# Evacuation Planning Strategies and Solutions

MGT-461

Participant Guide

*February 2025*

*Version 2.2*

## NTED Branded Disclaimer

This program was supported by Cooperative Agreement Number EMW-2020-CA-00045, administered by the U.S. Department of Homeland Security (DHS), National Training and Education Division (NTED). Points of view or opinions in this program are those of the author(s) and do not represent the position or policies of the DHS.

The Federal Emergency Management Agency's 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. Courses include subjects such as weapons of mass destruction terrorism, agroterrorism, cybersecurity, public 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.

# Table of Contents

# Course Introduction

This eight-hour management-level course is designed to provide emergency managers, first responders, transportation professionals, security and safety professionals, and government administrators with the ability to utilize current tools and technologies to institute best practices and strategies to plan for and execute an emergency evacuation. This course discusses the hazard conditions for which an emergency evacuation could be an appropriate protective action and inform participants on resources and methods to help them better prepare for an emergency evacuation. This course will allow participants to explore data, modelling tools, and simulations that assist with the implementation of an emergency evacuation.

This course is designed to equip participants with the knowledge and skills to assess evacuation options, choose appropriate tools and techniques, and employ strategies to plan for an emergency evacuation.

# Icon Map

**Definition:** Key term that is often field-specific and may be unfamiliar

**Discussion:** Instructor-facilitated, large-group discussion


**Example:** Descriptive illustration to show or explain a course concept

**Handout:** Additional information provided to facilitate the scenario-based activity

**Key Point:** Essential learning concept and discussion

**Knowledge Check:** Assess learners' knowledge or application of course content

**Participant Note:** Additional information for participants

**Resource:** Reference to books, websites, articles, and other external information sources

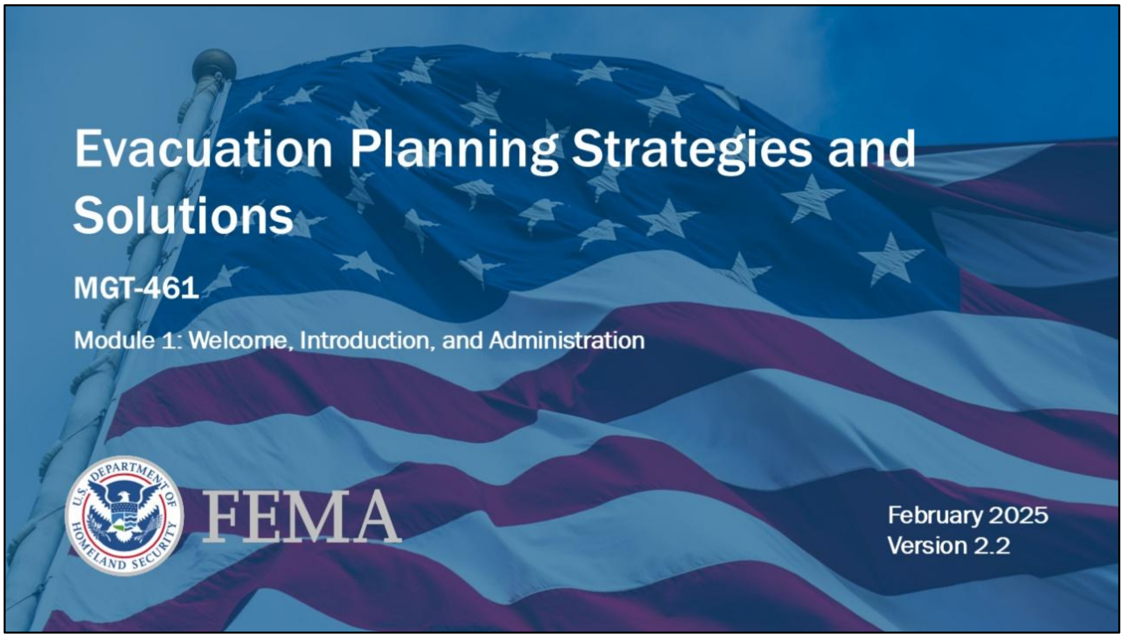
**Video:** Video clip that reinforces the course content or facilitates the scenario's progression

**Workbook:** Indicates that participants should turn to the referenced page in the Participant Workbook to complete an activity

# Module 1

# Welcome, Introduction, and Administration

# Module 1 Administration




**Slide 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.

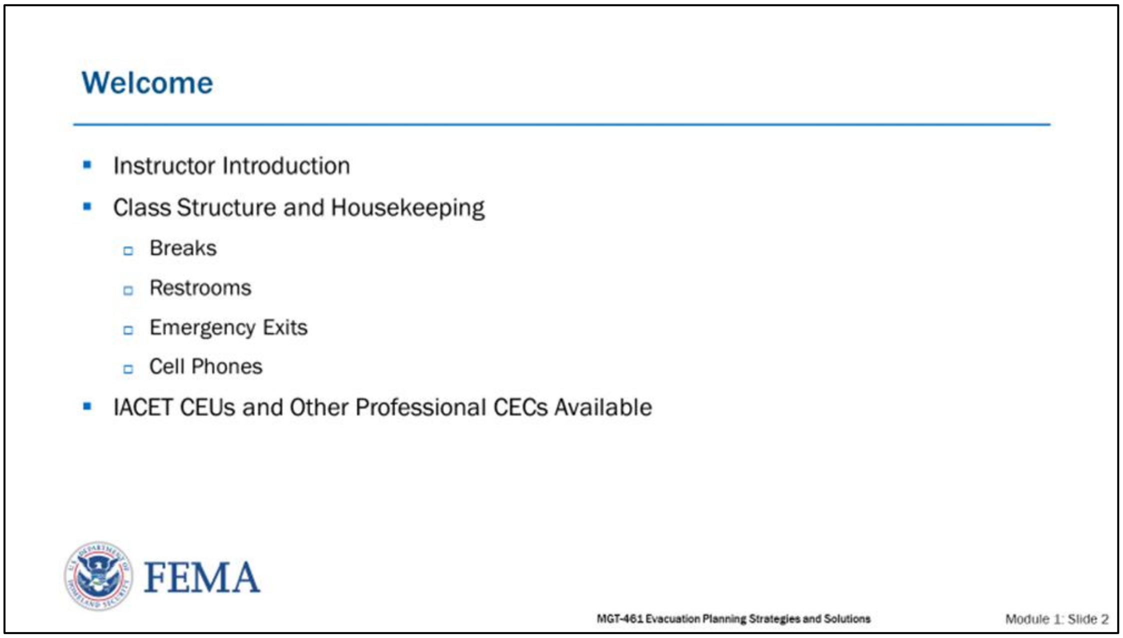
## Terminal Learning Objective (TLO)

Not applicable

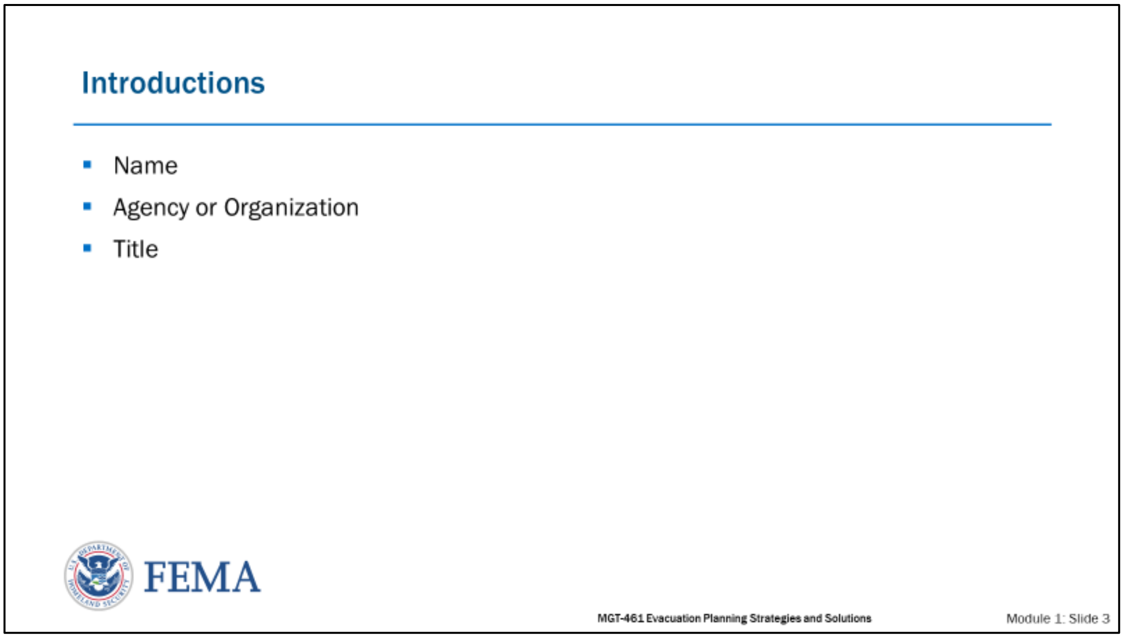
## Enabling Learning Objectives (ELO)

Not applicable

# Module 1 Content



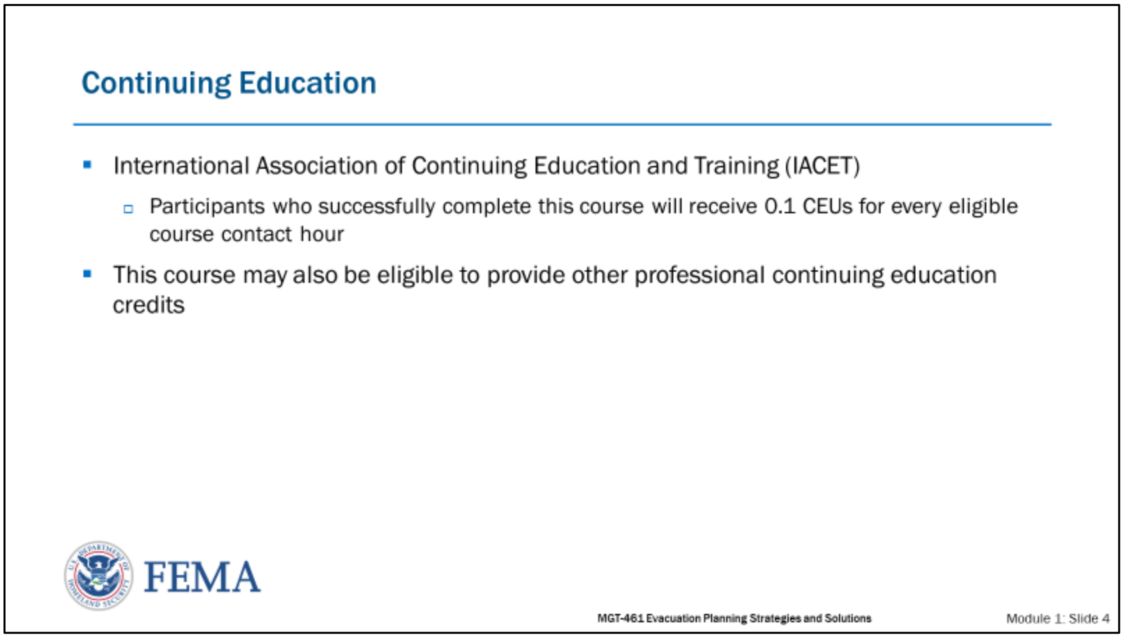

**Slide 2. Welcome**




**Slide 3. 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:

- Name;
- Organization or agency; and
- Expectations for the course.

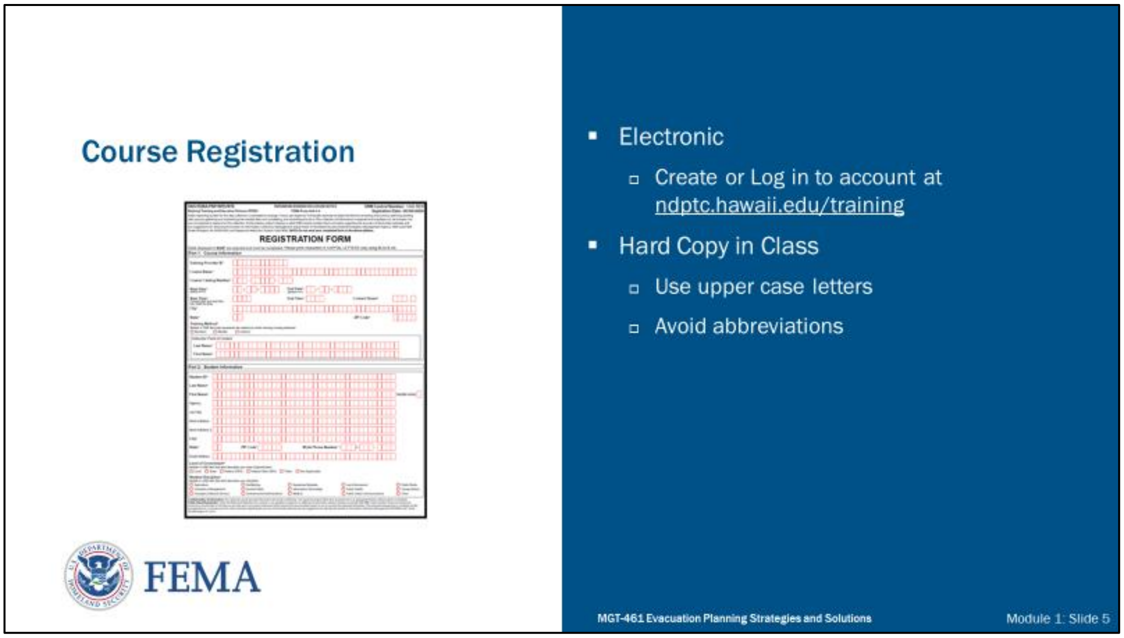



**Slide 4. Continuing Education**

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

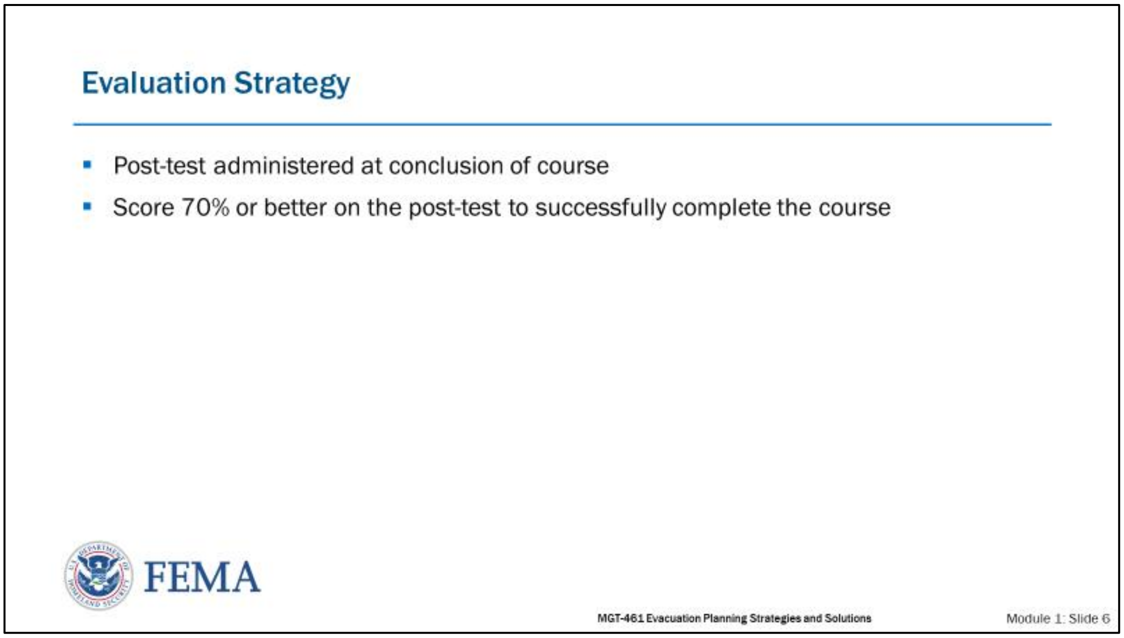
- International Association of Emergency Managers (IAEM) – Training hours
- Association of State Floodplain Managers (ASFPM) -- Continuing Education Credits (CEC)
- American Planning Association (APA) – Certification Maintenance (CM)

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 or ndptc-training@lists.hawaii.edu.




**Slide 5. 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.




**Slide 6. Evaluation Strategy**

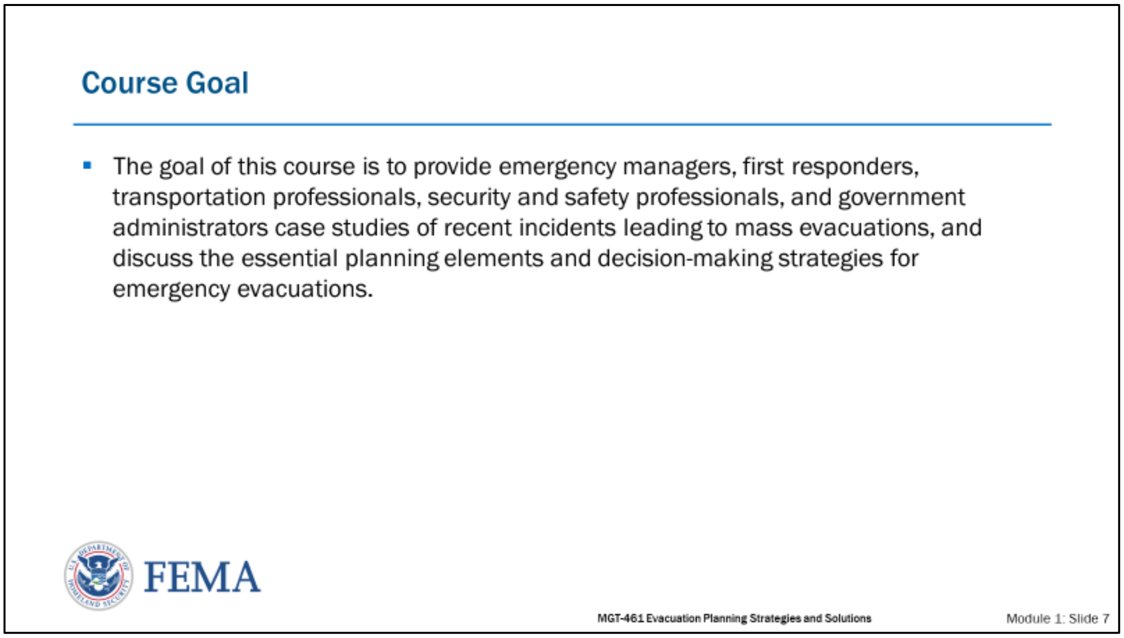
The evaluation strategy for this course follows FEMA's Responder Training Development Center (RTDC) guidance and uses resources, templates, and best practices that provide for instructional development and evaluation.

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. If a participant does not receive a 70 percent or above on the post-test, they will have the opportunity to take the test again. Should they need additional assistance after re-taking the test, an instructor will discuss any issues with the participant and offer another chance to take the test.

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

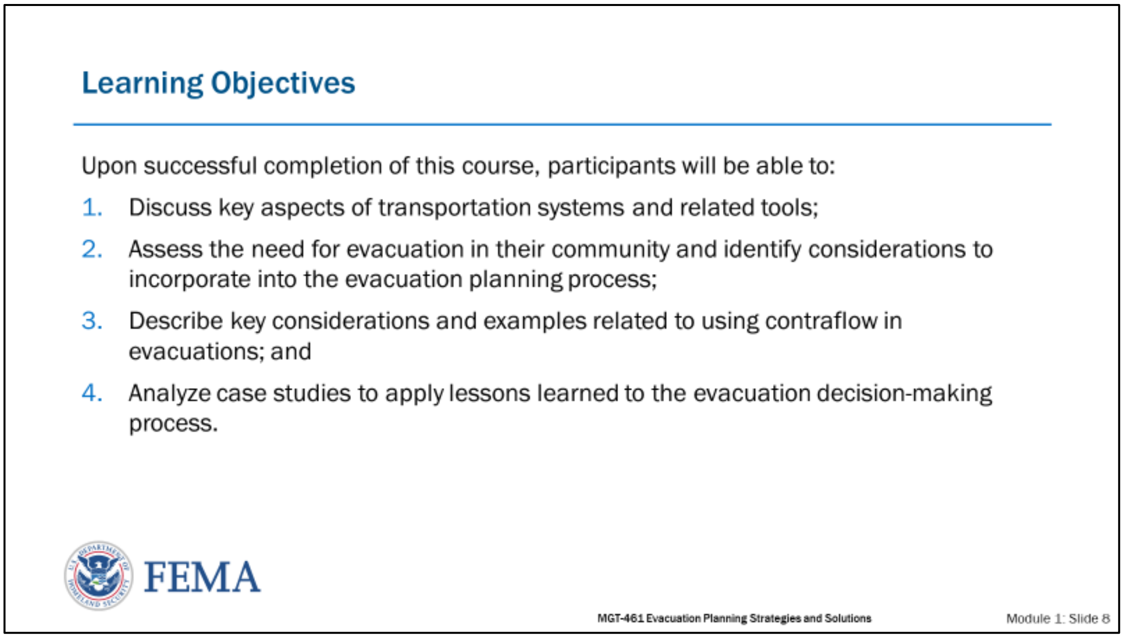
- Write legibly using uppercase letters.
- Use the same first name, last name, and date of birth provided on the participant registration form. This information is used to generate a unique participant identification number.
- Complete the Test Date field in the upper right-hand portion of the sheet 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.
- 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.




**Slide 7. Course Goal**

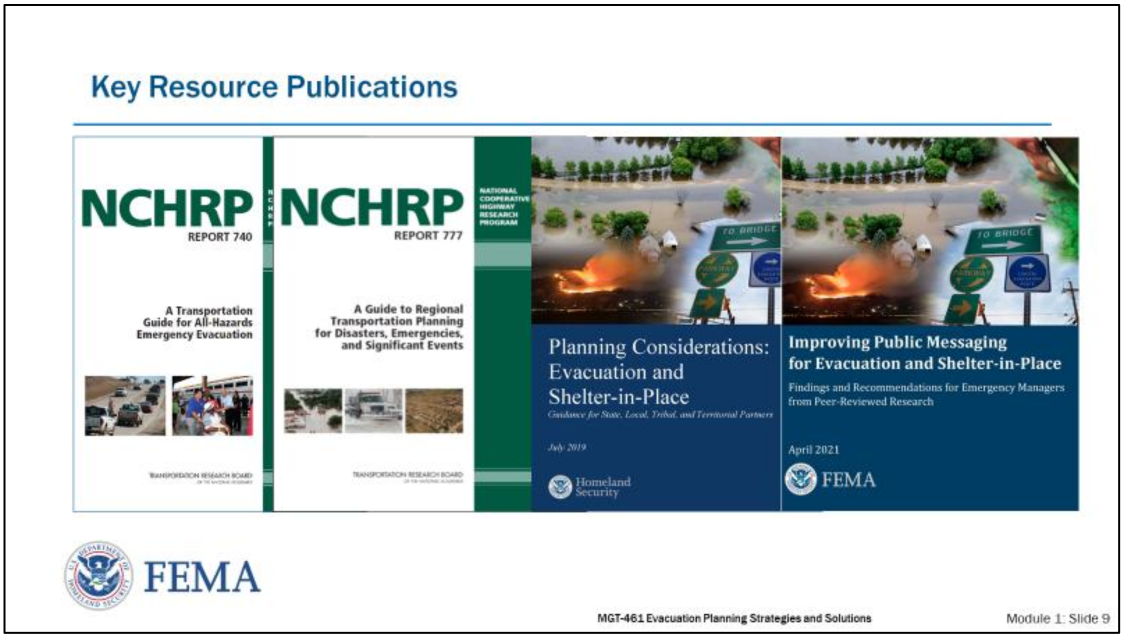
The goal of this course is to provide emergency managers, first responders, transportation professionals, security and safety professionals, and government administrators with case studies of recent hazard conditions leading to mass evacuations and discuss the essential planning elements and decision-making strategies for emergency evacuations.




**Slide 8. Learning Objectives**

Upon successful completion of this course, participants will be able to:

1. Discuss key aspects of transportation systems and related tools;
2. Assess the need for evacuation in their community and identify considerations to incorporate into the evacuation planning process;
3. Describe key considerations and examples related to using contraflow in evacuations; and
4. Analyze case studies to apply lessons learned to the evacuation decision-making process.




**Slide 9. Key Resource Publications**

The Transportation Research Board (TRB) and its National Cooperative Highway Research Program (NCHRP), have published several helpful resources for emergency management of transportation systems and evacuations, including two featured here. They offer steps for transportation planners, government officials, emergency managers, and others to plan for evacuations. These strategies can be applied to everyday traffic flow as well, e.g., using convertible lanes or contraflow lanes for everyday rush-hour traffic.

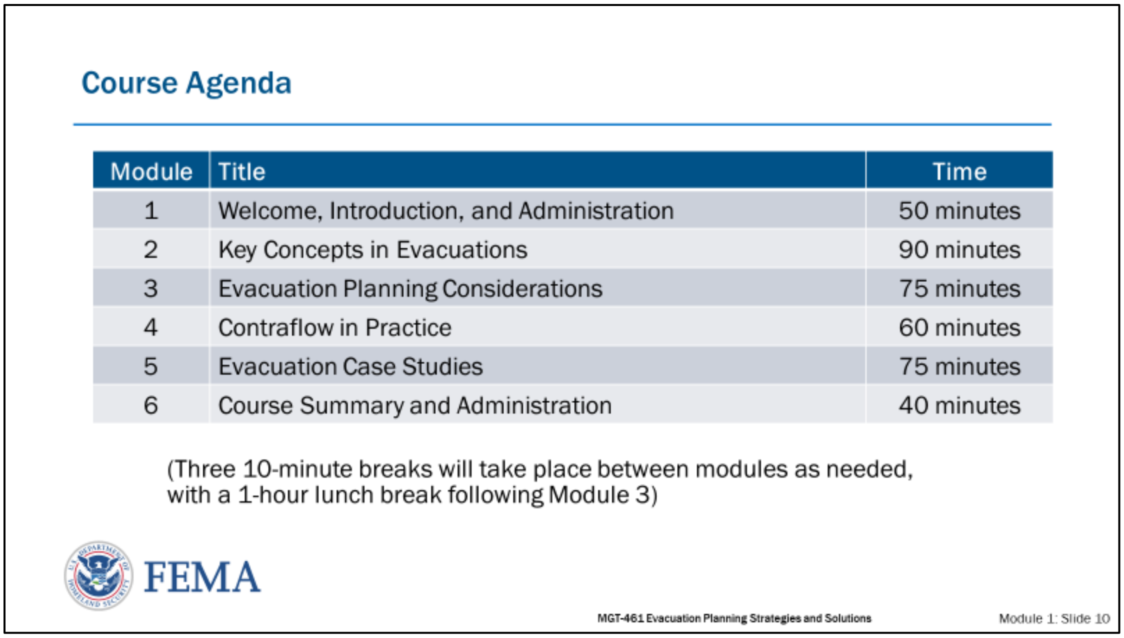
- The first featured guide, “A Transportation Guide for All-Hazards Emergency Evacuations” (NCHRP Report 740), uses an all-hazards approach that includes a range of “notice” and “no-notice” emergencies. The report follows the basic planning steps of the Federal Emergency Management Agency’s (FEMAs) Comprehensive Preparedness Guide (CPG) 101. Each chapter parallels one of the six main CPG steps. Each chapter is further subdivided into discrete tasks, with cross-references to tools such as templates or checklists at the end of each chapter.
- The second guide, “A Guide to Regional Transportation Planning for Disasters, Emergencies, and Significant Events” NCHRP Report 777), uses foundational planning principles, case studies, tips, and tools to explain implementation of transportation planning for possible multi-jurisdictional disasters, emergencies, and other major events.

FEMA also has produced several guides related to evacuation and sheltering in place.

- The third guide shown, “Planning Considerations: Evacuation and Shelter-in-Place,” also builds on CPG 101; it summarizes characteristics that state, local, tribal, and territorial partners should consider in planning for evacuation and/or sheltering in place. It includes job aids and checklists.
- The final guide, “Improving Public Messaging for Evacuation and Shelter-in-Place,” consists of a report and slide deck that document findings from peer-reviewed research and presents recommendations for effective community risk communication and warnings.

These guides are free to download. The TRB guides are available at www.trb.org; the FEMA guides are at fema.gov/emergency-managers/national-preparedness/plan/evacuation-shelter-in-place.

**Key Point:** These and other guides are available as resources to assist with evacuation planning.




**Slide 10. Course Agenda**

This course is composed of six distinct modules designed to address various topics as well as to satisfy administrative requirements. Each session includes an introduction, lecture content, and class discussions, which expand upon the topics or ideas that are presented.

Module 1: Welcome, Introduction, and Administration, 50 minutes

Module 2: Key Concepts in Evacuation, 90 minutes

Module 3: Evacuation Planning Considerations, 75 minutes

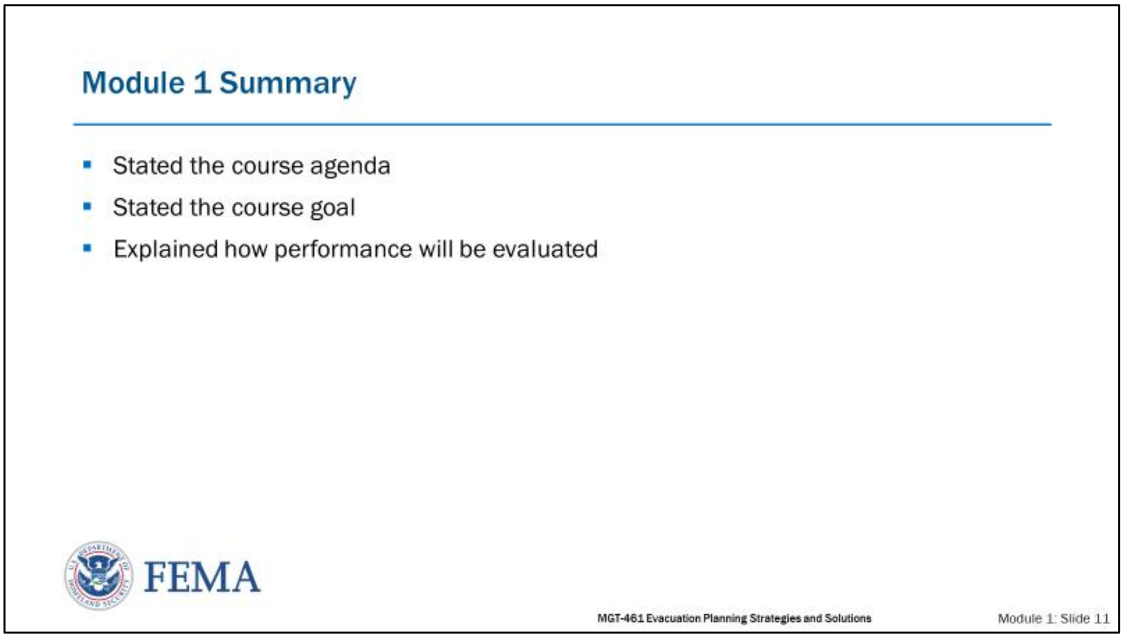
Module 4: Contraflow in Practice, 60 minutes

Module 5: Evacuation Case Studies, 75 minutes

Module 6: Course Summary and Administration, 40 minutes

Three 10-minute breaks will take place between modules as needed, with a 1-hour lunch break following module 3.

# Module 1 Summary




**Slide 11. Module 1 Summary**

In this module, participants:

- Stated the course agenda;
- Stated the course goal; and
- Explained how performance will be evaluated.

# Module 1 Reference List

FEMA (2019). Planning Considerations: *Evacuation and Shelter-in-Place Guidance for State, Local, Tribal, and Territorial Partners*. https://www.fema.gov/sites/default/files/2020-07/planning-considerations-evacuation-and-shelter-in-place.pdf

FEMA (2021). *Improving Public Messaging for Evacuation and Shelter-in-Place: Findings and Recommendations for Emergency Managers from Peer-Reviewed Research*. https://www.fema.gov/sites/default/files/documents/fema_improving-public-messaging-for-evacuation-and-shelter-in-place_literature-review-report.pdf

National Academies of Sciences, Engineering, and Medicine. (2013). *A Transportation Guide for All-Hazards Emergency Evacuation. (NCHRP) Report 740.* Washington, DC: The National Academies Press. https://doi.org/10.17226/22634.

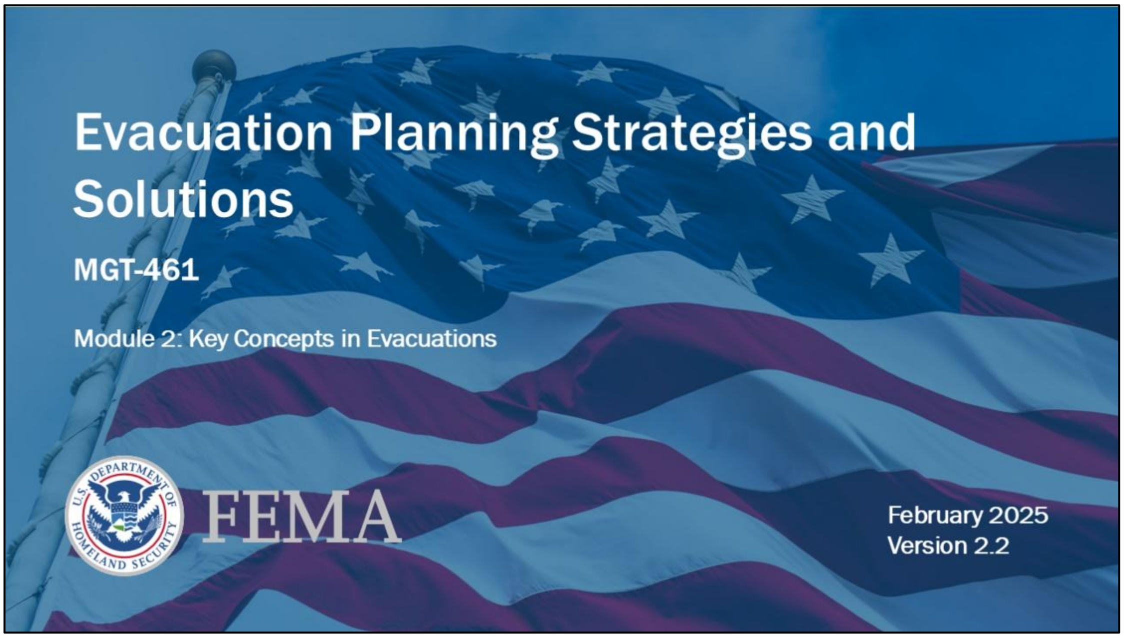
National Academies of Sciences, Engineering, and Medicine. (2014). *A Guide to Regional Transportation Planning for Disasters, Emergencies, and Significant Events. (NCHRP) Report 777.* Washington, DC: The National Academies Press. https://doi.org/10.17226/22338.

# Module

# 2

# Key Concepts in Evacuations

# Module 2 Administration




**Slide 12. Module 2: Key Concepts in Evacuations**

## Duration

90 minutes

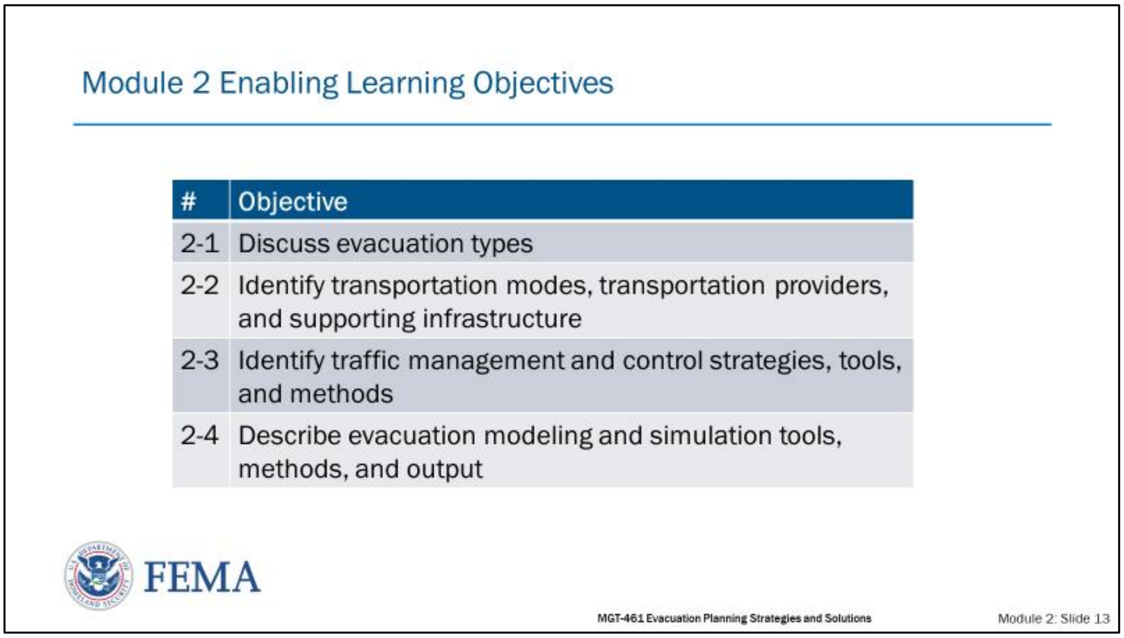
## Scope Statement

In this module, the instructor will highlight the role of transportation in evacuations and introduce the participants to key terms used for evacuations and evacuation planning. The module will also include risk and hazard vulnerability analysis of the participants' communities.

## Terminal Learning Objective (TLO)

Participants will be able to discuss key aspects of transportation systems and related tools.

# Module 2 Content



Module 2 Enabling Learning Objectives

| # | Objective |
|---|---|
| 2-1 | Discuss evacuation types |
| 2-2 | Identify transportation modes, transportation providers, and supporting infrastructure |
| 2-3 | Identify traffic management and control strategies, tools, and methods |
| 2-4 | Describe evacuation modeling and simulation tools, methods, and output |

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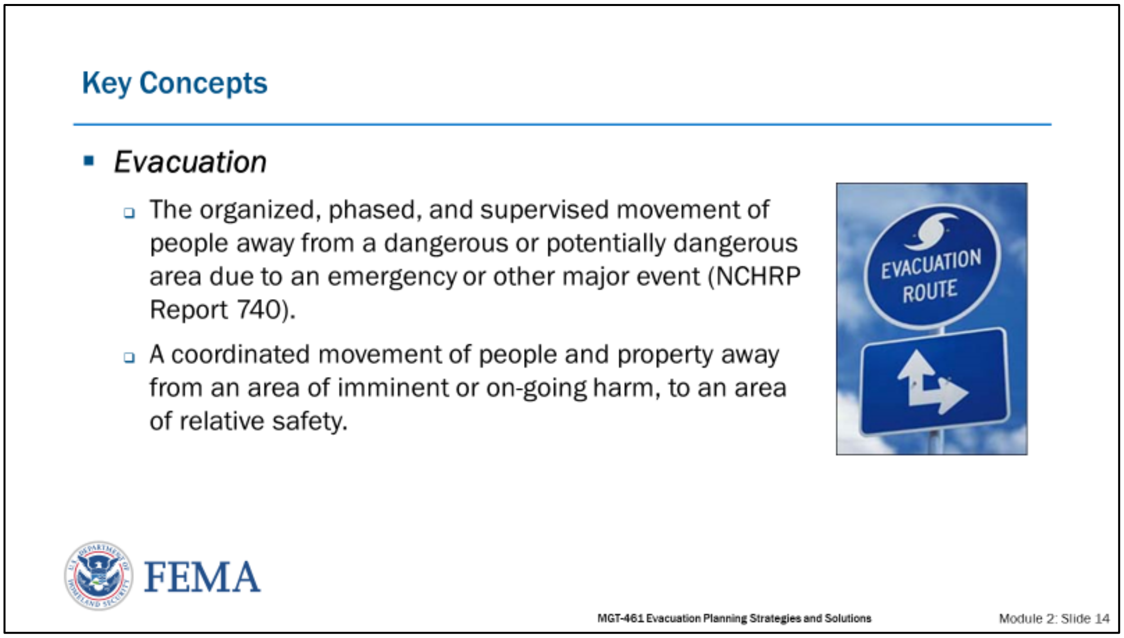
Module 2: Slide 13

**Slide 13. Module 2 Enabling Learning Objectives**

In this module, participants will:

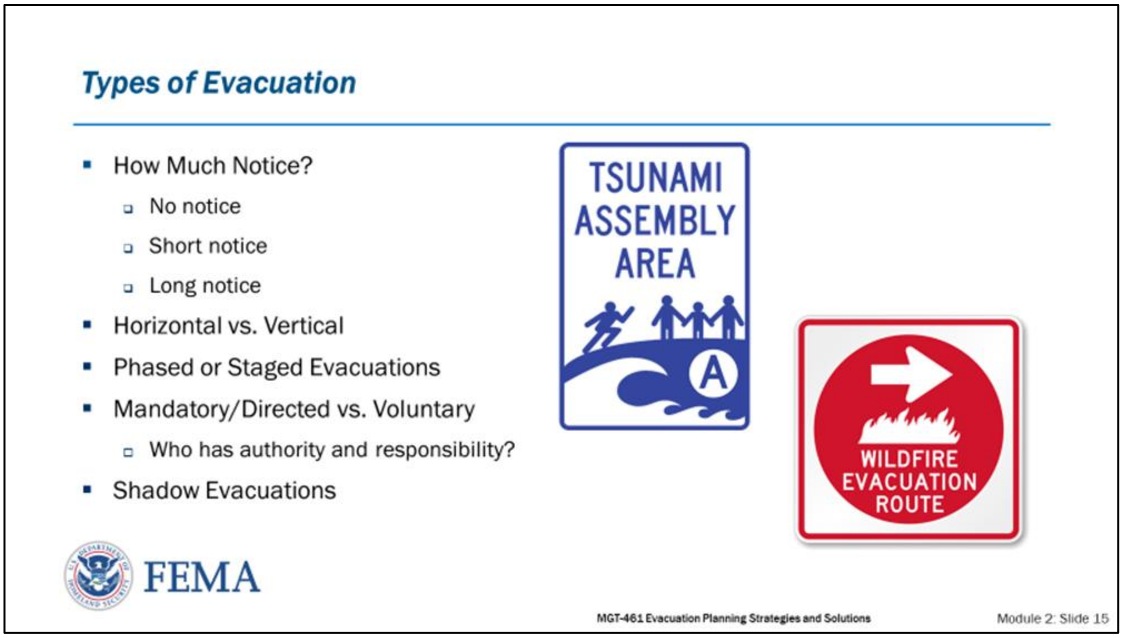
- Discuss evacuation types;
- Identify transportation modes, transportation providers, and supporting infrastructure;
- Identify traffic management and control strategies, tools, and methods; and
- Describe evacuation modeling and simulation tools, methods, and output.




**Slide 14. Key Concepts**

We will now go over a few key terms which are common in evacuation research and reports and will be used throughout this course. This will ensure that as we go through the course, everyone is working from the same definitions.

The first definition is from NCHRP Report 740, *A Transportation Guide for All-Hazards Emergency Evacuation*, which focuses on the transportation aspects of evacuation, particularly large-scale, multi-jurisdictional evacuation. The second definition is similar; it encompasses a wider range of situations and emphasizes the concept of relative safety.




**Slide 15. Types of Evacuation**

Evacuation decisions are based in part on how much notice there is before onset of hazards requiring protective action:

- No notice evacuations happen upon discovery of the event. An example of this could be an evacuation after a chemical release or volcanic activity.
- Short notice can be minutes, hours, or a day before the event, e.g., a wildfire, which may offer minutes to hours.
- Long notice – more than a day – typically is associated with large-scale natural disasters like tropical storms. For this type of evacuation, there can be days or more to plan and execute an evacuation.

