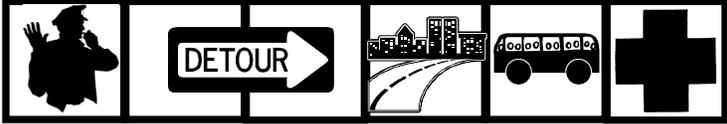


EVACUATION AND RE-ENTRY PLANNING COURSE

APPENDIX A EVACUATION STUDIES



Appendix A Evacuation Studies

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Weyauwega Train Derailment

Background

On March 4, 1996, in Weyauwega, Wisconsin, 35 cars of a Wisconsin Central freight train derailed and a tanker carrying propane exploded, setting fire to nearby buildings. Seventeen of the 35 railroad cars that derailed were also carrying hazardous materials, with 15 of those carrying liquid propane gas. A combination gasoline station, convenience store and feed mill was among those hit by flames.

The smoke drifted over the northeastern part of the city, and was visible as far away as New London, about 13 miles to the east of the incident.

The train was headed from Stevens Point to Neenah when the derailment took place at this central Wisconsin community of about 1,650. Residents of the city of Weyauwega, and the area within a two-mile radius around Weyauwega, were informed that:

- A fire is currently burning along the railroad tracks on the north side of the city.
- A number of tank cars containing Liquid Petroleum Gas under pressure are burning.
- At any time these tank cars could explode.
- The resulting shock wave and fireball could envelop much of the City of Weyauwega, as well as the surrounding area.
- The utilities (natural gas and electricity) have been cut off to the City of Weyauwega, and the surrounding area. This is done in order to limit the potential for more severe fires and explosions if one of the Liquid Petroleum gas tank cars, or other rail cars, blows up.
- The resident is responsible to provide for family pets. When feasible the Wisconsin Army National Guard will provide crews and Armored Personnel Carriers to provide transportation into the anticipated explosion zone to rescue pets.

The Evacuation

1,700 residents left their homes for three weeks. Residents who refused to evacuate, despite knowing these risks, were required to sign a “Waiver and Release and Assumption of the Risk” form; ultimately no one was injured. A majority of those being evacuated went to Red Cross shelters established in schools in outlying communities. Hundreds of citizens and businesses contributed food, shelter, and comfort to the displaced Weyauwega residents.

Weyauwega teachers, support staff and administrators worked to find classroom space elsewhere for 1,400 children. When it became obvious the evacuation would continue for more than just a few days, the school district recommended that children enroll in school districts near their hotels or other temporary housing.

Domestic Animals

Using armored personnel carriers, police and National Guard troops escorted 132 people into the town four days after the train wreck, but only for a few minutes to recover pets left at home, some without food and water. The pet rescue recovered more than 125 dogs, about 150 cats, and nearly 60 other creatures including caged birds, snakes, rabbits, a goat, a pet hog and an iguana.

Assessment

Since each town, municipal, and county emergency agency, department, and facility involved in the evacuation process already had its own evacuation plan in place, the evacuation process was carried out in an organized and timely manner. Each responsible group had a plan that included evacuation procedures for hazardous materials incidents. Because of these plans, each group knew what to do and what to expect from other groups involved in the evacuation process.

Hurricane Floyd

Excerpts from Quick Response Report #128

“South Carolina’s Response to Hurricane Floyd”

By Kirstin Dow and Susan L. Cutter

Hazards Research Lab

University of South Carolina

Note: Hurricane Floyd was a strong Category II hurricane that made landfall near Cape Fear, North Carolina, on September 16, 1999. Hurricane Floyd was huge in size, approximately 683 miles across, drenching 3-4 states at a time. Many coastal counties evacuated during Floyd’s journey up the eastern seaboard of the United States. This evacuation study focuses on South Carolina but has similarities to events that occurred in other southeastern states.

“Ten years after Hurricane Hugo, the largest evacuation in South Carolina history took place. Increased coastal development, tremendous population growth, and high participation rates stressed the evacuation process in unprecedented ways, most noticeably in major traffic jams along I-26. Hurricane planning in South Carolina had more salience and became both a major concern and a source of consternation for agencies and residents alike. Our analysis of evacuation decision making addressed three central topics based on the Hurricane Floyd evacuation experience: residents’ criteria and sources of information for evacuation decisions, factors contributing to traffic congestion, and differences in public and elected official opinions on priorities in planning and what constitutes a successful evacuation.

