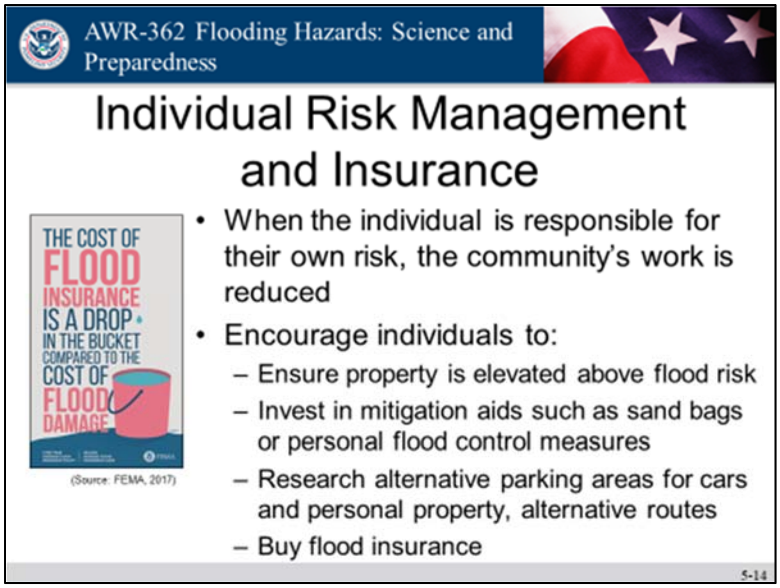


Slide 5-13. Floodproofing

Floodproofing is an alternative to raising or moving a structure. It is particularly well suited to historical buildings that may have restrictions forbidding certain modifications.

Dry floodproofing involves sealing a building against floodwaters by making all areas below the flood protection level watertight. This can be done by coating walls with waterproofing compounds or plastic sheeting and protecting building openings with removable shields or sandbags. Dry floodproofing is limited to two or three feet above the foundation of the building, due to the pressure exerted by deeper water on the walls and floors.

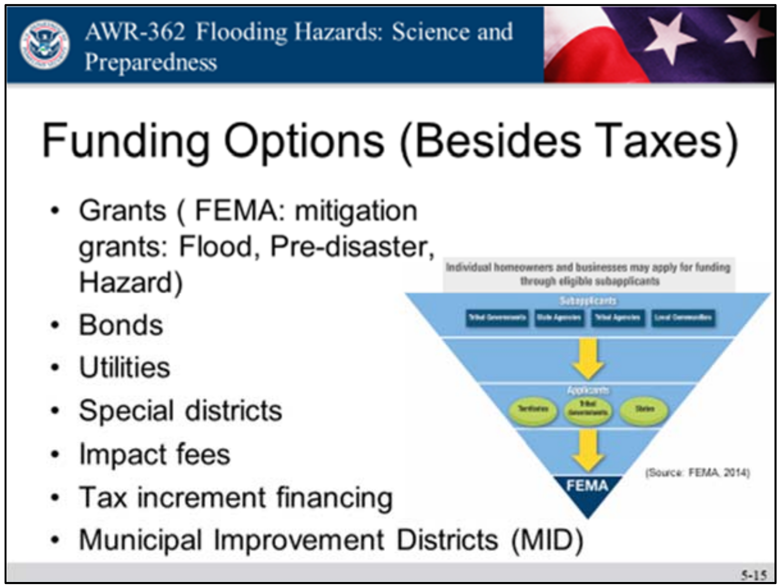
Wet floodproofing allows water to enter a building to reduce the pressure exerted by deep water. Wet floodproofing, at minimum, involves removing some valuable items, to the rebuilding of floodable areas. Wet floodproofing can dramatically reduce damage costs with little cost to mitigate the disaster, by simply removing furniture and electrical appliances out of the flood prone area.



Slide 5-14. Individual Risk Management and Insurance

According to FEMA, there are many reasons why individuals should insure against floods:

- *Floods are the nation's most common and costly natural disaster and cause millions of dollars in damage every year.*
- *Homeowners and renters insurance does not typically cover flood damage.*
- *Floods can happen anywhere--More than 20 percent of flood claims come from properties outside the high-risk flood zone.*
- *Flood insurance can pay regardless of whether or not there is a Presidential Disaster Declaration.*
- *Most federal disaster assistance comes in the form of low-interest disaster loans from U.S. Small Business Administration (SBA) and you have to pay them back. FEMA offers disaster grants that do not need to be paid back, but this amount is often much less than what is needed to recover. A claim against your flood insurance policy could and often does, provide more funds for recovery than those you could qualify for from FEMA or the SBA--and you do not have to pay it back.*
- *You may be required to have flood insurance. Congress has mandated federally regulated or insured lenders to require flood insurance on mortgaged properties that are located in areas at high risk of flooding. But even if your property is not in a high risk flood area, your mortgage lender may still require you to have flood insurance.*



Slide 5-15. Funding Options (Besides Taxes)

Flood mitigation is rarely cheap, but it is generally best to mitigate before a disaster rather than struggle to recover after. To do so effectively, communities must fund mitigation efforts in a sustainable and fair manner. Taxes are not the only option to do so. Some other revenue streams for flood mitigation are:

1. ***FEMA Grant Programs*** include the following:
    - Hazard Mitigation Grant Program;
    - Flood Mitigation Assistance;
    - Pre-disaster Mitigation Grant;
    - Repetitive Flood Claims; and
    - Severe Repetitive Loss.
2. ***Bonds:*** Bonds are forms of debt that allow communities to borrow money from investors and pay the money back with a fixed rate. Bonds are often used for infrastructure projects like stormwater improvements or public parks. Your community's bond rating will have an impact on how much you can borrow.

    In 2015, the Brookings Institute wrote a report on a new product called "resilience bonds." These bonds are based on financing infrastructure that is targeted to reduce a community's risk from catastrophe.
3. ***Utilities:*** Some communities create utility districts for flood control or stormwater systems. The funds paid into these utilities are used to improve the systems they protect.
4. ***Special Assessments Districts:*** Special assessment districts include property owners who benefit from a specific public improvement. These owners are charged a fee, which can be based on an attribute(s) of the property that is proportional to the

benefits received from the improvement, and which is charged to both new and existing development.

There are numerous possibilities, from temporary creations designed simply to raise revenue for a specific improvement to independent, special purpose governmental entities.

Since this is not a tax, special assessment districts are free from constitutional requirements of uniformity, equality, and double taxation. This technique shifts the financial burden from the general public to those directly benefiting. The revenues are more predictable than sources that depend on development cycles, which make issuing bonds easier.