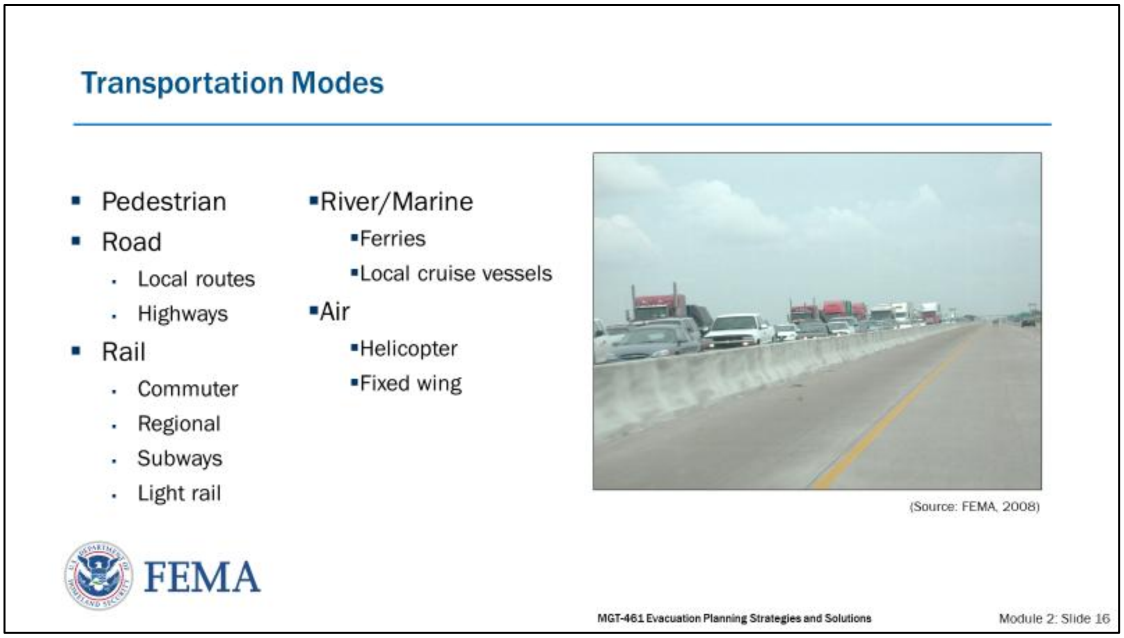
The next bullet points represent different types and properties of evacuations:

- **Horizontal evacuation** can be thought of as increasing map distance from the hazard.
- **Vertical evacuation** requires increase or decrease in elevation, typically combined with adding horizontal distance. High-rise buildings mostly require vertical evacuation; floods and particularly storm surges and tsunamis require sufficient vertical evacuation to escape inundation and runup.
- **Phased or staged evacuation**: with enough notice, evacuations may be staggered by location, time/resources needed to evacuate, transportation capacity, or a combination. This is most commonly used for tropical storms affecting densely populated areas. It may ease traffic loads and will give evacuees who need more time to evacuate a head start.
- **Voluntary or recommended evacuation** concentrates on people who are most vulnerable to a potential hazard and may need more time or additional resources to evacuate. Special traffic-control or transportation measures tend not to be implemented – or are done on a limited scale – for this type of evacuation.

- For **mandatory evacuation**, persons are "strongly urged" to relocate to a safer location. Personal discretion is not to be considered a deciding factor. A person who refuses to comply with a "mandatory" evacuation order may not be forcibly removed from his/her home; however, all public services will be suspended during a mandatory evacuation and those failing to comply with a mandatory evacuation order may not be rescued or provided with other lifesaving assistance. If conditions continue to deteriorate, at some point evacuation routes will be closed and emergency response curtailed.

**Key Point:** Evacuation authority and terminology varies by state; it is essential for all responsible for evacuation planning and/or implementation to fully understand the authorities and definitions in their state and local; jurisdictions, as well as those immediately adjacent.

- **Shadow evacuation** refers to people who choose to evacuate but are not under an evacuation order. During Hurricane Rita, millions of people who were not directed to evacuate took to the roads anyway.

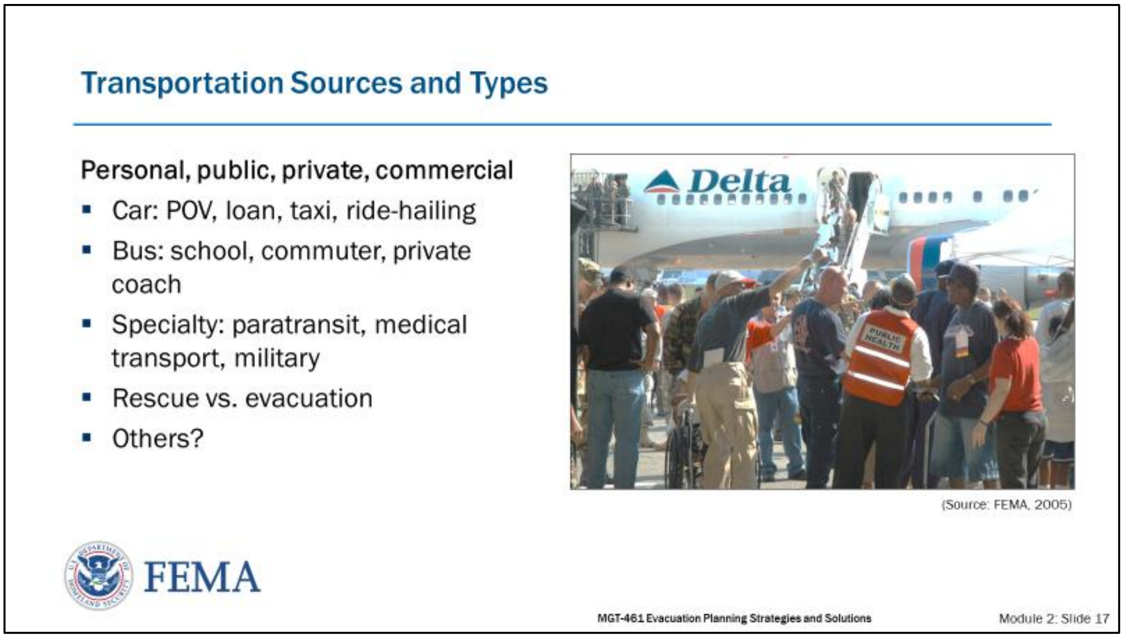



**Slide 16. Transportation Modes**

Most evacuation plans are built around roads and in particular highways. Rail, air, and water may be relevant for specific locales, depending on the hazard and amount of notice as well as the type of transportation infrastructure.

Pedestrian evacuation is more likely to be incorporated in local- rather than state-level plans. Pedestrian evacuation may be most relevant in short- and no-notice events, where travel distance is short and/or other transportation infrastructure is unavailable or unreliable, or as an intermediary mode (e.g., walking to a pickup point).

The list on this slide is not exhaustive. Does your community have others that are not listed? Possible examples: bicycles, large cruise ships




**Slide 17. Transportation Source and Types**

This slide lists a range of transportation sources and types. It is important to remember when you are planning that resource availability varies by season, time of day, amount of notice, anticipated length of the deployment, and the number of operators and supervisors that can reasonably be deployed without causing undue harm and disruption to current operations. With that understanding, transit agencies can maintain constant, current inventories of transit vehicles and support vehicles; fuel, tires, and other maintenance and servicing supplies; and rosters of operators, supervisors, maintenance and servicing personnel, and other support personnel. Many transit agencies regularly provide support across jurisdictional lines on an ad hoc basis as needs arise and as resources are available.

**Discussion:** What other transportation sources and types are available in your area?

For multi-jurisdictional evacuation planning, it is essential for transit managers and operations planners to be forthright and realistic with emergency managers and planners as to:

- The time it will take to deploy any spare buses and operators (or trains, ferry boats, or other mass transit modes);
- An approximate number of vehicles “immediately available” on an average day;
- The ramp-up time necessary for a larger no-notice event;
- The factors that would increase or decrease that ramp-up time, and what kind of support they could expect to provide for a notice event; and
- When most or all regular service might be expected to be cancelled or diverted.

Urban transit agencies often have subcontract relationships or agreements with other transportation providers, such as private coach operators for suburban transit operations, local bus operators, paratransit operators, and others. Transit agencies may also be a logical coordinating central point for other resources such as school buses, intercity buses, vanpool services, and other options.

**Participant Note:** A Vehicle Fleet Information Form provides an inventory resource. Similarly, highway resources such as variable message signs may be in many locations far from where they are needed for evacuation (such as at construction sites). It will take time to locate, move, and reset them.

**Participant Note:** FEMA provides two no-cost tools for eligible users: the Incident Resource Inventory System (IRIS), and the Resource Typing Library Tool (RTLT). IRIS is downloadable software requiring a free user account; RTLT is a cloud-based tool; information and links for both are available at https://www.fema.gov/emergency-managers/nims/components#resource-typing.

## Supportive Transportation Infrastructure and Services

- Traffic signals
- Portable, variable, and static signs, barriers/redirections
- Fuel, maintenance, crew care
- Vehicle tracking (all modes)
- Boarding/disembarking sites (all modes)
- Air traffic control


(Source: FEMA, 1999)

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Module 2: Slide 18

**Slide 18. Supportive Transportation Infrastructure and Services**

Supportive transportation infrastructure assists with keeping transportation running smoothly. Any hazard can impact these, and they can be used to assist with an evacuation.

After a series of several high-visibility mass evacuation complications, state departments of transportation (DOTs) have taken much more active roles in planning regional evacuations and, in some cases, have served as lead state agencies in the development of management and control strategies.

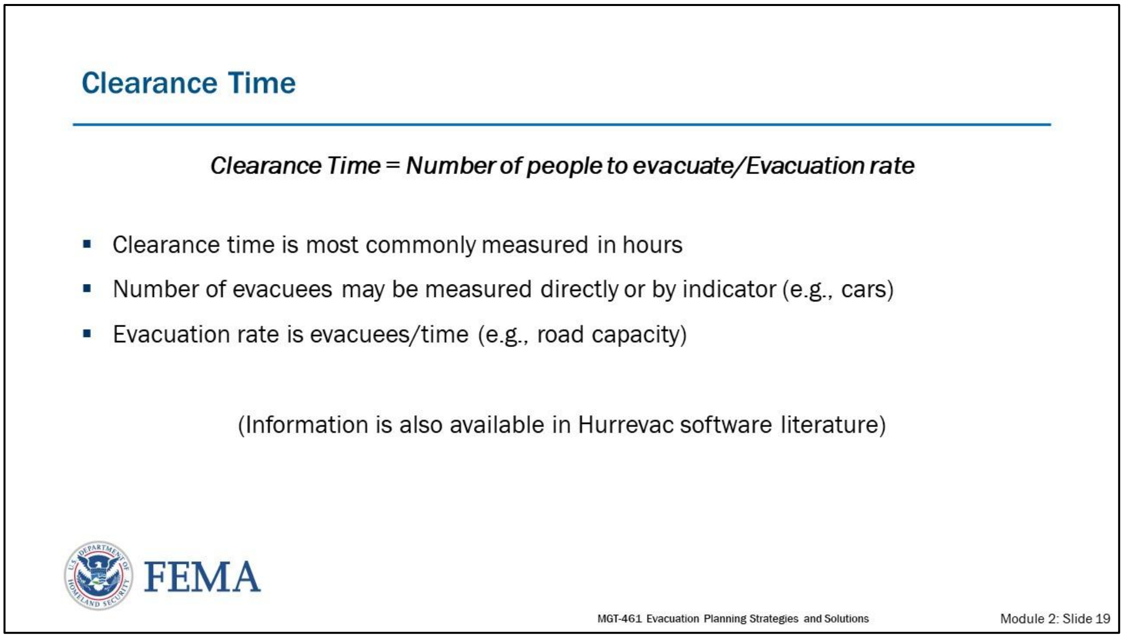
Several state DOTs employ dedicated full-time staff members whose primary responsibility is maintaining evacuation readiness and coordination with other state agencies. These personnel have proved to be valuable in establishing and maintaining communications and coordination with neighboring states where evacuations cover multi-state regions and where evacuation monitoring and control takes place from regional and statewide traffic management centers.

Two illustrations for which these measures have been particularly useful are for the complex region-wide freeway management plans that are now in place for New Orleans and Houston. The DOTs in Louisiana and Texas were instrumental in development of the plans, both of which now incorporate coordinated evacuation phasing, contraflow, and assisted evacuations.

The direction and control of transportation systems should not, however, be interpreted as extending into the direction and control of evacuations. Although transportation agencies play key roles in supporting and assisting in the execution of such orders, the review of practice showed that the declaration and timing of evacuations are decisions that are made by emergency mangers and law enforcement agencies and that there were no examples in which transportation agencies were involved in such decisions. Instead, transportation support activities were limited to actions such as the reconfiguration and implementation of traffic control, traffic management planning, and area-wide traffic monitoring, among many others.

Fuel is another important consideration. For a successful evacuation, it is imperative that adequate fuel supplies (primarily gasoline and diesel fuels) are available. Considerations include availability of fuel for individuals who are self-evacuating, availability of fuels for government-supplied transportation vehicles, and provision of fuel to emergency response vehicles along evacuation routes. Fuel capacity planning for the particular hazard in the evacuation route is important part of the evacuation planning process. This will include:

- Ensuring that adequate supplies of fuels (gasoline and diesel) are pre-positioned along evacuation routes.
- Special arrangements are made for fuel staging or deliveries along evacuation routes.
- Set up and regulate the use of separate refueling sites for the use of emergency responders during an evacuation.
- Charging stations for electric vehicles is a relatively new consideration that will become more important over the next several years.



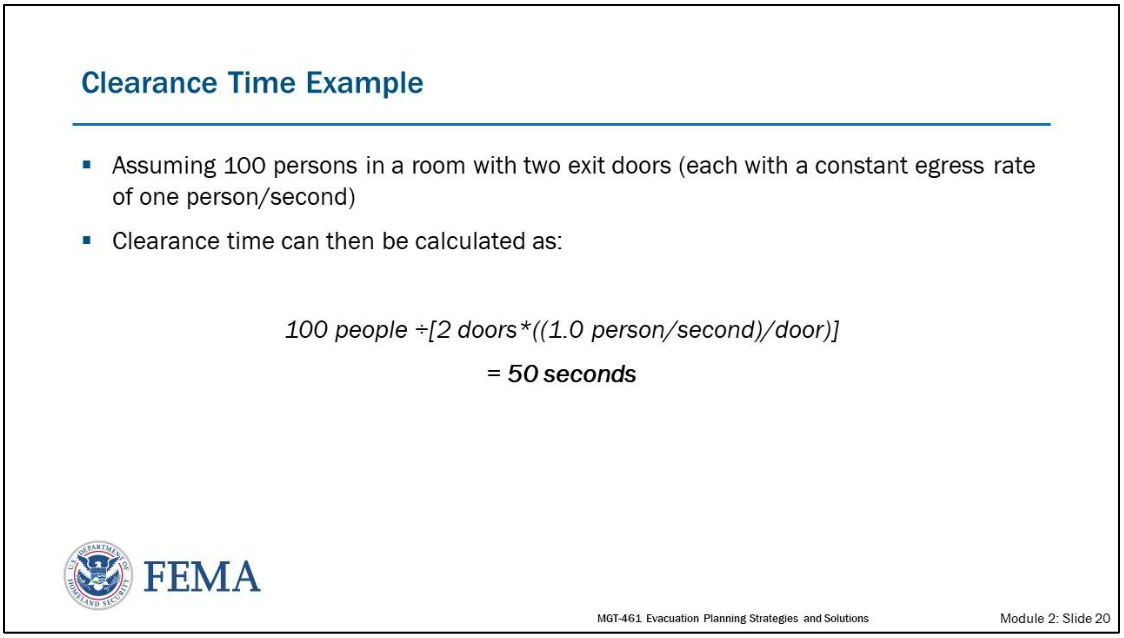

**Slide 19. Clearance Time**

The concept of clearance time can be fundamentally represented in a simple relationship of number of people needing evacuation and evacuation rate:

Clearance Time = Number of people to evacuate/Evacuation rate

- Clearance time is expressed in units of time (most commonly hours)
- Number of evacuees may be measured directly or by indicator (e.g., cars)
- Evacuation rate is evacuees/time (e.g., road capacity)

**Participant Note:** Hurrevac is the decision support tool of the National Hurricane Program, administered by FEMA, the US Army Corps of Engineers, and the NOAA National Hurricane Center. It combines live feed of weather systems with data from various states to assist with decision-making regarding hurricane evacuation and damage potential. It is a free program for emergency management officials and other decision-makers.

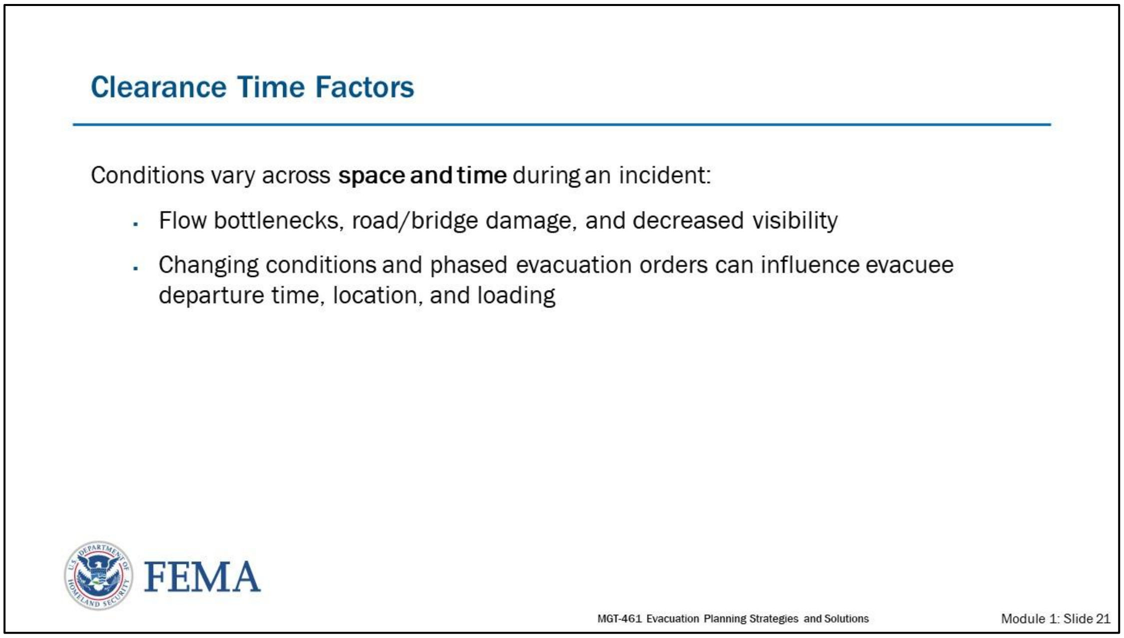



**Slide 20. Clearance Time Example**

Assuming there are 100 persons in a room with two exit doors, each with a constant egress rate of one person/second, clearance time can then be calculated as:

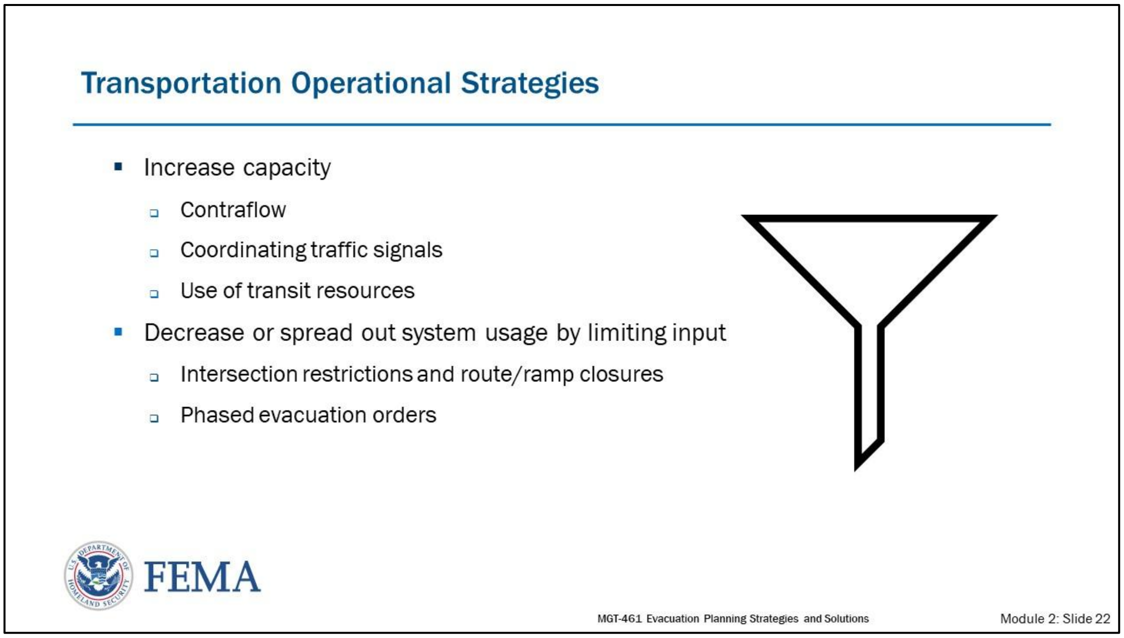
100 people ÷ [2 doors*((1.0 person/second)/door)] = 50 seconds

Building upon this simple linear relationship assumption, if the room had four doors or if its number of occupants was doubled to 200 people, clearance time would decrease to 25 seconds or increase to 100 seconds, respectively.




**Slide 21. Clearance Time Factors**

Incidents are not only dynamic but produce a variety of conditions over time and across the affected area. In addition to conditions directly related to incident onset, conditions related to people and infrastructure vary as well over time and space. Evacuation planning and decisions should incorporate known and potential changes, as well as those related to evacuation messages themselves.




**Slide 22. Transportation Operational Strategies**

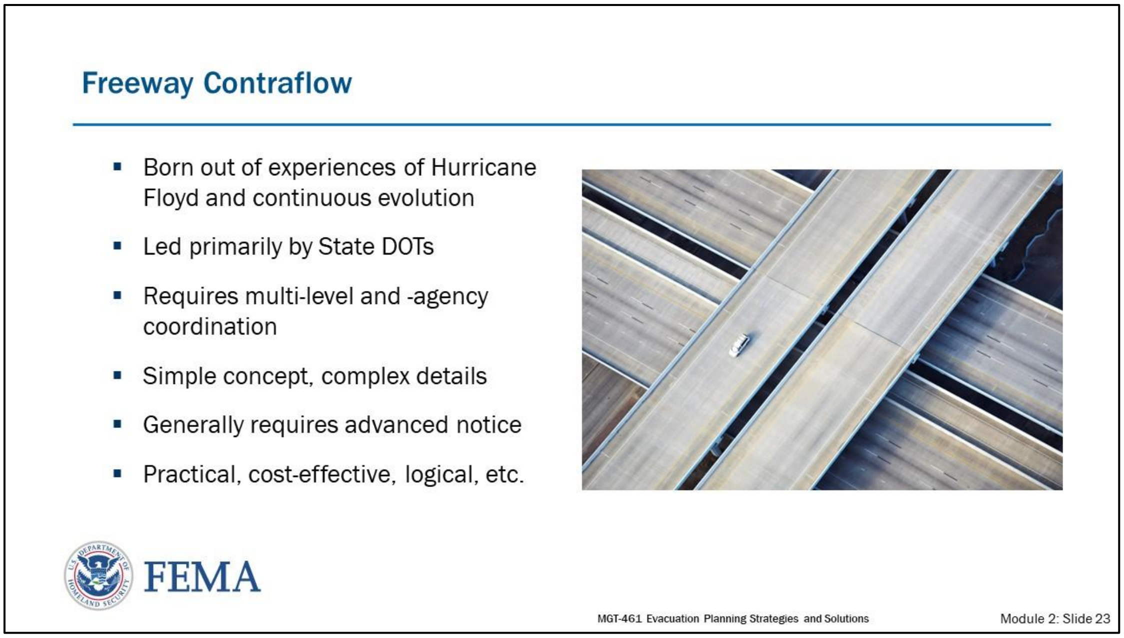
A variety of methods have been used to control and manage traffic during planned, unplanned, and emergency events. These approaches tend to fall into one of two categories: capacity enhancement or demand management (system usage).

Increasing system capacity includes modifying signal control to favor heavier movements, adding lanes, and using nearby and parallel routes.

Demand management includes employing techniques that limit or eliminate the generation of traffic demand, such as closing routes, restricting, delaying, or rerouting travelers, or phased evacuation.

No strategy is effective unless it is consistent with evacuee expectations and can be effectively communicated to evacuees, regardless of transportation mode. For example, shifting traffic demand to other routes will only be effective if drivers can reach their intended destinations without excessive additional travel distance, travel time, and/or delay. Some drivers, especially those familiar with a network, will seek alternate routes while resisting others. Thus, communication during events needs to be clear and actionable. Every message to evacuees (Wireless Emergency Alerts, highway advisory radio, dynamic message boards, or other media) must be timely, accurate, and useful. Old, incorrect, or extraneous information diminishes driver willingness to comply with provided directions.

In addition to resources (equipment, personnel, vehicles, communications abilities), transportation professionals have access to insights and strategies that can markedly improve transportation operations, especially in emergencies.

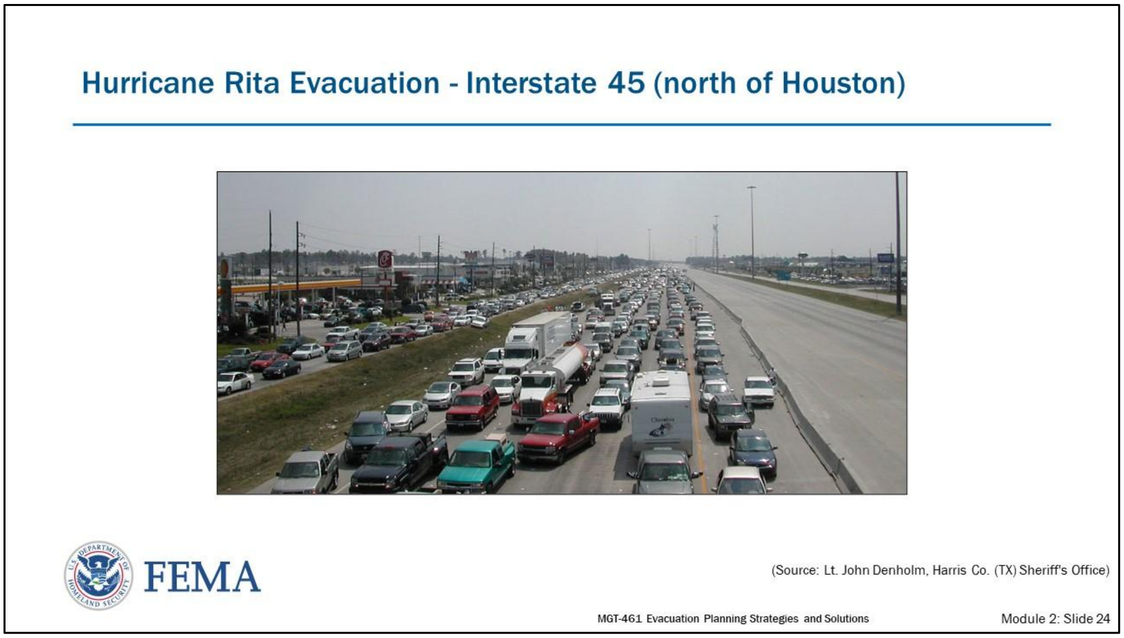



**Slide 23. Freeway Contraflow**

Contraflow is a form of reversible traffic operation in which one or more travel lanes of a divided highway are used for the movement of traffic in the opposing direction. The common definition of contraflow for evacuations has been broadened by emergency management officials, the news media, and the public to include reversal of flow on any roadway during an evacuation. It is a highly effective strategy *in* theory, because it can immediately and significantly increase the directional capacity of a roadway without the time or cost required to plan, design, and construct additional lanes.

Although the basic concept of contraflow is simple, it can be complex to implement and operate in practice. If not carefully designed and managed, contraflow segments have the potential to be confusing to drivers. To ensure safe operation, improper access and egress movements must be prohibited at all times during its operation. Segments must be fully cleared of opposing traffic before initiating contraflow operations. These are not necessarily easy tasks to accomplish, particularly in locations where segments are in excess of 100 miles and where interchanges are frequent. For these reasons, some transportation officials regard them to be risky and only for use during daylight hours and under the direst situations. These risks also explain why contraflow for evacuation has been planned nearly exclusively for freeways, where access and egress can be tightly controlled.

Contraflow evacuations have been used almost exclusively for tropical storms and wildfires. These two hazards affect much greater geographic areas and tend to be slower moving relative to other hazards. Because of their scope, they create the need to move larger numbers of people over greater distances than other types of hazards. In addition, contraflow often requires considerable staffing and material resources as well as time to mobilize and implement. Experiences in Alabama and Louisiana showed that the positioning of traffic control devices and enforcement personnel takes at least six hours in addition to the time to plan and acquire equipment for the event. In Florida, where needs are great and manpower resources are stretched thin, evacuation contraflow requires involvement from the Florida National Guard. For this reason (among others), Florida officials have been moving away from contraflow in favor of emergency shoulder use for many evacuations.




**Slide 24. Hurricane Rite Evacuation – Interstate 45 (north of Houston)**

Contraflow is also popular with the public because it is viewed as a logical utilization of the unused lane capacity of adjacent inbound lanes as shown in this photo.

Reversible roadways have a number of physical and operational attributes that are common among all applications. The principle physical attributes are related to spatial characteristics of the design, including its overall length, number of lanes, and the configuration and length of the inbound and outbound transition areas. The primary operational attributes are associated with the way in which the segment will be used and include the temporal control of traffic movements. The temporal components of all reversible lane segments include the frequency and duration of a particular configuration and the time required to transition traffic from one direction to another. **Peak-period commuter reversible applications, for example, typically last about two hours (not including setup, removal, and transition time), twice a day. Evacuation contraflow, however, may be implemented only once in several years and may last several days.**

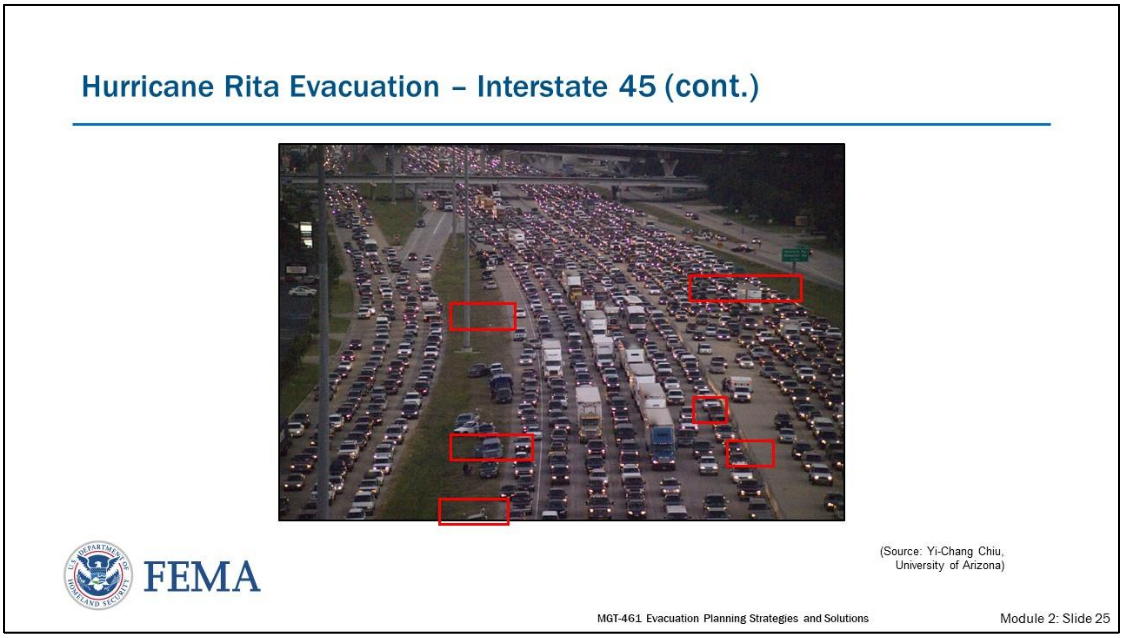
Like all reversible flow roadways, contraflow lanes need to achieve and maintain full utilization to be effective. Although this statement seems obvious, it can be challenging to achieve in practice. The most common reason for underutilization has been inadequate transitions into and out of the contraflow segment. Contraflow requires a transition section at the inflow and outflow ends to allow drivers to maneuver into and out of the reversible lanes from the unidirectional lanes on the approach roadways leading into it. Because these termini regulate the ingress and egress of traffic entering and exiting the segment, and they are locations of concentrated lane changing as drivers weave and merge into the desired lane of travel, they effectively dictate the capacity of the entire segment.

Inadequate designs at the downstream end of contraflow segments can also greatly limit its effectiveness. Experience and modeling have shown that inability to move traffic from contraflow lanes back into normally flowing lanes results in congestion backing up from the termination transition point in the contraflow lanes. Under demand conditions associated with evacuations, queue formation can occur rapidly and extend upstream for miles within hours. To limit the potential for such scenarios, configurations that require merging of normal and contraflow lanes are discouraged, particularly if they also incorporate lane drops. Two popular methods that are used to terminate contraflow include routing the two traffic streams at the termination onto separate routes and reducing the level of outflow demand at the termination by including an egress point along the intermediate segment.

The primary physical characteristics of contraflow segments are the number of lanes and the length. In general, contraflow segments are planned for a full "One-Way-Out" operation. Predesignated contraflow freeway segments range from approximately 25 to 180 mile, with most between 85 and 120 miles.

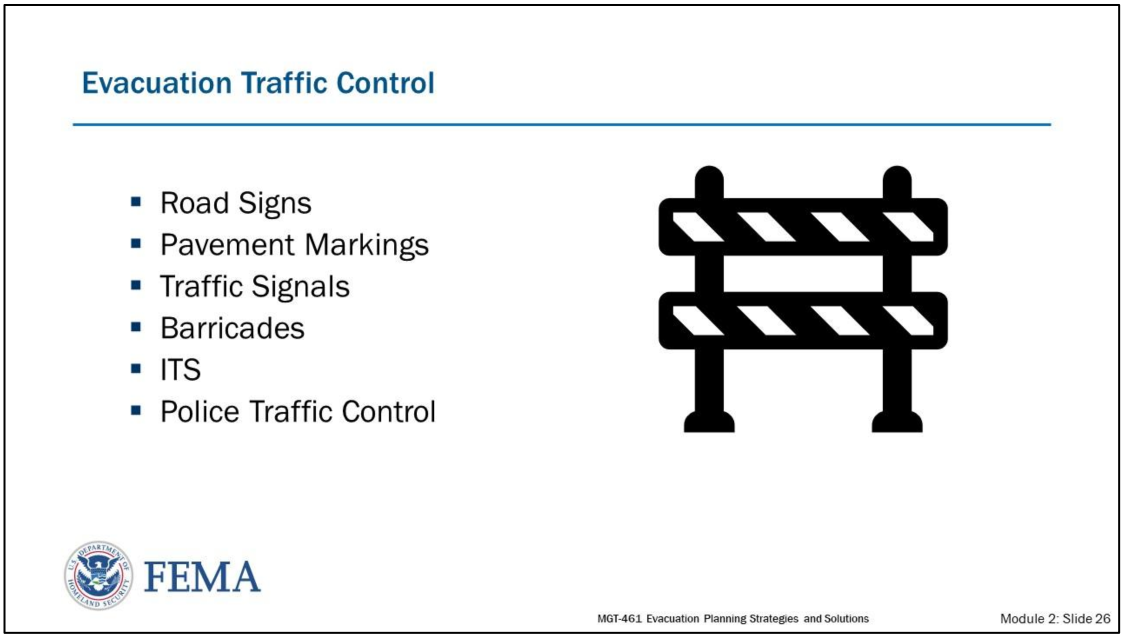
In the earliest versions of contraflow, nearly all of the planned segments that were identified in the study were initiated by means of median crossovers. After single-point loading strategies were shown to be less effective, many locations have changed to multi-point loading. The most popular of these are median crossovers, with supplemental loading achieved through nearby reversed interchange ramps.

Termination configurations may be broadly classified into two groups: split designs, in which traffic in the normal and contraflow lanes are routed onto separate roadways at the terminus, and merge designs, in which separate lane groups are reunited into normal flow lanes using various geometric and control schemes. Choosing a design at a particular location is a function of several factors, particularly expected traffic volume and configuration and availability of routing options at the end of the contraflow segment.



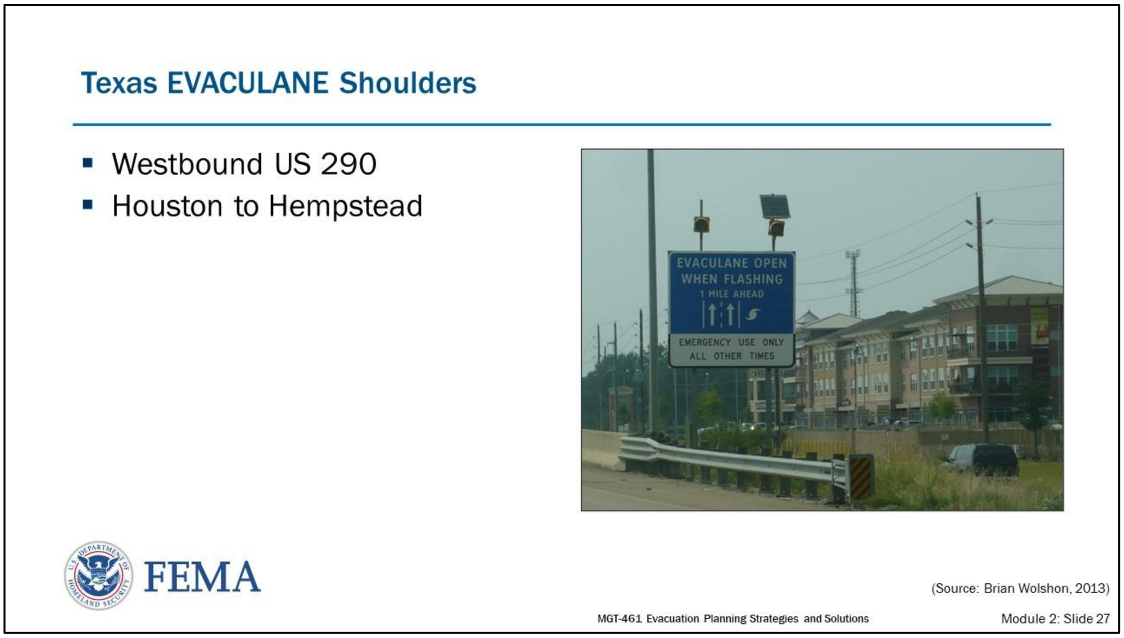

**Slide 25. Hurricane Rita – Interstate 45 (cont.)**

This photo illustrates common features, bottlenecks and interruptions in contraflow. The red box in the upper right shows law enforcement blocking an on-ramp to prevent wrong-way traffic. Boxes in lower right show an ambulance and associated disruption in flow. The three boxes on the left show various groups of vehicles pulled onto the grass – possibly breakdowns or collisions. The vehicles could be from a single family or group using multiple vehicles.



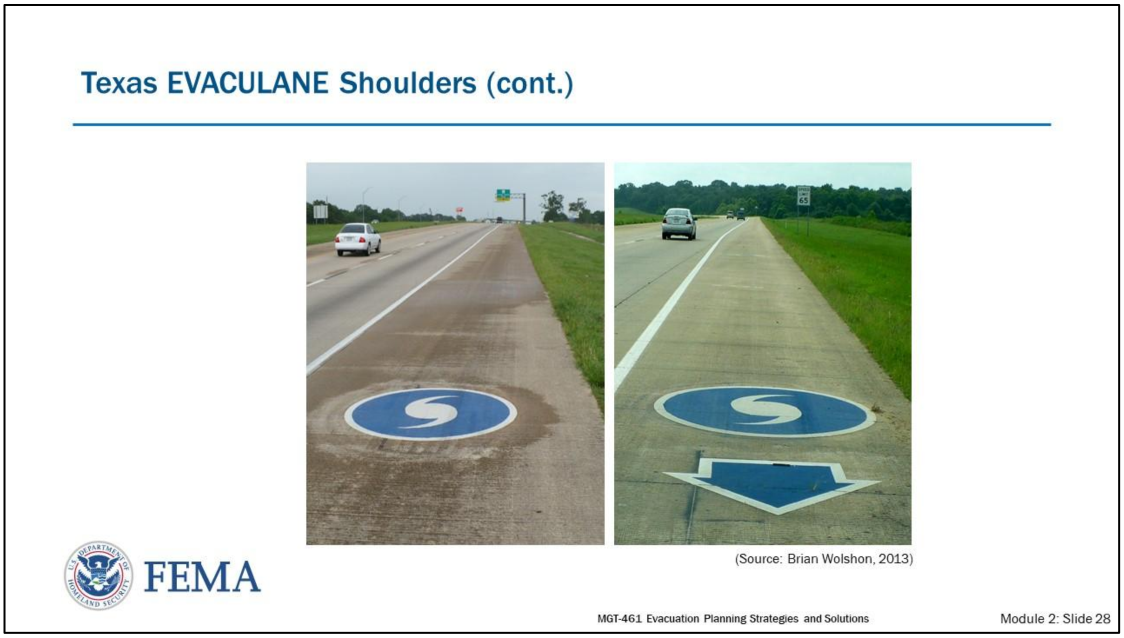

**Slide 26. Evacuation Traffic Control**

Evacuation traffic control relies on a combination of specific tools and procedures, and everyday supportive infrastructure (see slide 18 in this module). The following slides offer several examples. Intelligent traffic systems (ITS) are particularly useful for large-scale evacuations, as they allow centralized monitoring and control of multiple routes and possibly multiple transportation modes (e.g., railroad crossings). Some systems allow remote activation of gates, avoiding the need for crews to travel to specific sites to active them manually.




**Slide 27. Texas EVACULANE Shoulders**

In addition to the formally designated signs, numerous local transportation agencies have developed their own signs for local use in emergencies and evacuations. These include signs specifically for use on contraflow road segments to convey radio frequencies for evacuation travel information, as well as general information that would be conveyed via variable message signs. The photo shows another example developed by the Texas Department of Transportation (TXDOT) to facilitate the use of shoulder “Evaculanes” in Houston. Agencies typically follow broad Manual of Uniform Traffic Control Devices (MUTCD) guidance pertaining to shape, color, legend, and pattern, as well as other American Association of State Highway and Transportation Officials (AASHTO) standards pertaining to structural design and placement. They made sure that the shoulder was continuous, did not have starts and stops, and was functional the entire way of the Evaculane.

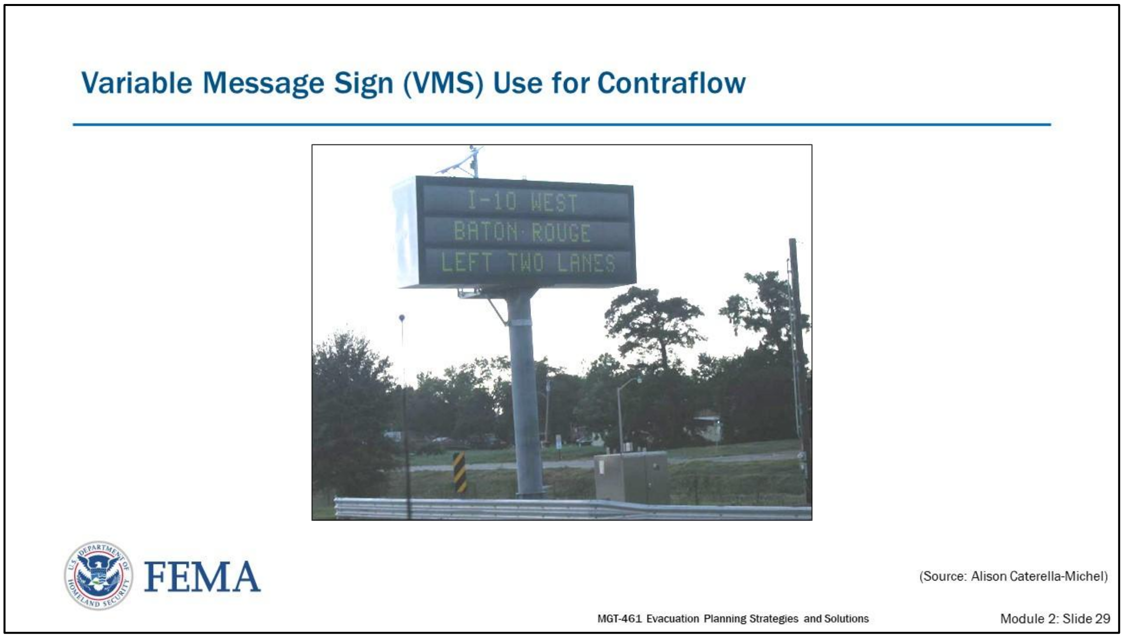



**Slide 28. Texas EVACULANE Shoulders (cont.)**

Another type of traffic control device that has come into use for evacuations is pavement markings. As with some of the previously mentioned signs, these markings have been developed for local use. Pavement markings for evacuations are much less common than signs.