The overall evacuation rate was relatively high, 64.2% (+/- 4.2%) in coastal counties. Responses of coastal residents and longitudinal research with Horry County residents suggest that the severity of the storm was the most important factor in respondents’ decisions to evacuate. Further, among the experienced Horry County residents, this heightened evacuation rate corresponded to their previously reported intentions to evacuate during future hurricanes. This experienced group considers a variety of information sources and consults regularly with some of them to assist their evacuation decision-making. They also are more likely to turn to the news media than government sources, such as gubernatorial orders.

Once evacuees were on the roads, major traffic pressure developed on the Interstate system. About 63% of respondents carried road maps, yet only 51% used them to determine their route. The majority of South Carolinians traveled out of state to destinations farther than necessary for safe sheltering. This destination aspect of decision-making merits further attention, as the traffic caused by the large number of evacuees from within South Carolina and other coastal states pushed the limits of the infrastructure capacity.

Despite the history of near misses and precautionary evacuations for South Carolina in recent years, over 90% of the respondents felt that given the uncertainties, calling an evacuation was the right decision. Respondents measured successful evacuations according to a number of criteria, many of which are extremely or very important to the majority of the respondents. These concerns were not strongly mirrored by the responses of elected officials overseeing local planning efforts. While traffic issues were a priority for both groups, emphasis on public information was significantly lower among elected officials, but quite important to the information-seeking respondents of this survey.

The survey of coastal residents highlighted a number of important lessons for future evacuations. First, more than 20% of the households took two or more cars, which added a significant number of vehicles to an already stressed traffic flow out of the coastal areas. Second, the public is using information other than evacuation advisories/orders in the decisions to remain in place or evacuate. Third, navigational information and the length of time to reach destinations needs to be improved. Finally, and perhaps most importantly, despite the uncertainty of the storm track and the ensuing criticisms of the evacuation process itself, public support for evacuation as a protective, precautionary strategy is strong.”

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EVACUATION AND RE-ENTRY PLANNING COURSE

APPENDIX B EVACUATION BEHAVIOR STUDIES



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Evacuation Warning

How People Receive Evacuation Warning

In 1988, Sorenson and Mileti summarized data published in reports on 24 disasters, including tsunami, flash flood, hazardous materials incidents, hurricanes and riverine floods.

They found that the number of people to actually receive evacuation warning varied.

- The lowest warning rates (as low as 30%) occurred in incidents of flash flooding such as the 1976 Buffalo Creek West Virginia Flood and the 1976 flash flood in Big Thompson Canyon, Colorado.
- With 3-4 hours, 90-100 percent of the population can be warned without highly specialized warning systems.
- Emergency officials, relatives and friends were primary sources in cases of short warning.
- The media played a larger warning role in events with longer lead-time.

In 1996, Thomas Drabek published a study of evacuation behavior among tourists and other transients, special populations that are often a major factor, particularly in hurricane evacuations. The study included interviews with the following:

- 520 tourists
- 83 business travelers
- 34 migrant workers
- 45 homeless persons
- 69 lodging industry executives
- 76 community officials.

The study produced the following information about evacuation warning:

- Among tourists and transients, media was reported to be the most frequent source of evacuation warning, but they received warning from this source “far less frequently” than residents did.
- Other sources such as “temporary neighbors” and lodging staff were frequently cited as the main source of warning.
- The length of forewarning was shorter for tourists and transients than for residents, and was perceived to lack precision.
- Over a third of the transients who were in locations where mandatory evacuation advisories were issued perceived the instruction as voluntary.

Effectiveness of Electronic Warning Sources

In 1988 Rogers and Sorenson documented the relative effectiveness of six different warning sources for fast developing events like a hazardous materials accident.