5. ***Impact Fees:*** Fees to offset the burdens of new development on the community. Fees contribute to regional equity by ensuring that a new development pays a fair share of the public costs that they generate. These fees are used to fund new schools and parks, construction or maintenance of public infrastructure directly connected to the new development, and off-site improvements and services.
6. ***Tax Increment Financing:*** TIF is a public financing method that has been used as a subsidy for redevelopment and community improvement projects in many countries, including the United States, for more than 50 years. It is a method that exploits future gains in taxes to finance current improvements (which theoretically will create the conditions for those future gains).

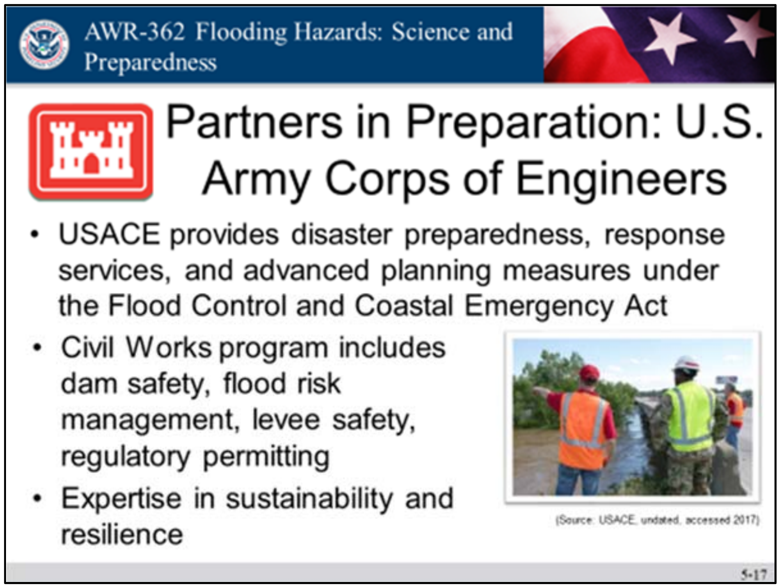
   When a development or public project is carried out, there is often an increase in the value of surrounding real estate, and perhaps new investment that will generate additional tax revenue to pay for the initial improvements.
7. ***Municipal Improvement Districts*:** A MID is a special assessment district that assesses fees to property owners in a specific area to fund public improvements that provide a benefit to the properties in the district. Much like a TIF, it is confined to a municipal (city) use.

Slide 5-16. Available Community Advice

We have already established that local governments have access to their state NFIP coordinators if they need assistance. In addition, there are several professional organizations whose members are involved in flood control and/or floodplain management.

Some of the larger ones include:

- American Society of Civil Engineers;
- American Planning Association;
- Association of State Floodplain Managers;
- Association of Stormwater and Floodplain Managers;
- Center for Watershed Protection;
- International Code Council;
- International Organization for Standardization;
- National Hazard Mitigation Association;
- American Meteorological Association; and
- American Geophysical Union.

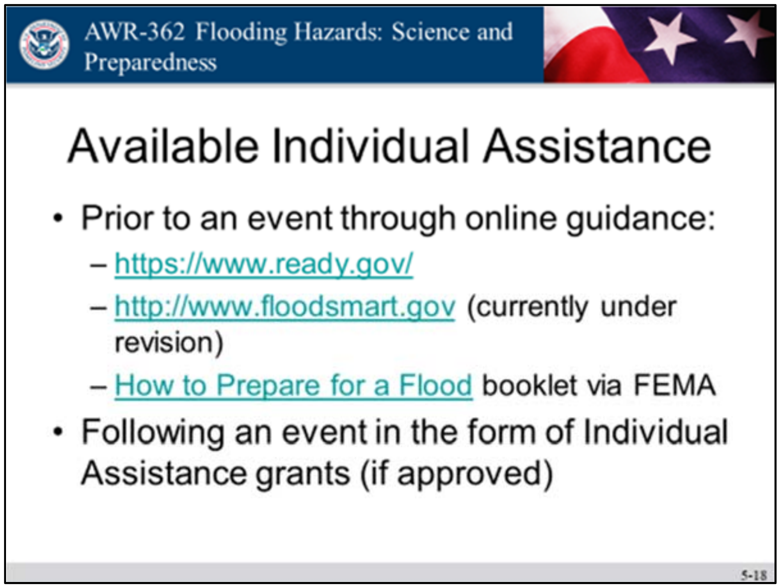


Slide 5-17. Partners in Preparation: U.S. Army Corps of Engineers

Because they are in separate departments of the federal government, with separate funding, the U.S. military (Department of Defense) is not often involved with FEMA (Department of Homeland Security). Military bases have their own emergency managers and disaster and mitigation plans, and to maintain our democracy, troops generally do not deploy within the U.S., with the exception of the National Guard during periods of extreme disaster or unrest. The military's humanitarian role in disaster response and recovery is not in the scope of this course, but there is one important exception to the separation of the military and FEMA when it comes to flood mitigation: The U.S. Army Corps of Engineers (USACE).

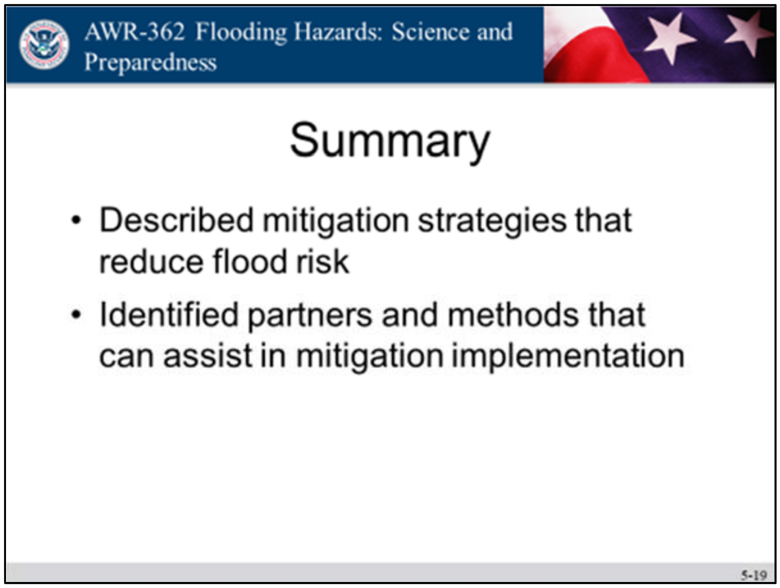
Under the Flood Control and Coastal Emergency Act, the U.S. Army Corps of Engineers provides disaster preparedness services and advanced planning measures designed to reduce the amount of damage caused by an impending disaster.

USACE maintains hundreds of dams, thousands of navigable waterways, hundreds of harbors, and restores wetlands across the nation. They run levee and dam safety programs. You are likely to encounter USACE when preparing for flooding or planning flood mitigation projects.