The slide shows an example of pavement markings used to designate shoulders for use as an additional travel lane. These markings were developed by TxDOT and have been affixed on shoulders along US-290, an evacuation route for the city of Houston west toward Hempstead. On the left side of the figure is the marking used for the inside shoulder adjacent to the normal flowing lanes. These markings are particularly important in advance of interchange ramps as the paved shoulder aligns with the off- and on-ramp auxiliary lane. The marking on the right side of the figure is used on the inside shoulder of the contraflow lanes. The difference is the addition of a directional arrow above the hurricane symbol to indicate the intended direction of travel.

The Florida Department of Transportation (FDOT) developed another example of evacuation-related pavement markings for placement in the vicinity of interchanges along I-10 between Jacksonville and Tallahassee. These markings are applied to the inside shoulders near interchanges to show the interchange (mile marker) number. These pavement markings are not meant for drivers; they have been installed so that aerial surveillance crews flying over I-10 during evacuation events can identify specific locations and reference traffic conditions based on its proximity to specific interchange and mile marker locations.




**Slide 29. Variable Message Sign (VMS) Use for Contraflow**

An example of a Variable Message Sign (VMS) in use during contraflow operations is shown in the figure photo. This sign, located just before a key decision point outside of New Orleans, was used to guide drivers into the appropriate lane based on their destination. At this location, the left two lanes are guided into the contraflow lanes west toward Baton Rouge, whereas the right two lanes continued in the normal flow lanes northbound toward Mississippi.

An example of a less sophisticated, though highly useful sign are “flood-level gauge” signs that are used on evacuation routes in New Orleans where roadways are prone to flooding. These passive flood depth measurers give drivers an idea of the depth of water in low-lying areas, especially near underpasses.

**Participant Note:** Pre-scripting messages for common hazards, events, and evacuation routes can save time during an evacuation.

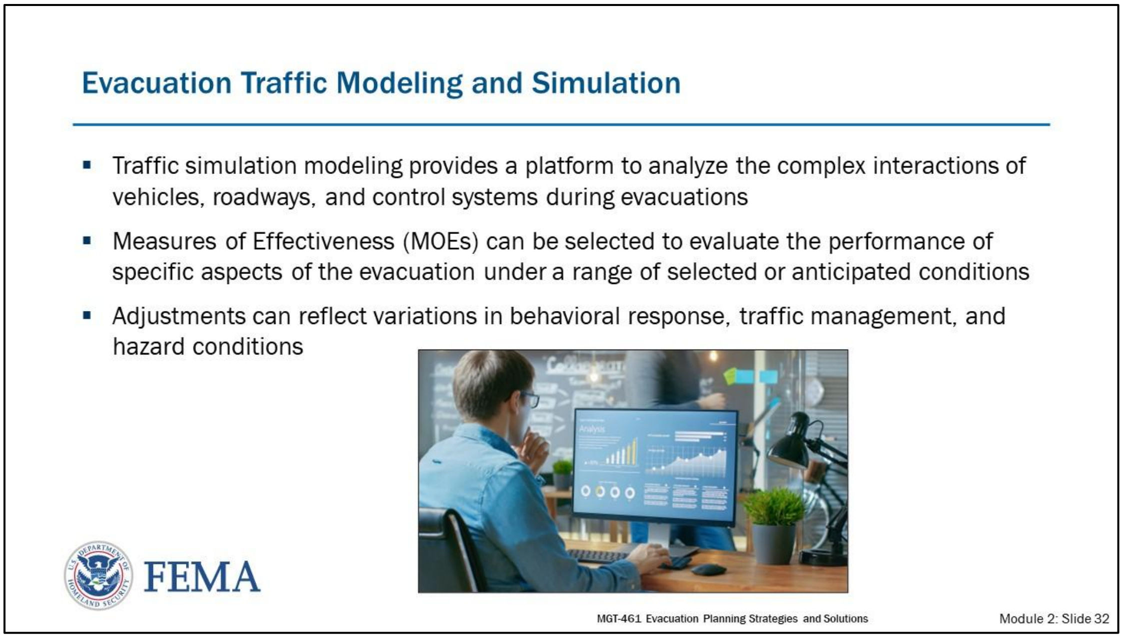

**Slide 30. Examples of Control Devices**

Traffic control devices and techniques for evacuation are well established for some hazards. The US DOT Federal Highway Administration (FHWA) created a Manual of Uniform Traffic Control Devices (MUTCD; most recently revised in 2022), which includes a section dedicated specifically to signing for emergency management. Chapter 2N in the manual includes guidance on the design, size, and placement of these devices. This chapter can be accessed on-line at https://mutcd.fhwa.dot.gov. Signs in this section of the MUTCD are meant to guide, restrict, or control traffic operations and to limit access to essential emergency and aid-related vehicles. The chapter also includes suggested signs for medical, welfare, registration, and decontamination centers that may be required for various types of hurricane, radioactive fallout, chemical, and general hazards. In addition to these facility location signs, the MUTCD includes one sign specific to evacuation.

In addition to the formally designated signs in the MUTCD, it is not uncommon for local transportation agencies to develop their own signs for local use in emergencies and evacuations. These include signs specifically created for use on contraflow segments to convey radio frequencies for evacuation travel information and to provide general information that would be conveyed on variable message signs (VMS). Because they are not included in the MUTCD, no formally established standards guide their design and implementation. Signing on contraflow segments is particularly important along the reverse flowing side of contraflow freeway lanes. When the alignments of directional freeway lanes become independent or separated by medians, drivers in contraflowing lanes may not always be aware of exit locations and services available, because they cannot see into the other lanes and the signs in their lanes face the opposite direction. To accommodate these drivers, agencies such as the Alabama DOT (ALDOT) use “fold-down” signs adjacent to contraflow lanes. When not in use, these signs are folded upward and appear as blank sign backs as shown on the left side of figure photo. When needed, a crew unlocks the latches, permitting the bottom half of the sign to fall into the open position and secures the bottom sign half to the sign supports (see the right side of the figure photo).

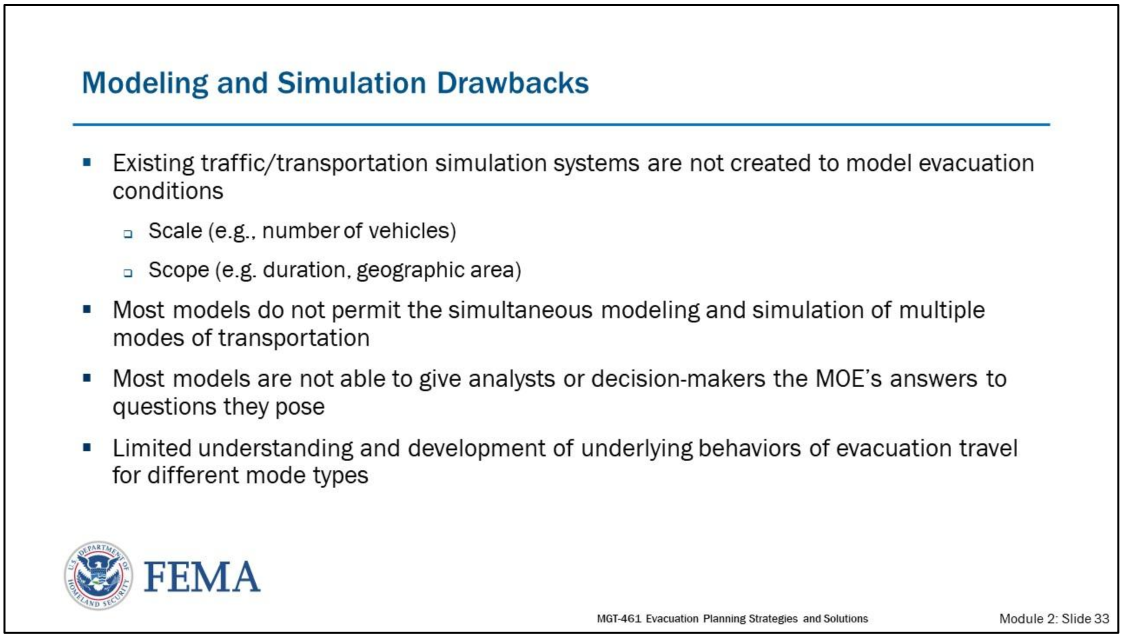

**Slide 31. Example of Control Devices**

To maintain readiness for the implementation of traffic control devices during the hurricane season, ALDOT, as with several other states, also maintains ready-for-use mobile transport vehicles for rapid deployment. An example of one of these vehicles, loaded to implement contraflow on I-65, is shown in the figure. Pre-setup "go trailers" are inventoried before the disaster. This lets them get out immediately and start control. It is essential to ensure that trailers with specialized equipment have vehicles and drivers/crews specifically assigned to them upon activation.




**Slide 32. Evacuation Traffic Modeling and Simulation**

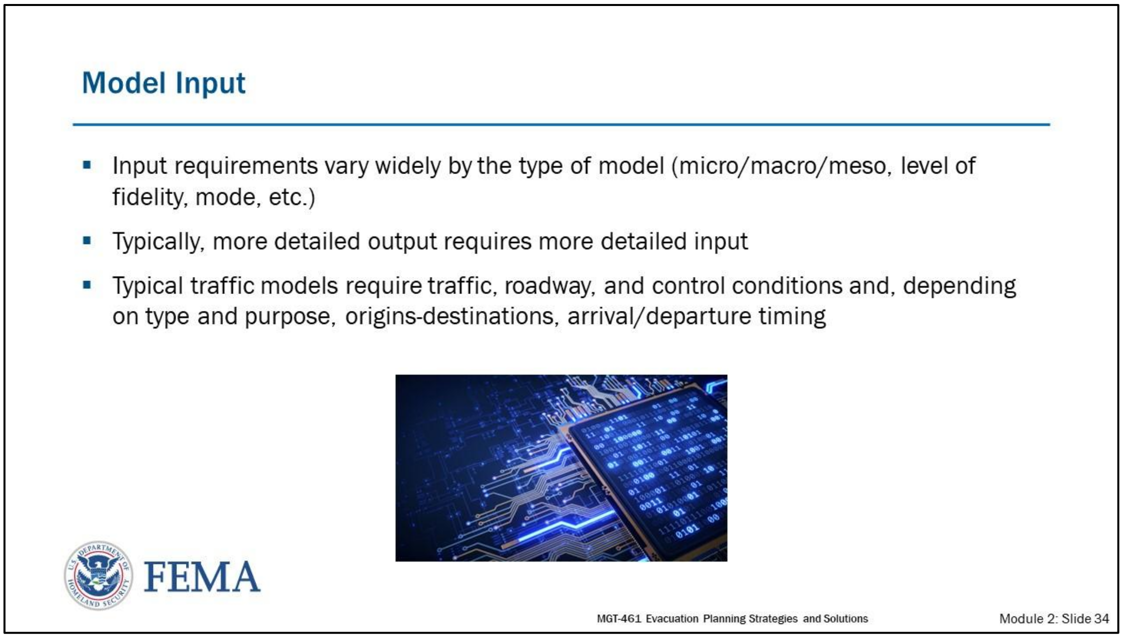
Selection of a particular modeling tool for a specific location and hazard can be challenging. All simulation systems come with varying levels of development effort, input detail, computational speed, output fidelity, and degree of difficulty for the user. The selection of any specific system can also vary by purpose. This module will use modeling tools available at no charge to the public or authorized users. There are several commercial products available, some specific to an end-use or hazard; it’s worth asking students what they use.




**Slide 33. Modeling and Simulation Drawbacks**

Although simulation is a useful and promising avenue for mass evacuation analysis, it has limits and drawbacks, including significant effort required to code, calibrate, and validate the model. Calibration is particularly difficult for evacuations because few comparative evacuation traffic data sets exist. Another is the limited level of user-friendliness of the system.

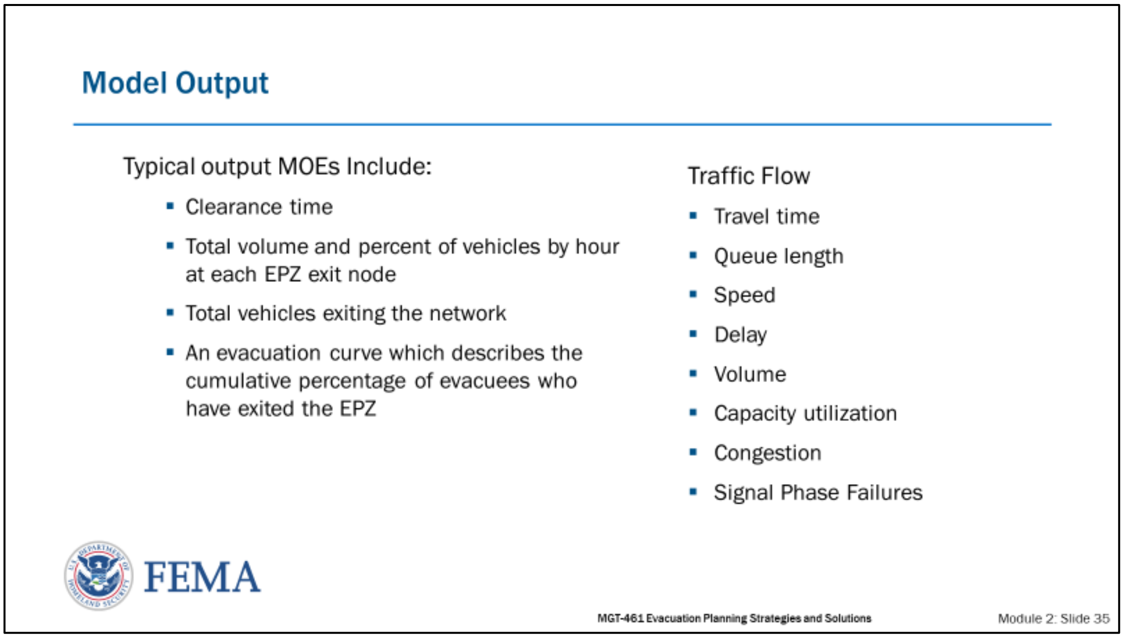
As George Box pointed out (1989), "...all models are approximations. Essentially, all models are wrong, but some are useful. However, the approximate nature of the model must always be borne in mind..." As he also pointed out (2009), "…the question you need to ask is not 'Is the model true?' (it never is) but 'Is the model good enough for this particular application?'"




**Slide 34. Model Input**

Input requirements vary widely by the type of model (micro/macro/meso, level of fidelity, mode, etc.); more detailed output typically requires more detailed input.

Common traffic models require traffic, roadway, and control conditions and, depending on type and purpose, origins-destinations, arrival/departure timing.




**Slide 35. Model Output**

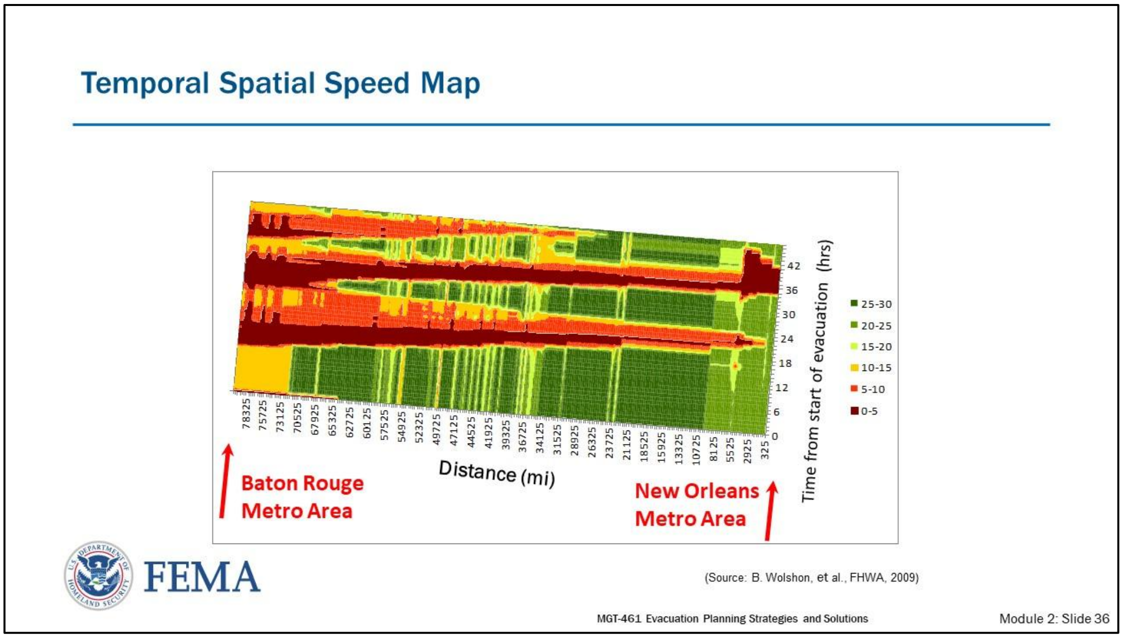
Output may be used to assess different aspects of the system, including those that are emergency management or traffic-oriented.

Typical output MOEs include:

- Clearance time
- Total volume and percent of vehicles by hour at each EPZ exit node
- Total vehicles exiting the network
- An evacuation curve which describes the cumulative percentage of evacuees who have exited the EPZ

Traffic Flow output can be:

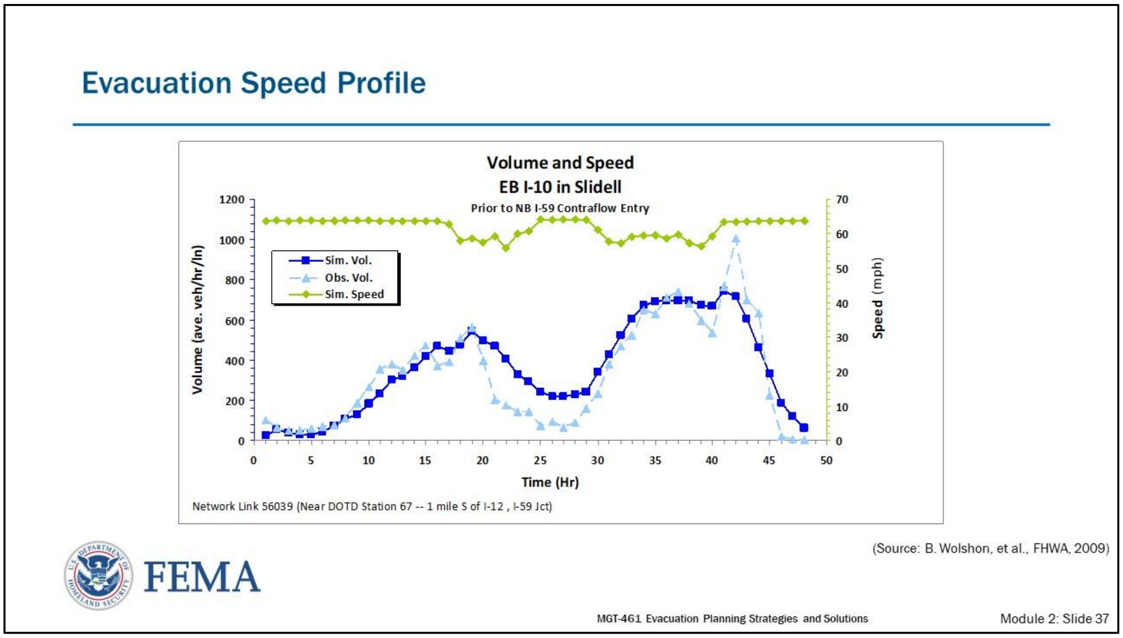
- Travel time
- Queue length
- Speed
- Delay
- Volume
- Capacity utilization
- Congestion
- Signal phase failures




**Slide 36. Temporal Spatial Speed Map**

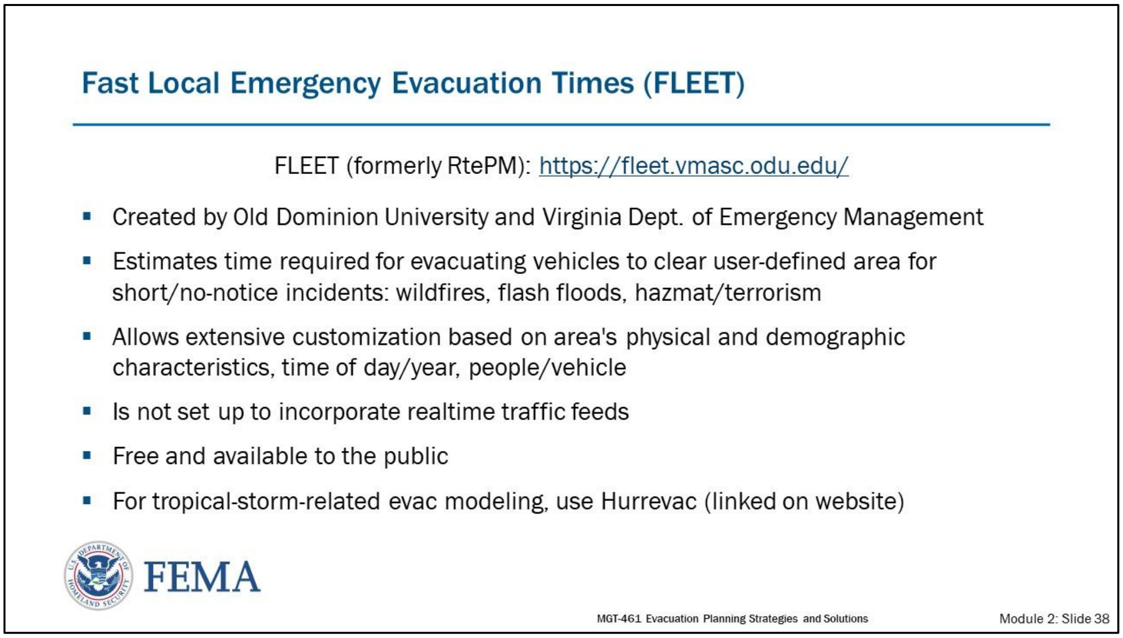
The Y-axis in this model output shows distance in miles between New Orleans and Baton Rouge, approximately 80 miles (the three digits closest to the graph on each label are to the right of the decimal point, so the rightmost value is 0.325 mi and the leftmost is 78.325 mi; best not to ask why it was done this way). The X-axis shows time form start of evacuation, ranging from 0 to 48 hours. If you follow a time, for example hour 12 from New Orleans to Baton Rouge, you will see that the traffic is “green” until you get to Baton Rouge. This allows you to see when the traffic is going to increase. You can also look at one set place and see when it gets more crowded and when it thins out. Therefore, if you choose a location on the Y-axis near New Orleans and follow the time up, you can see that traffic is “green” in that spot in New Orleans until around hour 20, then a small clearing again between hour 24 and 36, then it is “red” again.

This type of modeling can help with planning and decision-making.




**Slide 37. Evacuation Speed Profile**

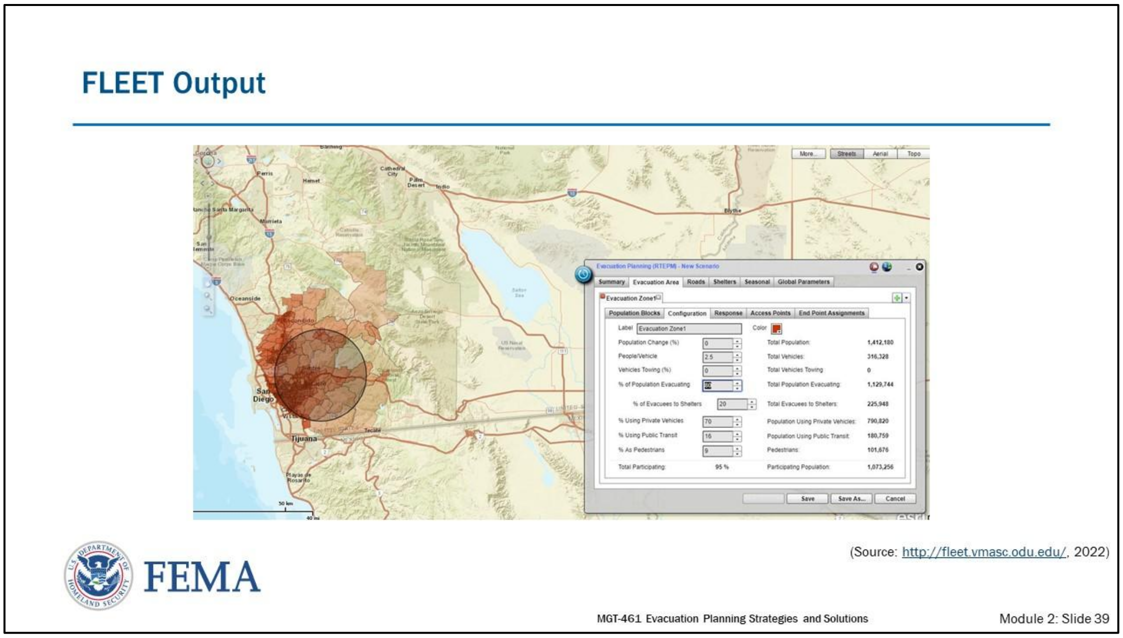
This output shows observed volume versus simulated volume. The dark blue line with solid squares is simulated volume and the light blue line (solid triangles) is actual observed volume. The green line (solid diamonds) shows simulated speed before contraflow entry. The point of this is to see that the modeling for this particular simulation was pretty accurate. The light blue line follows the same trend as the simulated or dark blue line.




**Slide 38. Fast Local Emergency Evacuation Times (FLEET)**

FLEET is a software program formerly known as RtePM. FLEET was:

- Created by Old Dominion University and Virginia Dept. of Emergency Management
- Estimates time required for evacuating vehicles to clear user-defined area for short/no-notice incidents: wildfires, flash floods, hazmat/terrorism
- Allows extensive customization based on area's physical and demographic characteristics, time of day/year, people/vehicle
- Is not set up to incorporate realtime traffic feeds
- Free and available to the public
- For tropical-storm-related evac modeling, use Hurrevac (linked on website)

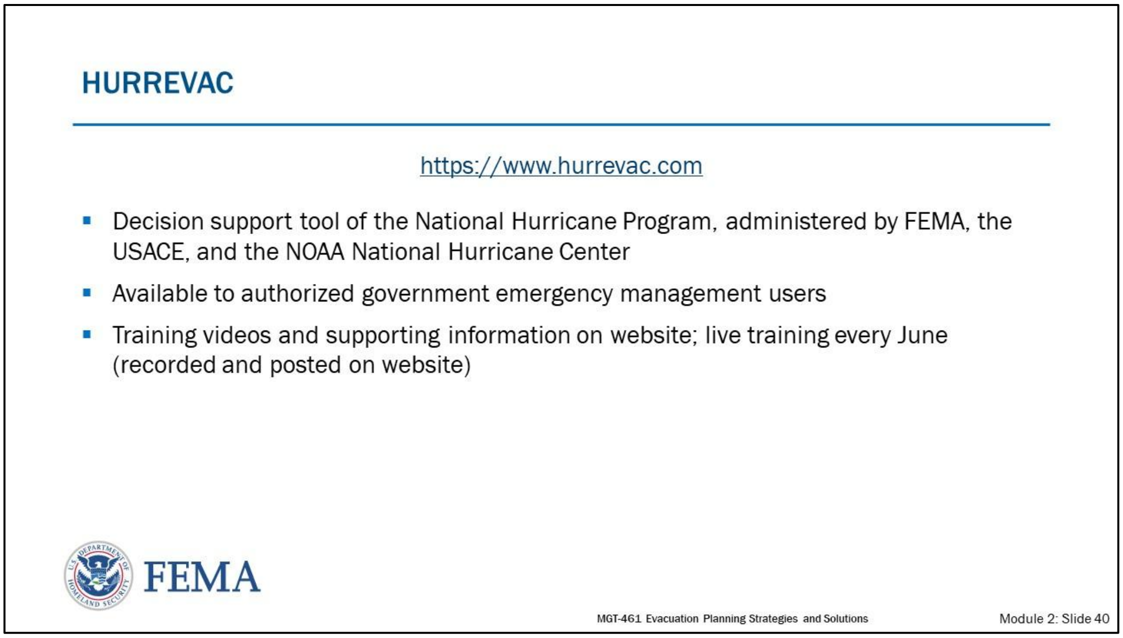



**Slide 39. FLEET Output**

The goal of FLEET (originally called RtePM) is to enhance state and local emergency managers' capabilities to plan for and manage emergency evacuations for short/no-notice events like wildfires, rapid flooding, and hazmat releases. One method of accomplishing this is through the development of an information management and analysis system that leverages existing data repositories and legacy software. Some of the features are:

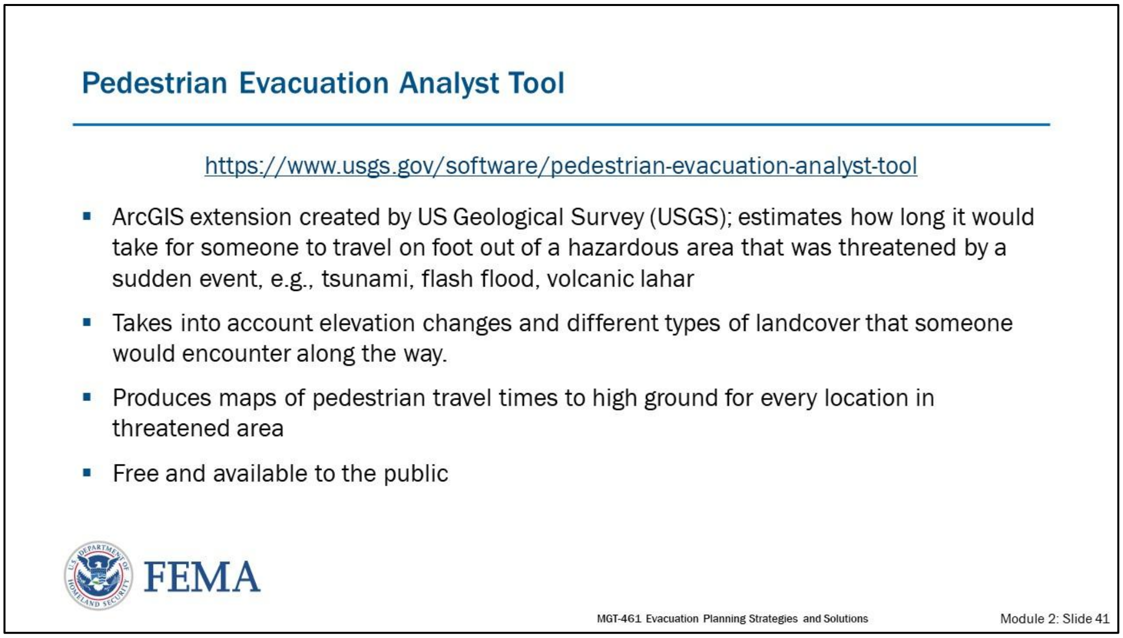
- Collects, processes, and stores traffic network and behavior model parameters
- Accepts and verifies parameters specified to generate traffic flow and clearance times
- Generates traffic flow information and clearance times
- Maintains a repository of scenarios

This is a sample scenario in southern California. The circle represents a 15-mile radius of evacuation. You can adjust the parameters to the desired conditions. For example, what percent of the population do you expect to evacuate, what percent will use personal cars, and what percent will use public transportation? This will output actual numbers of how many you need to plan for. FLEET is available gt http://fleet.vmasc.odu.edu/.



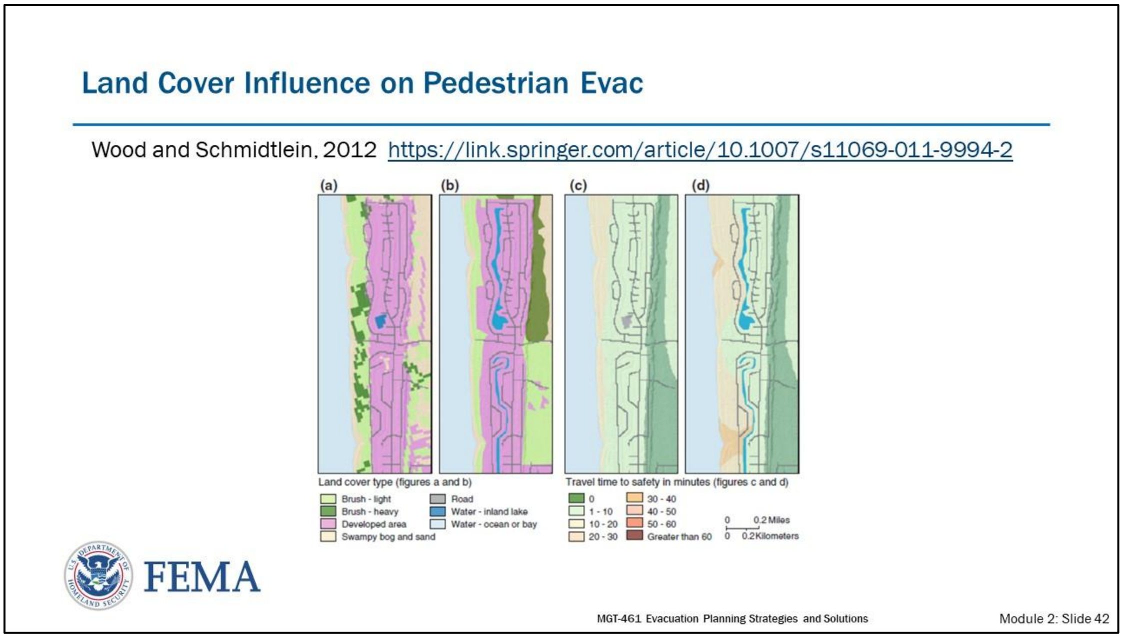

**Slide 40. HURREVAC**

Hurrevac is the decision support tool of the National Hurricane Program, administered by FEMA, the US Army Corps of Engineers, and the NOAA National Hurricane Center. It combines live feed of weather systems with data from various states to assist with decision-making regarding hurricane evacuation and damage potential. It is a free program for emergency management officials and other decision-makers. Live online training is offered every June; the training is recorded and available on the Hurrevac website, https://www.hurrevac.com.



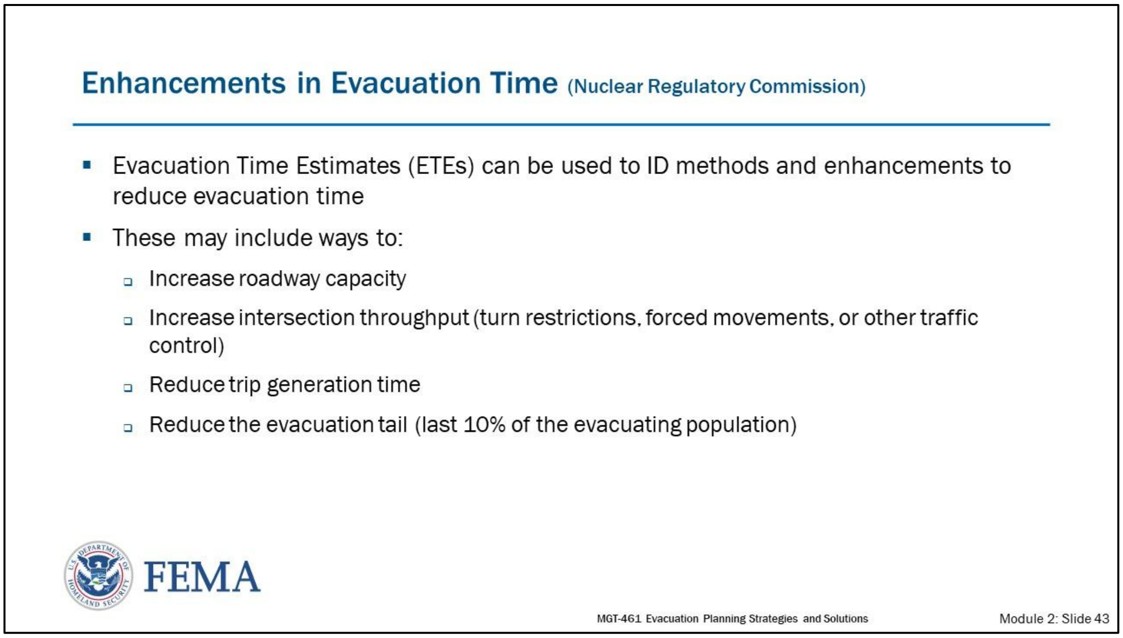

**Slide 41. Pedestrian Evacuation Analyst Tool**

Pedestrian evacuation is most likely to be incorporated in local- rather than state-level plans; it may be most relevant in short- and no-notice events, where travel distance is short and/or other transportation infrastructure is unavailable or unreliable, or as an intermediary mode (e.g., walking to a pickup point). When planning for pedestrian evacuation it is essential to consider not only map (i.e., horizontal) distance, but change in elevation (topography) type of terrain, vegetation, and physical barriers (e.g., streams, ravines, steep slopes). The US Geological Survey (USGS) created a tool for this purpose, initially but not exclusively for tsunami evacuation. It is free and available to the public at https://www.usgs.gov/software/pedestrian-evacuation-analyst-tool.




**Slide 42. Land Cover Influence on Pedestrian Evac**

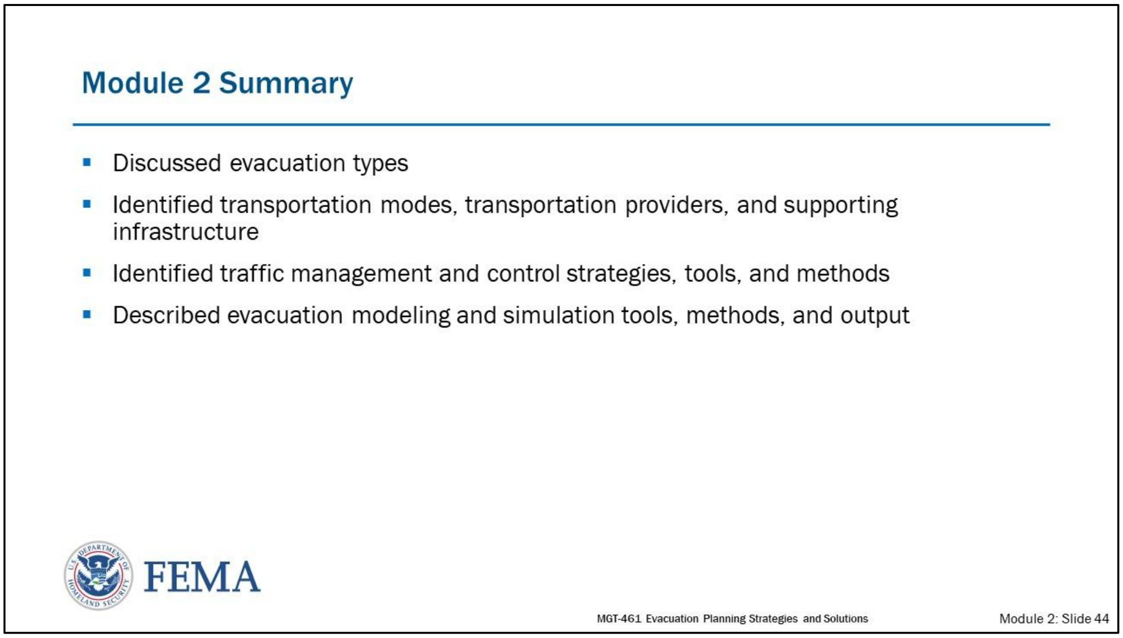
This slide shows output from the USGS Pedestrian Evacuation Analyst Tool, using a tsunami scenario on the Long Beach peninsula in Washington. The left pair of figures (a and b) show land cover; the right pair (c and d) show estimated travel time to safety.




**Slide 43. Enhancements in Evacuation Time (Nuclear Regulatory Commission)**

Nuclear Regulatory Commission guidance states that Evacuation Time Estimates (ETEs) can be used to identify methods or improvements that may reduce the evacuation time. When evaluating potential improvements in evacuation time, the assessment may be limited to those roadways or sections of the Emergency Planning Zone (EPZ) which most affect the ETE. It is not expected that every intersection or roadway segment be evaluated for improvements in evacuation time, but that a prudent and thorough assessment be conducted.

Each of the items on the slide should be addressed with a discussion provided on the level of effort and results of each assessment. The results should include that actual reduction in evacuation time observed in the modeling output or should include expected reduction in evacuation time for suggested improvements such as reducing the evacuation tail.




**Slide 44. Module 2 Summary**

In this module, participants:

- Discussed evacuation types
- Identified transportation modes, transportation providers and supporting infrastructure
- Identified traffic management and control strategies, tools, and methods
- Described evacuation modeling and simulation tools, methods, and outputs

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# Module 3

# Evacuation Planning Considerations

# Module 3 Administration


**Slide 45. Module 3: Evacuation Planning Considerations**

## Duration

75 minutes

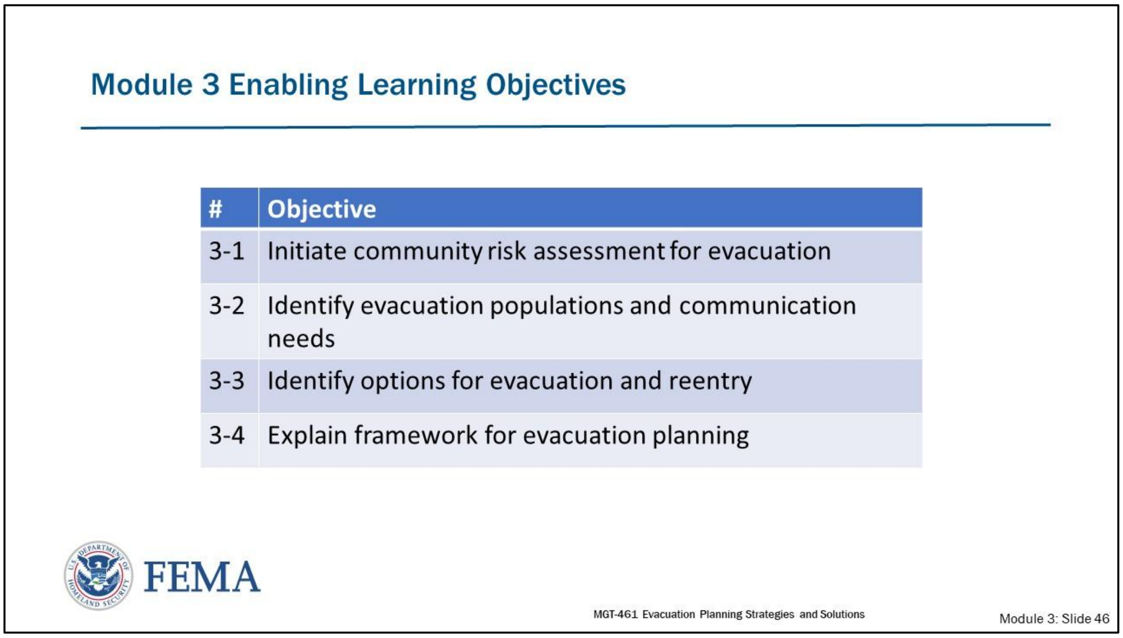
## Scope Statement

In this module, the instructor will highlight and summarize several of the foundational principles of evacuation planning, specifically the formation and interaction of teams for collaborative work in plan developments including identification of stakeholders, committees, and/or organizations. Among the key topics covered will be steps in the planning process and identification of evacuation population and infrastructure and system needs during evacuation.