- Sirens and alarms prompting people to seek additional information from the media.
- Tone-radio alerts that broadcast a warning message over the radio.
- Automatic dialing telephone systems that hang up all telephones in the system, block out incoming calls, ring the phones and play a warning message.
- A dual media and emergency official system where the Emergency Alert System (formerly known as Emergency Broadcast System) is activated and local officials also go through risk areas to disseminate warning.
- Combination of siren and tone-alert radio.
- Combination siren and ring-down system.

Rogers and Sorenson concluded that no single warning system design is the best for all communities

Evacuation Compliance

Sorenson and Mileti documented a range of evacuation compliance rates from 32 percent to 98 percent.

The belief that an evacuation advisory sends the risk area population frantically fleeing is not substantiated by this research.

- When people perceived themselves to be in a high-risk area the average evacuation rate was 40 to 100 percent. Among persons who perceived their area to be at low risk, e.g. from hurricanes, the average evacuation rate was 25 to 35 percent.

According to this study, people leave when they perceive a sense of urgency.

- In 1979 a chlorine gas leak in Mississauga, Ontario created the need to evacuate approximately 40,000 households.
- Approximately 90 percent of the first group of evacuees from Mississauga left in the first 60 minutes - 60 percent of that group left within the first 10 minutes.
- Data from hurricane evacuations suggests that approximately 20-30 percent of the resident population leave even before an evacuation warning if the perception of high risk exists.

In Drabek's research he found that one-fourth of transients ignored initial evacuation warnings completely and one-third started to leave right away. Drabek found that the following influenced the evacuation behavior patterns among transients:

- Disaster phase - When the evacuation occurs prior to impact (e.g. hurricane), the affected individuals receive more and better evacuation information than when the evacuation occurs after impact (e.g. earthquake). Transient earthquake victims

tended to be unfamiliar with their location, which led to inability to follow evacuation instructions.

- Disaster location - In areas where escape routes are minimal, for example southeastern beaches, tourists and transients tend to depart more quickly toward home. In urban areas transients tended to stay.

Elderly Response to Evacuation Warning

Ronald Perry studied the evacuation warning compliance patterns of different age groups in response to three riverine floods, one volcanic eruption and one hazardous materials incident.

- The study found that the elderly (age 65 or older) either have higher or similar compliance rates than the other age groups.
- In other words the elderly are significantly more like to comply with an evacuation warning, or no statistical difference exists between age groups.
- In the three riverine flooding events, the elderly were more likely to comply with evacuation warning than any group.
- Dr. Perry hypothesized that this behavior may be a function of the positive correlation between age and flood experience.

Dr. Perry concluded, “portraying the elderly as non-compliant with evacuation warnings is simply not correct.”

Repeat Response to Evacuation Warning

Another commonly held concept is that repeated “false alarms” will deter people from complying with evacuation warning.

Kirsten Dow and Susan Cutter studied responses to evacuation orders for Hurricanes Bertha and Fran during the summer of 1996.

- Both hurricanes prompted evacuation orders for portions of the South Carolina and North Carolina coasts.
- Both orders were based on predictions of landfall locations that ultimately proved to be wrong, with landfall in both instances just over the border in North Carolina.
- The study consisted of face-to-face interviews with residents of Hilton Head, SC, Myrtle Beach, SC, and Wilmington, NC.

The data collected in the study indicates that “the influence of unnecessary evacuations for Bertha played only a small role in evacuation decisions about Hurricane Fran.”

- Hurricane Fran was a stronger hurricane and evacuation rates actually increased in Myrtle Beach and Hilton Head.
- South Carolina residents did not expect to change evacuation behavior in the future based on the “false alarms” of Bertha and Fran.

The study found that personal assessment plays a strong role in the decision to evacuate. Individuals considered the following factors:

- Home construction and location
- Family safety and needs
- Data from the Weather Channel on storm tracks, storm strength and probabilities.

Decisions to evacuate were determined by perceived risk as defined by the factors listed above, rather than on the experience in the last evacuation.

While the data collected was useful, it indicated that each community's decision on a warning message delivery system must be based on the nature of the risks and the probability of occurrence.

Evacuation Destinations

Where Evacuees Seek Shelter

Sorenson and Mileti found in the data they studied that between 6% and 36% of the evacuees went to public shelter.