Slide 5-18. Available Individual Assistance

There are multiple sources of good advice on how individuals can prepare their home and family to respond to a flood. Three examples are listed on this slide, but the resources cited in the reference section before each module contain many more.



Slide 5-19. Summary

In this module, participants:

- Described mitigation strategies that reduce flood risk; and
- Identified partners and methods that can assist in mitigation implementation.

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AWR-362
Flooding Hazards: Science and Preparedness

Module 6: Course Summary and Administration

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Module 6: Course Summary and Administration – Administration Page

Slide 6-1. Course Summary and Administration

Duration

40 minutes

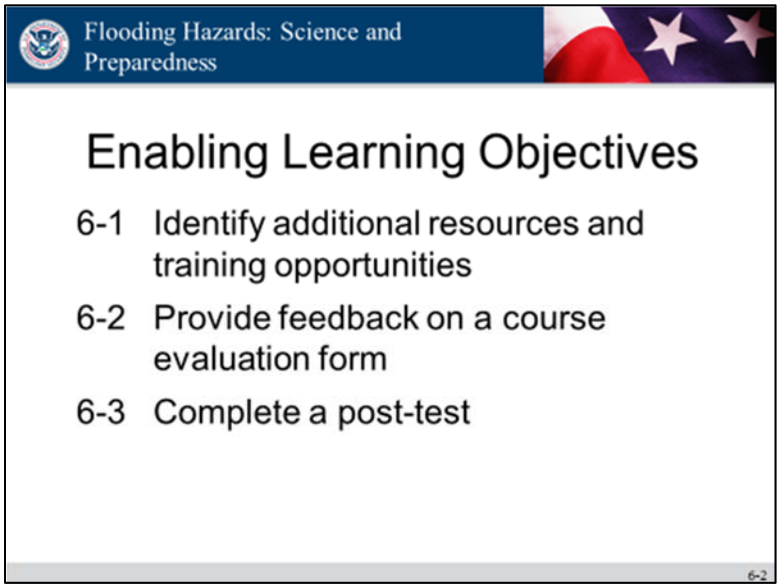
Scope Statement

In this module, instructors will lead a short discussion to review the course goal and content. Participants will complete an objectives-based post-test. Participants must score at least 70 percent to receive a Certificate of Completion. Participants will complete a course evaluation form and provide feedback on the course instruction, content, and materials. Additional information will be provided about other FEMA training opportunities.

Terminal Learning Objective (TLO)

Participants will successfully complete a post-test and final administrative tasks for the course.

Enabling Learning Objectives (ELOs)



Slide 6-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

6-1 Identify additional resources and training opportunities;
6-2 Provide an evaluation of the course materials and instruction; and
6-3 Complete a post-test.

Resources

- Instructor Guide (IG)
- Class roster
- Course presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- Post-Test Key with ELO Mapping
- One of each of the following items per participant:
    - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
    - Post-test
    - Answer Sheet
    - Course Evaluation Form

Instructor-to-Participant Ratio

2:40

Reference List

National Domestic Preparedness Consortium (NDPC). 2012. NDPC Website. https://www.ndpc.us

Practical Exercise Statement

Not Applicable

Assessment Strategy

- Instructor observation of participant involvement in classroom discussion
- Instructor-led discussion to gauge participant grasp of the subject matter and to ensure that participant understands both how performance will be evaluated and how evaluation will impact participant outcomes
- Instructor administration of objectives-based post-test to assess the knowledge participants have gained in each module

Flooding Hazards: Science and Preparedness

Icon Map

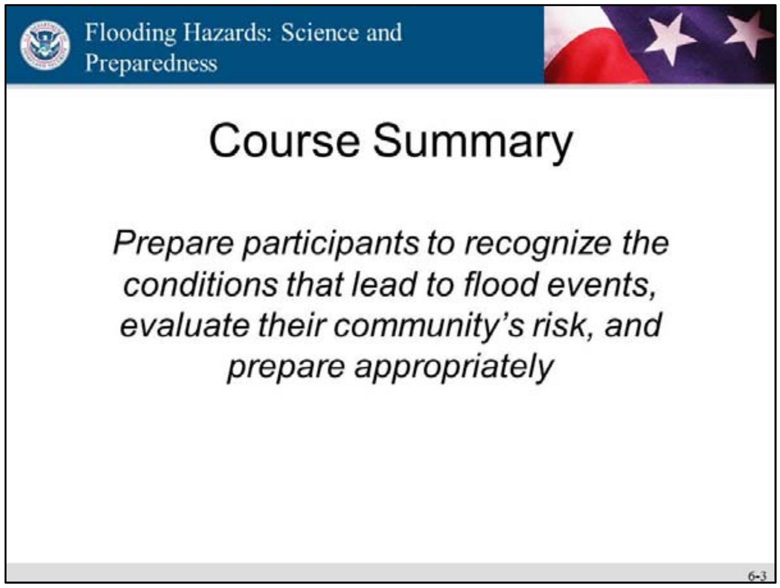
Knowledge Check: Used when it is time to assess participant understanding.

Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:

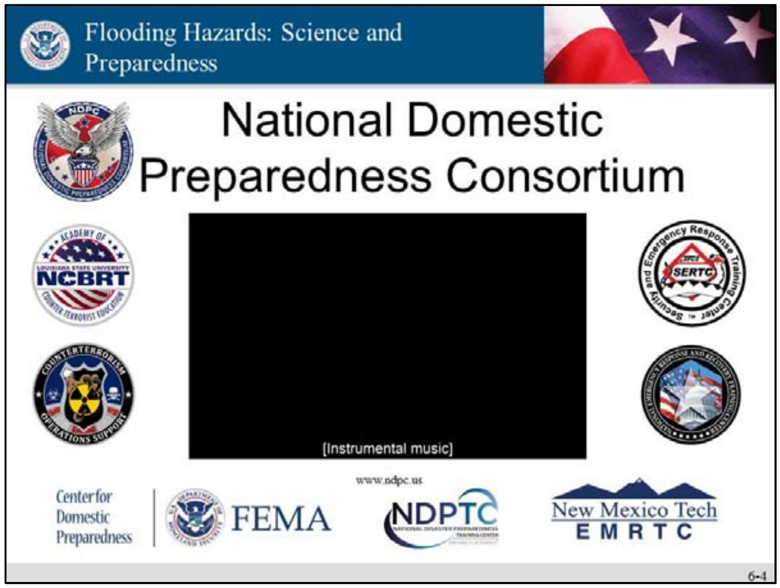


Slide 6-3. Course Summary

This course has prepared participants to recognize the conditions that lead to flood events, evaluate their community's risk, and prepare appropriately.

Participants can now:

- Differentiate between types of flooding hazards based on the meteorological and hydrological conditions;
- Access and interpret FEMA flood risk maps;
- Identify organizations involved in forecasting and monitoring flooding, and understand the products they issue; and
- Describe preparedness and mitigation actions to be taken in anticipation of flooding events.