## Terminal Learning Objective (TLO)

Participants will be able to assess the need for evacuation in their community and identify considerations to incorporate into the evacuation planning process.

## Module 3 Content

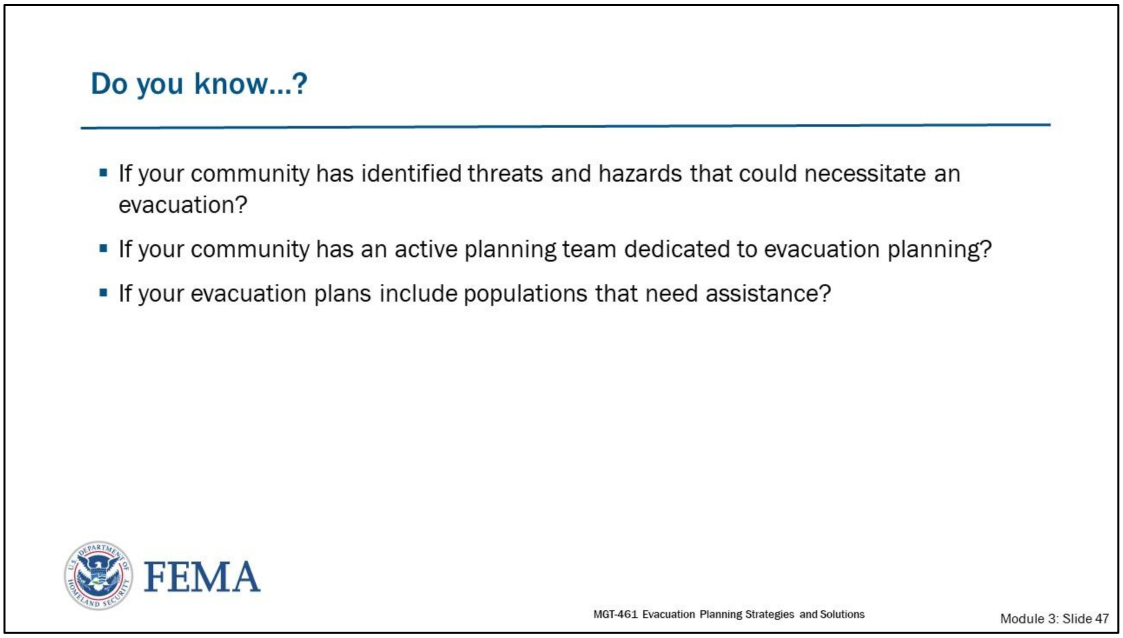



| # | Objective |
|---|---|
| 3-1 | Initiate community risk assessment for evacuation |
| 3-2 | Identify evacuation populations and communication needs |
| 3-3 | Identify options for evacuation and reentry |
| 3-4 | Explain framework for evacuation planning |

**Slide 46. Module 3 Enabling Learning Objectives**

In this module, participants will:

- Initiate community risk assessment for evacuation;
- Identify evacuation populations and communication needs;
- Identify options for evacuation and reentry; and
- Explain framework for evacuation planning.

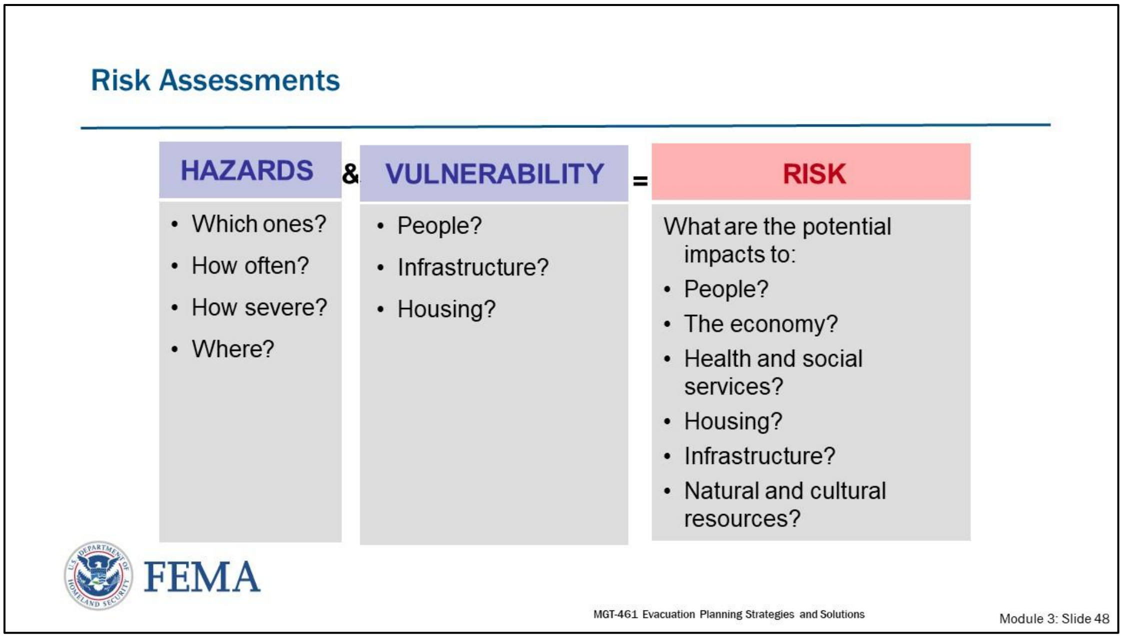



**Slide 47. Do you know…?**

**Discussion:** Instructor-facilitated, large-group discussion

Questions to consider:

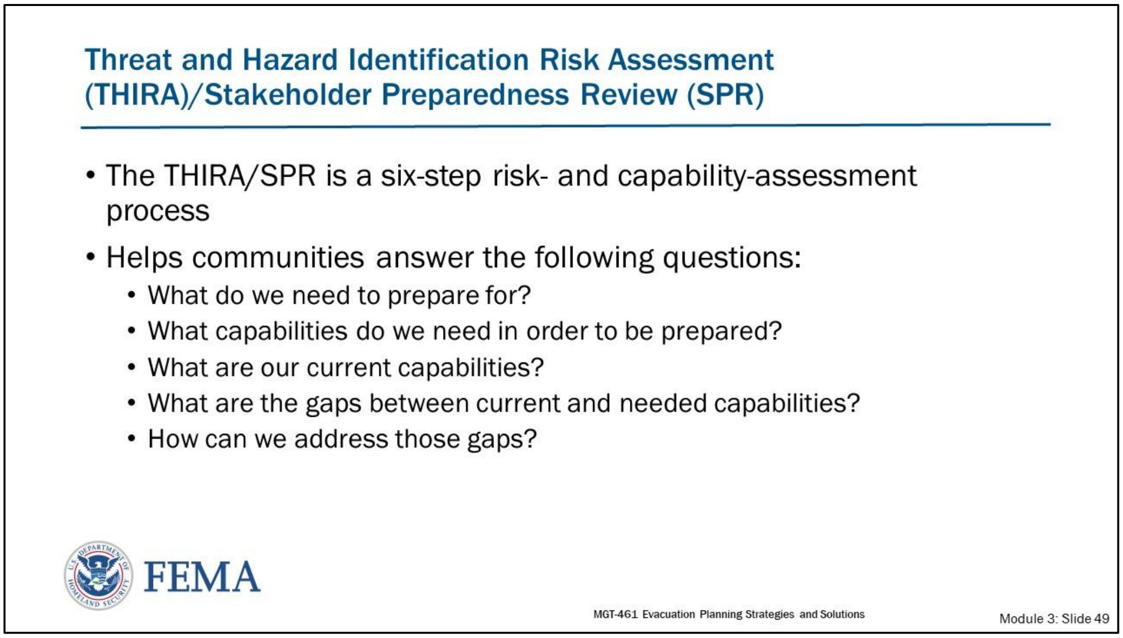
- Do you know if your community has identified threats and hazards that could necessitate an evacuation?
- Do you know if your community has an active planning team dedicated to evacuation planning?
- Do you know if your evacuation plans include populations that need assistance?




**Slide 48. Risk Assessments**

Questions to consider:

- What are your hazards? How often do they happen? How severe are they? Where do the occur or where in your jurisdiction is affected?
- Vulnerability can refer to people, property, and the environment. Who or what is vulnerable to the hazard?
- Risk is the potential impact. What are the potential effects? Whom/what do they affect and how? What are the short- vs long-term effects?




**Slide 49. Threat Hazard Risk Assessment (THIRA)/Stakeholder Preparedness Review (SPR)**

The THIRA is a six-step risk assessment process. It is FEMA’s process to assess risk and vulnerability.

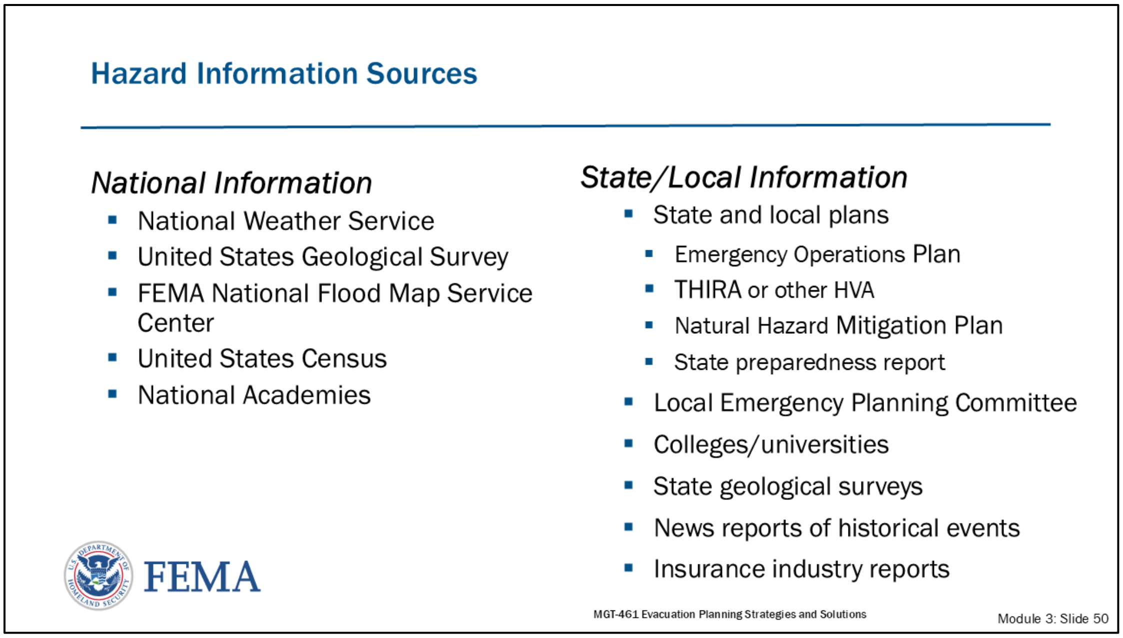
THIRAs and other hazard vulnerability assessments (HVAs) help communities and organizations understand *and prioritize* what they need to plan for, potential resources, access to those resources, and what mitigation steps are possible.

Most states have a THIRA and there are many local ones in place. It is advisable to get a hold of these THIRAs to start your planning processes for evacuations. Regardless of whether you use a THIRA or other type of HVA, it’s important to make that part of your planning foundation.

THIRAs can help a community answer the following questions:

- What do we need to prepare for?
- What capabilities do we need in order to be prepared?
- What are our current capabilities?
- What are the gaps between current and needed capabilities?
- How can we address those gaps?

**Participant Note:** AWR-401-W Threat and Hazard Identification and Risk Assessment and Stakeholder Preparedness Review provides an introduction to the THIRA process in a short-form web-based format. MGT-310 Threat and Hazard Identification and Risk Assessment and Stakeholder Preparedness Review provides more in-depth information on the THIRA/SPR process in an interactive mobile instructor-led delivery format.




**Slide 50. Hazard Information Sources**

**Discussion:** Which have you used? What others do you use?

This slide lists some sources that provide the necessary information, from local to national, for identifying and characterizing relevant risks for your community, the first step in creating your emergency evacuation plan.

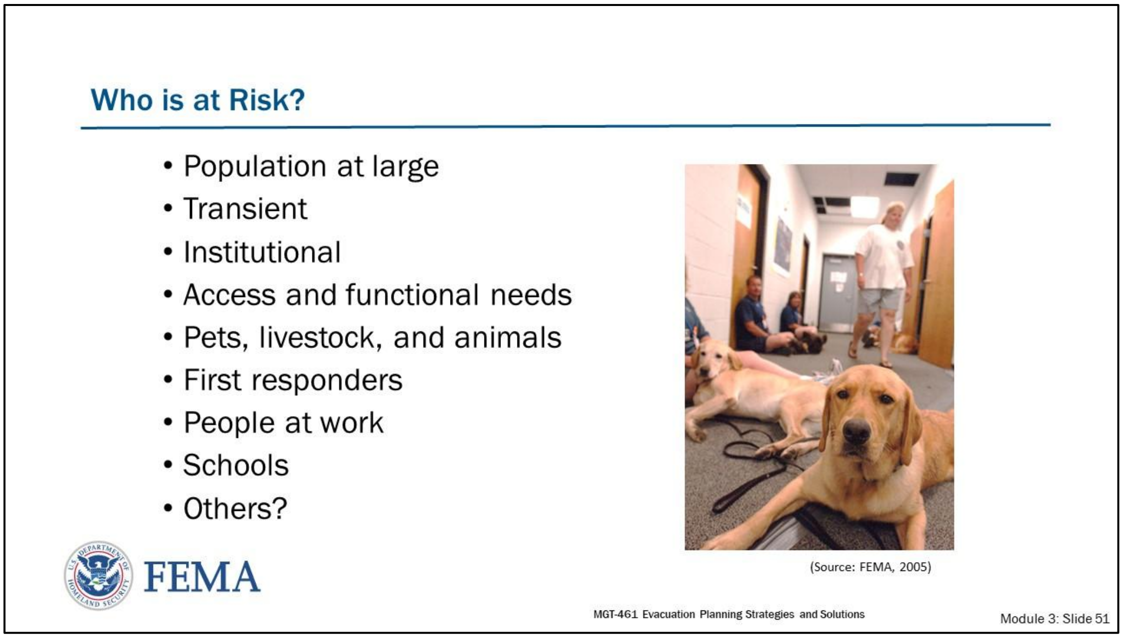
Some resources for national information include:

- National Weather Service
- United States Geological Survey
- FEMA National Flood Map Service Center
- United States Census
- National Academies

State/Local Information could come from:

- State and local plans
    - Emergency Operations Plan
    - THIRA or other HVA
    - Natural Hazard Mitigation Plan
    - Community Wildfire Protection Plan
    - Community and site-specific hazmat plans
    - After action reports

    - State preparedness report
- State mitigation plan
- Local Emergency Planning Committee
- Colleges/universities
- State geological surveys
- News reports of historical events
- Insurance industry reports

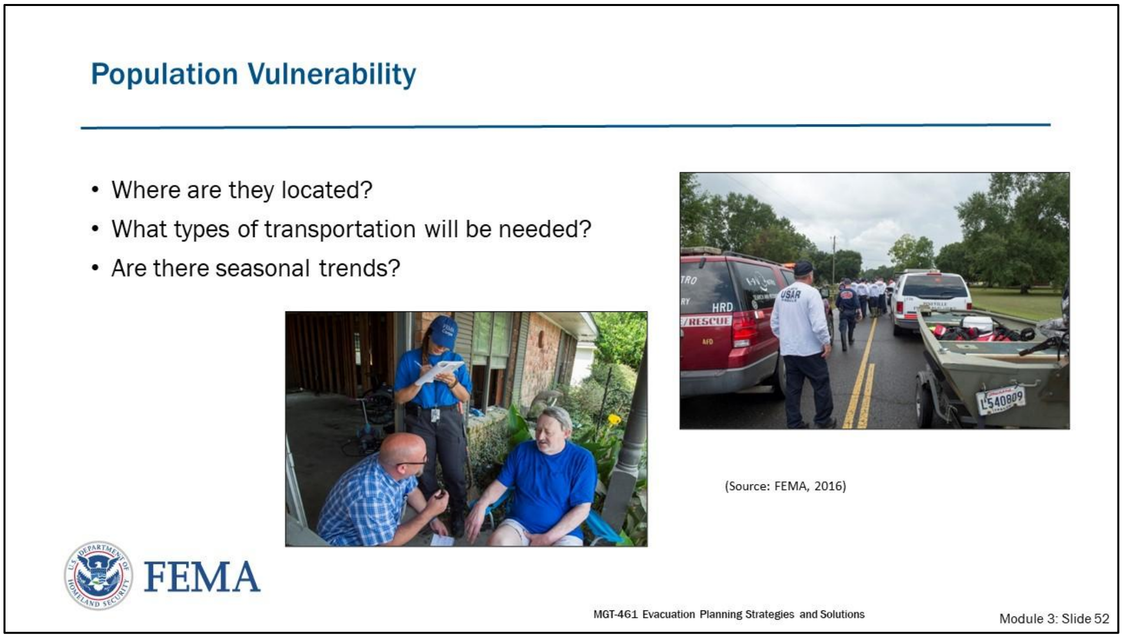



**Slide 51. Who is at Risk?**

Now that we have discussed identifying what the risks are, let's talk about who is at risk.

The list on this slide is broad but not exhaustive.

**Discussion:** How would you describe your populations at risk? Where are they? How does type and level of risk differ among them? Where would you look for this information and which community partners should you engage to ensure that your most vulnerable are adequately represented in your plans?

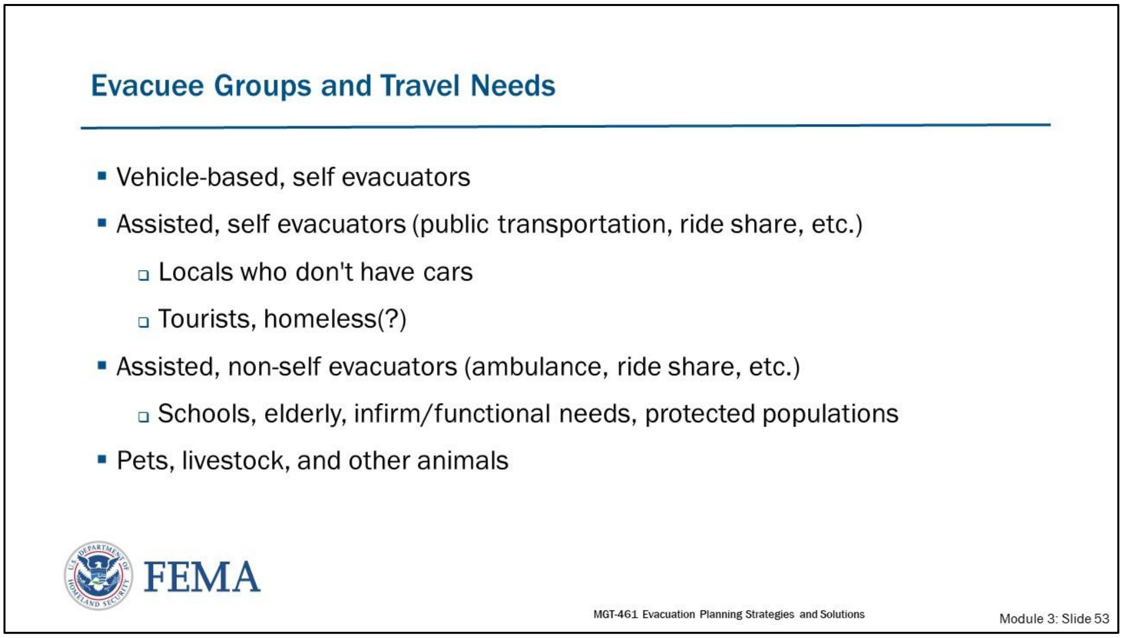



**Slide 52. Population Vulnerability**

Part of identifying vulnerable populations is knowing where they are (location, type of building - if any), and how that relates to transportation networks and resources.

Will you need special types of transport? Ferries? Extra bus routes? Who has those resources, when are they available, and how do you request them? If you're directing people to “go to higher ground” for example, how would you address people with access and functional needs, who might need more or specialized assistance?

What about seasonal trends or events, e.g., festivals, road races, large conferences, or sporting events? What vulnerabilities do they add to your jurisdiction and how will you plan for them?




**Slide 53. Evacuee Groups and Travel Needs**

There are a few broad evacuee categories, based on evacuation capabilities.

**Vehicle-based self-evacuators** are willing and able to evacuate and have the means to do so in a private vehicle.

**Assisted self-evacuators** are willing and able to evacuate but do not have access to a private vehicle. They may rely on public transit (e.g., city bus or rail), ride share, bicycle, or walking.

**Assisted non-self-evacuators** need assistance AND transportation. This includes physically or cognitively limited, hospitalized, or institutionalized people. Resources such as ambulances may be important in assisted evacuations for this population. If using ambulances for this purpose, it’s better not to assign on-duty units staffed for 911 calls, rather to bring additional units or assign non-emergency transfer units (e.g., wheelchair vans). Many daycare centers would fall under this category as well.

Hospitals and nursing homes are required to have their own plans in place, but the gap between plans and reality may be substantial. In addition, many hospitals and nursing homes, for example, may have agreements with the same transportation providers; this may be adequate for an incident at a single facility but would be insufficient in a major emergency that affects a large area. Additional examples include pets, livestock, and other animals.

This highlights the importance of collaborating and communicating with neighboring entities. FEMA’s “Planning Considerations: Evacuation and Shelter-in-Place" and NCHRP 740 provide templates, checklists, and additional guidance for identifying and addressing specialized transportation needs.

## Assisted Evacuations

- Evacuation planning has historically been targeted at persons with personal vehicles
- A substantial percentage of potential vulnerable populations do not have personal vehicles


(Source: fema.gov, 2015)

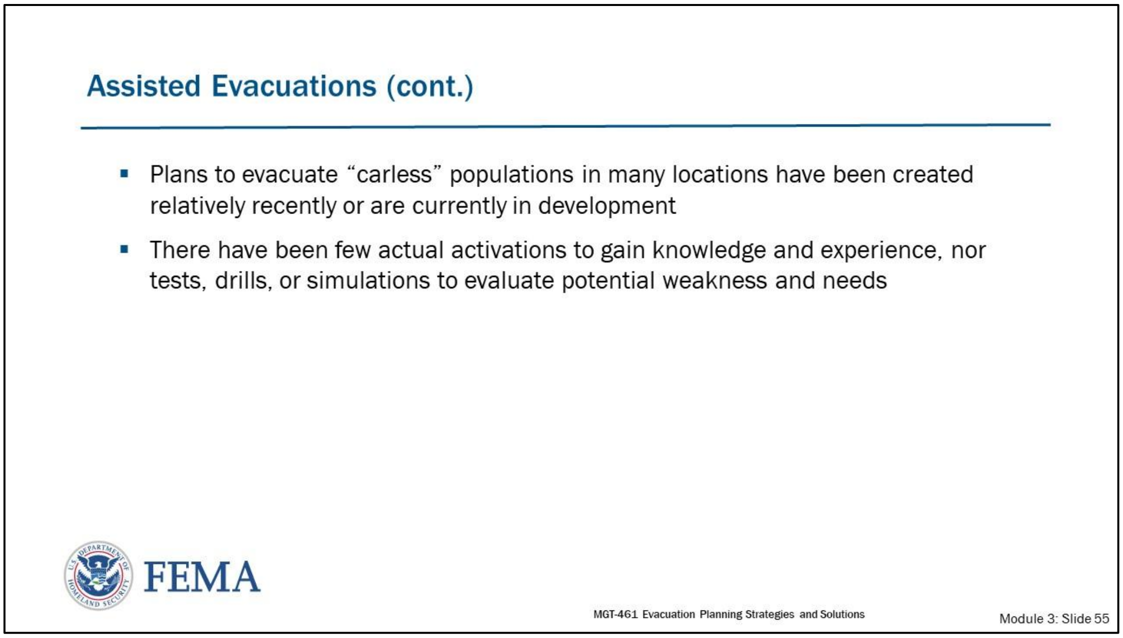
FEMA

MGT-461 Evacuation Planning Strategies and Solutions

Module 3: Slide 54

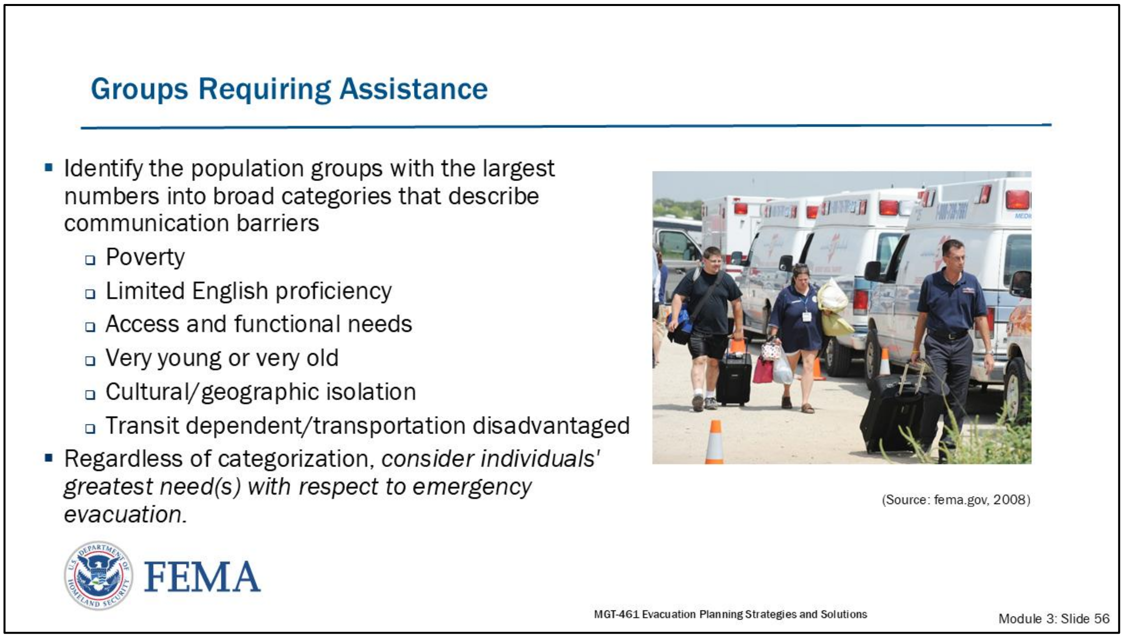
**Slide 54. Assisted Evacuations**

Assisted evacuations are necessary for people who do not have their own way to evacuate during an emergency. Attention to the topic of “assisted evacuation” increased greatly in the wake of the terrorist attacks of September 11, 2001, in which marine transit played a major role in evacuating Lower Manhattan, and after Hurricane Katrina in 2005, in which evacuation plans failed to evacuate carless residents. Subsequent mass evacuations have shown variable improvement as well as substantial remaining gaps.




**Slide 55. Assisted Evacuations (cont.)**

Few states or urban areas have adequate planning for carless evacuees and most evacuation planning focuses on evacuation via privately-owned vehicles, ignoring or underutilizing public transportation. Hess and Gotham (2007) studied counties in rural New York and found that multi-modal evacuation planning is not seriously considered in most evacuation plans. The United States Government Accountability Office (GAO) conducted a national study concerning disadvantaged population evacuation preparedness. The GAO found that state and local governments are not adequately prepared for evacuating disadvantaged populations. Finally, Bailey et al. (2007) surveyed the emergency response and evacuation plans in 20 metropolitan areas with higher than average proportions of minorities, low income levels, limited English proficiency, and households without vehicle access. It was found that few agencies had included transportation-disadvantaged population in their emergency plans.




**Slide 56. Groups Requiring Assistance**

There is a range of terms for people considered to be the most vulnerable in emergencies. No single term has been universally accepted, although terminology such as vulnerable, DAFN (disabled, access and functional needs), CMIST (communication, maintaining health, independence, support, and transportation), and special needs, are common. It si important for all involved to use common terminology, and for that terminology be respectful, non-discriminatory, and suitably descriptive for the intended purpose.

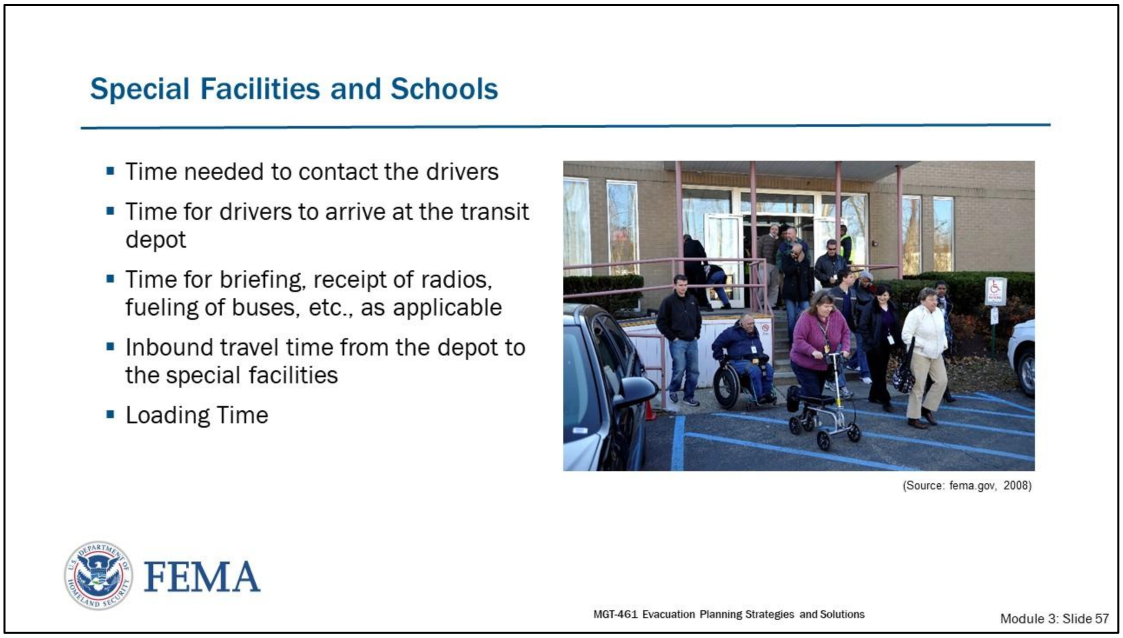
Those that could require assistance can include:

- Frail elderly and people with physical or cognitive disabilities, whether using home health or residing in nursing homes and assisted living facilities
- People who are not proficient in English
- Hospital patients, visitors, and staff
- Tourists
- People without independent transportation
- Homeless people
- People with animals: pets, livestock, and service animals
- Incarcerated people
- “Protected” populations (e.g., those being sheltered from abusers)

Example

**Example:** The State of Texas Emergncy Assistance Registry (STEAR - https://tdem.texas.gov/stear/) helps state and local governments identify those likely to need assistance in evacuations and other emergencies. Those encouraged to register include:

- People with disabilities
- People who are medically fragile
- People with access and functional needs such as:
- People who have limited mobility
- People who have communication barriers
- People who require additional medical assistance during an emergency event
- People who require transportation assistance
- People who require personal care assistance

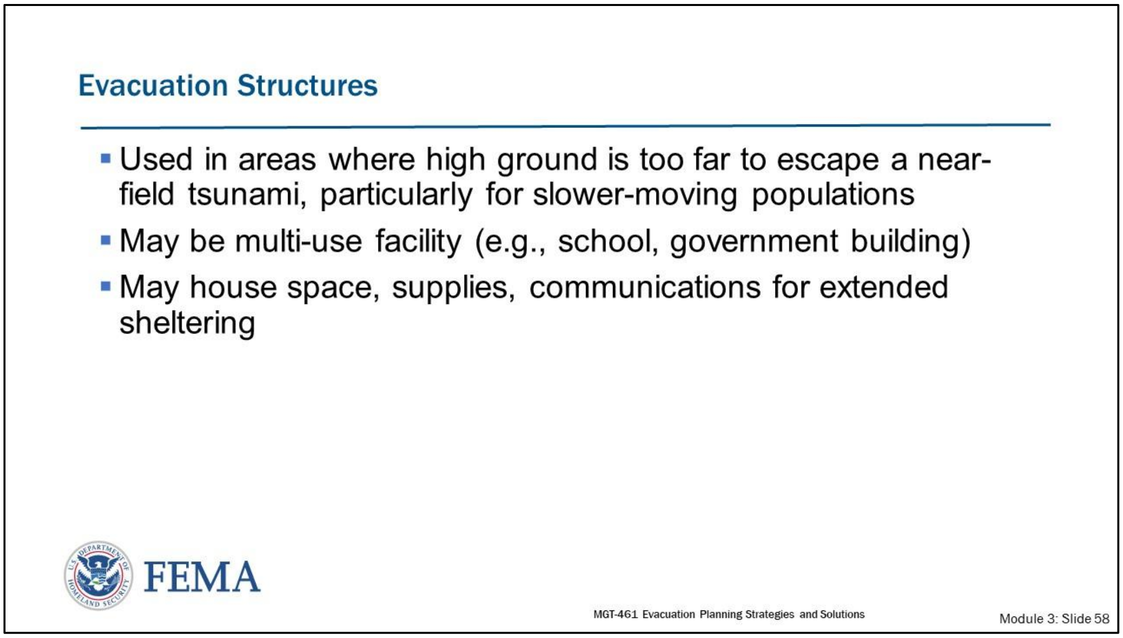



**Slide 57. Special Facilities and Schools**

The Nuclear Regulatory Commission (NRC) defines Special Facilities as those where residents are confined or dependent upon facility personnel for transportation. This includes, but is not limited to, hospitals, nursing homes, jails, and prisons. Facility personnel are counted in the special facility population group.

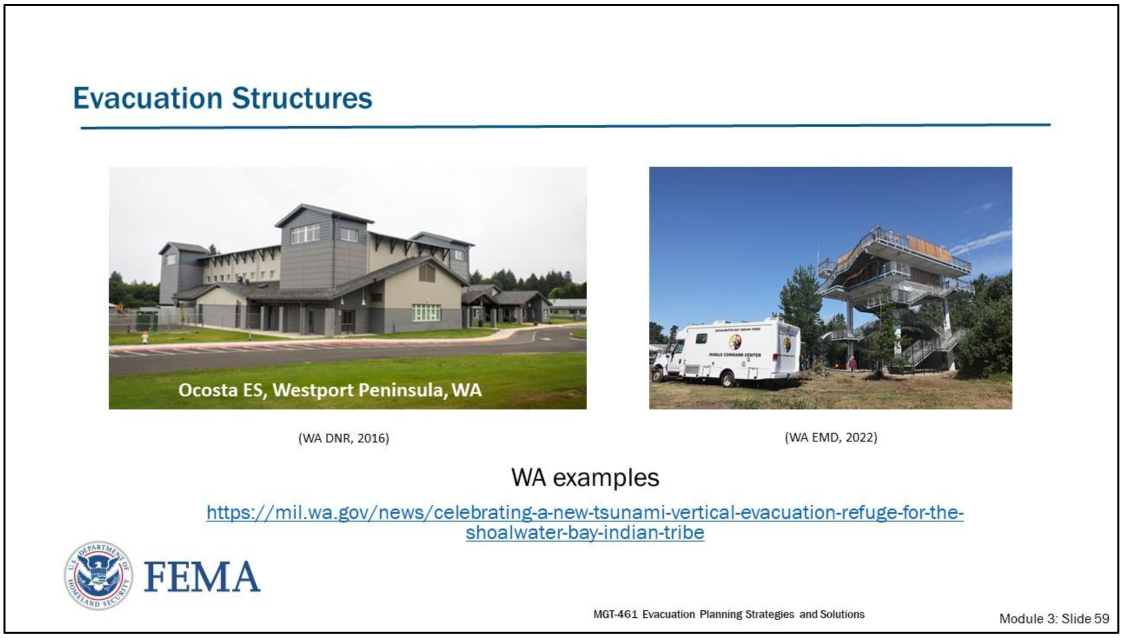
Special facilities vary in provided services as well as residents and may not need to provide transportation for 100 percent of their population. With sufficient notice and suitable conditions, nursing homes and assisted living facilities may be able to have local family members pick up some residents, and hospitals can discharge patients who are safe to travel. Resources needed to evacuate special facilities typically include buses, vans, ambulances, and automobiles.

The capacity of transit buses and private coaches is based on adults; the capacity of school buses is based on children. Considering that residents are evacuating with their belongings, including clothing, medicines, pets, etc., a reasonable estimate for buses is 50 percent of the stated seating capacity, with no separate standing room. Regardless of attributes (e.g., separate luggage storage in private coaches), capacities assumed for buses and other transportation should be specified.



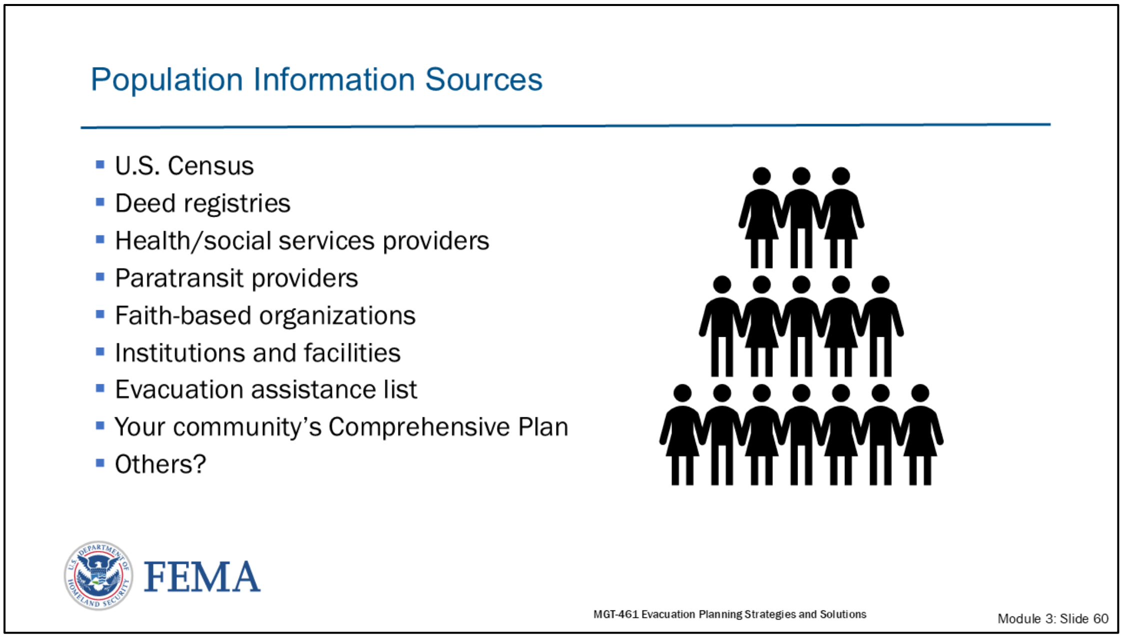

**Slide 58. Evacuation Structures**

Some areas at risk for tsunami inundation are vulnerable in part because there is no suitable evacuation route for a near-field tsunami (i.e., one resulting from a local earthquake and thus requiring immediate evacuation as soon as the shaking stops). This could be due to horizontal distance, challenging terrain, reliance on bridges that are unlikely to survive shaking, or people who are unable to evacuate on foot without assistance. Some of those areas now host vertical evacuation structures, either stand-alone towers or multi-use facilities, that people can reach without needing to travel too far or too long.




**Slide 59. Evacuation Structure Examples**

This slide shows two recently completed vertical evacuation structures in the state of Washington. Ocosta Elementary School (left photo) was renovated in 2016 to include a vertical evacuation structure that is available to the community as well as school students and staff. The photo on the right shows a stand-alone evacuation tower in Tokeland, completed in 2022 as part of a partnership that included the Shoalwater Bay Indian Tribe, FEMA, and the Washington Emergency Management Division. Both structures were part of Washington's Project Safe Haven.

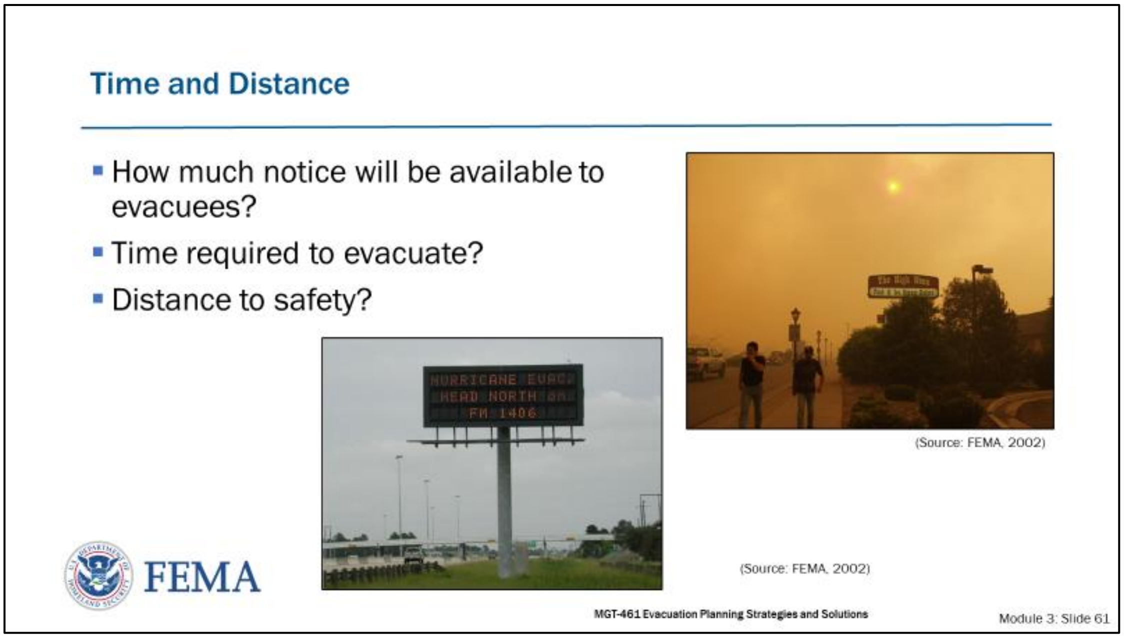



**Slide 60. Population Information Sources**

There are resources that provide information about populations in your jurisdiction in order to plan for their safety. These include:

- US Census – neighborhoods, subdivisions, schools, churches, organizations, etc
- Special Facilities Database – a list of all institutions in a jurisdiction (hospitals, nursing homes, schools, etc.) - if you have one of these in your jurisdiction, it is likely the product of several data sources, including state health department, state education department, and local school districts.
- Other databases – special facilities, reception/pickup locations, transportation assistance (mass trans, drivers, ADA, etc.).

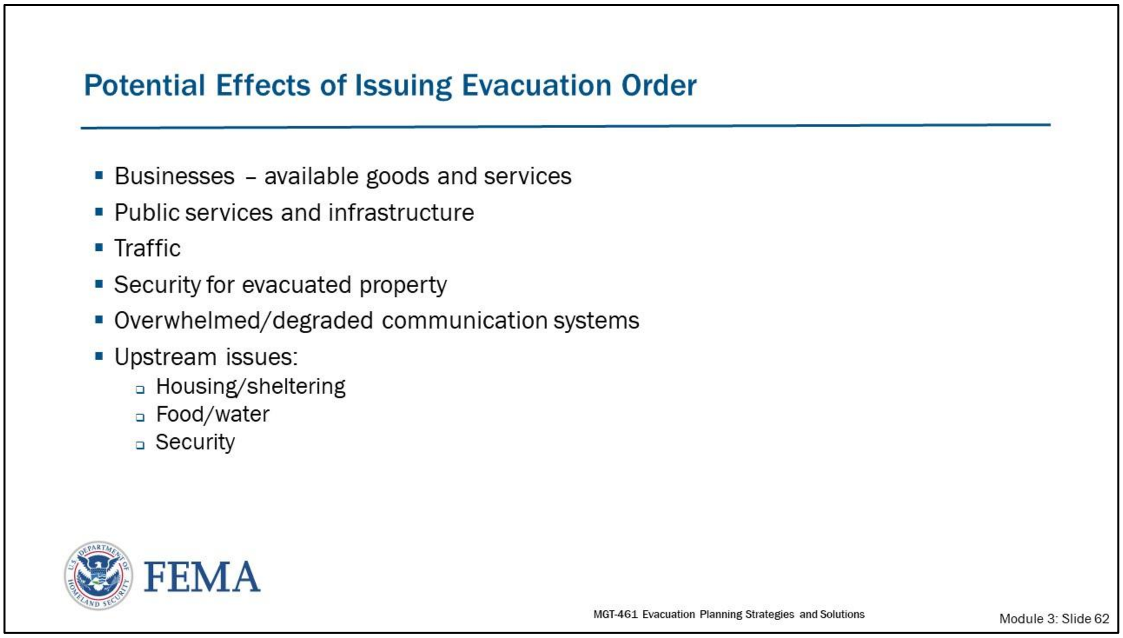
**Participant Note**: Although the primary source of information is the US Census, it's important to use local sources to gain resolution beyond census tracts and blocks. Supplemental information sources include local planning departments and deed registries, tourism and business bureaus, local public health agencies, utility providers, public safety agencies, insurance providers, and Local Emergency Planning Committees.