Most (60-88%) of the people in their study sought shelter in the homes of friends and relatives.

Drabek found that transients behaved somewhat differently, depending on the transient type.

- Among migrant workers, 22% went to public shelter, 41% went to homes of nearby relatives, and 12% went to stay with friends out of the area.
- Approximately 29% of the homeless moved into a “makeshift” protected location such as under a bridge and about 49% went to public shelter.
- Most (45%) of business travelers relocated to a safer area within their lodging establishments. Approximately 11% of business travelers went to public shelter and another 11% went home. The remainder moved to another commercial lodging location.

In the FEMA Higher Education course, *The Social Dimensions of Disaster*, the following social factors affecting shelter decisions were identified:

- Relatives nearby who are outside the risk area will be a preferred shelter location.
- Relatives invite family to their homes in a disaster situation even if prior conflict exists.
- If the length of forewarning is short, the options for shelter are reduced, sending more people to public shelter.
- With more warning, people have more options to consider.
- If the evacuation is estimated to be short (one or two days), evacuees are more likely to stay with friends or relatives.
- For longer periods, evacuees are more likely to seek other options for their families, including public shelter and short-term rental.
- When community preparedness is high, public shelters are more likely to be used because the shelters will be better equipped and more appealing to evacuees. Information is likely to be more readily available so that more people are informed about availability and location of public shelters.
- Typically, most families evacuate together, however the type of hazard may affect evacuation behavior. Data from the Three Mile Island nuclear station accident in 1979 indicates that pregnant women and mothers with preschool children had high rates of evacuation, while husbands and older children remained at home.

- Larger communities provide more options for shelter and fewer evacuees will go to public shelters.
- Poorer families are more likely to utilize public shelters because lack of transportation and lack of financial resources may limit their options.

How Evacuees Get to Shelter

According to *The Social Dimensions of Disaster*, most residents of the risk area use their own vehicles when they evacuate.

- Official transportation was the second most likely form of evacuation transportation.

Drabek found that most transients also used their own vehicles to evacuate.

- Rental cars were the second most frequent choice of evacuation transportation for transients.

Disaster research has also shown that the transportation aspect of evacuation tends to be controlled and rational.

- The rate of traffic accidents has not been shown to increase.
- Quarentelli completed research in 1980 that involved 64 different incidents requiring the evacuation of over one million people - only 10 deaths related to the actual movement operations occurred (with seven resulting from one helicopter crash).

During the twenty years since that research was completed, there have obviously been some changes in the population patterns of risk areas. Coastal areas at risk from hurricane effects have become more densely populated.

- During the summer of 1999, thousands were evacuated from the Gulf coast to avoid Hurricane Bret, and thousands more evacuated from Florida to Virginia because of Hurricane Floyd.
- While evacuation routes became heavily congested, particularly in areas where flooding blocked important highways, traffic accidents were not a major problem.
- Some Floyd evacuees did choose to return home to take their chances with the weather rather than the traffic, but they did so in an orderly manner.

Evacuation Behavior of Domestic Animal Owners

FEMA's Independent Study Course, *Animals in Disaster Awareness and Preparedness* (Module A, IS-10), and *Community Planning* (Module B, IS-11), includes the following information about the behavior of pet owners in emergency evacuations.

The following incidents are described:

- After the Three Mile Island nuclear accident in 1979 many misinformed owners left animals to stray, resulting in traffic accidents and overloading of humane shelters and veterinary practices.
- During the evacuation resulting from a large spill of white phosphorus and liquid sulfur in Dayton, OH in 1984, pet owners attempting to rescue their pets created traffic jams by driving in the opposite direction to the evacuating traffic.
- Following the Oakland, CA firestorm in 1991, hundreds of cats and dogs were never reunited with their owners because the owners could not be found.
- After Hurricane Andrew struck South Florida in 1992, many victims were distressed when they discovered they could not stay at public shelters if they brought pets with them.
- During Georgia floods in 1994 some pet owners refused to evacuate in a timely and safe manner because they could not take their pets with them. Others were prevented from attempting to rescue their pets from flooded houses using boats