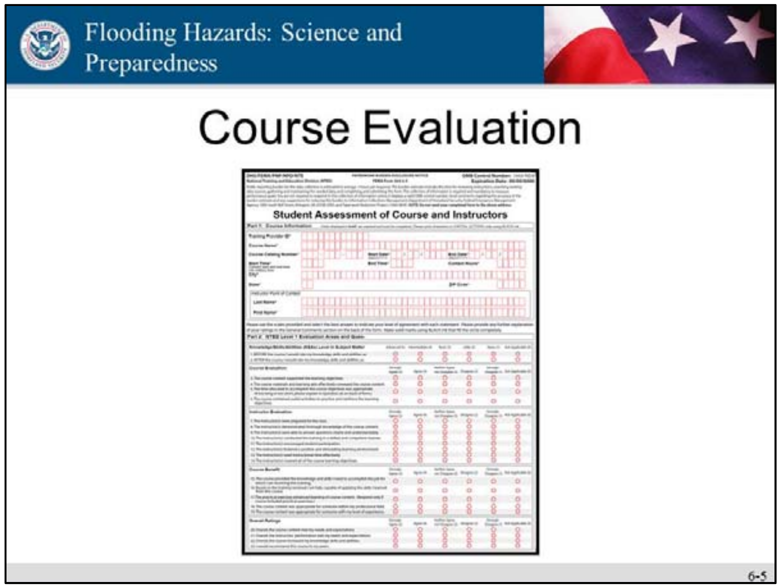
Slide 6-4. National Domestic Preparedness Consortium (NDPC)

The National Domestic Preparedness Consortium (NDPC) is a professional alliance sponsored through the Department of Homeland Security/FEMA National Preparedness Directorate.

The NDPC membership includes:

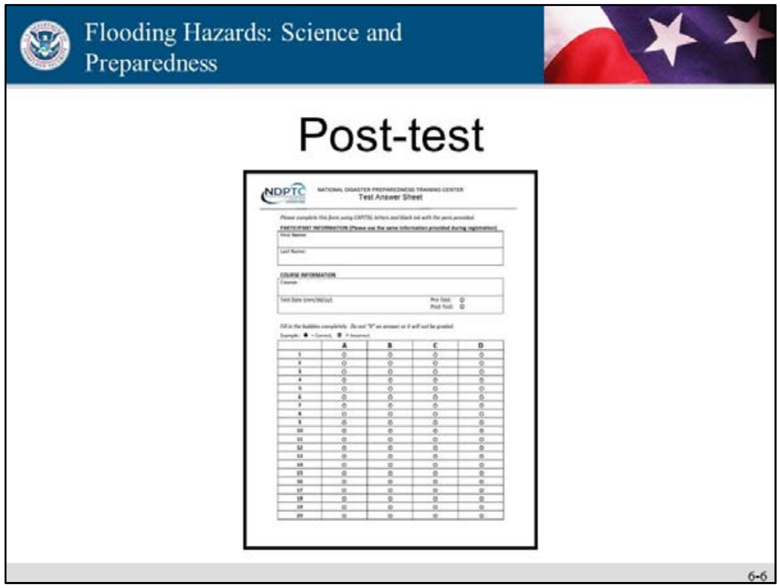
- University of Hawai‘i: National Disaster Preparedness Training Center (NDPTC);
- Louisiana State University’s Academy of Counter-Terrorist Education: National Center for Biomedical Research and Training;
- Texas A&M: National Emergency Response and Rescue Center;
- The New Mexico Institute of Mining and Technology: Energetic Materials Research and Testing Center;
- Center for Domestic Preparedness (CDP);
- US Department of Energy Nevada Test Site: Counter-Terrorism Operations Support; and
- Transportation Technology Center, Inc./Security and Emergency Response Training Center.

Each member brings a unique set of assets to the domestic preparedness program.



Slide 6-5. Course Evaluation

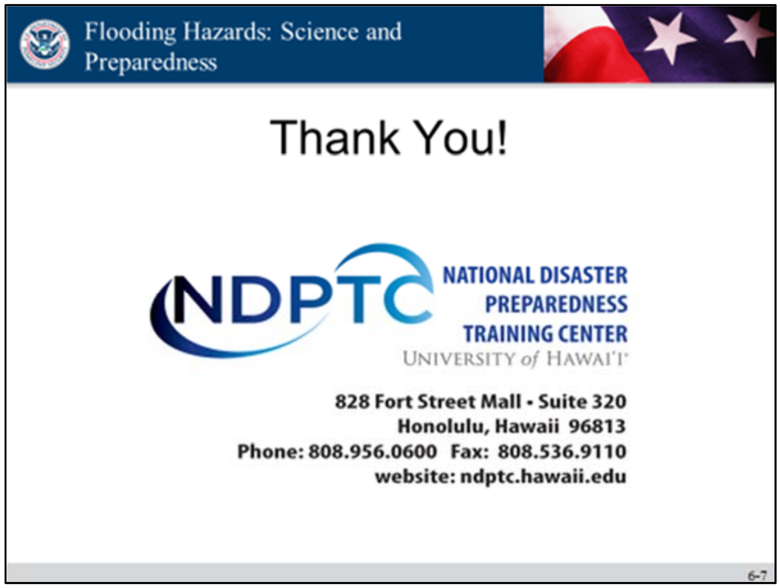
The instructor will distribute a Course Evaluation Form to participants and ask them to provide constructive feedback on the course material and instruction. Participants have 15 minutes to complete the form.



Slide 6-6. Post-test

This course concludes with a post-test, which allows the instructor to evaluate participant knowledge on the topics addressed in the course. The post-test provides participants with an opportunity to demonstrate mastery of the Terminal Learning Objectives, and is similar in design and content to the pre-test that participants completed at the beginning of the course. Participants' pre-test and post-test scores will be compared to measure the benefit of the course and identify the knowledge and skills participants gained during their attendance.

Unlike the pre-test, every question should be answered. Participants must not leave any answers blank on the answer sheet. Participants will have 20 minutes to complete the post-test, and should work independently to complete the answers.



Slide 6-7. Thank You!

NDPTC works collaboratively to develop and deliver training and education in the areas of disaster preparedness, response, and recovery to governmental, private, tribal, and non-profit entities, and under-represented/under-served communities.

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Flooding Hazards: Science and Preparedness

Appendix A: Flooding: Understanding Risk, Forecasts, and Warnings

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Appendix A: Module 4 Activity: Flooding: Understanding Risk, Forecasts, and Warnings

Practical Exercise Statement

Using the 2016 floods in Baton Rouge, LA, as a case study, the practical exercise consists of receiving and interpreting a series of escalating watches/warnings in a flood scenario. This exercise allows participants to interpret flood insurance risk maps (FIRMs); read and interpret the language and graphics of forecasts from the National Weather Service; recognize outlooks, watches, and warnings; and read a hydrograph.