**Slide 61. Time and Distance**

Factors to consider:

- What are the time factors?
  - During a no notice event, there is no pre-evacuation protective measure; everything will happen on the back end. For example, a sudden chemical release might be discovered by initial responders generating an evacuation order.
  - The more notice, the more opportunities for actions such as pre-impact evacuation.
- How much time will people have to make a decision and initiate their evacuation? How much time will they have to evacuate? How much time will they need to evacuate?
- How large is the potential impact area? How big will your evacuation area(s) be, how many people does it include, and how far will they have to go?

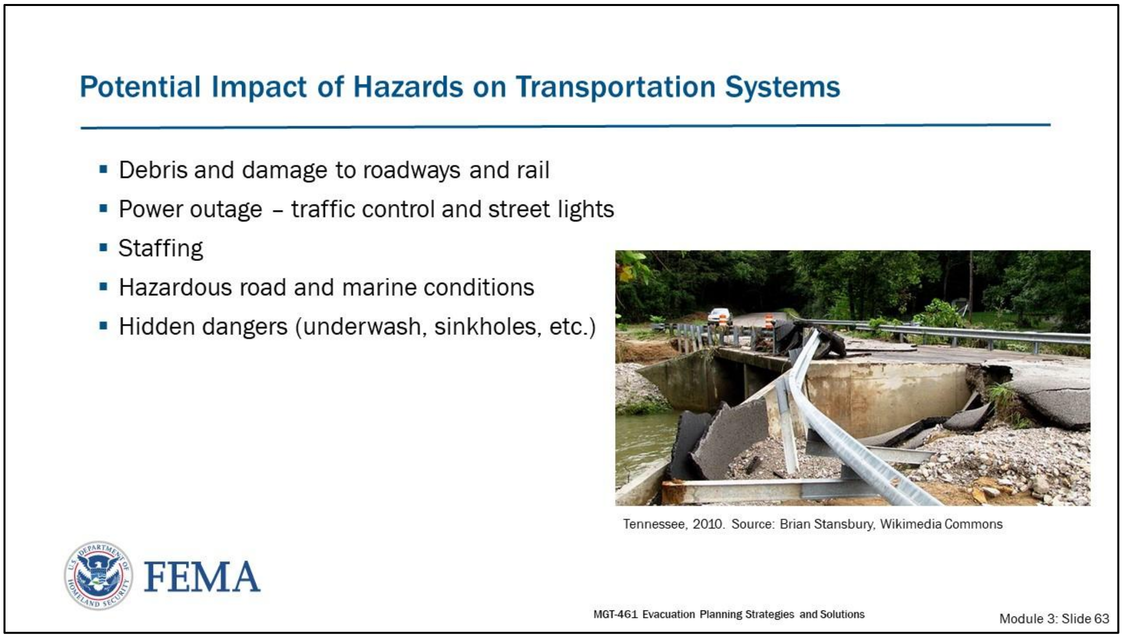



**Slide 62. Potential Effects of Issuing Evacuation Order**

When considering issuing evacuation orders, potential evacuation effects must be carefully explored.

Factors to consider:

- What is the impact to local businesses, those at the destination, and those along the way? What are the available goods and services?
- What is the impact on public services and infrastructure?
- Communication systems will be extremely busy and may be degraded by the incident. How will you deal with this?
- Upstream issues can pose additional complications. Where will everyone go? Where will they find housing and shelter? How far will they have to go? Will there be enough food and water available at the destinations?
- How will you provide security in the evacuated area and along the route? If outside of your jurisdiction, who is responsible for providing it at the destination?
- In addition to considering evacuation effects, consider effects of *not* directing evacuation.




**Slide 63. Potential Impact of Hazards on Transportation Systems**

Other impacts to consider are the conditions into which you are sending people:

- What are road (and rail) conditions like with respect to damage, debris, standing or moving water? How is visibility and how is that likely to change?
- Are street lights, powered signs, and traffic signals working? How will you maintain traffic control during a power outage?
- What are your staffing needs vs. Availability? How will you keep your people safe?

There are many safety considerations; evacuating can be more dangerous than sheltering-in-place, even with the threat of a serious hazard looming. Weather (rain, snow, wind, extreme heat or cold) and wildfire smoke create hazards of their own. Cars can overheat, get stuck, or run out of fuel, leaving their occupants at the mercy of their surroundings. People can experience medical emergencies on the road and may not be able to provide an accurate location or may be difficult for response personnel to locate or reach. Secondary effects of hazards, and provision of emergency services along evacuation routes, *always* should be considered in evacuation planning.


**Slide 64. Reentry Considerations**

Although post-evacuation reentries do not involve the same life-or-death urgency as evacuations, they can generate enormous demand over a short time, resulting in traffic congestion, delayed access, and frustration. Reentry can put returning evacuees at risk if roads and other highway infrastructure are not sufficiently cleared, repaired, and free from flooding or other dangers. If services have not been fully restored, premature reentry could place many people at risk. Because of these issues and the need to maintain security in evacuated areas, it is common to regulate initial reentry. Such measures are necessary to provide for the safety of returning evacuees and to maintain security for exposed properties and possessions.

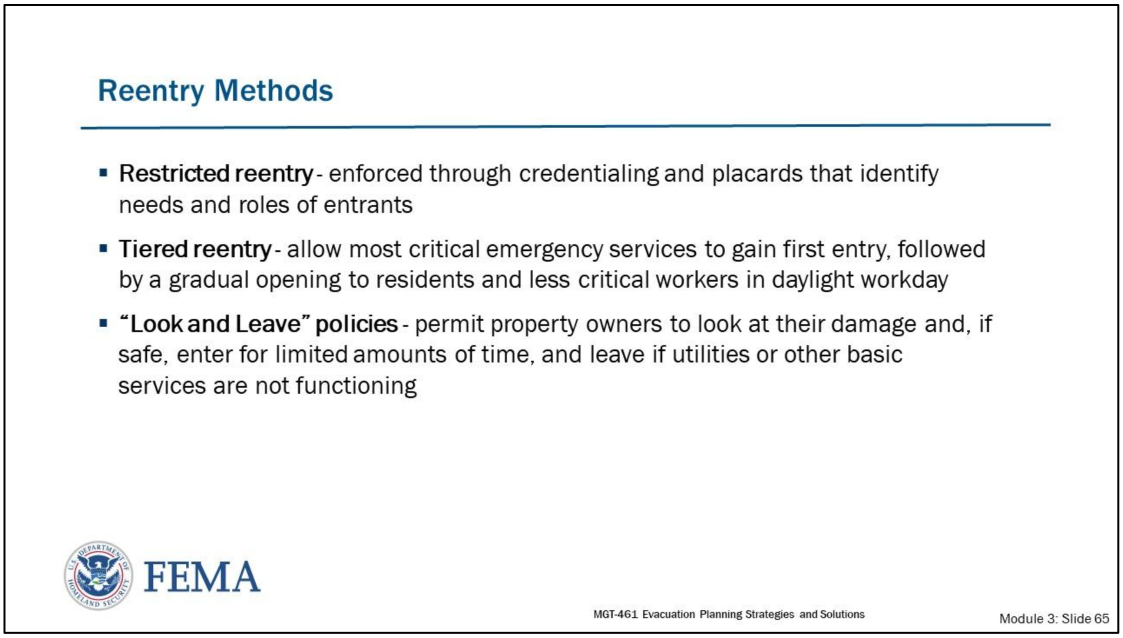
**Reentry planning should be part of evacuation planning; it should be in place before evacuees return.** Your evacuation plan should address:

- What makes it safe to return? Who decides this?
- Who determines when and how to return?

In most communities, reentry decisions are up to local officials. Some questions to consider:

- What are reentry advantages, disadvantages, and pitfalls?
- What happens if you start reentry too soon?
- What if you wait too long?
- How do you deal with those that do not have ID?
- Who assists with reentry (e.g., law enforcement, public health, fire, utilities)?

Another reentry challenge is potentially needing to support large-scale return of assisted evacuees to their original locations. In addition to putting returning evacuees at risk, delayed or unsupported reentry damages trust and can delay recovery.




**Slide 65. Reentry Methods**

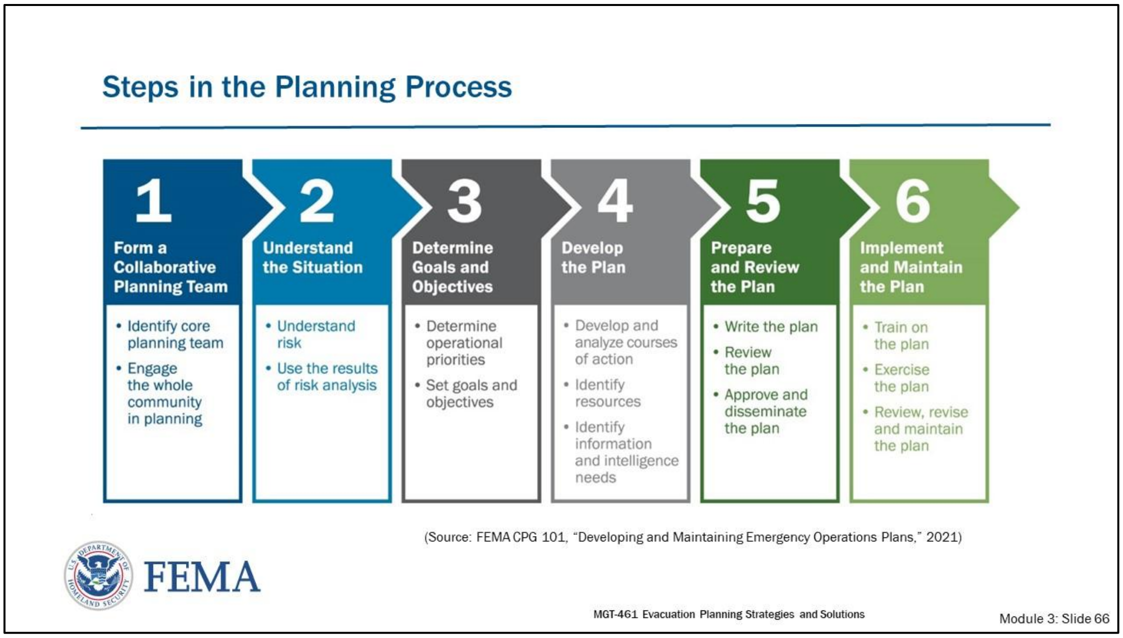
There are three main methods of reentry:

- Restricted – certain groups or people are allowed in;
- Tiered – gradual reentry with most urgent needs first; and
- Look and Leave – for everyone who can come and go but not stay.

One way that restrictions can be maintained and enforced is achieved through credentialing and placard programs that identify entering residents and response personnel and certify the validity of their purpose.

Another is achieved by tiered reentry processes in which the most critically needed emergency services and personnel gain first entry. This is then followed by a gradual opening of areas to residents and less critical workers. A third way to maintain and enforce restrictions is to establish "Look and Leave" policies that permit property owners to look at their damage and, if safe, enter for limited amounts of time, but that require them to leave if utilities or other basic services are not functioning.

Unmanned Aircraft Systems (UAS, aka "drones") may be useful in place of look and leave, allowing occupants to perform exterior assessment of their property/residence/business via direct video feed.

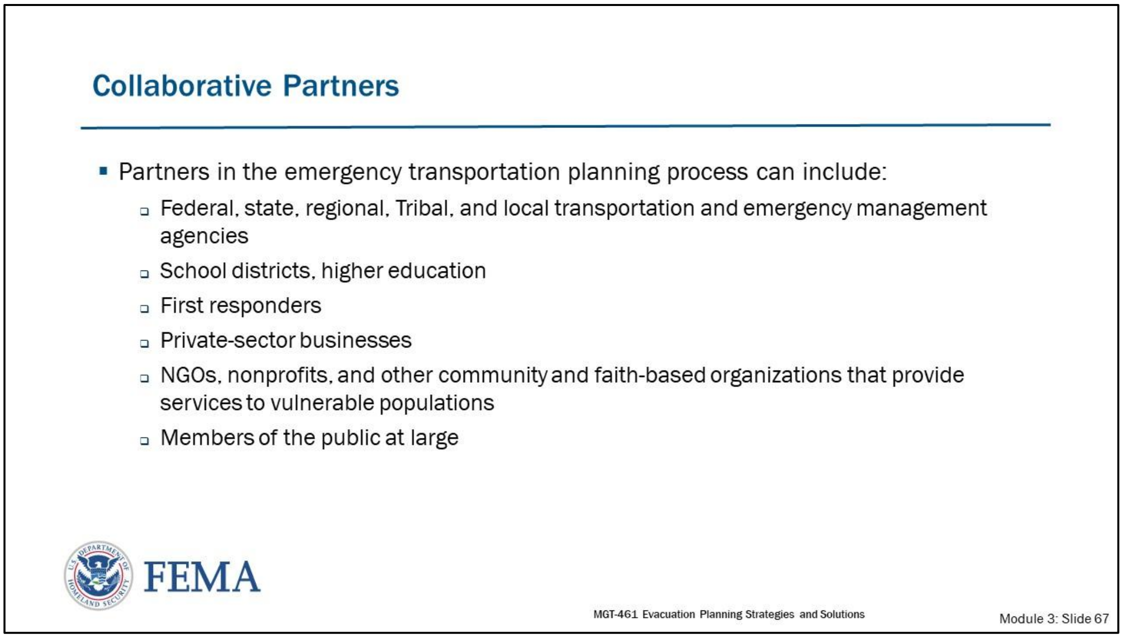



**Slide 66. Steps in the Planning Process**

This is a detailed version of the steps in the planning process. This chart is included in your student handout for better viewing and comes from FEMA's Comprehensive Preparedness Guide (CPG) 101. We will go over the steps as an overview to the planning process, but much more detail on each step can be found in the FEMA CPG 101 and the NCHRP-740 Report.

- Step 1 is to Form a Collaborative Planning Team. This entails engaging the right people and oganizations for emergency evacuation planning. It is important to identify a core planning team who is responsible for decision-making. It is equally important to make this a genuine whole-community procss, including members from the full spectrum of organizations and entities involved in evacuation planning and support.
- Step 2 is to Understand the Situation. What are your hazards and threats? This can be determined through risk assessments and vulnerability analysis. This is dicussed in detail in the awareness class prior to this management level course. You can get a copy of your jurisdiction's THIRA (or other HVA) or conduct one yourself. The basics of conducting a THIRA include identifying the risks that could affect your community, determining their potential impact, and how to address the capability needs to react to the threats and hazards.
- Step 3 is to Determine Goals and Objectives. This includes deciding on possible strategies. Evacuation may not always be the best strategy for every situation.
- Step 4 is Plan Development. The plan can then be developed based on outcomes from the previous steps.
- Step 5 is Plan Preparation Review and Approval. This includes writing the plan, reviewing it, revising it, and finalizing the plan.
- Step 6 is Plan Implementation and Maintenance. This includes exercising the plan, reviewing it on a reguar schedule, and revising the plan as needed.

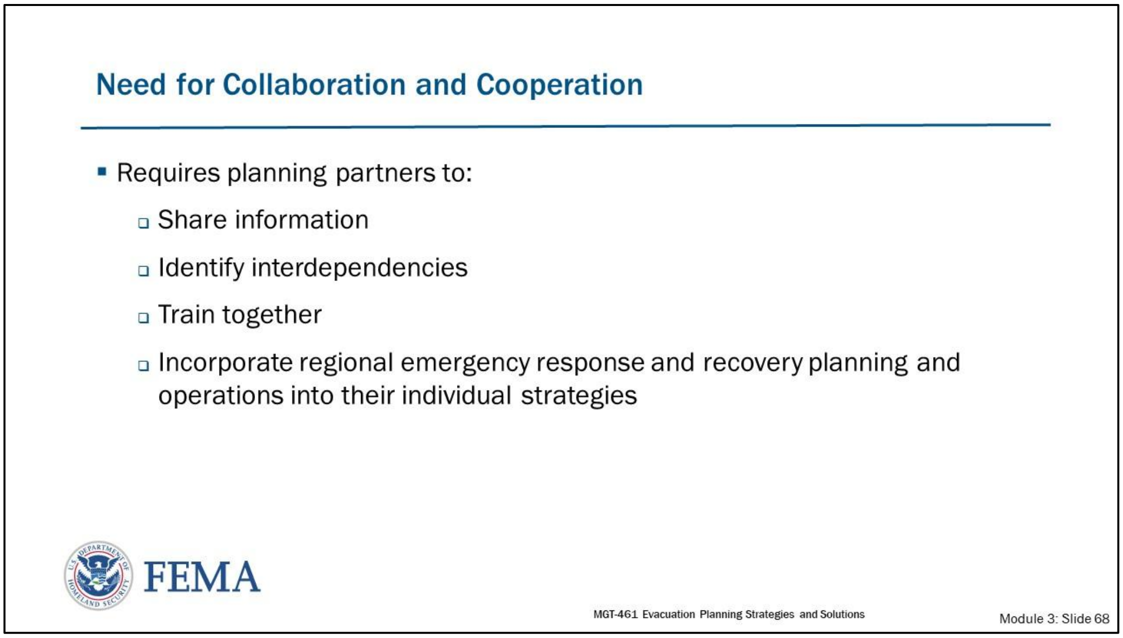
**Key Point:** It is important to maintain communication and collaboration throughout the planning process, in order to ensure key stakeholders and members from the whole community are present.




**Slide 67. Collaborative Partners**

Step 1 in the planning process is Forming a Collaborative Planning Team. It should start with a multi-disciplinary, multi-jurisdictional core planning team that will organize and execute evacuation operations, from pre-incident through reentry. This team should include emergency management agencies; law enforcement, fire, and emergency medical personnel; state and local transportation agencies; public information specialists; public transit representatives; mass care specialists; public health services organizations; political decision-makers; and others as appropriate. Team members may be from public, private, or volunteer sectors. Partners in the emergency transportation planning process can include:

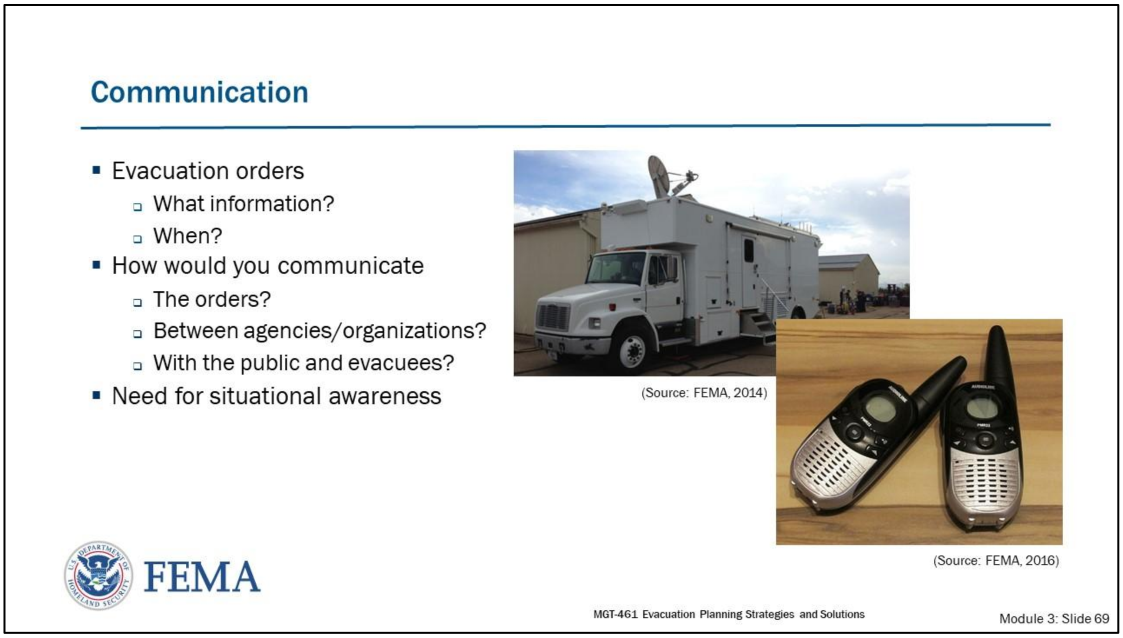
- Federal, state, regional, tribal, and local agencies
- School districts
- Private-sector businesses
- NGOs, nonprofits, and other community and faith-based organizations that provide services to vulnerable populations
- Members of the general public




**Slide 68. Need for Collaboration and Cooperation**

Collaboration and cooperation depend on building relationships, and the communication needed to establish and sustain those relationships range from less formal communication to more formal and interdependent communication (as might be seen with intergovernmental relationships). Successful cooperative planning relationships often develop from ongoing collaboration that incorporates the full range from informal to formal communication.

Collaboration builds partnerships among various transportation modes and systems, utilities, public and private stakeholders, layers of governments within the region, and interdependent internal and external communications systems. It requires planning partners to share information, identify interdependencies, train together, and incorporate regional emergency response, and recovery planning and operations into their individual strategies.



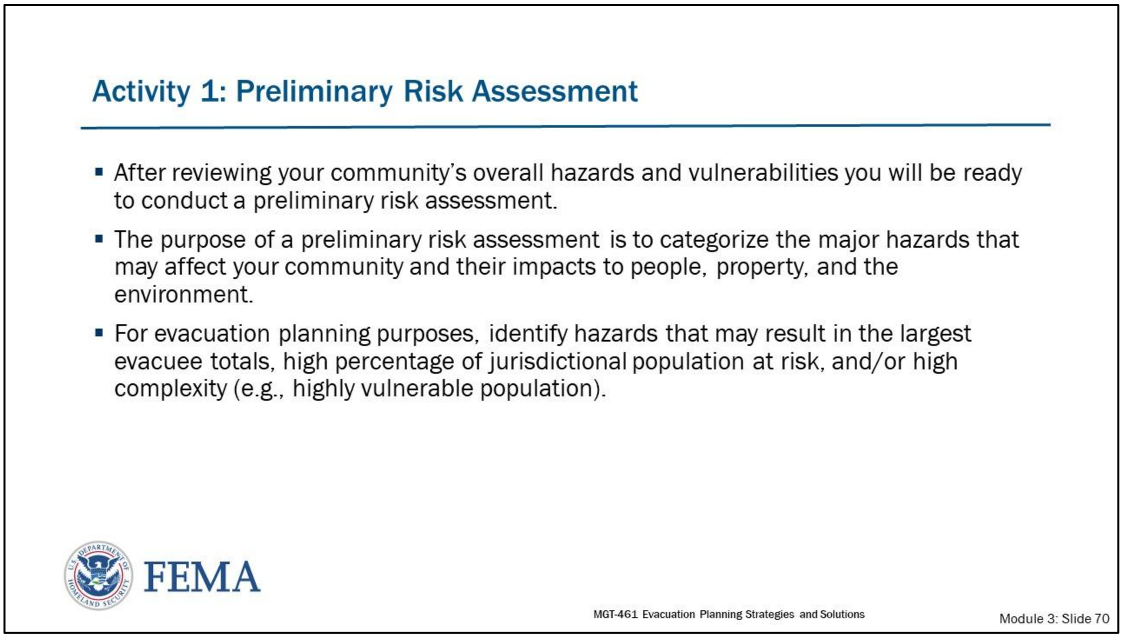

**Slide 69. Communication**

During both evacuation and reentry, communication with the community becomes especially critical. Emergency communications may include alerts and warnings; directives about evacuation, curfews, and other self-protective actions; and information about response status, family members, available assistance, and other matters that impact response and recovery.

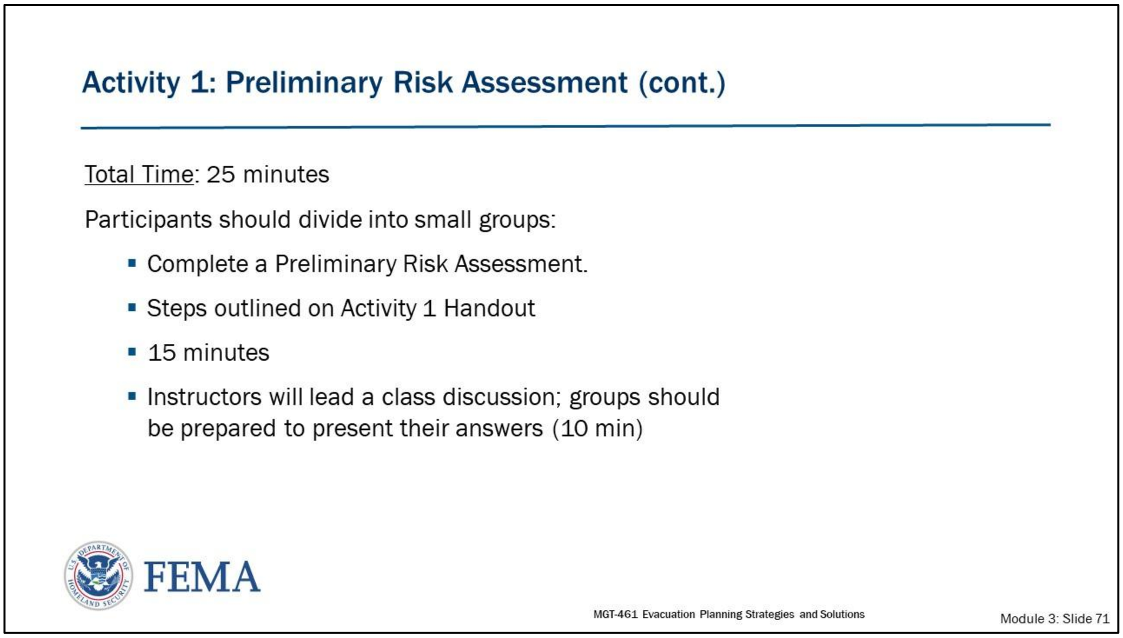
Well-conceived and effectively delivered messages can help ensure public safety, protect property, facilitate orderly evacuation, and reentry.

The extent to which people respond to a message is influenced by many factors, including individual characteristics and perceptions. Factors that have impact in evacuation communication are:

- What evacuation orders will you give? Voluntary/mandatory? What information will you include in the orders?
- How early do you start your evacuation orders? Whom do you start with? How do you direct them?
- How will you disseminate the orders?
- How and what will you communicate between agencies and organizations?
- How do you ensure everyone receives and understands the order? Consider incident-related effects, e.g., power outages, infrastructure damage (as detailed in Slide 63). What are your alternatives?

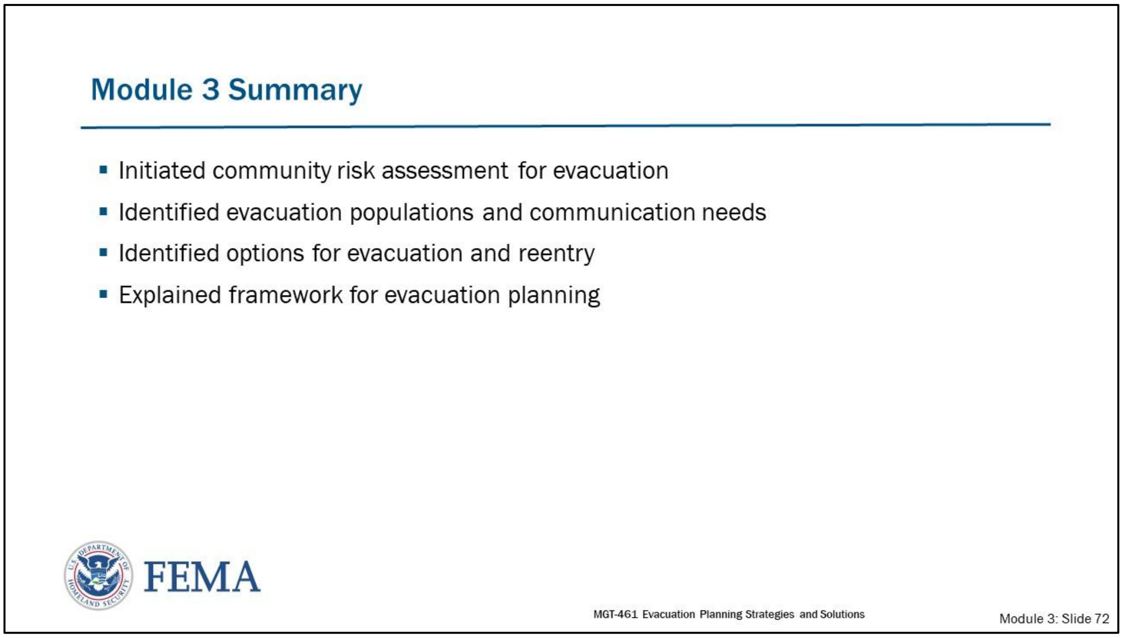



**Slide 70. Activity 1: Preliminary Risk Assessment**




**Slide 71. Activity 1: Preliminary Risk Assessment (cont.)**

# Module 3 Summary




**Slide 72. Module 3 Summary**

In this module, participants:

- Initiated community risk assessment for evacuation
- Identified evacuation populations and communication needs
- Identified options for evacuation and reentry
- Explained framework for evacuation planning

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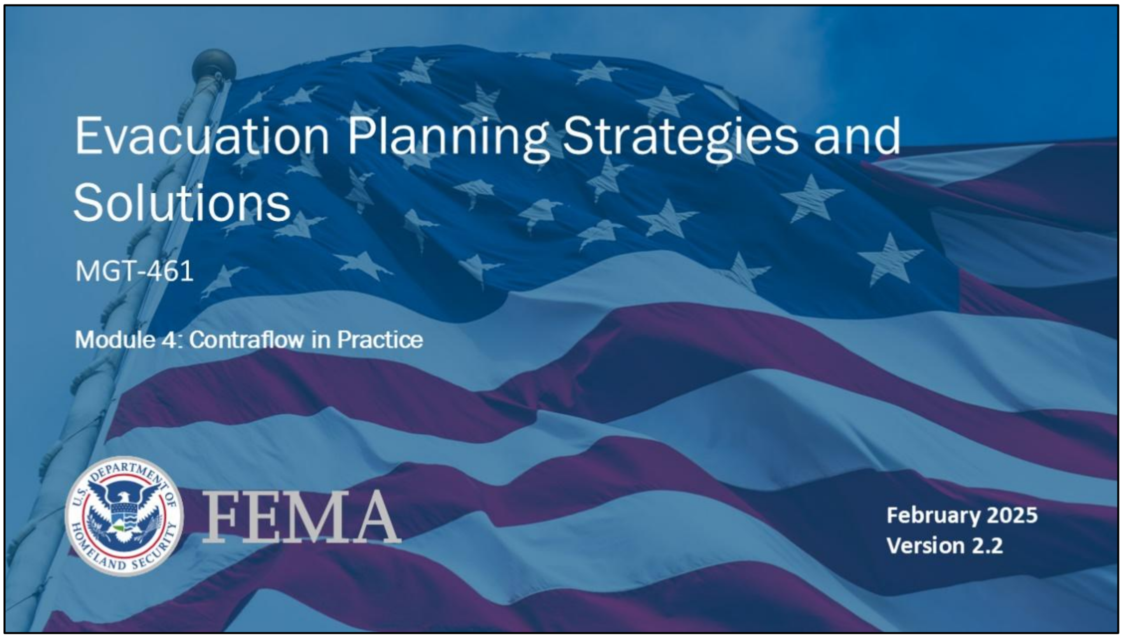
# Module 4

# Contraflow in Practice

# Module 4 Administration




**Slide 73. Module 4: Contraflow in Practice**

## Duration

60 minutes

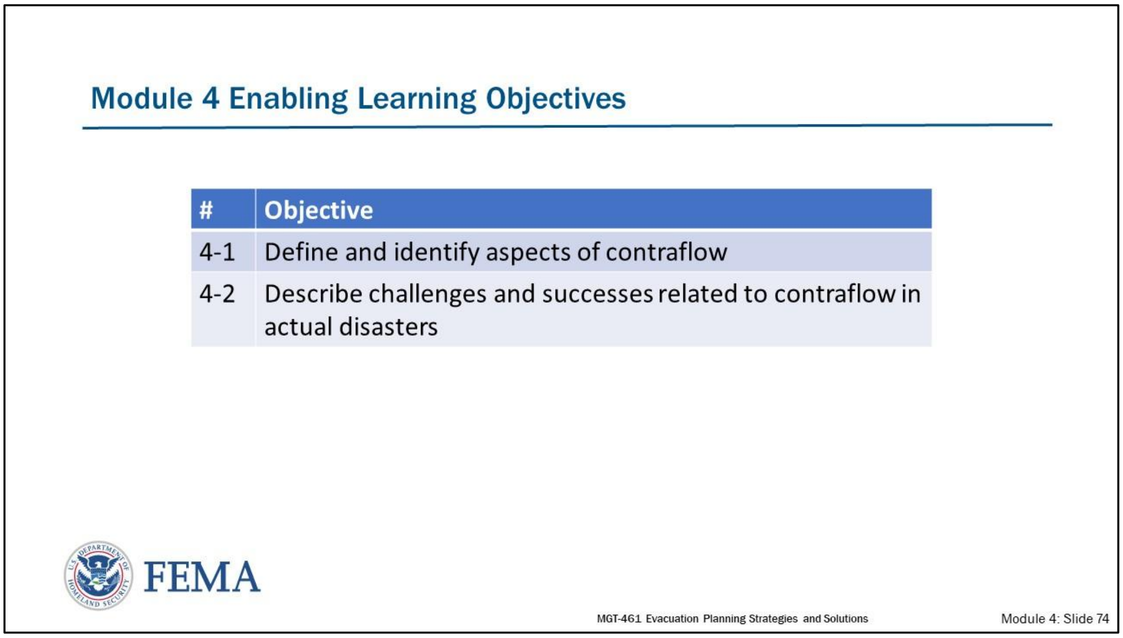
## Scope Statement

In this module, the instructor will discuss principles and examples of contraflow and city-assisted strategies for large-scale evacuations. Key topics include city-assisted evacuation examples, considerations in designing contraflow systems, deciding to implement them, and assessing them during and after the event. The instructor will provide two examples of contraflow use and assessment in real incidents.

## Terminal Learning Objective

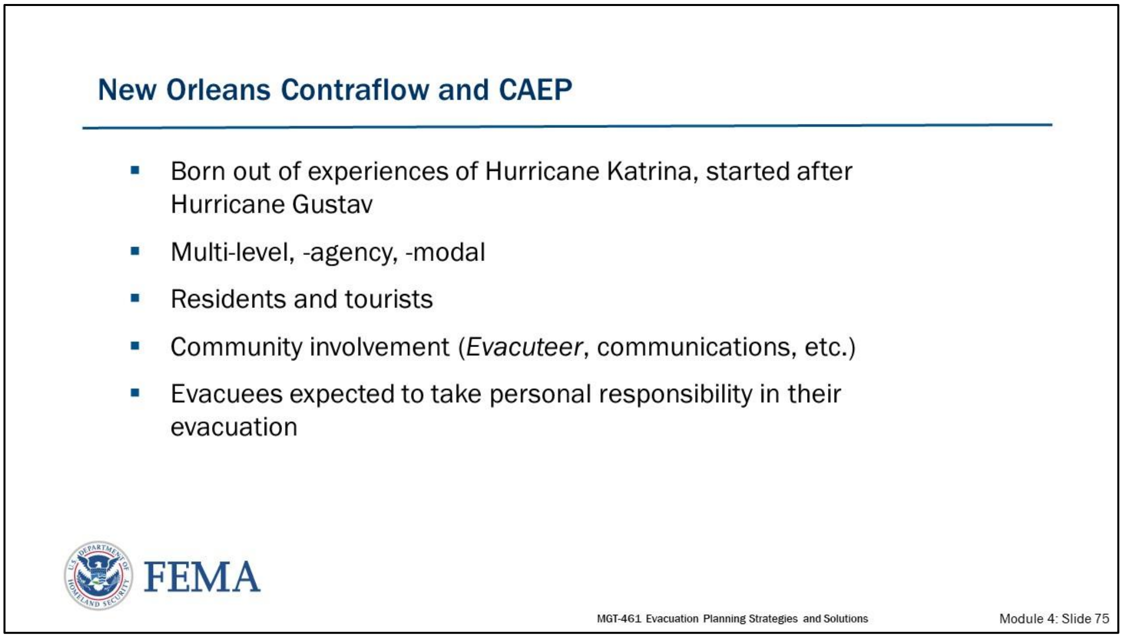
Participants will be able to describe key considerations and examples related to using contraflow in evacuations.

## Module 4 Content




In this module, participants will:

- Define and identify aspects of contraflow; and
- Describe challenges and successes related to contraflow in actual disasters.

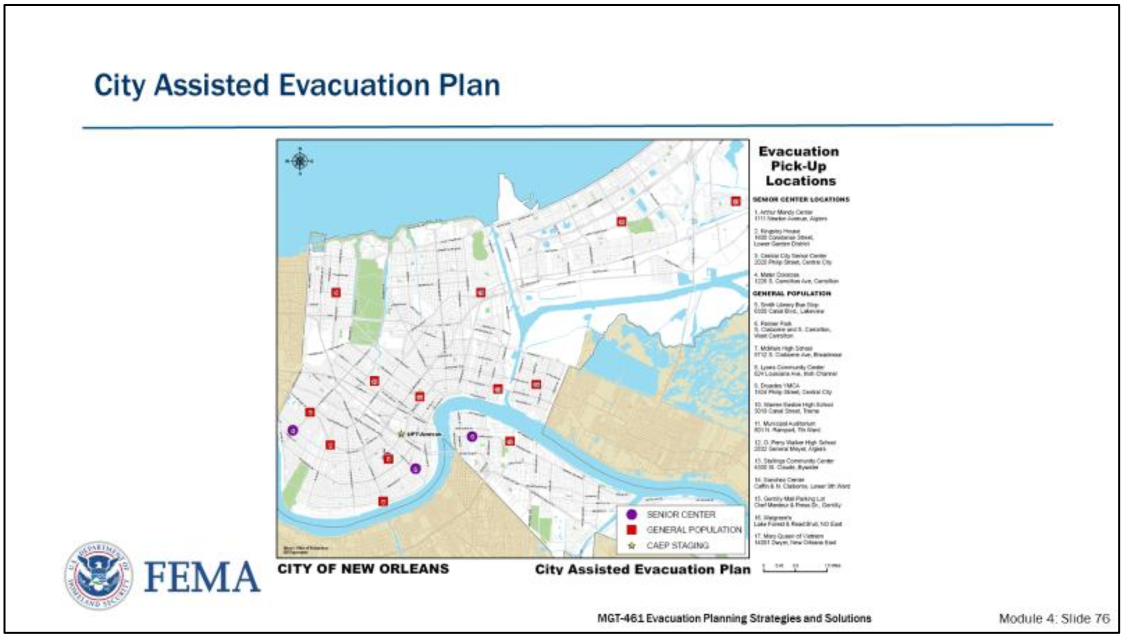



**Slide 75. New Orleans Contraflow and CAEP**

The section discusses some of the evacuation plans developed using the evacuation simulations and models (described in Module 2) as well as lessons from previous incidents.

CAEP is the City Assisted Evacuation Plan in New Orleans, Louisiana, intended to assist carless evacuees.

These strategies in New Orleans were born out of the experiences of evacuation and difficulties with evacuation during Hurricane Katrina (2005); CAEP was started after Hurricane Gustav (2008).



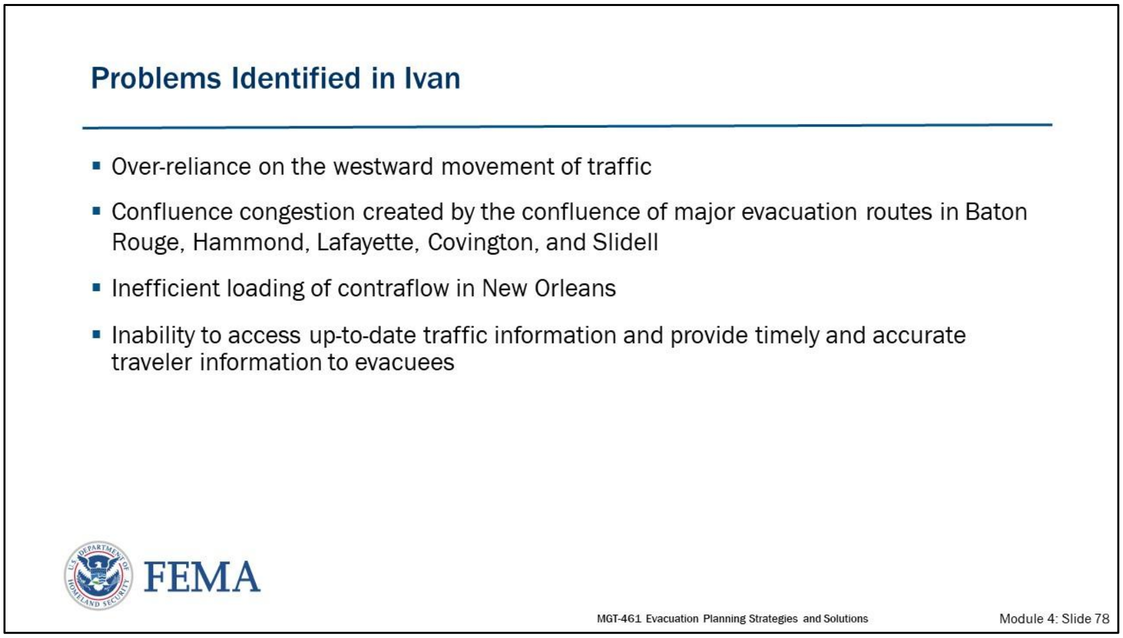

**Slide 76. City Assisted Evacuation Plan**

The New Orleans City Assisted Evacuation Plan (CAEP) and the 2007 Jefferson Parish Publicly Assisted Evacuation Plan are/were used by local authorities for the evacuation of carless residents within these areas. The CAEP for the City of New Orleans estimates that 20,000 people would use public transportation services during an evacuation of the area. Seventy percent of this total (14,000 people) would be expected to evacuate through the New Orleans Arena (NOA) on buses provided by the State of Louisiana. The remaining 6,000, assumed to be senior evacuees, would be evacuated by Amtrak at the Union Passenger Terminal (UPT). To reach the NOA or UPT, residents would need to first go to one of 17 pick-up locations dispersed at various strategic points around the area. Of the 17 locations, four are Senior Center Pick up Locations (SCPLs) and the other 13 are General Public Pick up Locations (GPPLs).

The CAEP has estimated that at any given time the tourist population of New Orleans ranges from 5,000 to 50,000 people, depending on what events are occurring at the time. Assuming a large percentage of the tourist population could self-evacuate using personal vehicles or rental cars, ~20% of them could need evacuation assistance. For modeling purposes, it was assumed that no more than 10,000 tourists would need evacuation assistance. The CAEP also states that tourists would be processed at one of two hotel staging centers (HSCs), although locations of the HSCs would not be announced until 84 to 60 hours before the projected arrival of tropical storm force winds and Regional Transit Authority (RTA) would not begin airport runs until H58. For the purpose of the current study, it was assumed that all assisted tourist evacuees would be processed in the French Quarter area, the main tourist hub of the city. These tourists would then be transported to the New Orleans International Airport where they would be flown out of the region. Also, it was assumed that RTA would begin airport runs at H54 instead of H58 to be able to evacuate all tourists before the airport shuts down.