Introduction

Baton Rouge, LA, experienced major flooding in August 2016.

Action to be Completed

Work with your group to answer the questions in your group using the handouts provided. Share your ideas in a discussion, and note your answers for reference on the question sheets provided.

Rationale

Flooding situations can develop rapidly. This exercise provides an opportunity for participants to work together in groups to understand and appreciate different decisions and courses of action that they may need to make in a flooding situation.

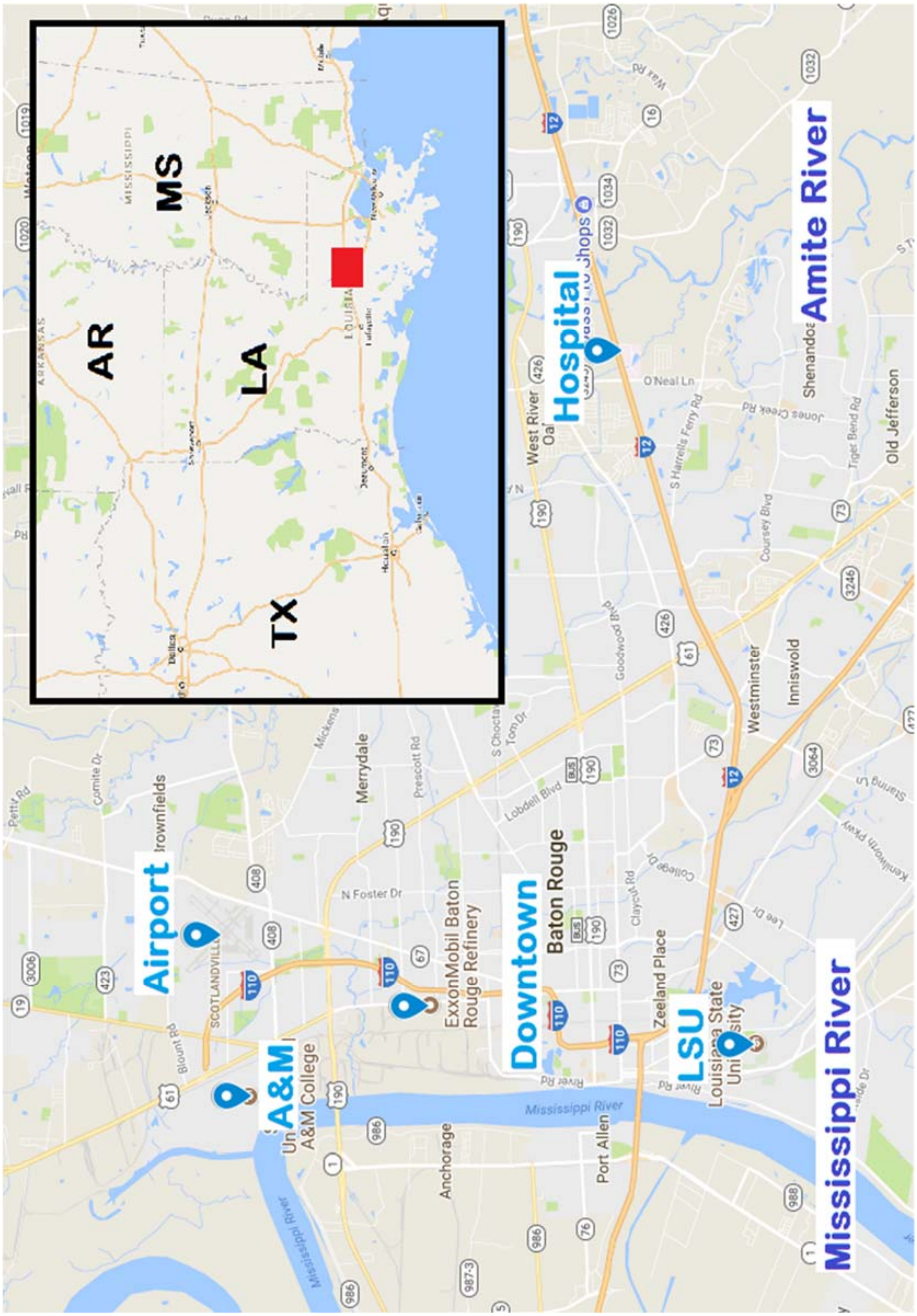
Time Necessary to Complete

40 minutes

Resources

Each group will have a binder with Handouts 1-6.

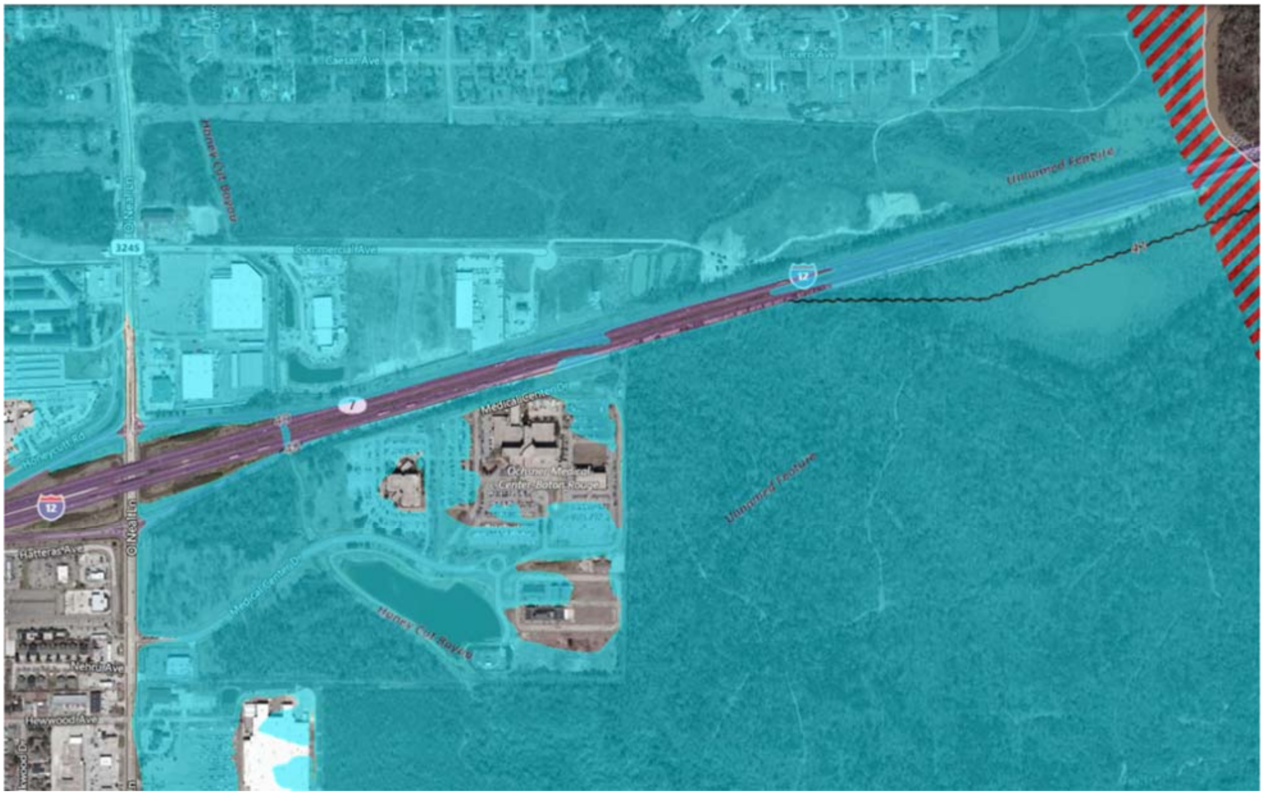
Handout #1



(Source: Google Maps, annotated by Rob Dale, 2017)

Handout #2 – Flood Insurance Rate Map

Medical Center and Interstate



Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Floodway
- Special Floodway
- Area of Undetermined Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Future Conditions 1% Annual Chance Flood Hazard
- Area with Reduced Risk Due to Levee

Airport


Blount Rd
Southern Memorial Gardens
ZONE A
ZONE AE
Elm Grove Garden Dr
Veterans Memorial Blvd
Baton Rouge Metropolitan Airport
Harding Blvd
NORTH BATON ROUGE
Jones St
Hooper Rd
Ford St
St Pius Ave
Sharon Hills Blvd
Cedar Glen Dr
Guynell Dr
110
408
67

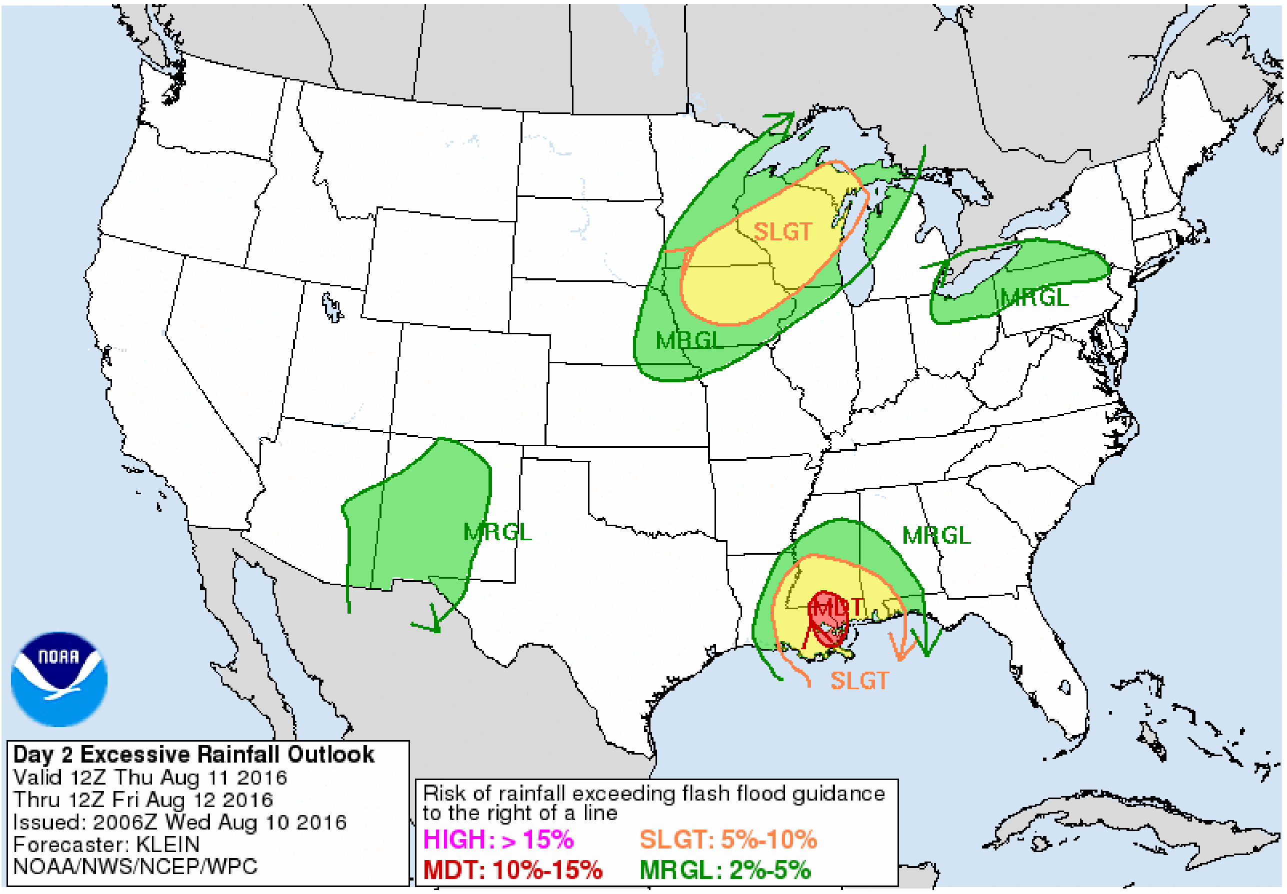
Discussion Questions

- Where are possible sources of flooding in Baton Rouge, LA?

- According to the FIRM, what is the risk at the airport? At the medical center?

- If the area is not in the 1% floodplain, can flooding still happen?

Handout #3 – Wednesday PM



(Source: NOAA, 2016)

Wednesday Evening
Issued: 2006 UTC Wed Aug 10 2016
Valid: 12 UTC Thu Aug 11 2016 thru
12 UTC Sat Aug 13 2016

12:00 UTC = 7:00 am CDT
20:00 UTC = 3:00 pm CDT

Handout #3 (continued)

HAZARDOUS WEATHER OUTLOOK
NATIONAL WEATHER SERVICE NEW ORLEANS LA
512 PM CDT WED AUG 10 2016

THIS HAZARDOUS WEATHER OUTLOOK IS FOR PORTIONS OF SOUTHEAST LOUISIANA...SOUTH MISSISSIPPI AND THE ADJACENT COASTAL WATERS.
DAYS TWO THROUGH SEVEN...THURSDAY THROUGH TUESDAY
SCATTERED TO NUMEROUS THUNDERSTORMS ARE EXPECTED THROUGH THE ENTIRE PERIOD WITH **A FEW STRONGER STORMS POSSIBLE AT TIMES**. THE GREATEST RISK WILL BE FREQUENT LIGHTNING STRIKES...WIND GUSTS OF 30 TO 40 MPH...AND **WIDESPREAD LOCALLY HEAVY RAINFALL THAT CAN RESULT IN LOCALIZED FLOODING OF LOW LYING AND POORLY DRAINED AREAS**. WATERSPOUTS AND TROPICAL FUNNELS WILL BE POSSIBLE EACH DAY.