**Slide 77. Evacuspot Sculpture (French Quarter)**

In addition to the formal governmental plans, various voluntary and civic groups have been created to provide support for assisted evacuations. An example of one of these in New Orleans is *Evacuteer*. Evacuteer.org is a non-profit organization that works closely with the City of New Orleans; it annually recruits, trains, and manages 500 evacuation volunteers (Evacuteers) to assist in the City's assisted evacuation plan. Their goal is to support the estimated 35,000 New Orleanians without the ability or a safe option to evacuate. Evacuteers work at the 17 neighborhood pick-up points, the Union Passenger Terminal, and at City Hall to assist with 3-1-1 hotline. The pick-up locations, known as Evacuspots, are marked by 14-foot stainless steel statues, shown in the slide. Designed by a local artist, these statues were funded by FEMA, the Arts Council of New Orleans, and the New Orleans Office of Homeland Security and Emergency Preparedness.




**Slide 78. Problems Identified in Ivan**

Although the storm track ultimately negated the need for evacuation in Louisiana, Ivan was valuable for illuminating the weaknesses in the existing south Louisiana evacuation plan. Before the 2004 season, evacuees were urged to leave as early as possible and move to areas of safety; however, there were few plans to proactively manage the movement of traffic on a regional level. The only plans in place were freeway contraflow operations over ~20 miles of I-10 in the New Orleans area. The I-10 contraflow plan was developed in 2000, in the wake of Hurricane George in 1998 and the increased acceptance of contraflow in other states following Hurricane Floyd in 1999.

While some officials touted the Ivan evacuation as a success for New Orleans, that was largely a matter of perspective. Quantitative and qualitative evidence clearly demonstrated that volume and speed of westbound evacuation traffic out of the metropolitan New Orleans area increased significantly soon after contraflow operations were initiated. Emergency management officials also were quick to indicate that everyone who wanted to evacuate was able to do so before projected storm landfall. The number of people who “wanted or were able” to evacuate, however, was affected by the turn of Hurricane Ivan that spared Louisiana. Still, cross-state travelers on I-12 and evacuees heading north and west from the New Orleans area were severely affected by congestion and delay. Some out-of-state evacuees reported travel times near 24 hours for the 250-mile trip across Louisiana. Trips that spanned the 80 miles from New Orleans to Baton Rouge in some cases exceeded hours during some periods during the evacuation.

After completing a review of traffic volume and speed data collected on routes throughout the region, traffic video, media accounts, and interviews of evacuees, four primary issues were identified by the Task Force, including:

- Overreliance on westward traffic movement;
- Inefficient loading of the contraflow freeway segment out of New Orleans;

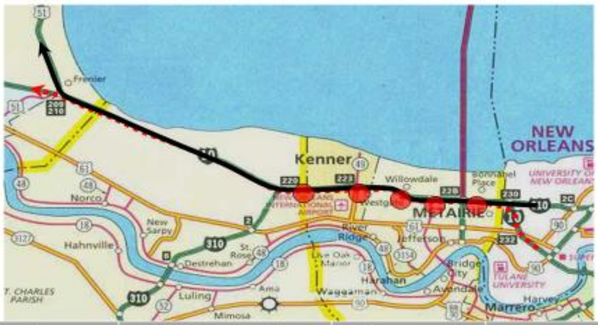
- Extreme congestion resulting from confluence of multiple regional evacuation routes in Baton Rouge, Hammond, Lafayette, Covington, and Slidell; and
- Inability to access real-time traffic information and communicate timely and accurate travel information to evacuees.


**Slide 79. Hurricane Ivan Evacuation – Interstate 10 (west of New Orleans)**

Due to several possible causes, contraflow initiation resulted in a bottleneck that effectively controlled capacity of the entire segment downstream of that point. Traffic conditions downstream of the initiation point were nearly free flowing, while traffic upstream of the crossover was moving at a crawl, as shown in photos. These conditions also meant that neither normal nor contraflow lanes were fully used.

Contraflow entry points with inadequate inflow transitions result in traffic congestion and delay before the contraflow segment and prohibit the segment from carrying capacity-level demand. This was illustrated by I-10 contraflow segment in New Orleans during the Ivan evacuation. Evacuating traffic vehicles in the left and center outbound lanes of I-10 were transitioned across the median and into the contraflow lanes using paved crossover. However, the combination of the crossover design, temporary traffic control devices, the presence of enforcement personnel, and weaving vehicles, created a flow bottleneck that restricted inflow into the contraflow lanes. This caused two problems: it limited the number of vehicles that could enter contraflow lanes, limiting flow beyond the entry point significantly below its capability; and it caused traffic queues upstream of the crossover that extended back for more than 14 miles. This plan was significantly improved before the Katrina evacuation one year later by permitting vehicles to enter contraflow lanes at multiple points, spatially spreading demand over a longer distance and reducing length and duration of the congested conditions. Inadequate designs at the downstream end of contraflow segments can also greatly limit its effectiveness.

## Contraflow Benefits and Alternatives




(Source: B. Wolshon, et al., JTE, 2006)

| Scenario | 12h Volume at max. flow | Evacuees moved | Increase over no c/f |
|---|---|---|---|
| Ivan w/o contraflow | 49,464 vehicles | 123,660 people | --------- |
| Ivan w/ contraflow | 67,224 vehicles | 168,060 people | 35.9% |
| I-10/I-610 Loading Plan | 97,572 vehicles | 243,930 people | 97.3% |

FEMA

MGT-461 Evacuation Planning Strategies and Solutions

Module 4: Slide 80

**Slide 80. Contraflow Benefits and Alternatives**

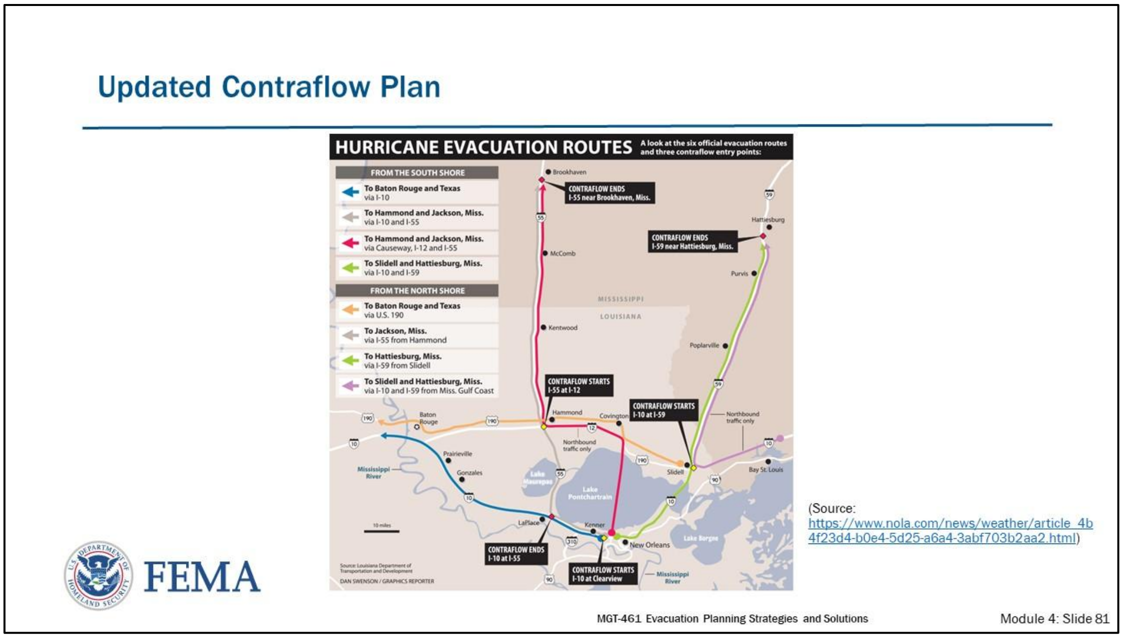
The Ivan evacuation confirmed a prior research study that identified the shortcomings of the I-10 contraflow loading. Clearly, the effect of the control presence at the crossover restricted volumes through this area. Traffic modeling was used to identify a method that would allow full utilization of the contraflow lanes without limiting capacity of normal side lanes or vice versa.

The original approach placed the first contraflow loading point further upstream, ahead of the I-10/I-610 interchange, with two additional contraflow loading points in Jefferson Parish. This configuration would prevent normal outbound and contraflow traffic streams from merging. Under this plan, evacuees in Orleans Parish traffic could choose their evacuation route by entering either I-610 or I-10. I-610 would lead to Hammond via I-55, and I-10 would be transitioned into contraflow lanes and continue toward Baton Rouge. In Jefferson Parish, normal entrance ramps along I-10 would provide access to I-55 toward Hammond, and additional contraflow loading points would be provided for access to I-10 toward Baton Rouge. These additional loading points would provide direct access by using existing exit ramps as on-ramps.

Overall, this configuration was expected to accomplish several objectives. First and foremost, it would spatially spread demand loading. It also would give evacuees flexibility in their routing choices but would place those decision points on the surface street system instead of the interstate system, where maximizing capacity was a necessity. This plan was thought to be ideal from an efficiency standpoint, for its ability to balance traffic on the separate sides of the freeway, for eliminating a major merge point, for removing the decision point (capacity restraint) from the interstate, and for providing access to evacuees from both parishes to both evacuation routes (I-10 and I-55). Another significant advantage is that it would permit spatial spreading of demand into the freeway lanes. Rather than loading traffic into the system at a single point, entering traffic demand would be spread over six downstream interchanges. The anticipated benefits of this plan were clearly supported by the results of traffic simulation modeling.

Ultimately, a multi-lane crossover prior to I-10/I-610 was rejected. Disagreement over constructability, cost, and time required to build the crossover eliminated it from consideration.

However, knowledge gained from the traffic modeling was applied, leading to a plan using three interchanges and a single-lane crossover. Simulation modeling showed that outflow volumes were only ~15% lower than that for the original concept. Final access points (interchanges) were selected based on input from Louisiana State Police (LSP) and Louisiana Department of Transportation and Development (LADTD), considering other factors such as interchange configurations, construction requirements, emergency access, and population distribution.




**Slide 81. Updated Contraflow Plan**

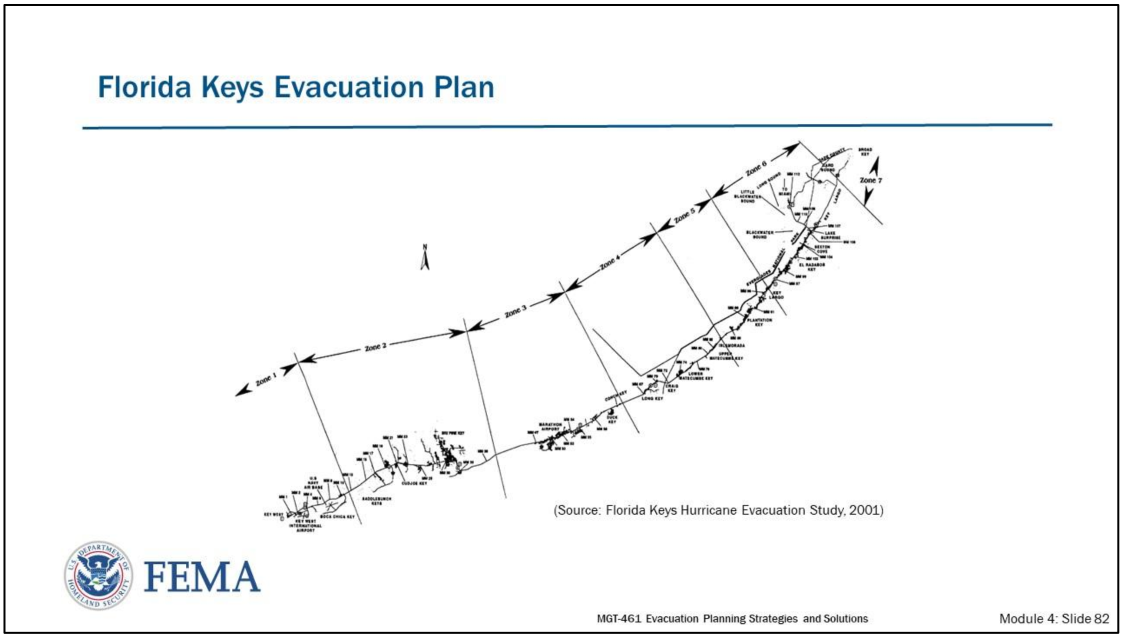
The updated plan, schematically represented in the figure, sought to move traffic north instead of just west, away from vulnerable coastal areas. Although a significant departure from historical behavior, the northern inland movement of evacuees is a logical and safe recommendation. It aimed to move people away from the immediate threat zones of the coast and into inland areas where the impact of the storm would be attenuated during its inevitable decay overland.

The plan also attempted to eliminate converging traffic streams by using parallel routes and contraflow operations. Rather than rearrange directional traffic patterns in Baton Rouge, the Katrina plan, to the greatest extent possible, restricted movement of traffic on westbound I-12 into the capital area. To eliminate I-12 westbound traffic, the final plan had a much higher reliance on contraflow operations on northbound I-55 and I-59, which required the contraflow segments used in Katrina to stretch well into Mississippi.

The vehicles that comprised I-12 westbound evacuation traffic during Ivan came from four sources: I-55 northbound from the normal side lanes of New Orleans I-10; the Causeway Bridge across Lake Pontchartrain; I-10 eastbound across the twin spans of Lake Pontchartrain; and I-10 westbound traffic from Mississippi, Alabama, and Florida. To accommodate this traffic, all movements were directed north onto I-55 or I-59. From east to west, this traffic was handled by directing all I-10 westbound traffic entering Louisiana north on I-55 in normal northbound lanes.

To avoid merging traffic streams at this location, the outbound vehicles from New Orleans on I-10 eastbound crossed to normally southbound I-59 lanes. The traffic that crossed Lake Pontchartrain on the Causeway Bridge was sent on I-12 westbound to I-55 northbound. To avoid merging traffic on I-55, I-55 northbound traffic from New Orleans crossed to normally southbound I-55 lanes. This resulted in seven of the nine lanes exiting New Orleans from the east bank of the Mississippi River being forced to travel north instead of west. For those evacuees that still desired westward evacuation, alternate east-west routes such as US-190 were suggested. This also was intended to simplify routes and thus minimize evacuees' confusion, better use available infrastructure – particularly historically underutilized noninterstate routes such as US-190 and the Lake Pontchartrain Causeway bridge; and spread New Orleans evacuees into three directions instead of one or two.

Another key aspect was to “phase” the evacuation as much as possible. Many of the most vulnerable regions in Louisiana are coastal and marsh areas south of New Orleans. It was recognized that evacuees from these areas would need to come through the New Orleans area to reach safe destinations. To the extent possible, emergency management officials in south Louisiana were advised to call for evacuations in the most vulnerable areas first to allow these people to pass through the most highly populated regions before traffic volume and congestion began to build, to avoid “trapping” them in the most threatened areas. Overall effects on evacuation were unclear, but it’s worth reinforcing the concept of evacuees having a destination in mind before getting on the road.



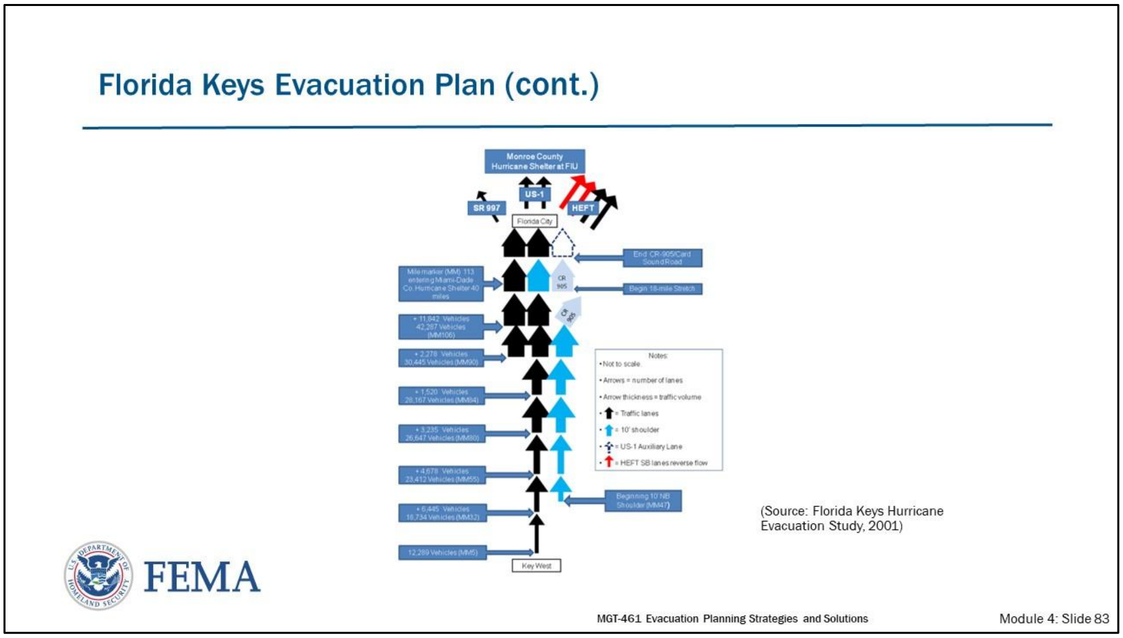

**Slide 82. Florida Keys Evacuation Plan**

Modeling work led by the Florida Department of Transportation (FDOT) used traffic simulation to assess potential traffic conditions associated with an evacuation of the Florida Keys. This analysis was unique because of the unique nature of the Florida Keys and its conditions that included:

- High risk potential
- Effectively one route out
- Susceptible to traffic and roadway incidents
- Use of contraflow is problematic
- Approximately 80,000 resident and tourist evacuees
- Highest concentration in the Lower Keys
- Long travel distance
- Potential effects of “mainland” traffic
- Designated as a Florida “Area of Critical State Concern”
  - Unique nature and value makes the Keys important to the state as a whole
  - State, rather than local government, has authority over many key civil issues
- Evacuation
  - Must be able to undertake a full evacuation in 24 hours
- Growth and Development
  - New construction is limited by ability to serve water, sewer, evacuation

Because of these constraints, traffic movements could effectively be governed by capacity of a few localized areas (e.g., intersections and ramps) where congestion was likely to occur. Early FDOT analyses showed that traffic flow through a few signalized intersections could significantly affect, if not directly dictate, overall clearance of evacuees over the 100-mile segment of US-1 from Key West to the Florida mainland. Thus, there were advantages to first micro-modeling these locations to assess their flow characteristics, then include those conditions in a separate network-level macro-model. In this effort, a simulation modeling approach was taken that used a combination of separate and individual models at different levels of abstraction.

Another issue was the creation of merge congestion caused by the elimination of additional travel lanes through more populated islands where additional capacity was needed to serve local traffic. However, neither of these conditions could be captured in detail or would be observable using macro-level modeling. Based on this, FDOT was able to apply micro-scale modeling to analyze the influence of localized, facility-specific design features like intersections, then use a macroscopic model to simulate and analyze traffic conditions at high levels over the full length of US-1. This could also be used for micro-level analyses of freeway merge areas and contraflow loading and unloading points, in series with later macro-level analyses.




**Slide 83. Florida Keys Evacuation Plan (Cont.)**

The traffic model used to estimate the clearance time for an evacuation of the Florida Keys was based on assumptions regarding traffic characteristics and conditions during an evacuation. These assumptions were extensively discussed and agreed upon by a multi-interagency, multi-disciplinary Project Steering Committee. This effort was intended to produce a model based on consensus assumptions, so that the outcome and consequent recommendations could be used by stakeholder agencies as the authoritative source for evacuation planning in the Keys.

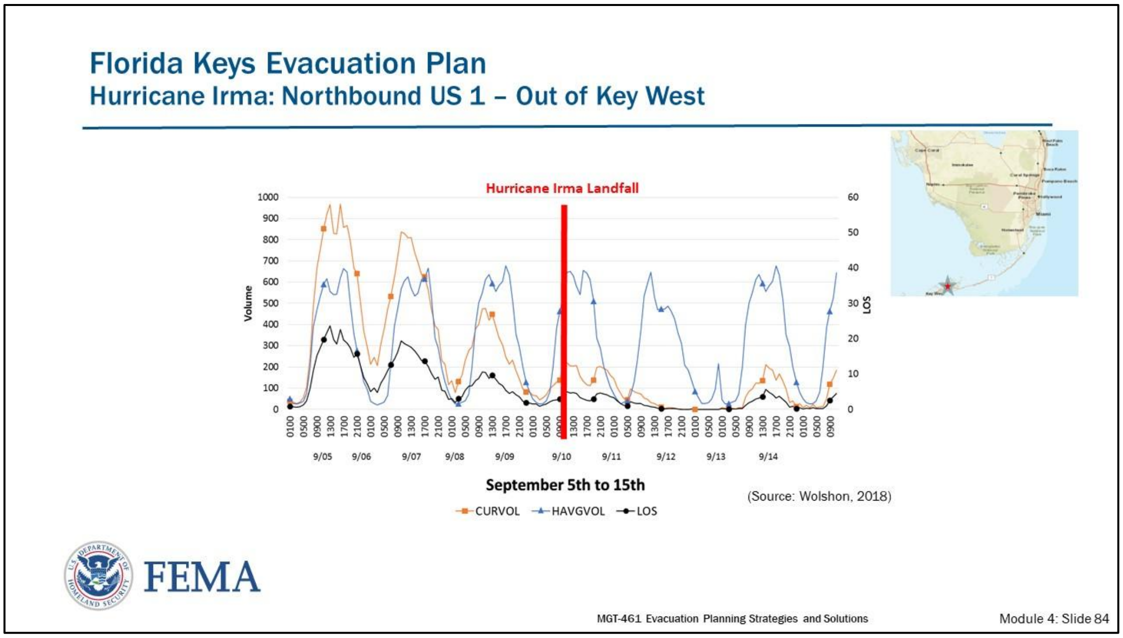
The analysis of the Keys evacuation traffic scenarios was conducted as part of the 2001 Florida Keys Hurricane Evacuation Study (aka "The Miller Model") which used a linear model representation of link flows. In it, the Florida Keys evacuation route was divided into 31 roadway links (Link A1 through Link U) in the Miller Model. The 31 roadway links extend from Mile Marker 2.0 in Key West/Stock Island to the southern terminus of Florida's Turnpike in Florida City (a distance of approximately 125 miles). Each roadway link represents a different cross section on the highway network, including:

- Two-lane undivided (2L) – one through lane in each direction
- Three lanes (3L) – one through lane in each direction with a center turn lane
- Four-lane undivided (4L) – two through lanes in each direction
- Four-lane with a divided median (4LD) – two through lanes in each direction with a raised or depressed median
- Five lanes (5L) – two through lanes in each direction with a center turn lane

The study examined clearance time under numerous scenarios, including existing road configuration and various lane and intersection capacity improvements. Among the findings of this work was that clearance times ranged from 12 to 47 hours, based on amount of population, behavioral response, downstream traffic, etc. The results were all also comparable to the 2001 results and, as such, were used to support state policy.

An important aspect of the Keys evacuation plan was to add road capacity out of the Keys using available infrastructure as evacuation demand was added to US 1 from successive islands as evacuees moved out of the islands. As shown on this slide, outbound road capacity was planned to be gained from existing traffic lanes, existing shoulders, existing auxiliary lanes, and ultimately from other routes – including contra flowing lanes at the far north end of the evacuation route.

The next three slides show the evacuation traffic from September 5 to September 15, 2017, before, during, and after Hurricane Irma.




**Slide 84. Florida Keys Evacuation Plan Hurricane Irma: Northbound US 1 – Out of Key West**

The chart shows northbound traffic at US 1 out of Key West. **The orange curve represents Irma evacuation traffic, blue historical traffic, and purple Level of Service (LOS).**

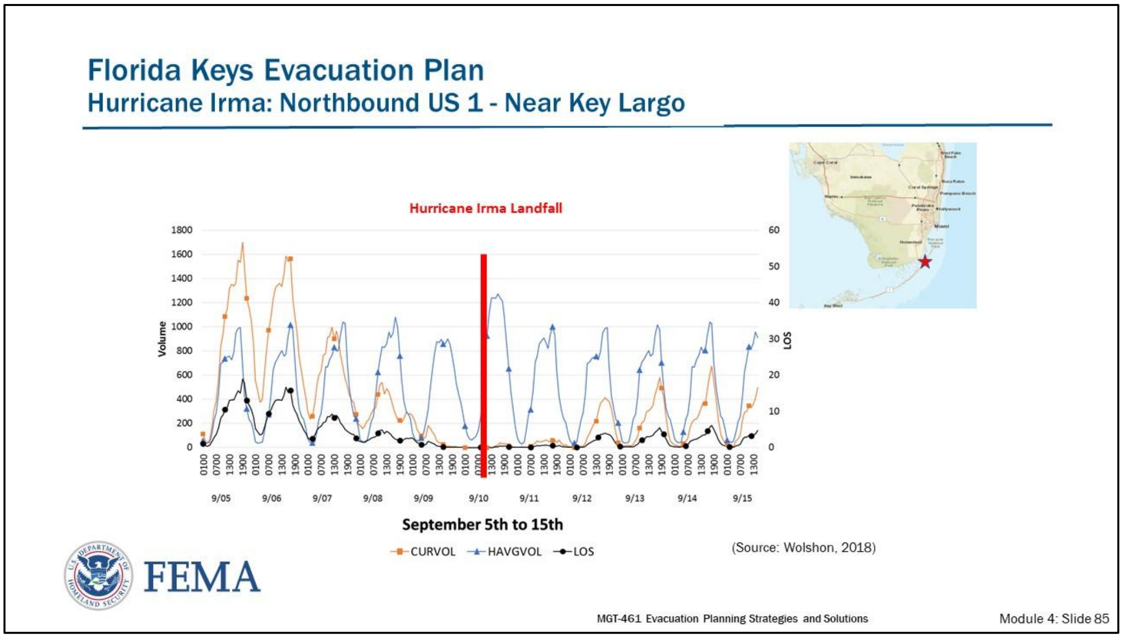
Not surprisingly, the evacuation started earlier than anywhere else in the state. What was somewhat of a surprise was the fact that the evacuation took place well before storm landfall and over several days, rather than the potential "last day" evacuation as theorized in the "bad case" planning assumptions. Volumes were high but relatively "steady" as LOS were in the B/C range during peak of the evacuation, probably because this was a more regulated evacuation.

The LOS analysis shown here has been approximated to give a general idea of congestion as the storm progressed. The data are for locations where evacuation (i.e., outbound) traffic existed. The LOS values in the graph correspond to the general descriptions of passenger cars per mile per lane (pcpmpl) provided below.

- LOS A: 0-11 pcpmpl - High Speeds, Easy to Change Lanes
- LOS B: 11-18 pcpmpl - High Speeds, Changing Lanes is Slightly Inhibited
- LOS C: 18-26 pcpmpl - High Speeds, Changing Lanes is Impacted
- LOS D: 26-35 pcpmpl - Slightly Reduced Speeds, Lane Change is Difficult
- LOS E: 35-45 pcpmpl - Speeds Significantly Reduced, Lane Changing is Difficult
- LOS F: > 45 pcpmpl - Severe Speed Reductions resulting in "gridlock" and "standstill" conditions

For comparison, the LOS line during the evacuation is shown with "average traffic conditions" in the days before the evacuation took place. These lines are meant to give an idea of how congestion at these locations during evacuation was compared with the days preceding the storm. Evacuation volume and historical average volume are used for hourly flows (vehicles per hour) of vehicles passing over the detector. Thus, when LOS was high, there could have been "un-serviced demand" that included queued volumes unable to move due to congestion.

The data represent spot checks throughout the state where FDOT has placed permanent detection sites. These are hourly "averages," showing general daily/weekly/hourly traffic trends, including periods of high density but with traffic that could, overall, be freely flowing for a longer duration and could be assumed to be a "low congestion" period. Traffic certainly won't flow freely all the time throughout a mass evacuation, but the data offer a general sense of what is happening at these locations, including congestion and other problems outside of these locations. The conditions show where such problem spots may exist.

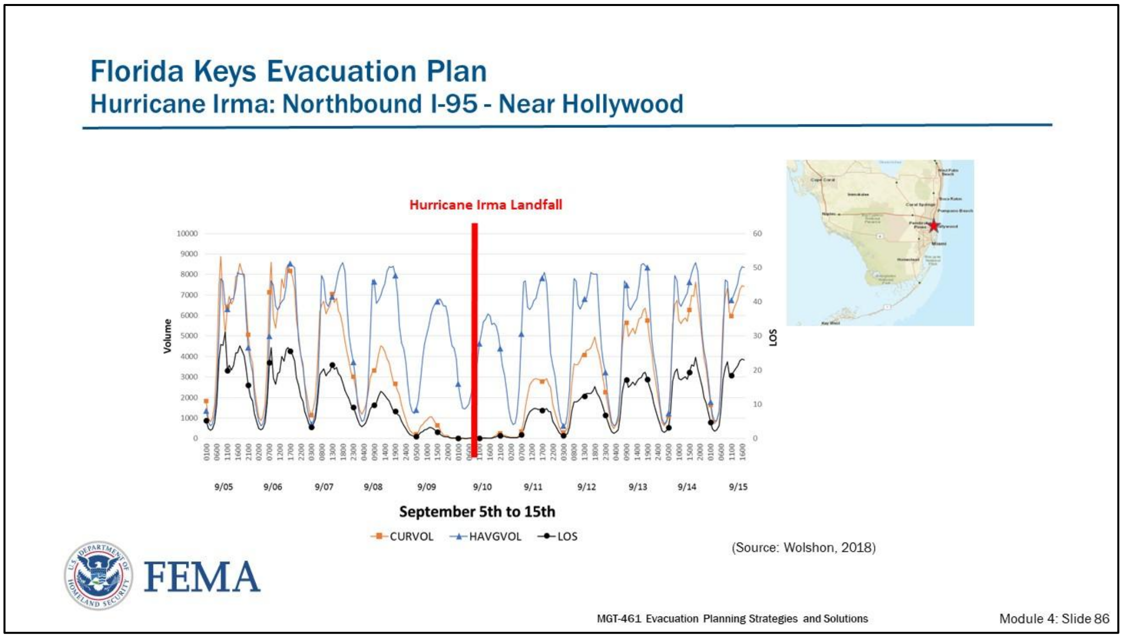



**Slide 85. Florida Keys Evacuation Plan Hurricane Irma: Northbound US 1 – Near Key Largo**

The chart shows northbound traffic at US 1 near Key Largo.

Again, this is earlier than other areas. LOS in the C range during peak

As with traffic data recorded out of Key West, most evacuation took place several days before landfall. The volumes were higher here because they included evacuees from throughout the Keys. Because of the earlier evacuation, volumes were similarly high as seen in Key West but relatively “steady” and in LOS C range during peak evacuation activity.



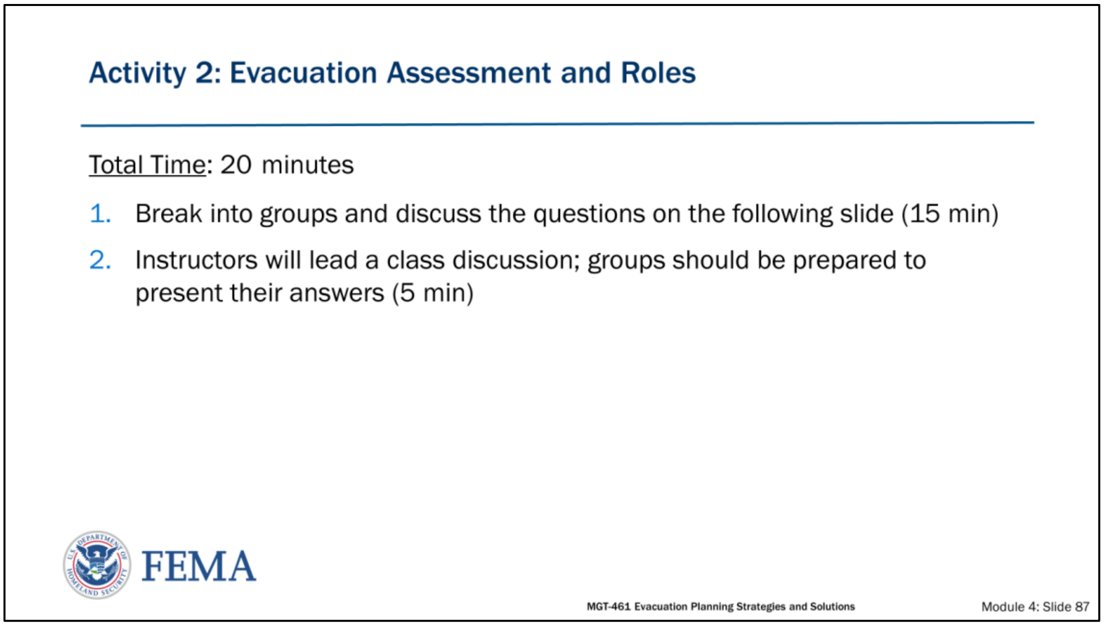

**Slide 86. Florida Keys Evacuation Plan Hurricane Irma: Northbound I-95 – Near Hollywood**

The chart shows northbound traffic at I-95 near Hollywood.

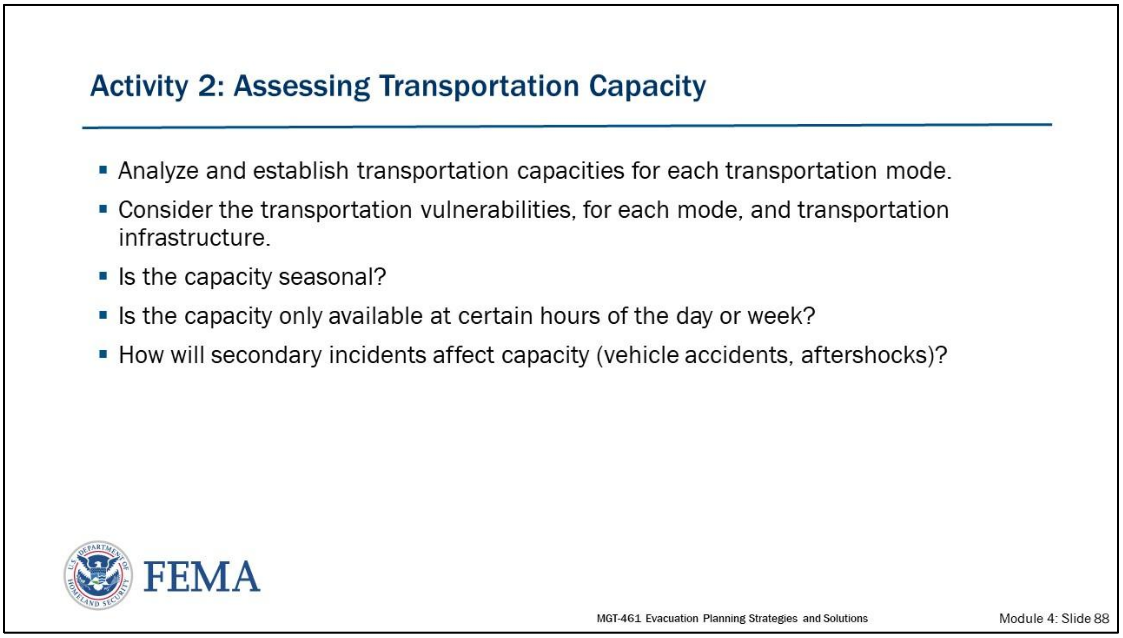
The traffic looks great: peak evacuation occurred 72 to 48 hours before landfall with LOS C.

Although no traffic volumes were available in a location immediately out of the Keys, this graph shows northbound traffic on I-95 near Hollywood, some 30 miles north of Miami. Here evacuation generally flowed well and, again, early with peak evacuation traffic occurring about 48 to 72 hours before storm landfall with LOS in the C range.

It is also interesting to note that traffic conditions tended to follow the daily patterns of more routine, non-emergency conditions. In fact, evacuation volumes surpassed typical daily volumes only for a few hours during morning periods in the days preceding the storm.

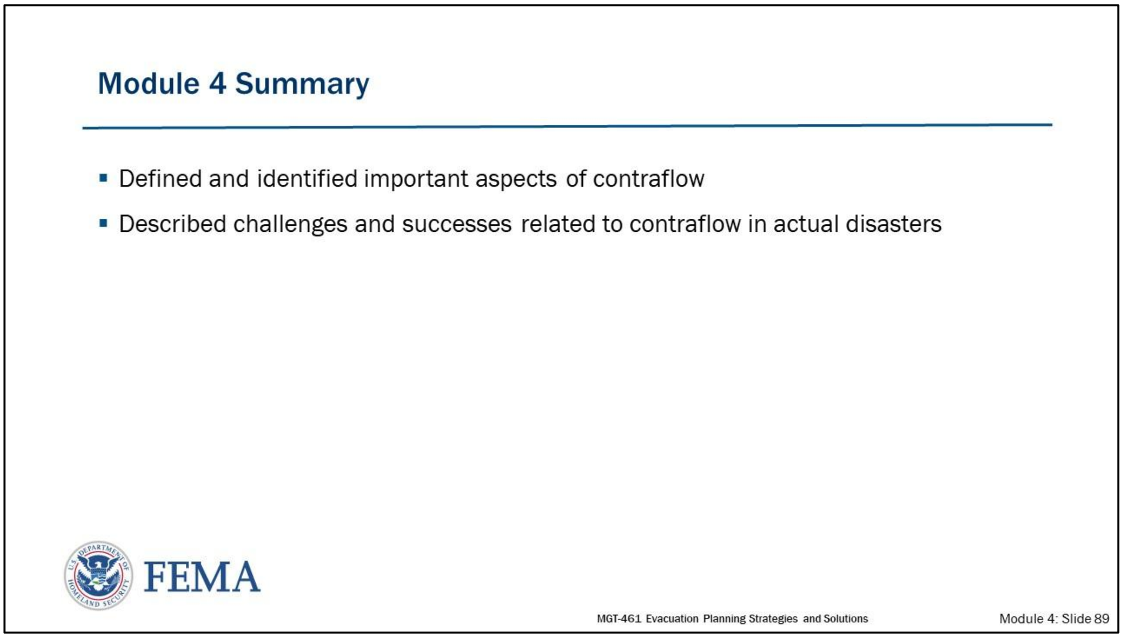



**Slide 87. Activity 2: Evacuation Assessment and Roles**




**Slide 88. Activity 2: Assessing Transportation Capacity**

# Module 4 Summary




**Slide 89. Module 4 Summary**

In this module, participants:

- Defined and identified important aspects of contraflow; and
- Described challenges and successes related to contraflow in actual disasters.

# Module 4 Reference List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# Module 5

# Evacuation Case Studies

# Module 5 Administration


**Slide 90. Module 5: Evacuation Case Studies**

## Duration

75 minutes

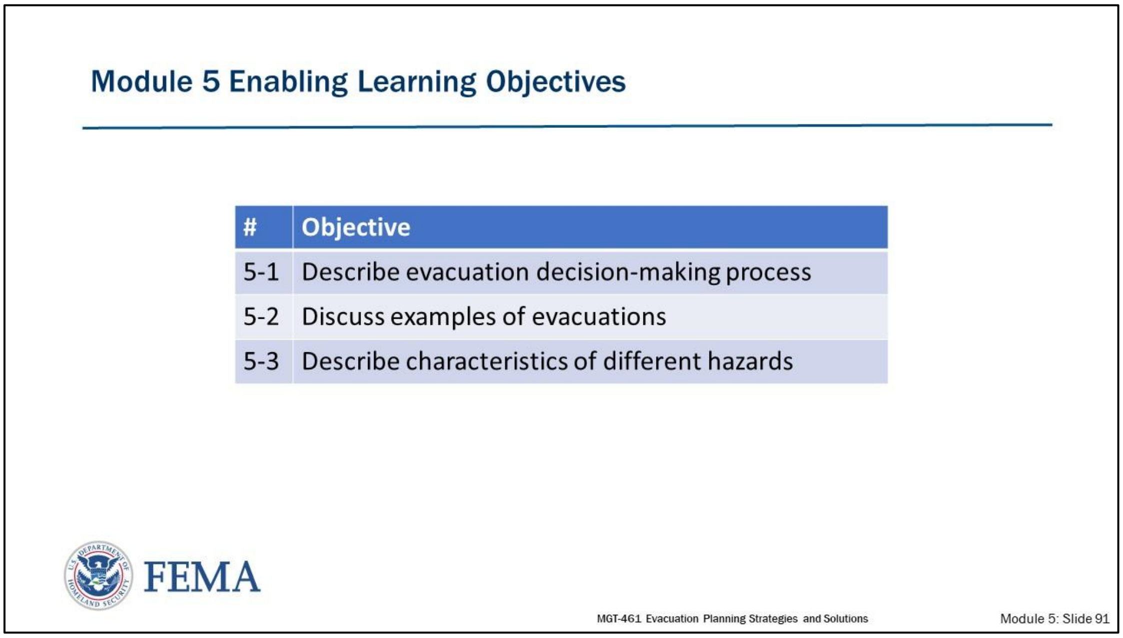
## Scope Statement

In this module, the instructor will provide case studies showing characteristics and associated evacuation decision-making, along with specific lessons, across a range of hazards.

## Terminal Learning Objective

Participants will be able to analyze case studies to apply lessons learned to the evacuation decision-making process.

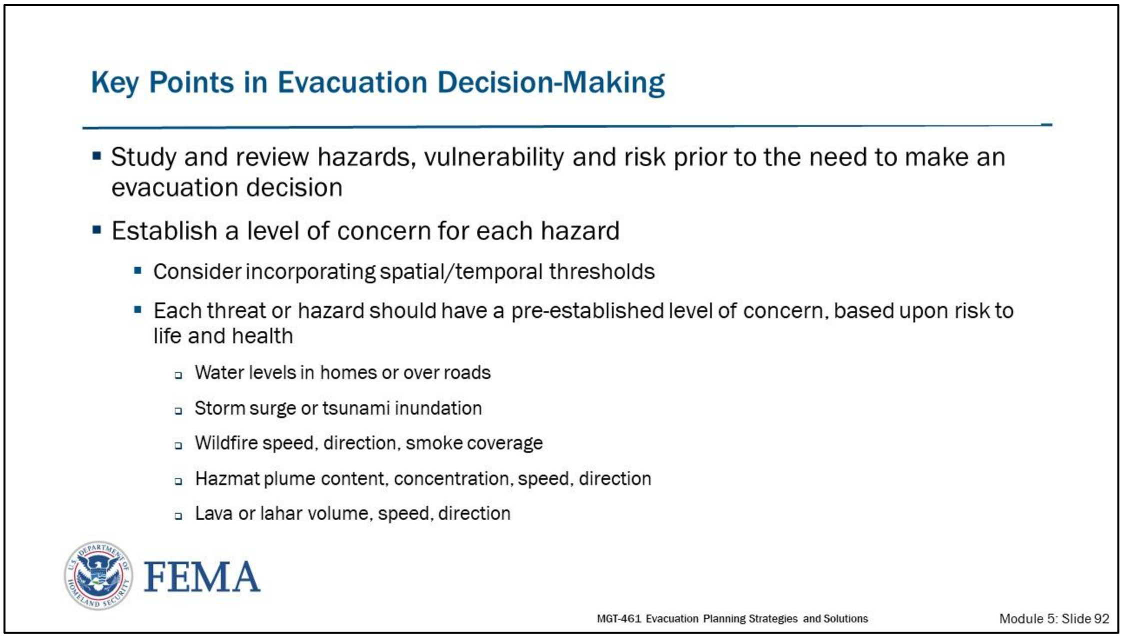
## Module 5 Content




**Slide 91. Module 5 Enabling Learning Objectives**

In this module, participants will:

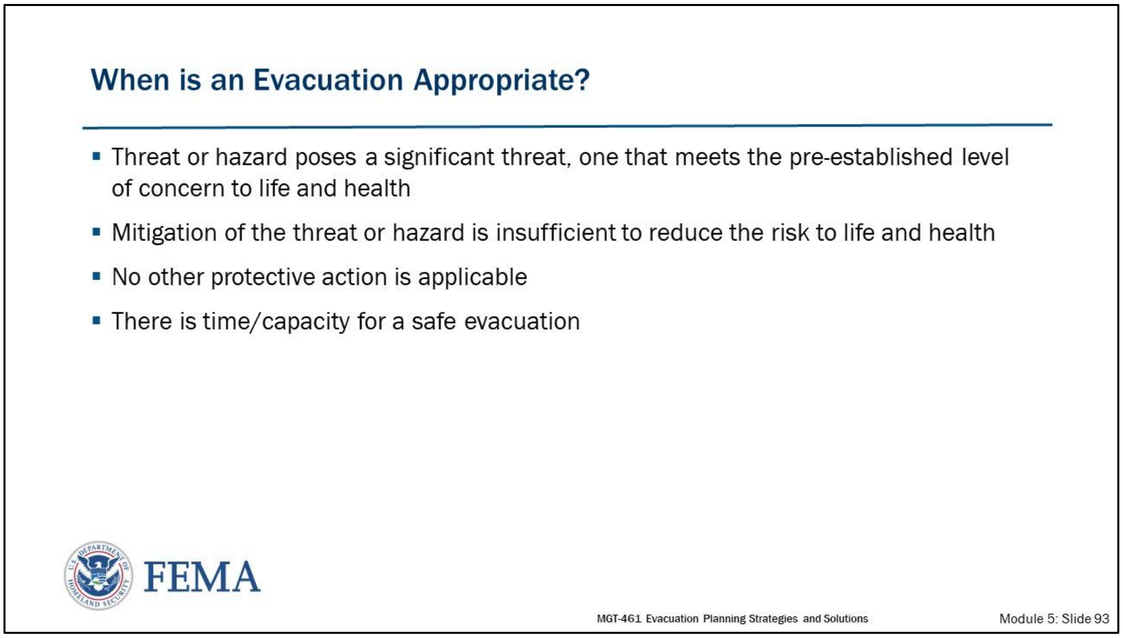
- Describe evacuation decision-making process;
- Discuss examples of evacuations; and
- Describe characteristics of different hazards.