SPOTTER INFORMATION STATEMENT...
SPOTTER ACTIVATION MAY BE NEEDED TONIGHT INTO SATURDAY FOR FLOOD MONITORING. REPORT ANY FLOODING PROMPTLY TO THE NATIONAL WEATHER SERVICE OFFICE IN SLIDELL.

Discussion Questions

- What is the risk of flash flooding in Baton Rouge?

- How many days are there to plan for flooding?

Handout #4 – Thursday AM

(Source: NOAA, 2017)

Handout #4 (continued)

FLASH FLOOD WATCH
NATIONAL WEATHER SERVICE NEW ORLEANS LA
432 AM CDT THU AUG 11 2016

...FLASH FLOOD WATCH IN EFFECT THROUGH SATURDAY MORNING...

THE NATIONAL WEATHER SERVICE IN NEW ORLEANS HAS ISSUED A

* **FLASH FLOOD WATCH** FOR PORTIONS OF SOUTHEAST LOUISIANA AND SOUTHERN MISSISSIPPI...INCLUDING THE FOLLOWING AREAS...IN SOUTHEAST LOUISIANA...ASCENSION...ASSUMPTION...EAST BATON ROUGE...EAST FELICIANA...IBERVILLE...LIVINGSTON...NORTHERN TANGIPAHOA...POINTE COUPEE...ST. HELENA...ST. JAMES...ST. JOHN THE BAPTIST...WASHINGTON...WEST BATON ROUGE AND WEST FELICIANA. IN SOUTHERN MISSISSIPPI...AMITE...PIKE...WALTHALL AND WILKINSON.

* **THROUGH SATURDAY MORNING**

* ABUNDANT TROPICAL MOISTURE POOLED AROUND A WEAK SURFACE LOW PRESSURE SYSTEM NEAR THE MISSISSIPPI COAST WILL ALLOW FOR FAVORABLE CONDITIONS FOR HEAVY RAINS AND THE POTENTIAL OF FLASH FLOODING IN THE CENTRAL GULF COAST REGION. **STORM TOTAL RAINFALL ACCUMULATIONS THROUGH SATURDAY MORNING COULD RANGE BETWEEN 5 AND 8 INCHES WITH SOME LOCALLY HIGHER AMOUNTS CLOSE TO 10 INCHES**...PARTICULARLY ALONG THE MISSISSIPPI COAST AND INTO THE METRO NEW ORLEANS AREA.

* **IMPACTS INCLUDE FLASH FLOODING IN LOW LYING AND POORLY DRAINED AREAS AS WELL AS ELEVATED LEVELS ON AREA RIVERS AND STREAMS.**

Discussion Questions

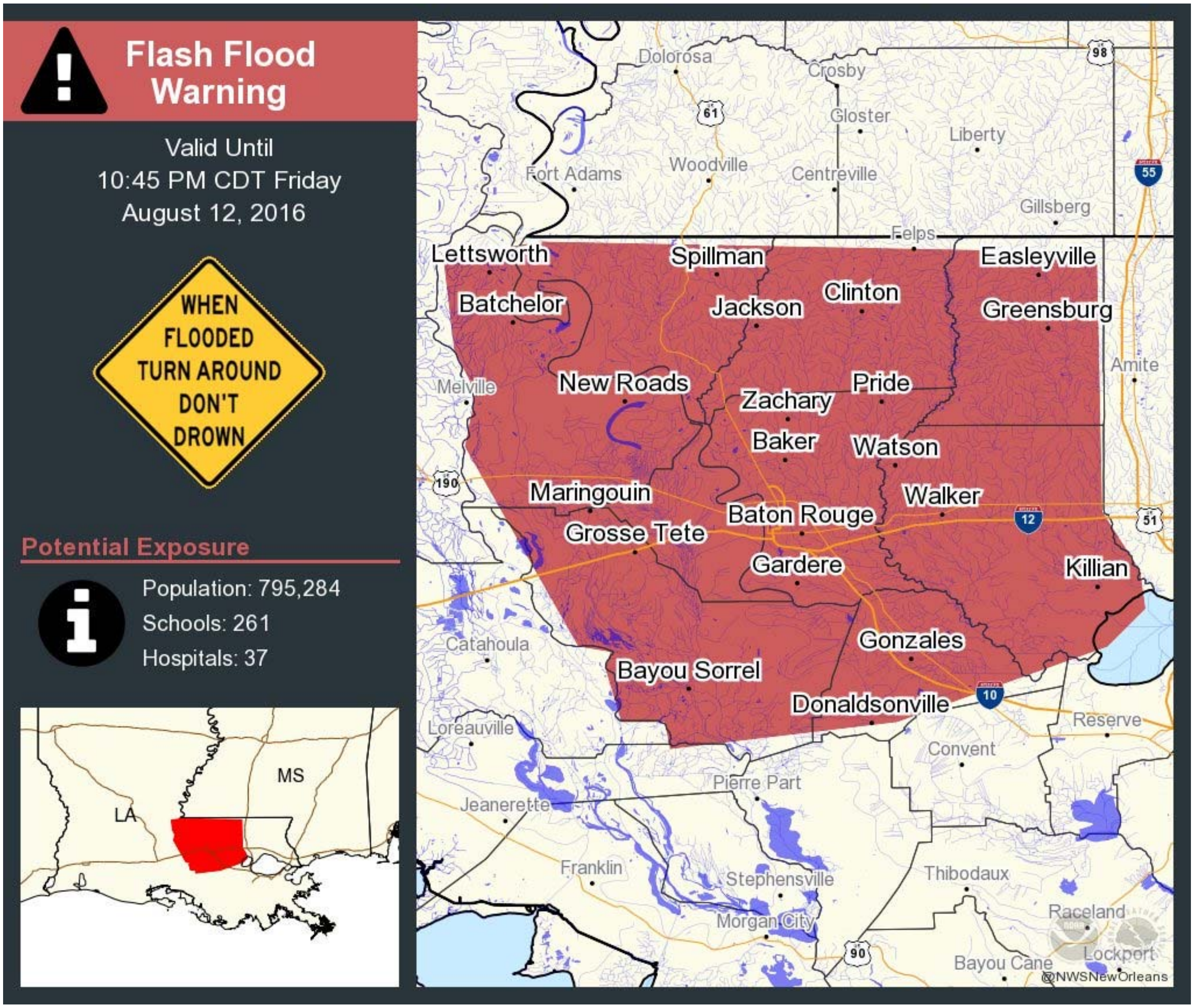
- Where is Baton Rouge, LA in relation to the Flash Flood Watch?