**Slide 92. Key Points in Evacuation Decision-Making**

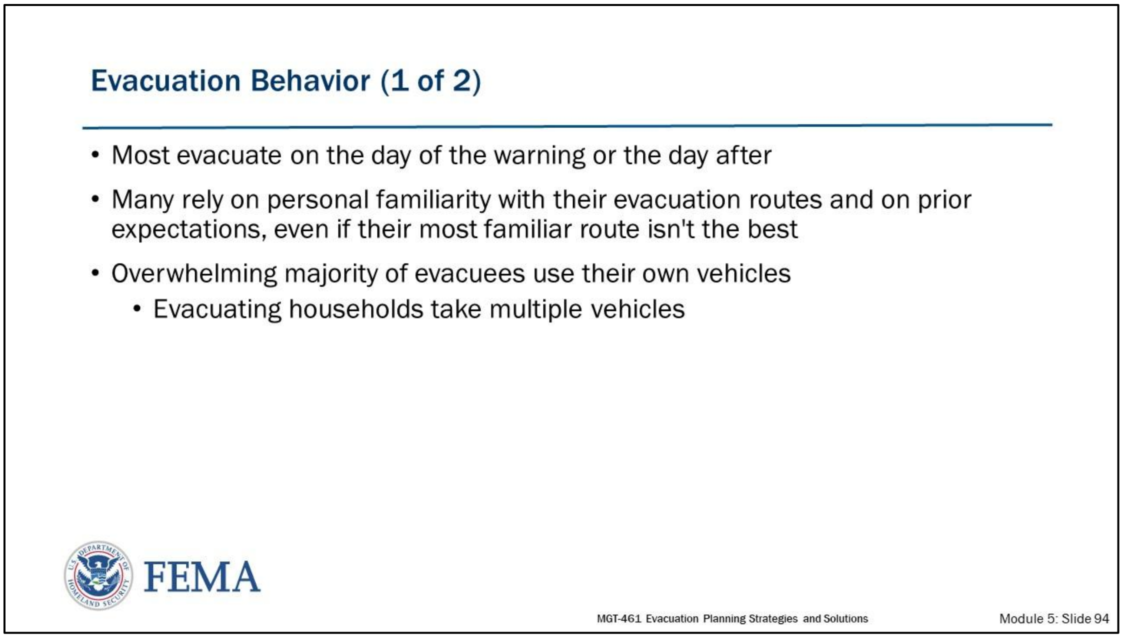
Evacuation decision-making begins long before an emergency occurs. It is critical that emergency managers, emergency response providers, and elected leaders are aware of the hazards/threats and associated vulnerabilities their communities face.

Establishing predetermined levels of concern for the most common hazards is an essential step in the evacuation decision-making process. Predetermined levels of concern represent significant potential or actual threats to human life. If a community is vulnerable to flooding, how much flooding constitutes a threat to life and health? Put another way, how much water in a home, or what rainfall rate, is considered a threat to life and health that requires evacuation?




**Slide 93. When is an Evacuation Appropriate?**

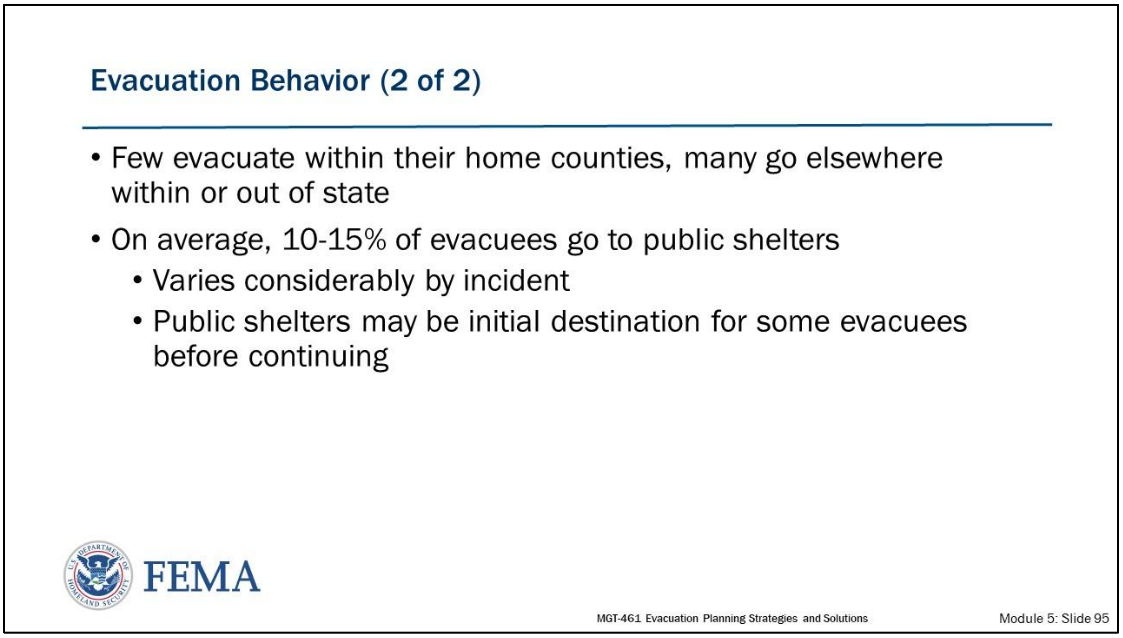
Evacuations are never easy and careful consideration must be given before initiating one. Evacuations can create their own hazards and cascading effects across the community, including Traffic congestion/disruption, staffing shortages, moving vulnerable people, demand on community resources, and increased collisions and other incidents. Community leaders should understand and have confidence in their process and structure when issuing evacuation orders. The key decision point is whether life and health are significantly threatened; that is the determining factor between ordering evacuation or not. If such a threat exists, can't be sufficiently mitigated, no other protective action is feasible, and there is sufficient time and capacity to move those at risk to safety, it's time to evacuate.




**Slide 94. Evacuation Behavior (1 of 2)**

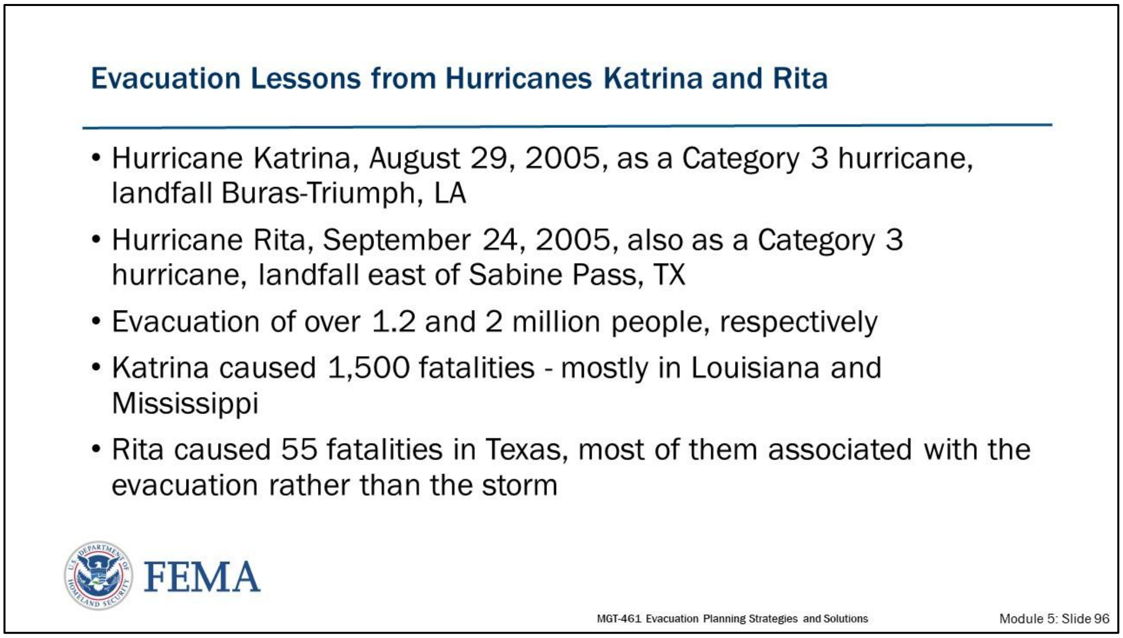
Multiple studies and incident reports indicate that most people choosing to evacuate do so on the day of the warning or the day after. Few evacuees have relied on written materials received before the event or recommendations during the event from local officials or the news media.

Some rely on personal familiarity with their evacuation routes and on prior expectations about time, safety, or convenience, even if their preferred route isn’t the one recommended. The overwhelming majority of evacuees use their own vehicles and many of the rest get rides with peers who do have vehicles; evacuating households owning multiple vehicles typically take as many as they can. Evacuees tend to rely principally on interstate highways, especially if these are readily available and connect to their expected evacuation destinations (Wu et al. 2012).




**Slide 95. Evacuation Behavior (2 of 2)**

For tropical storms (i.e., long-notice events), few evacuees remain within their home counties, many go elsewhere within state, and many evacuate out of state. Approximately 10-15% of evacuees go to public shelters – which typically are resources of last resort – although some use those shelters as initial stops before continuing.



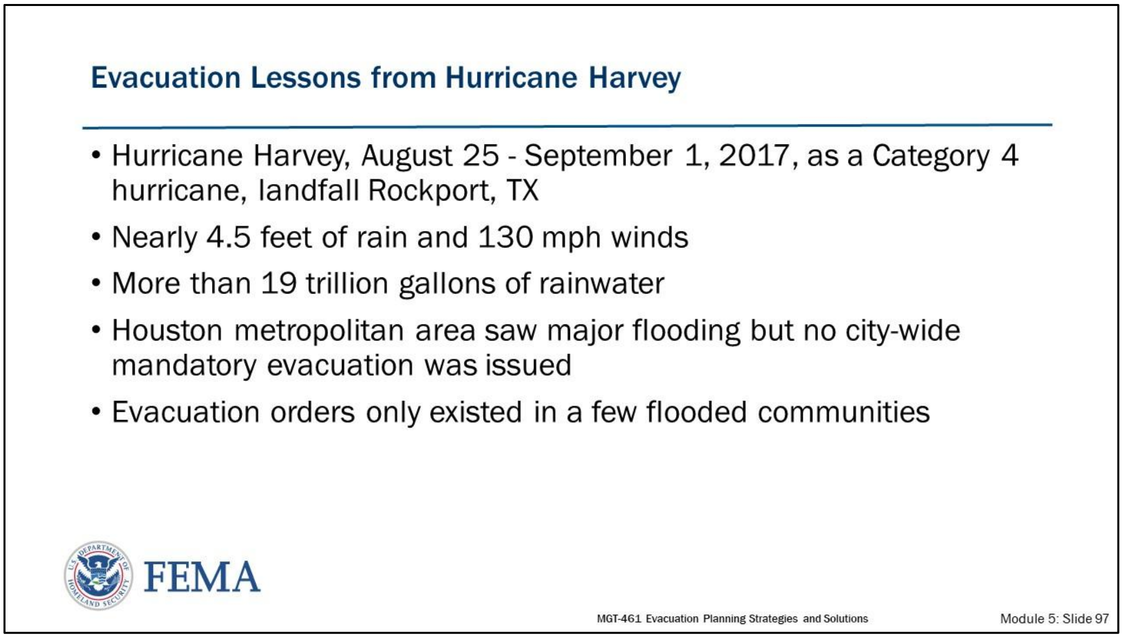

**Slide 96. Evacuation Lessons from Hurricanes Katrina and Rita**

Protective-action decision-making is one of the most challenging aspects of emergencies and disasters; moving people from an affected/threatened area comes with its own risk. Moving critical medical patients from homes, hospitals, or assistance centers is a difficult task. We must consider the consequences of ordering an evacuation and as well as those not ordering one.

We will review case studies where evacuations were enacted before or after an impact in this and the next several slides. These case studies are not intended to drive a class debate about effectiveness of the decisions, rather to provide a contrast among a range of incidents and ideally an opportunity to learn from them.

At time of occurrence, Hurricanes Katrina and Rita were two of the ten costliest hurricanes in US history. Katrina made landfall at Buras-Triumph, Louisiana, around 6:00 am CDT on Monday, August 29, 2005, as a Category 3 hurricane. Despite the evacuation of over 1.2 million people, Katrina caused 1,500 fatalities, mostly in Louisiana and Mississippi. Less than a month later, Hurricane Rita made landfall east of Sabine Pass, Texas, around 3:00 am CDT on Saturday, September 24, also as a Category 3 hurricane. Ahead of Rita, more than two million people evacuated Texas and Louisiana coastal areas. Vehicles without fuel and those stranded because of breakdowns created a hundred-mile traffic jam, which lasted more than a day for some. Fatalities included 24 nursing home residents whose bus caught on fire – mostly due to it being poorly maintained (NTSB, 2007) – as well as others in accidents and from heat. Hurricane Rita caused 55 fatalities in Texas, most of them associated with evacuation rather than the storm itself (Wu et al. 2012).

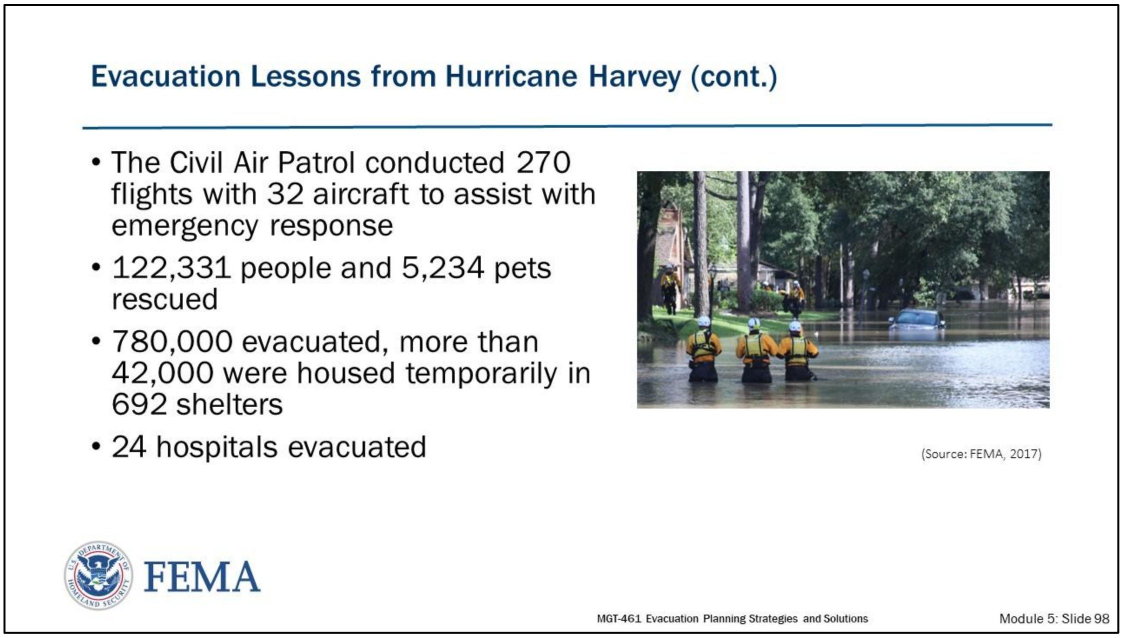
After accounting for inflation to 2022 dollars, Hurricane Katrina remains the costliest tropical cyclone to strike the US, with estimated damage of US$160 Billion (NOAA, 2023).




**Slide 97. Evacuation Lessons from Hurricane Harvey**

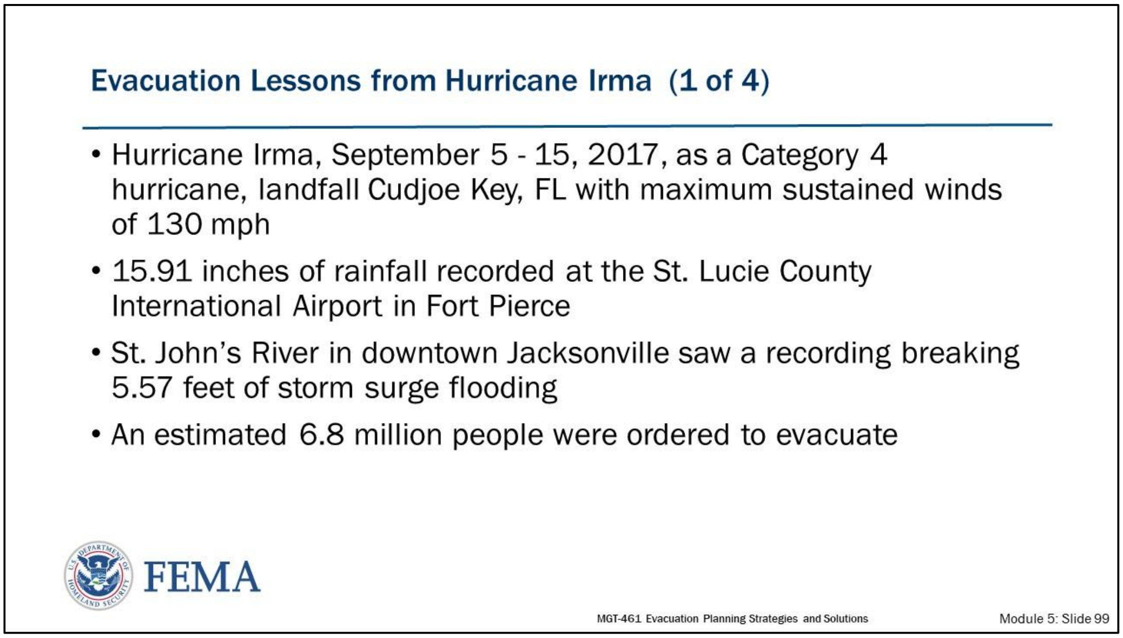
### Hurricane Harvey

Hurricane Harvey made landfall as a Category 4 storm on August 25, 2017. Harvey's eye of first made landfall on San Jose Island and then near Rockport and Fulton, Texas, at ~10 PM CDT. With nearly 4.5 feet of rain and 130 mph winds, Harvey generated the largest disaster response in Texas history. Besides wind and storm surge, hurricanes and tropical storms are notorious for producing torrential rainfall and flooding. Unfortunately, Harvey was unique – so far. Instead of moving inland and farther away from the coast, Harvey stalled over South and Southeast Texas for days, producing catastrophic devastating and deadly flash and river flooding. More than 19 trillion gallons of rainwater fell on parts of Texas, causing widespread, catastrophic flooding. Nearly 80,000 homes had at least 18 inches of floodwater, 23,000 of those with more than 5 feet. The Houston area experienced the largest amount of rainwater ever recorded in the continental US from a single storm (51.88 inches). Before Harvey made landfall, authorities encouraged residents to evacuate low lying and coastal areas, but a region-wide mandatory evacuation order was not issued.




**Slide 98. Evacuation Lessons from Hurricane Harvey (cont.)**

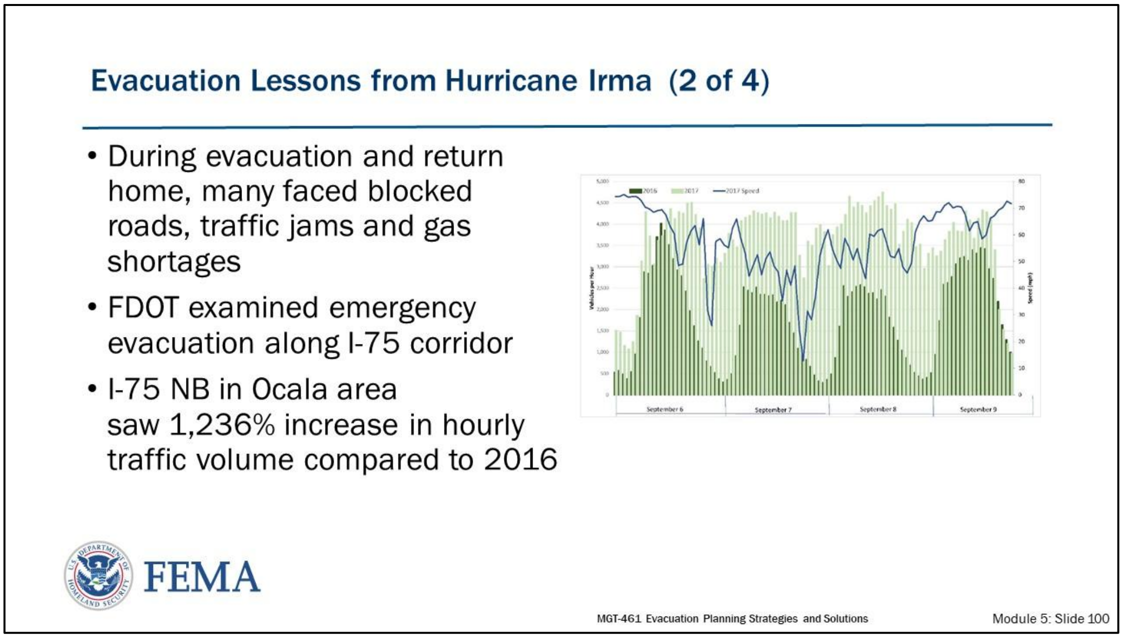
The Civil Air Patrol conducted 270 flights with 32 aircraft to assist with emergency response. Twenty-four hospitals were evacuated, 61 communities lost drinking water capability, 23 ports were closed, and 781 roads were impassable. Nearly 780,000 Texans evacuated their homes. In the days after the storm, more than 42,000 Texans were housed temporarily in 692 shelters. Local, state, and federal first responders rescued 122,331 people and 5,234 pets.




**Slide 99. Evacuation Lessons from Hurricane Irma (1 of 4)**

Hurricane Irma made landfall as a Category 4 Hurricane near Cudjoe Key, Florida, at 9:10 AM EDT on Sunday, September 10, 2017, with maximum sustained winds of 130 mph. The hurricane affected Florida and adjacent states from September 5 to September 15, 2017. Irma topped out with 15.91 inches of rainfall recorded at St. Lucie County International Airport in Fort Pierce. Irma's extensive size and slow movement made for several hours of tropical storm force winds, which resulted in widespread tree and power line damage across the area. Trees fell on roofs and cars, damaging property, and sadly taking a life in southwest Georgia. While many counties across the Florida Big Bend and southwest Georgia were impacted, the greatest impacts were across the eastern portion of the area near the I-75 corridor. There were >6.5 million customers without power in Florida, >930,000 in Georgia, and >45,000 in Alabama. On the St. John's River in downtown Jacksonville, there was 5.57 feet of storm surge flooding, exceeding the record of 4.1 feet in 1964 from Hurricane Dora.

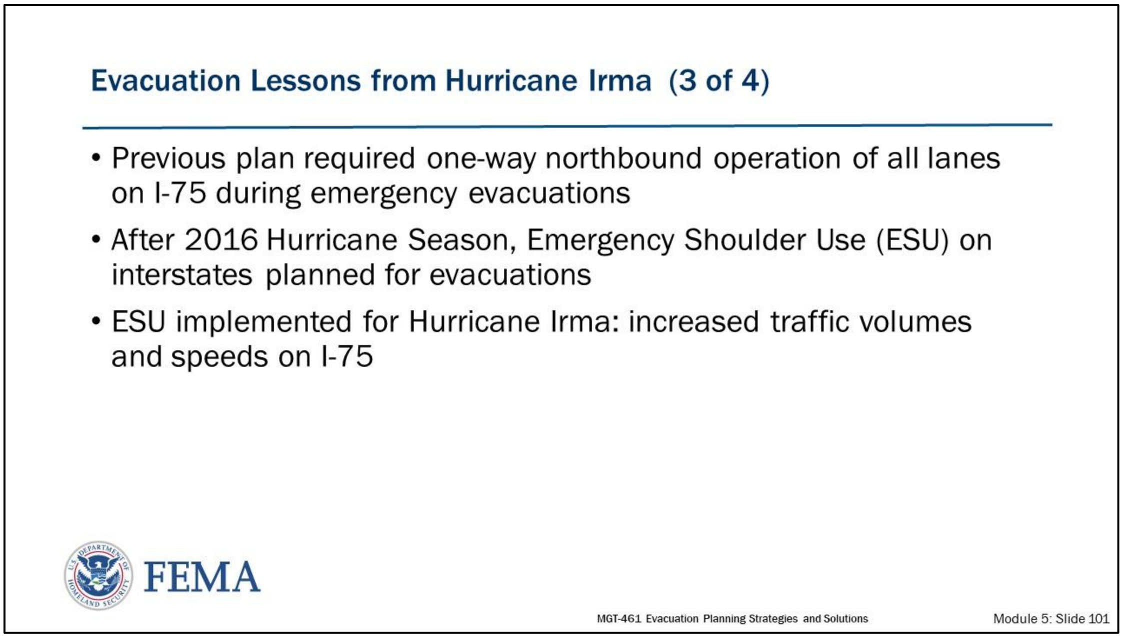
Throughout Florida, almost 700 emergency shelters were opened. The shelters collectively housed ~192,000 people, with >40% of them staying in shelters in South Florida, including 31,092 in Miami-Dade County, 17,263 in Palm Beach County, 17,040 in Collier County, and 17,000 in Broward County. Additionally, more than 60 special needs shelters were opened, housing >5,000 people by September 9. On September 8, a mandatory evacuation was called by Miami-Dade County, Broward County, and Monroe County in advance of Irma. Tolls were suspended throughout the state to support evacuation. Approximately 6.8 million people were ordered to evacuate.




**Slide 100. Evacuation Lessons from Hurricane Irma (2 of 4)**

During evacuation and return, many Florida residents faced blocked roads due to stranded vehicles, traffic jams, and gas shortages. On October 12, Governor Scott directed FDOT to examine ways to expedite emergency evacuation along the I-75 corridor, specifically between Wildwood and the Florida-Georgia state line. The study corridor included I-75 and two parallel north/south facilities, US 98/US 19/US 27 west of I-75 and US 301 east of I-75.

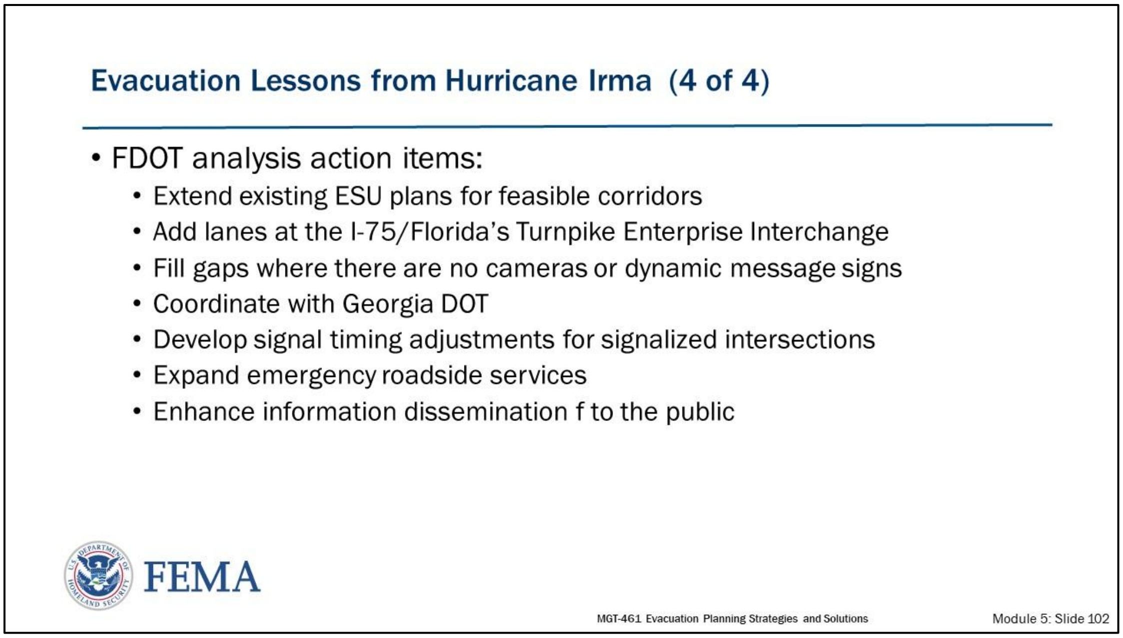
On a typical day, I-75 in Marion County has 81,000 vehicles, ~3,600 vehicles/hour. By 2040, I-75 is projected to have 142,000 vehicles on a typical day. The figure on the slide shows a comparison of hourly traffic volumes along I-75 in Ocala and at the Florida-Georgia state line for September 6 to September 9 of the previous year 2016 (dark green) and for September 6 to September 9, 2017 (light green) during the evacuation. I-75 northbound in the Ocala area experienced an hourly traffic volume with a 1,236% increase over the same day the previous year and experienced pockets of severe congestion (FDOT 2018).




**Slide 101. Evacuation Lessons from Hurricane Irma (3 of 4)**

Previous evacuation plans required one-way northbound operation of all lanes on interstates. After the 2016 Hurricane Season, it was decided to use shoulders on interstates for evacuations. Emergency Shoulder Use (ESU) was used during Irma.

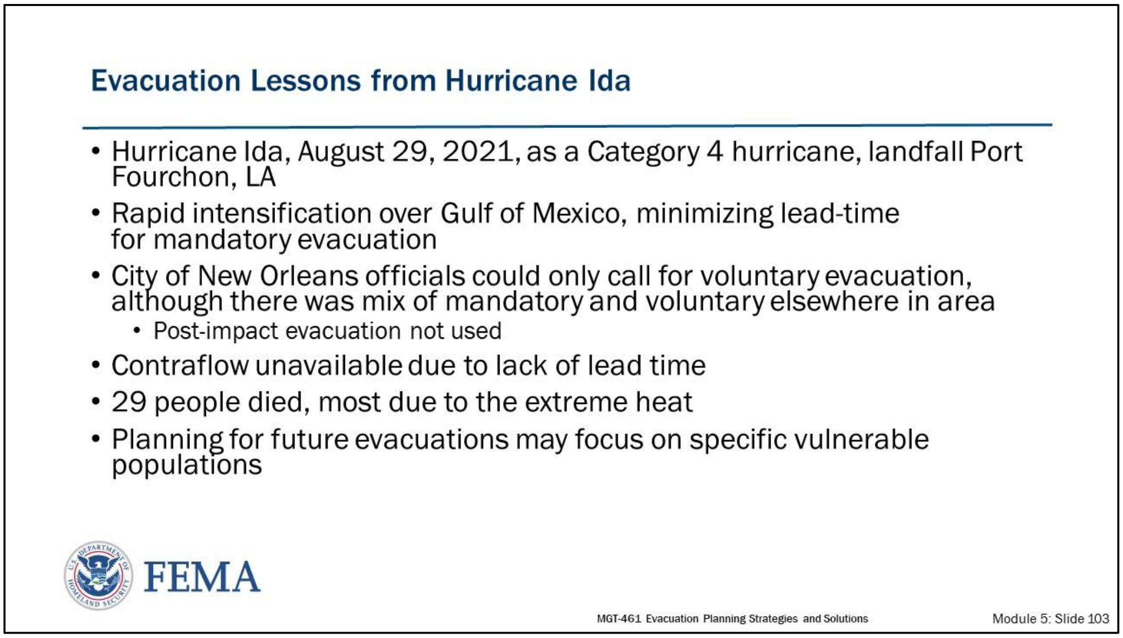
During ESU operations, hurricane response and recovery support, including out-of-state resources, could travel in the opposite direction of evacuating traffic to pre-position their assets. Transportation Management Center (TMC) staff and State Emergency Operations Center (SEOC) staff (FDOT and Florida Highway Patrol) continuously monitored traffic conditions using available traffic cameras and vehicle counters. Real-time monitoring allowed TMC operators to dispatch emergency response vehicles to clear stranded or disabled motorists. During the I-75 ESU operation, 18 Emergency Roadside Assistance Vehicles (Road Ranger service patrols) assisted 506 motorists. During the I-4 ESU operation, six Road Ranger patrols assisted 26 motorists. Comparison of traffic flow and speed showed increased traffic volumes and speeds during I-75 ESU implementation (FDOT 2018).




**Slide 102. Evacuation Lessons from Hurricane Irma (4 of 4)**

The Florida Department of Transportation (FDOT) conducted Irma evacuation analysis along the I-75 corridor and identified the following for improving evacuation:

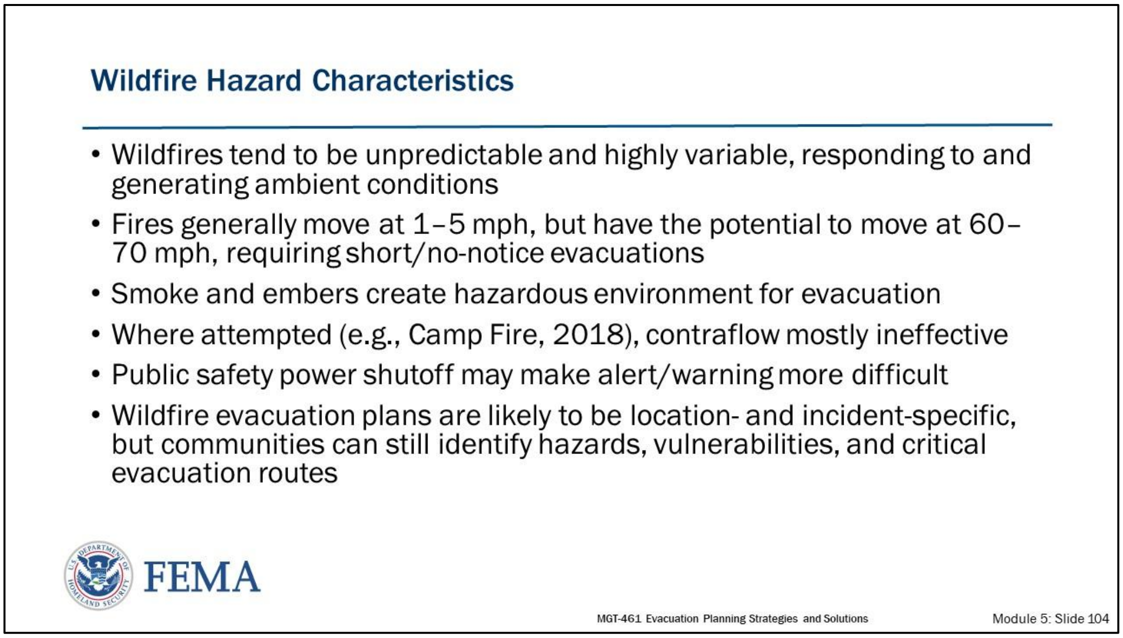
- Extend existing Emergency Shoulder Use (ESU) plans for feasible corridors;
- Construct additional lanes at the I-75/Florida's Turnpike Enterprise (Turnpike) Interchange for increased throughput;
- Fill gaps where there are no cameras or dynamic message signs;
- Develop signal timing adjustments for signalized intersections along US 98/US 19/US 27 and US 301 to increase throughput during emergency evacuations;
- Expand emergency roadside services (Road Ranger service patrols and wrecker services) on key evacuation corridors; and
- Identify additional methods to enhance dissemination of information to the public.




**Slide 103. Evacuation Lessons from Hurricane Ida**

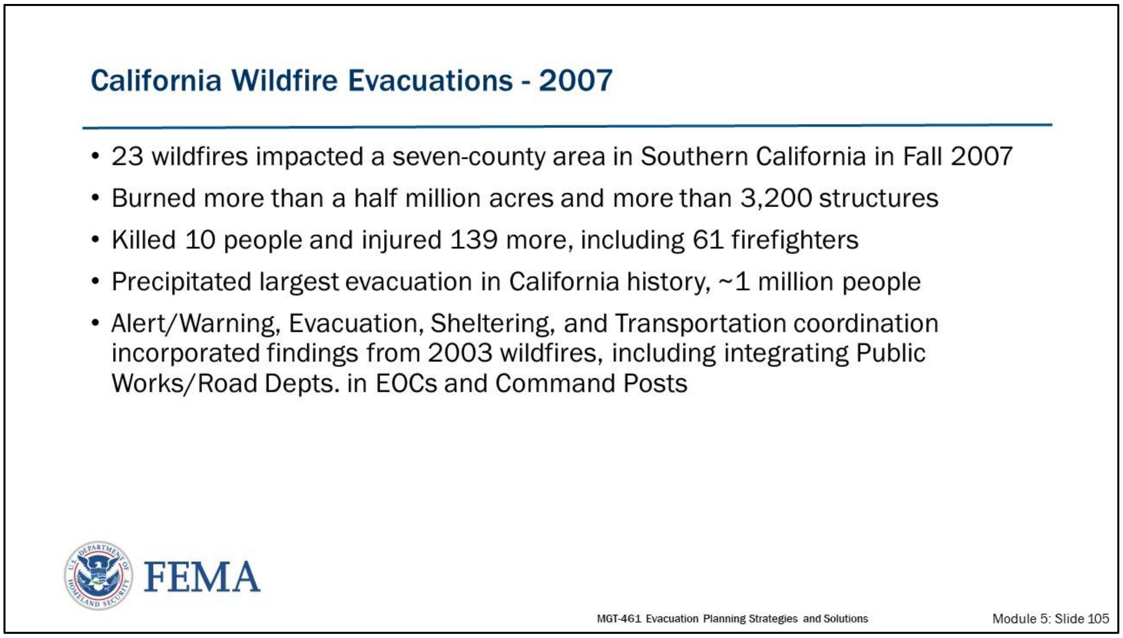
Hurricane Ida made landfall over Port Fuchon, LA, (~60 mi due south of New Orleans) as a Category 4 storm, on August 29, 2021. Like many recent tropical storms, it intensified rapidly before landfall, thus leaving insufficient time for a large-scale evacuation in New Orleans. NOLA city officials called for a voluntary evacuation, recognizing that there wasn't enough time to set up contraflow move large numbers of people without potentially putting them at risk from being on the road when the storm hit. Areas around NOLA had a mix of mandatory and voluntary evacuation.

Post-impact evacuation, which was not used, can move people out of an affected area, thus minimizing the size of a potentially dependent population without exposing them to the storm while in transit.



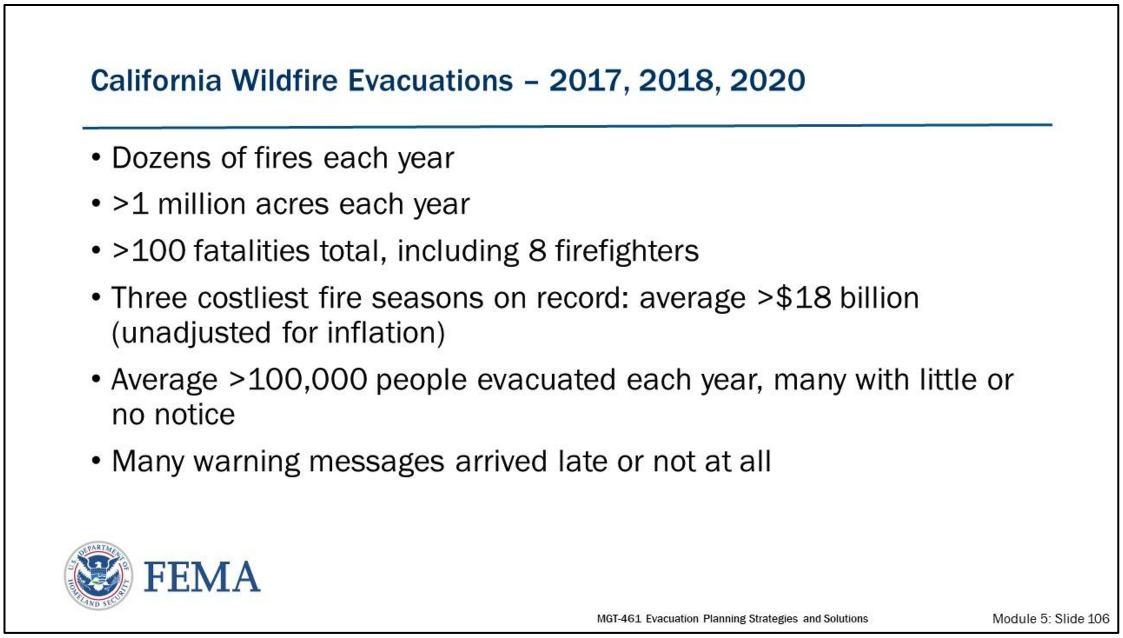

**Slide 104. Wildfire Hazard Characteristics**

Wildfires present different evacuation challenges relative to tropical storms. Although many coastal communities have detailed plans with specific timelines to initiate emergency evacuation procedures for hurricanes, wildfires are less predictable and tend to offer far less warning. Wildfires can spread at a rate of 1-5 mph but can advance at speeds of 60-70 mph when driven by strong winds, high fuel, and favorable topography. This extreme variability makes specific path forecasting difficult and requires flexible plans. That doesn’t preclude identifying potential high-risk areas and paths of fire travel, along with possible evacuation routes. Rural communities may have few options for evacuation, necessitating evacuation based as much on egress path as direct threat. Observations In California and elsewhere indicate the range of hazards evacuees and responders face: smoke- and ember-filled atmosphere with near-zero visibility and high levels of carbon monoxide and other toxicants and degraded/failed communication systems due to power outages, tower damage, and loss of cellular traffic data.



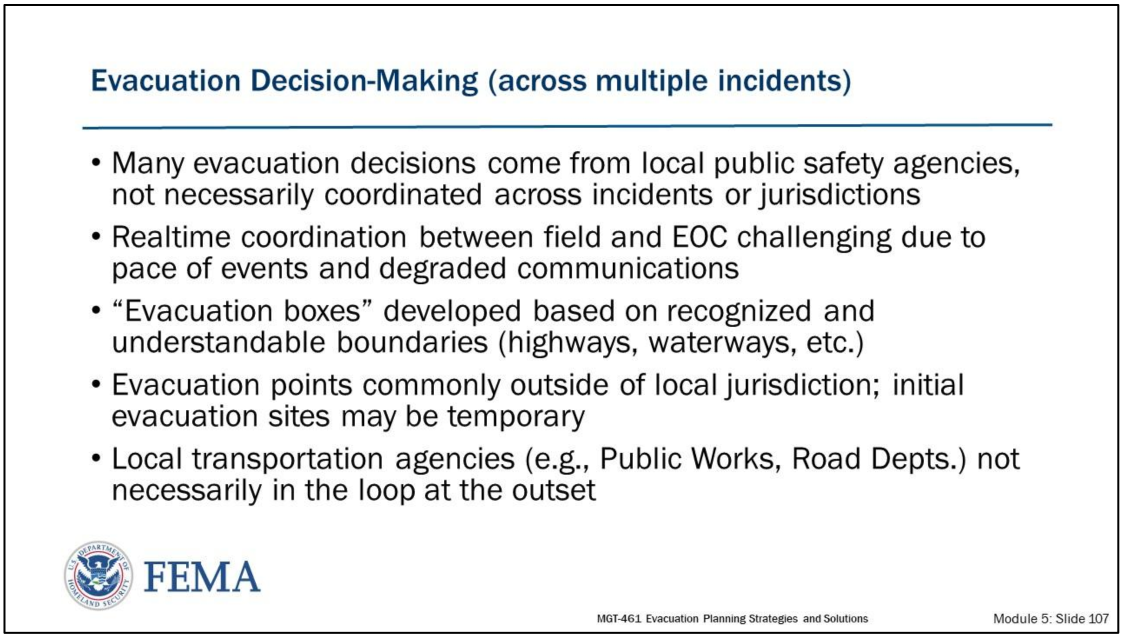

**Slide 105. California Wildfire Evacuations – 2007**

Between October 20 and November 9, 2007, a series of 23 wildfires raged across a seven-county area in Southern California that encompassed Los Angeles and San Bernardino counties in the north and San Diego and Imperial counties near the US–Mexican border in the south. The fires killed 10 people and injured at least 139 more (GOES 2007), including 61 firefighters (CNN 2007), while burning 517,267 acres and destroying 3,204 structures (GOES 2007). The fires also precipitated California’s largest evacuation to that point, possibly as many as one million people (“Scale of the Fire’s Disruption” 2007). Many successful actions taken were informed by problems with the response to large wildfires in that area in 2003.




**Slide 106. California Wildfire Evacuations – 2017, 2018, 2020**

In 2017-2020, California had its 3 costliest fire seasons to that point, each comprising dozens of individual fires burning >1 million acres and necessitating short- and no-notice evacuations of entire towns and facilities under dangerous conditions. More than 100 people, including 8 firefighters, were killed in total; >100,000 people were evacuated each year on average.




**Slide 107. Evacuation Decision-Making (across multiple incidents)**

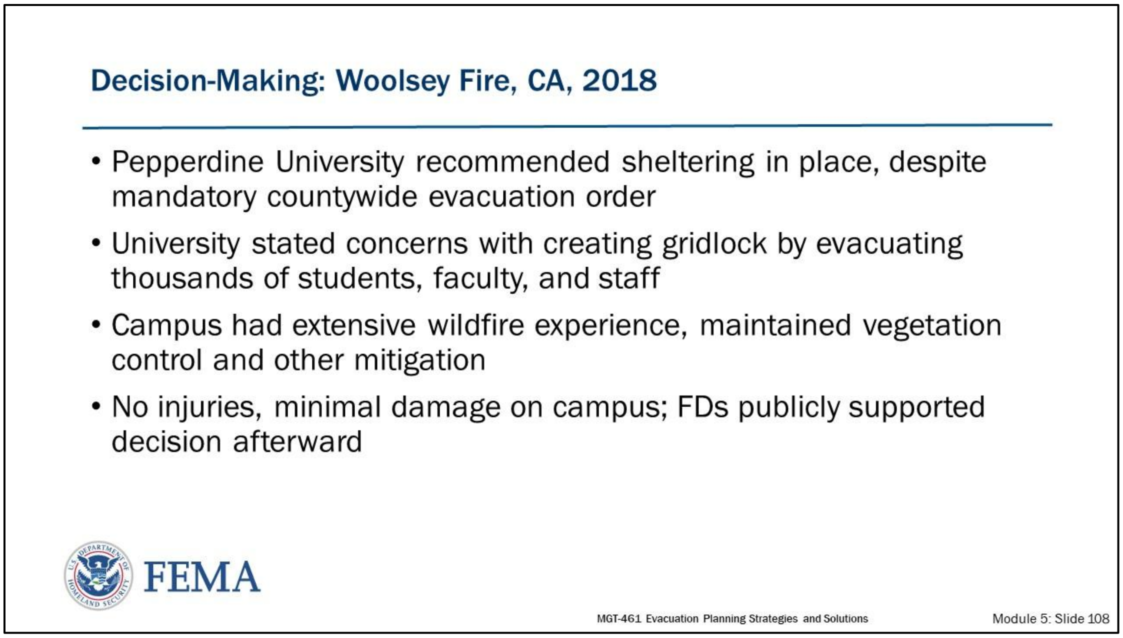
Initial decisions to evacuate and determination of when evacuations can begin largely come from local fire, law, and/or emergency management agencies, possibly informed by state and agencies; as the incident progresses, deployed state or federal incident management teams may make recommendations to local officials. For most of the fire in CA and the rest of the US West Coast, local agencies developed "evacuation boxes" based on recognizable and understandable physical boundaries, such as highways and waterways, and relayed that information to law enforcement and city or county EOCs. Once the decision was made, law enforcement and transportation officials were responsible for implementing evacuations.

Meetings with local officials showed that fire officials designated where and when to evacuate based on knowledge and experience of weather conditions, fuel source availability, and threats to population. However, it was clear that their job was to fight fires and not evacuate people. The actual evacuation process was managed and controlled by law enforcement agencies. Local transportation and public works agencies played a minor role overall in the evacuation by providing barricades, variable information signs, and closing roads as directed by law enforcement officials. One challenge in 2003 that was addressed in later years was that the agencies responsible for road management were omitted from the decision-making process.

Evacuation notices varied from mostly voluntary in early years to mostly mandatory by 2017. During the 2007 wildfire evacuations, there was no implementation of proactive traffic management techniques such as contraflow or priority signalization. In general, such actions appeared to be viewed somewhat negatively because of the additional staffing they likely would require. Despite this, contraflow operations were seriously discussed for Ramona (north of San Diego) but were never implemented. The San Diego mayor requested people stay home and off the roads to free capacity for evacuee traffic, responders, and general safety. Although the impact of the request cannot be measured, it demonstrates proactive messaging and effective use of media to convey to residents and visitors how they can facilitate emergency actions.

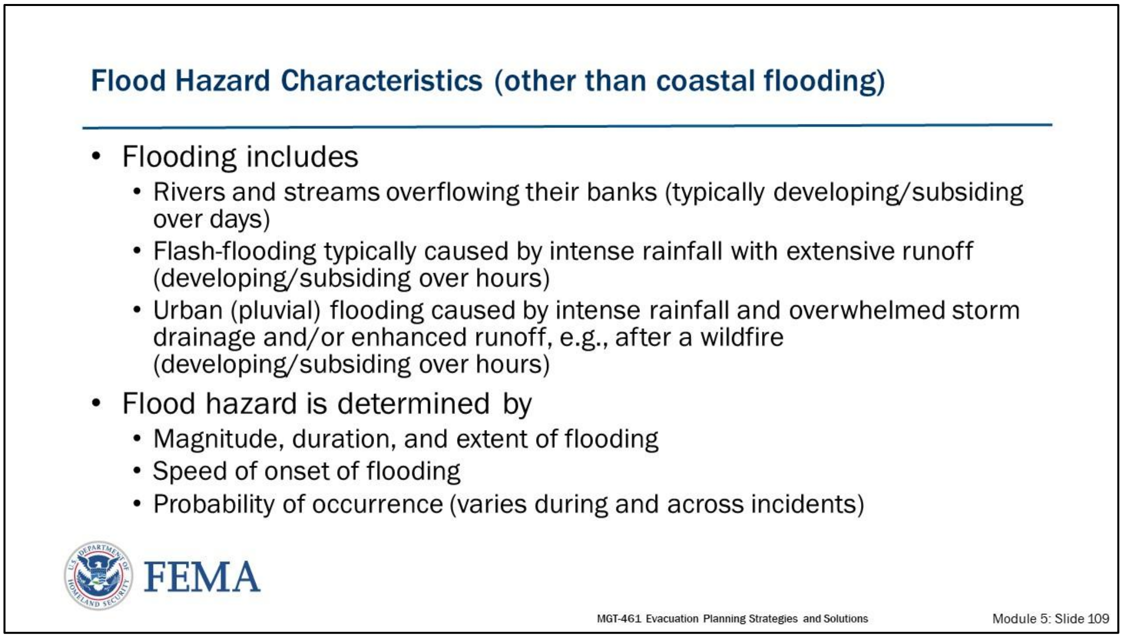
As a result of the wildfires, ~15 major highways were closed fires because of dangerous conditions; these closures do not appear to have affected the evacuation. Most notably, the most heavily traveled highways of Interstates 5, 8, and 15 were closed at different times. To compensate for these closures, local officials worked with their federal counterparts at the Camp Pendleton Marine Corps Base to permit public use of on-base roadways for evacuation traffic to access northbound I-5 in lieu of I-15.

One of the ways in which Caltrans assisted with road closures was by releasing the “Caltrans Commuter Alert,” which provided location and details about road closures throughout the seven affected counties. These road closures were illustrated through geographic information systems by providing detailed maps that depicted road closures as well as wildfire perimeters. San Diego and Caltrans provided mapping services to assist responders and the public.




**Slide 108. Decision-Making: Woolsey Fire, CA, 2018**

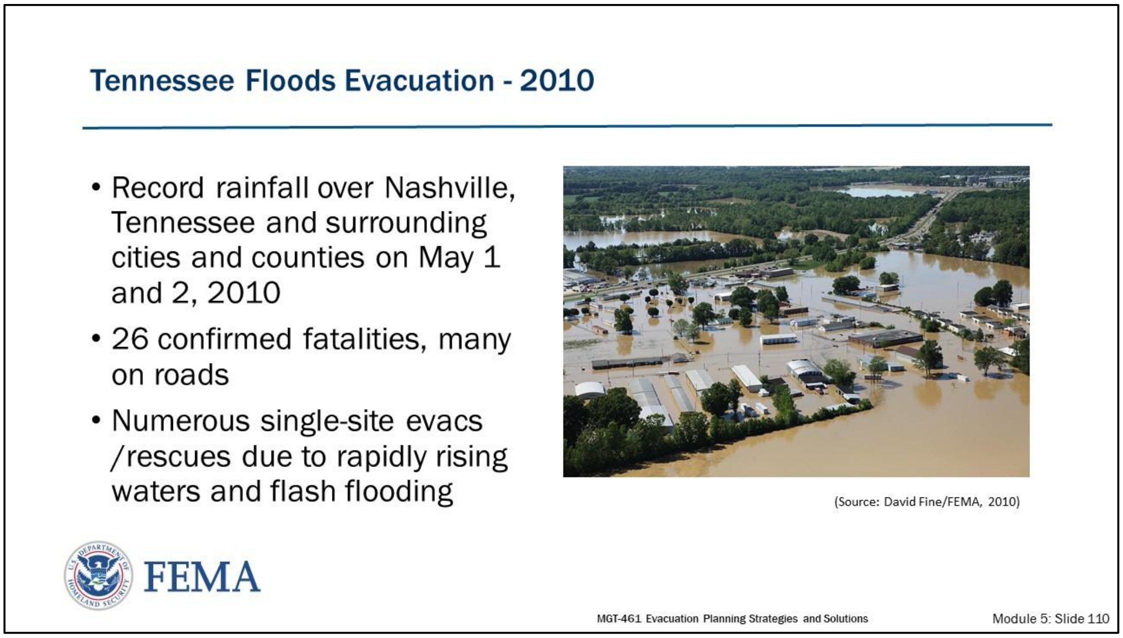
During the Woolsey Fire in 2018, Pepperdine University (near Malibu) administration stated concerns about clogging roads with thousands of students, faculty, and staff. They “encouraged” but did not order people to evacuate, choosing instead to shelter in place in campus, using predesignated, mitigated facilities. Although they were criticized for this at the time, they had been through wildfires before and had conducted wildfire mitigation and preparedness on campus. There were no injuries and minimal damage on campus; local and state Fire agencies publicly supported the decision.




**Slide 109. Flood Hazard Characteristics (other than coastal flooding)**

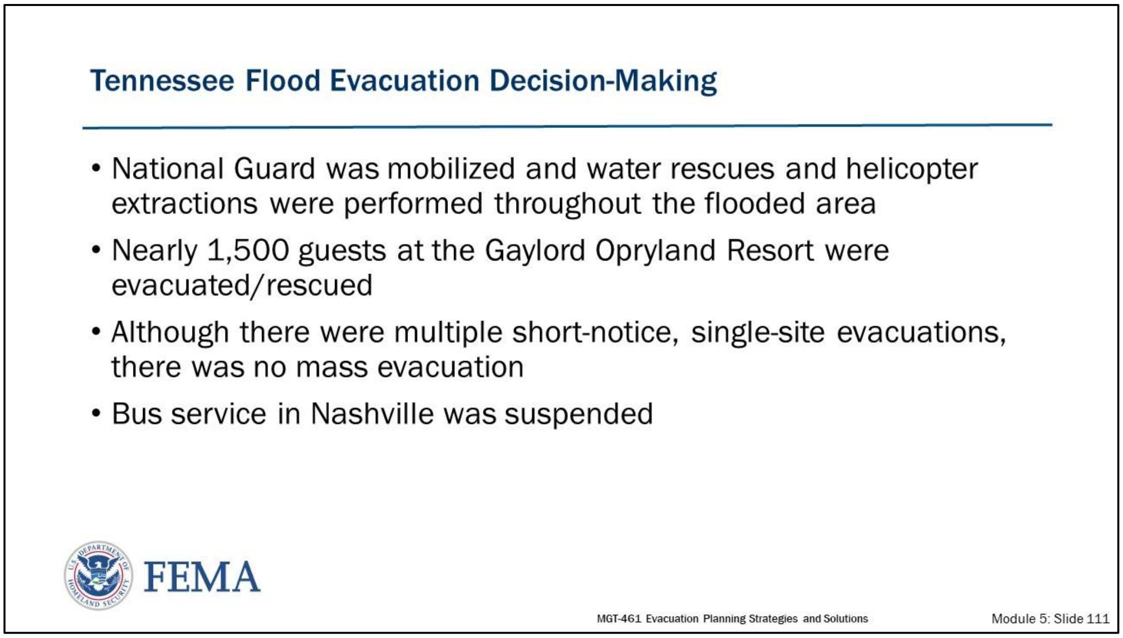
Flood hazards include actual or potential inundation that involves risk to life, health, property, and natural floodplain resources and functions. It includes three elements: severity (magnitude, duration, and extent), probability, and onset speed.

Severity and onset speed are determined by long-term and immediate meteorological and hydrological characteristics of a watershed. The biggest losses in developed areas come from catastrophic events. Such events are rare, but their magnitude makes even a small chance for such a disaster a matter of concern. More frequent flooding occurs on bottomlands near a river or stream, where the watercourse might overtop its banks on ~annually. These differences in probability are expressed as recurrence intervals (average period for a flood that equals or exceeds a given magnitude), expressed as a period of years. The probability of occurrence of a given flood can also be expressed as the odds of recurrence of one or more similar or bigger floods in a certain number of years. The term, “100-year flood,” arguably the worst risk-communication term in use, simply indicates a 1% probability of occurrence in any year; **it does not preclude such events occurring multiple times in one or more years**.




**Slide 110. Tennessee Floods Evacuation – 2010**

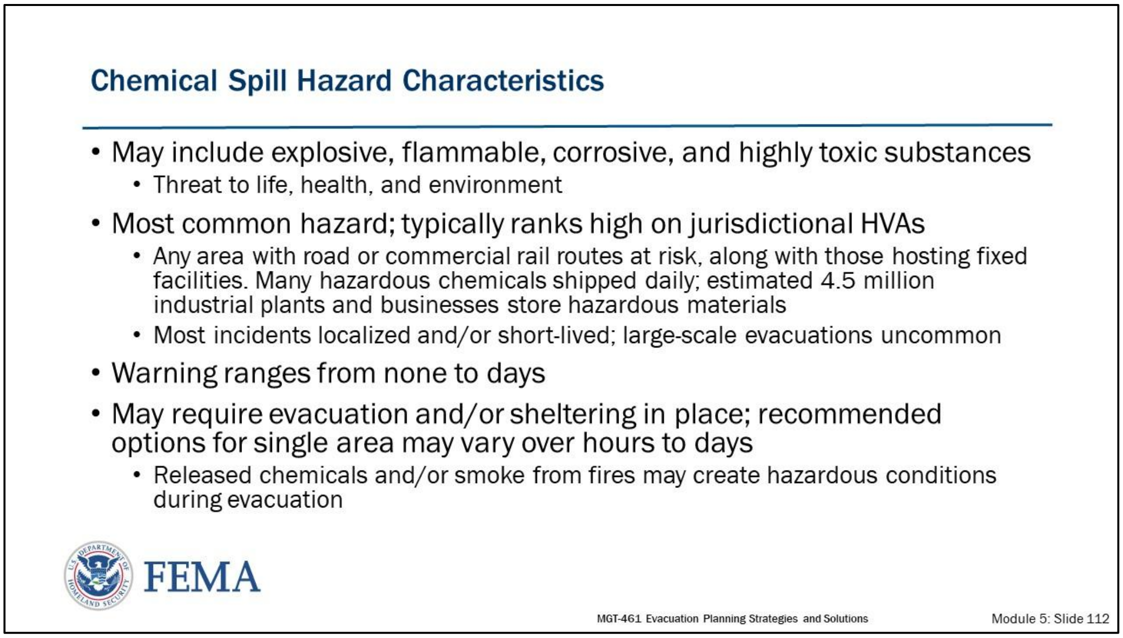
Historical record rainfall in Nashville, TN and surroundings on May 1-2, 2010, caused a 1,000-year flood. The flooding and power outages were experienced across middle and west Tennessee. Rainfall across western and middle TN totaled 10-15", with areas to the south and west of greater Nashville, along the I-40 corridor, receiving 18-20". This resulted in rapid rise of the Cumberland River and its tributaries. The swollen river crested at 51.86 feet on Monday evening, May 3. The governor further declared 52 of Tennessee's 95 counties as disaster areas. As a result of the event, TN suffered 26 confirmed fatalities due to associated tornadoes, flooded homes, and roadways. Most reported deaths involved people getting swept away in cars. Numerous nursing homes, apartment complexes, and residences were evacuated due to rapidly rising waters and flash flooding (Deborah et al. 2013).




**Slide 111. Tennessee Flood Evacuation Decision-Making**

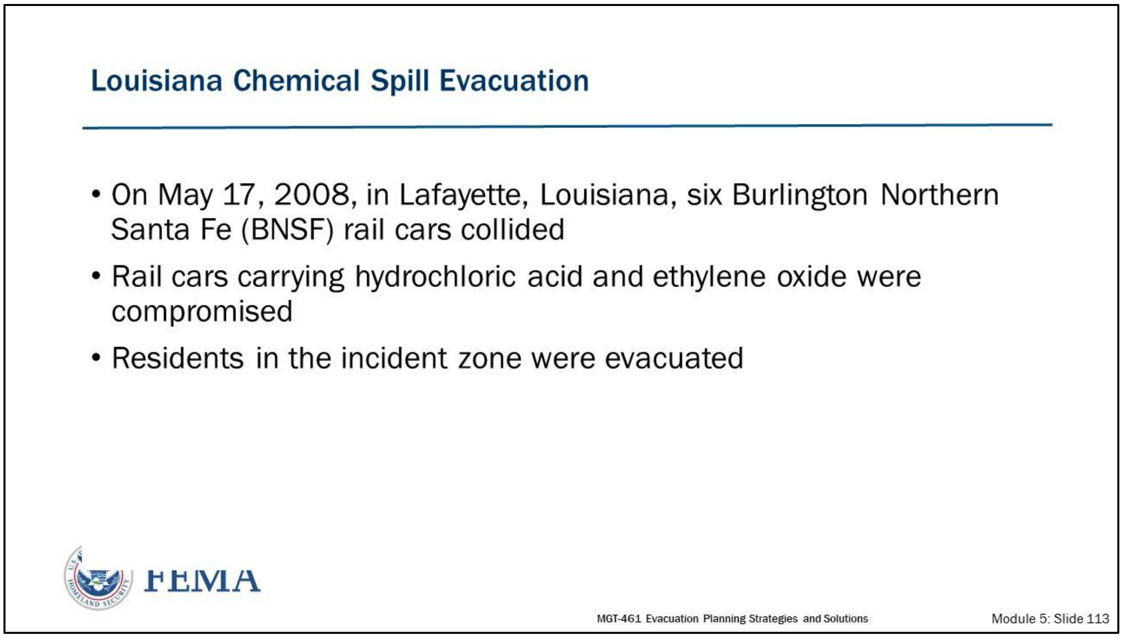
National Guard soldiers from the 1176th Transportation Company were deployed in middle TN to assist local agencies in rescue operations. Water and helicopter rescues were performed as flood waters inundated hundreds of roads. Many residents lost all their possessions as homes were destroyed or sustained major damage.

Nearly 1,500 guests at the Gaylord Opryland Resort, located alongside the Cumberland River, were also forced to evacuate. They were taken by bus to a high school located on higher ground. Overall bus service in Nashville was suspended because the system’s headquarters were severely flooded. The Trousdale County Jail was evacuated, and people from that jail were transported to Wilson County. The American Red Cross in Nashville sheltered ~2,000 people across TN with ~1,200 of them in Nashville. There was no reported lack of boats or buses, but there was no mass evacuation. All residents were able to be relocated and everyone self-evacuated as they saw the water rising (Deborah et al. 2013).



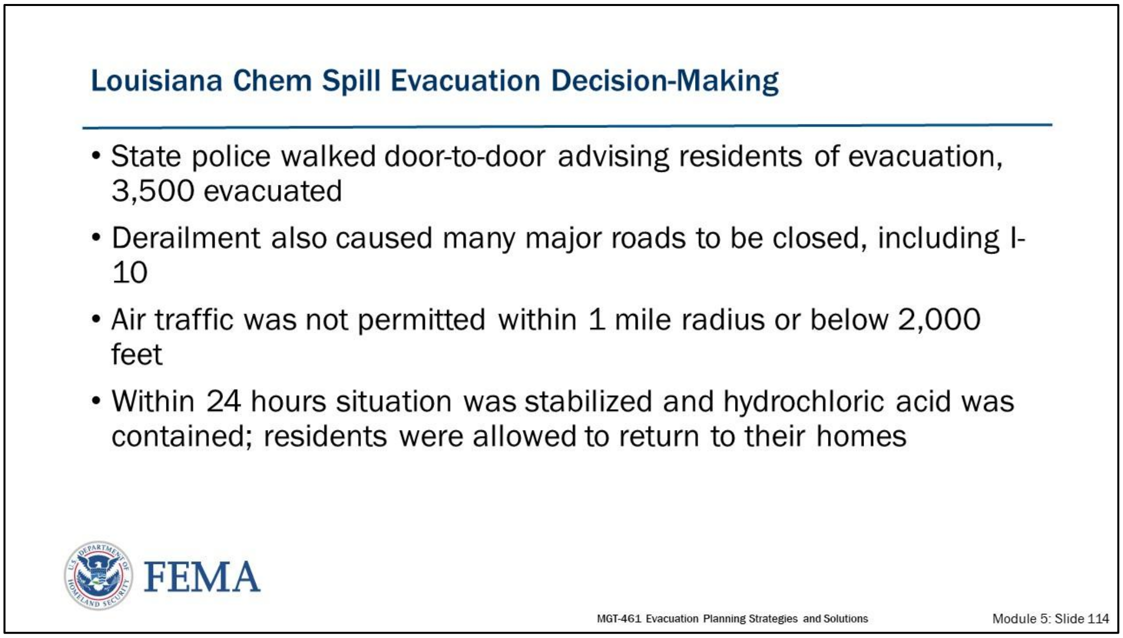

**Slide 112. Chemical Spill Hazard Characteristics**

Hazardous materials ("hazmat") are chemical, biological, or radiological substances that, if released or misused, can pose a threat to health or the environment. These most common hazmat releases are due to transportation incidents, although releases at fixed facilities are common as well. Hazmat is shipped daily on the nation's highways, railroads, waterways, and pipelines, so a community may be at risk without any chemical plants or other fixed facilities. Facilities are easier to plan for, as the location is constant and hazmat quantities and types can be identified on advance; large sites are required to report maximum and typical quantities to state and local authorities (typically via a local emergency planning committee – LEPC), along with containment and mitigation resources and plans, and worst- and likely-case planning scenarios. Depending on incident characteristics and severity, response may include site control, contamination and control, and decontamination. It also may require evacuation or sheltering in place for the area immediately and potentially affected by the incident.




**Slide 113. Louisiana Chemical Spill Evacuation**

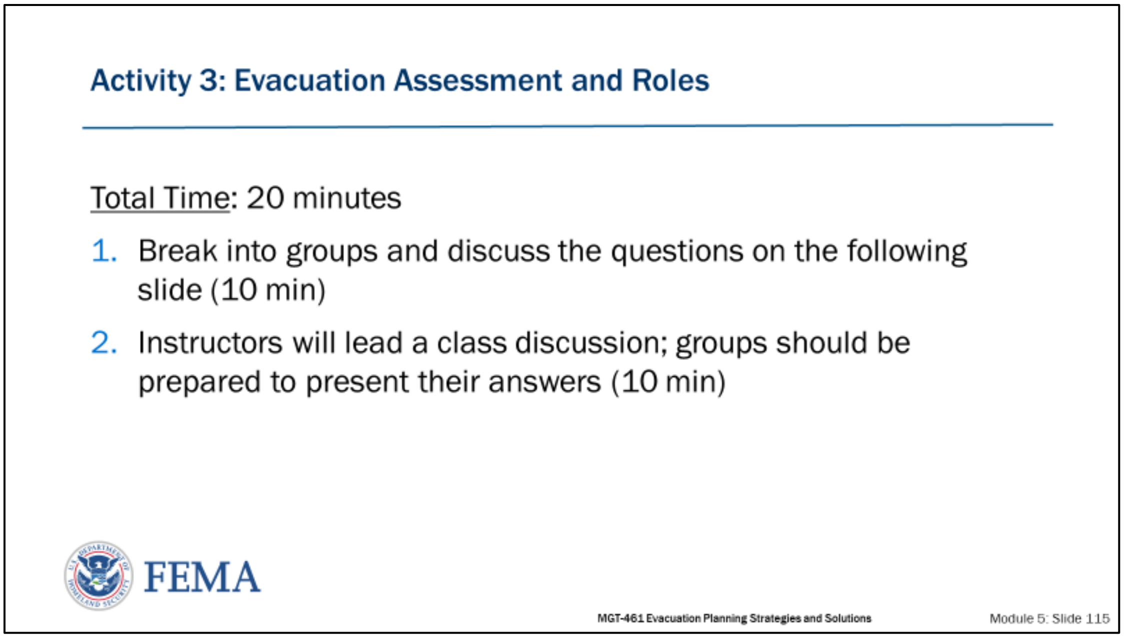
On May 17, 2008, in Lafayette, LA, ~125 miles west of New Orleans, emergency responders ordered an early-morning mandatory evacuation after six BNSF rail cars collided. Two of the rail cars carrying hydrochloric acid and another carrying ethylene oxide were compromised and created an explosion hazard along with a potentially toxic plume. The Incident Commander immediately ordered evacuation from the affected and at-risk zone (Deborah et al. 2013).



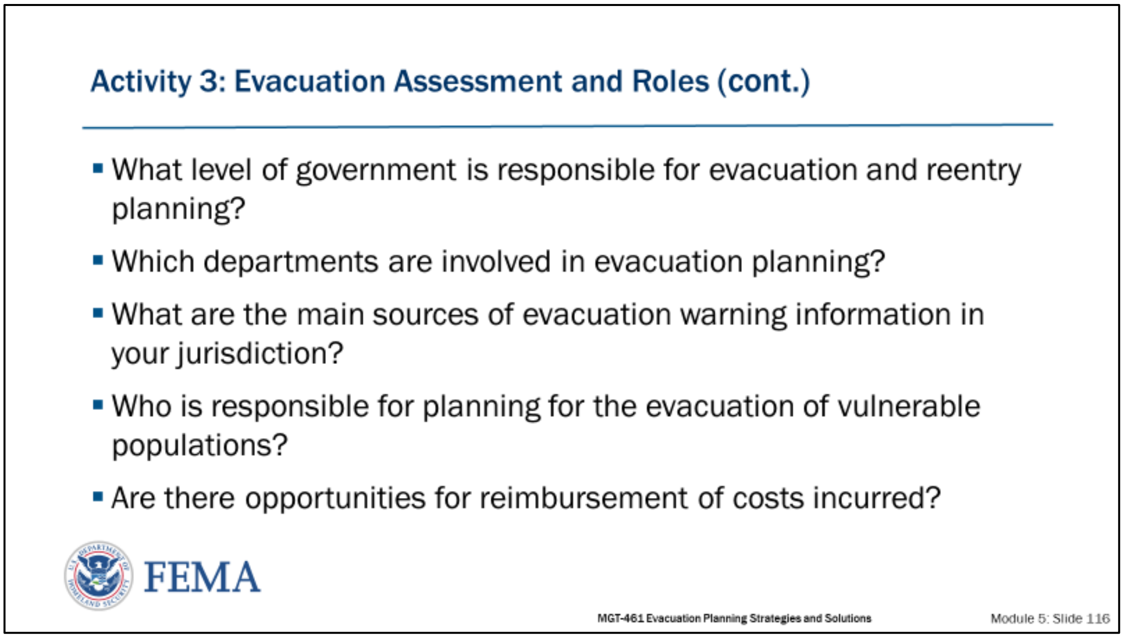

**Slide 114. Louisiana Chem Spill Evacuation Decision-Making**

State police walked door-to-door advising residents of the evacuation and recommended that they take enough supplies for 48-hours. There were no reports of assisted evacuations; however, among these mandatory evacuees were 161 residents of a nursing home who did need to be relocated to safety. This included 35 residents deemed too frail to travel who were taken to local hospitals to wait out the danger.

The derailment also impacted many local businesses. The release forced them to close during the derailment and subsequent clean-up. State police also reported that five people, including two railroad employees, were taken to the hospital and treated for eye and skin irritation. Air traffic was not permitted within the one-mile radius and within a ceiling of 2,000 feet. Once the situation was stabilized and the acid was contained, residents were allowed to return to their homes. This occurred within 24 hours of the initial event. All affected people were reimbursed for food and hotel expenses by BNSF (Deborah et al. 2013).

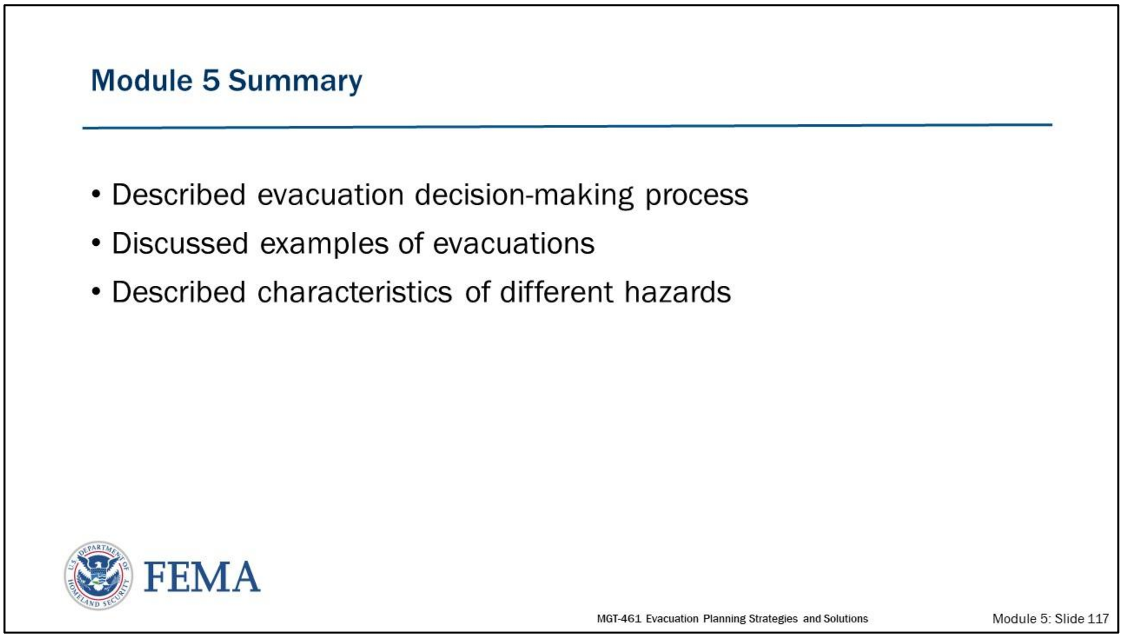



**Slide 115. Activity 3: Evacuation Assessment and Roles**




**Slide 116. Activity 3: Evacuation Assessment and Roles (cont.)**

## Module 5 Summary




**Slide 117. Module 5 Summary**

In this module, participants:

- Described evacuation decision-making process;
- Discussed examples of evacuations; and
- Described characteristics of different hazards.

# Module 5 References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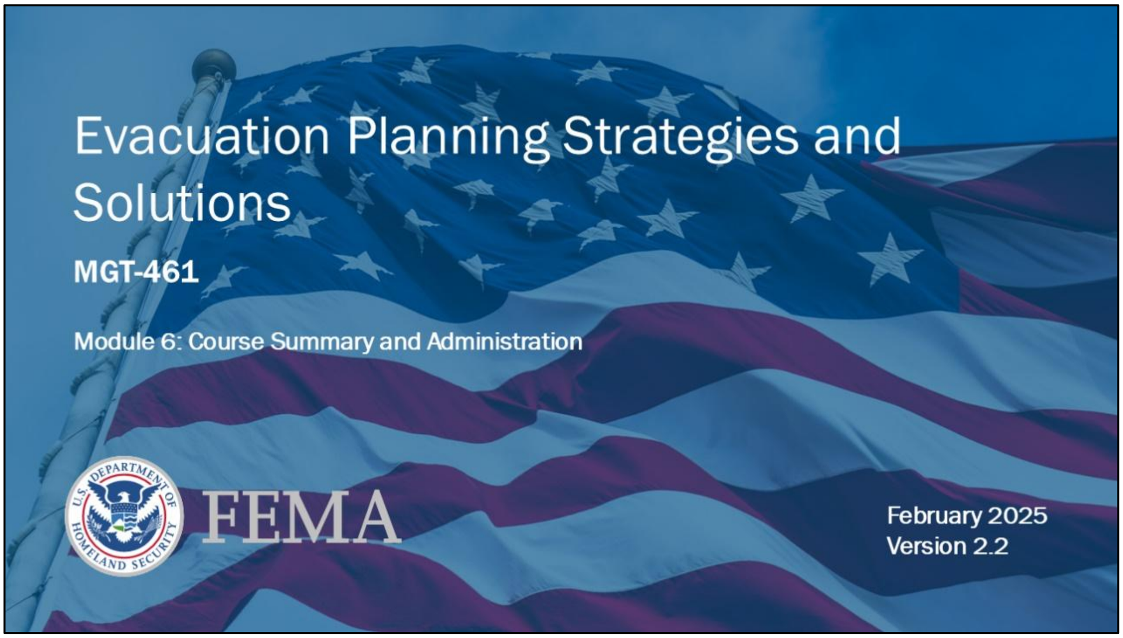
# Module

# 6

# Course Summary and Administration

# Module 6 Administration




**Slide 118. Module 6: 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.

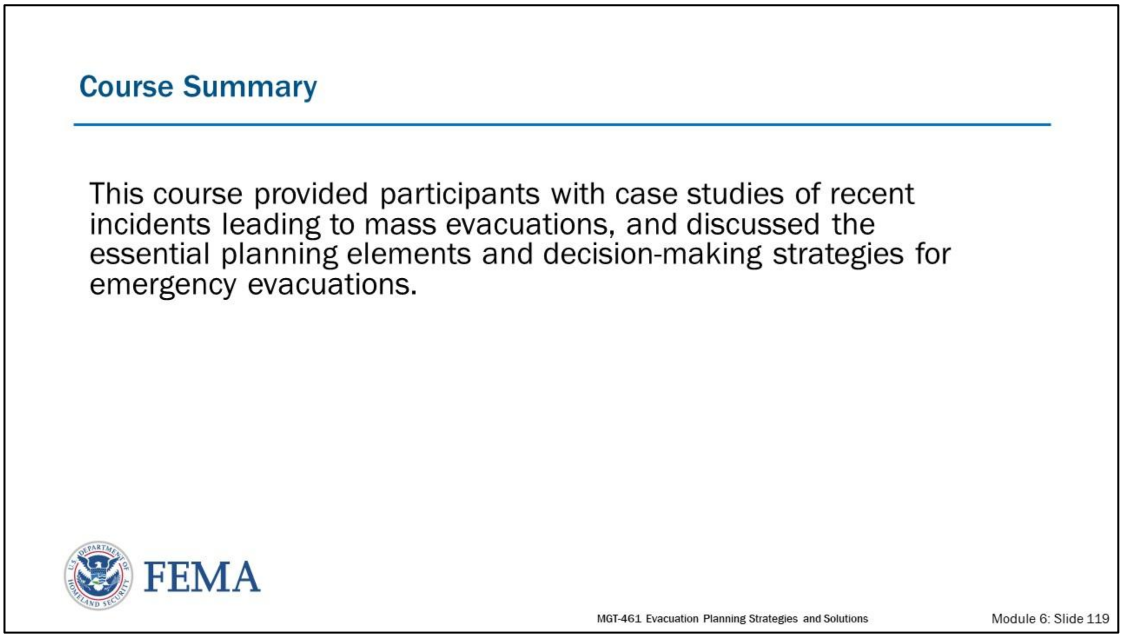
## Terminal Learning Objectives (TLO)

Not applicable

## Enabling Learning Objectives (ELO)

Not applicable

# Module 6 Content




**Slide 119. Course Summary**

This course provided participants with case studies of recent incidents leading to mass evacuations, and discussed the essential planning elements and decision-making strategies for emergency evacuations.


**Slide 120. National Domestic Preparedness Consortium**

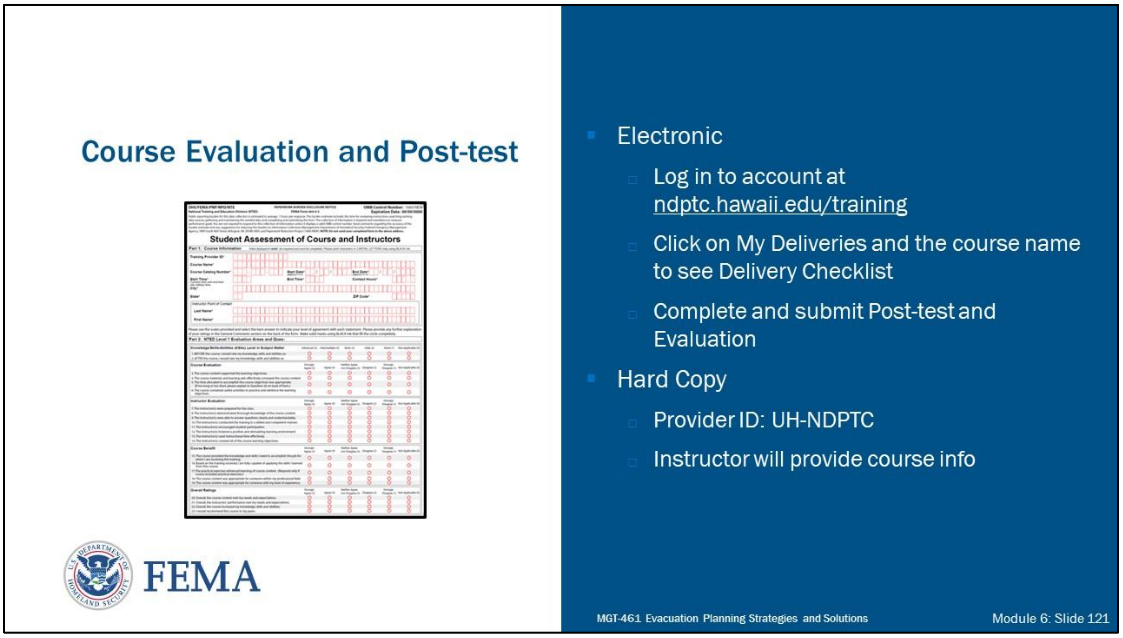
The National Domestic Preparedness Consortium (NDPC) is a professional alliance sponsored through the Department of Homeland Security/FEMA National Preparedness Directorate.

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.

Full NDPC video can be found on YouTube.




**Slide 121. Course Evaluation and Post-test**

Participants are asked to provide constructive feedback on the course material and instruction through a Course Evaluation. Participants will have approximately 10 minutes to complete the Course Evaluation.

This course concludes with a post-test, which allows the instructors 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. Participants will have 10 minutes to complete the post-test and should work independently.

Participants who completed their Course Registration and Pre-test online should complete the Course Evaluation and the Post-test electronically. Participants can access the Course Evaluation and Post-test by accessing their Delivery Checklist:

- Log in to their account at https://ndptc.hawaii.edu/accounts/login/
- Select the course delivery under My Deliveries or Past Deliveries to access the Delivery Checklist

If a participant is unable to complete the electronic version of the Course Evaluation and Post-test, the instructors will distribute a hard copy Course Evaluation Form, Post-test, and Test Answer Sheet.


**Slide 122. Thank you for attending!**

This concludes NDPTC's "Hurricane Awareness" training course. Thank you for attending!

Contact us at:

National Disaster Preparedness Training Center

NDPTC.hawaii.edu

808-956-0600

# Appendix A

# Glossary

**CDP:** Center for Domestic Preparedness

**DHS:** Department of Homeland Security

**EMRTC:** New Mexico Tech's Energetic Materials Research and Testing Center

**FEMA**: Federal Emergency Management Agency

**NCBRT**: National Center for Biomedical Research and Training

**NCERST**: The Transportation Technology Center's National Center for Emergency Response in Surface Transportation

**NERRTC**: National Emergency Response and Rescue Training Center

**NDPC**: National Domestic Preparedness Consortium

**NDPTC:** National Disaster Preparedness Training Center

**NIMS:** National Incident Management System

**NTS-CTOS:** Nevada Test Site/Counter-Terrorism Operations Support

**NWS:** National Weather Service

**TLO:** Terminal Learning Objective

**TRB:** Transportation Research Board

# Appendix

# B

# Activity Handouts

## Activity 1: Preliminary Risk Assessment

1. Select a hazard in your community for which an evacuation may be a protective action.

    a. Hazard:

    b. Hazard characteristics:

    c. Where would you find this information?

2. Estimate the total population that could be affected by the hazard, as a percentage.

    a. Percent of total population needing evacuation:

    b. Identify the vulnerable populations which might need assistance:

    c. Percent that would need assistance with evacuations:

    d. Where would you find this information?

3. What major transportation infrastructures may be affected?

4. What institutional facilities might be affected?

    a. Where would you find this information?

5. What are the animal needs for this type of evacuation?

6. Who has these resources?

## Activity 2: Transportation Capacity Planning Analysis

## Hazard:

| Transportation Mode | Capacity (#) | Seasonal (Yes/No) | Hours Available | Potential Impacts from Hazard |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Activity 2: Transportation Capacity Planning Analysis (continued)

## Hazard:

| Transportation Mode | Capacity (#) | Seasonal (Yes/No) | Hours Available | Potential Impacts from Ha |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Activity 3: Evacuation Assessment and Roles

- What level of government is responsible for evacuation and reentry planning?

- Which departments are involved in evacuation planning?

- What are the main sources of evacuation warning information in your jurisdiction?

- Who is responsible for planning for the evacuation of vulnerable populations?

- Are there opportunities for reimbursement of costs incurred?