- After Hazard Simplification, what type of watch would this be?

- If conditions worsen, what is the next product you could expect to be issued by the local NWS WFO?

- Given the forecast, list one or two preparations that you would recommend to the hospital and the airport.

Handout #5 – Friday AM



(Source: NOAA, 2017)

Handout #5 (continued)

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BULLETIN - EAS ACTIVATION REQUESTED
FLASH FLOOD WARNING
NATIONAL WEATHER SERVICE NEW ORLEANS LA
1042 AM CDT FRI AUG 12 2016
...FLASH FLOOD EMERGENCY...

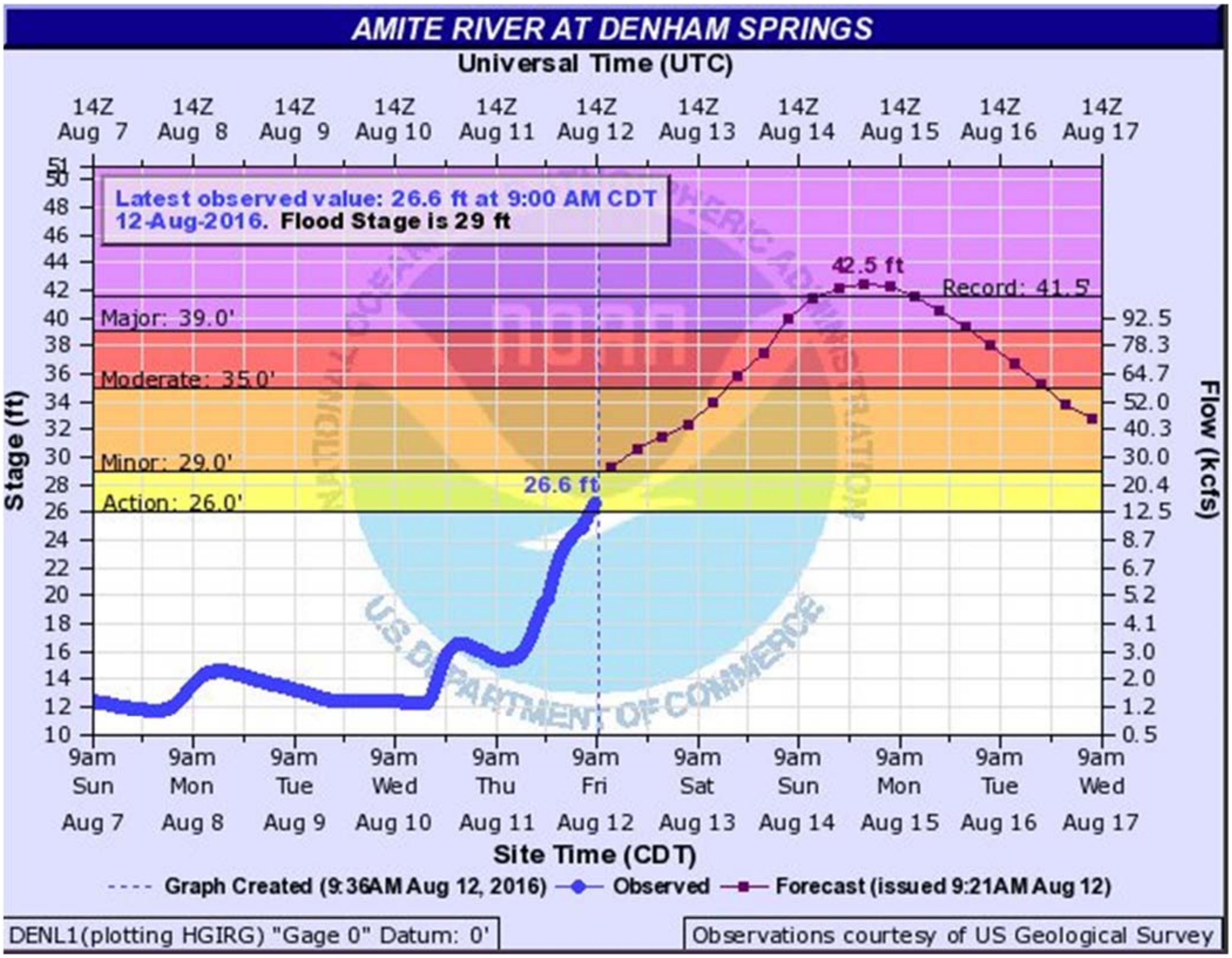
THE NATIONAL WEATHER SERVICE IN NEW ORLEANS HAS ISSUED A
* FLASH FLOOD WARNING FOR...
  NORTHEASTERN WEST FELICIANA PARISH IN SOUTHEASTERN LOUISIANA...
  WESTERN ST. HELENA PARISH IN SOUTHEASTERN LOUISIANA...
  NORTHEASTERN EAST BATON ROUGE PARISH IN SOUTHEASTERN LOUISIANA...
  EAST FELICIANA PARISH IN SOUTHEASTERN LOUISIANA...
  WESTERN AMITE COUNTY IN SOUTHERN MISSISSIPPI...
  EASTERN WILKINSON COUNTY IN SOUTHERN MISSISSIPPI...
* UNTIL 115 PM CDT
* AT 1038 AM CDT...EMERGENCY MANAGEMENT OFFICIALS REPORTED HEAVY
  RAIN AND WIDESPREAD FLASH FLOODING REQUIRING RESCUES AND
  EVACUATIONS IN SEVERAL LOCATIONS WITHIN THIS WARNED AREA. RAINFALL
  AMOUNTS BETWEEN 6 AND 13 INCHES OF RAIN HAVE FALLEN THIS MORNING.
  FLASH FLOODING IS ALREADY OCCURRING.
  THIS IS A FLASH FLOOD EMERGENCY FOR A LARGE AREA BETWEEN CROSBY
  MISSISSIPPI SOUTHWARD TO PRIDE AND GREENWELL SPRINGS LOUISIANA. THIS
  IS A PARTICULARLY DANGEROUS SITUATION. SEEK HIGHER GROUND NOW!
  ADDITIONAL RAINFALL AMOUNTS OF 2 TO 4 INCHES ARE POSSIBLE IN THE
  WARNED AREA.
```

Discussion Questions

- Is Baton Rouge in the Flash Flood Warning?

- What are your concerns at the hospital? Airport?

Handout #6 – Friday AM



(Source: NOAA, 2017)

Discussion Questions

- What is the current level and stage of the Amite River?

- When is the river forecast to peak and how high will the peak be?

- What type of message would you convey to the public regarding the progress of flooding, based on the hydrograph and text of the warning? Craft a sentence or list two to three bullet points.