ORNL/TM-9692

ENERGY DIVISION

EVACUATION DECISION-MAKING: PROCESS AND UNCERTAINTY

Dennis Mileti*
John Sorensen
William Bogard*

*Colorado State University

Date Published: September 1985

Prepared for the
Office of Nuclear Safety
U.S. Department of Energy
Washington, D.C. 20545

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-840R21400

CONTENTS

CONTENTS (continued)

LIST OF TABLES

ABSTRACT

The purpose of this study was to describe the processes of evacuation decision-making, identify and document uncertainties in that process and discuss implications for federal assumption of liability for precautionary evacuations at nuclear facilities under the Price-Anderson Act. Four major categories of uncertainty are identified concerning the interpretation of hazard, communication problems, perceived impacts of evacuation decisions and exogenous influences. Over 40 historical accounts are reviewed and cases of these uncertainties are documented. The major findings are that all levels of government, including federal agencies experience uncertainties in some evacuation situations. Second, private sector organizations are subject to uncertainties at a variety of decision points. Third, uncertainties documented in the historical record have provided the grounds for liability although few legal actions have ensued. Finally it is concluded that if liability for evacuations is assumed by the federal government, the concept of a "precautionary" evacuation is not useful in establishing criteria for that assumption.

1. INTRODUCTION

1.1 UNCERTAINTIES IN EVACUATION DECISION MAKING

The historical record of evacuations clearly illustrates that uncertainties have, on occasion, affected all aspects of evacuation decision making. The consequences of these uncertainties have been varied in past evacuation cases; they range from the insignificant to those contributing toward increased loss of life and property associated with particular disasters. This work has assembled and catalogued uncertainties in the evacuation decision-making process from existing evacuation research.

Research suggests that uncertainties fall into four general categories. First, uncertainties have been documented in reference to how people and organizations interpret threatening situations and their roles in the evacuation decision-making process. Specifically, uncertainties have surfaced to constrain sound evacuation decision making because of interpretation of the hazard, hazard information obtained directly or through others, and in reference to who is to do what as part of the decision-making process. Second, uncertainties in reference to communications have been numerous in the record of past evacuations. Evacuation decision making includes a multitude of different actors and organizations at varied governmental levels. Uncertainties have prevailed in a number of evacuations over whom to communicate with, as well as when and how that communication might occur. Third, evacuation decision makers have, on occasion, been a source of uncertainties themselves;

concern over the impacts of their decisions -- whether these concerns are warranted or are unfounded -- have constrained sound evacuation decision making and been a source of uncertainty in the evacuation decision process. For example, concerns have included fear of public panic, the costs of an unnecessary evacuation and so on. Finally, a set of factors exogenous to the evacuation decision-making process has surfaced to inject uncertainty into decision making; for example, the state-of-the-art in the sciences which are used to predict the impact of a disaster. These four uncertainty categories -- interpretation, communication, perceived impacts, and exogenous influences -- are elaborated on in greater detail in the body of this report.

1.2 THE GENERAL EVACUATION DECISION-MAKING PROCESS

All evacuations are in some ways unique. Nevertheless, each consists of a general set of activities and decision points that are largely common to all evacuations. Common activities to all evacuations, for example, are detecting that a hazard and threat exists for a population; making the decision to alert those who would be responsible for public safety; making the decision that evacuation is the recommended protective action; and carrying the warning and advisement to the public. Obviously, the process includes decision points and communications. Often, formal channels have been supplemented or replaced by informal ones. Occasionally, steps in the process are by-passed.

1.3 PURPOSE

This work describes the steps and processes of evacuation decision making; documents evacuation events, key decision points and relevant actors and organizations which are part of the general evacuation process; and identifies uncertainties that have risen in the historical record of evacuations to constrain sound evacuation decision making and/or evacuation effectiveness. The objectives are then brought to bear for any implications we see for evacuation coverage for liability under the Price-Anderson Act.

2. THE EVACUATION DECISION-MAKING PROCESS

The uncertainties that have risen to affect historical evacuations are clearly better viewed in terms of what aspect of the general decision-making process that they affected than they are viewed on their own. Consequently, this section illustrates and defines the general components, common decision points and processes that are somewhat characteristic of all evacuations. These common points and processes are schematically represented in Figure 1. Key decision points are represented by boxes in the figure, and key linkages between decisions (communications) are indicated by arrows. Uncertainty and ambiguity can exist at each key decision point and at each communication link. The particular actors and organizations involved with each decision, as well as, who actually participates in the communications process will vary given the actual evacuation examined. In some cases, it could be a single actor or agency; in others it could include a diverse set of people, groups, and organizations. The purpose of this section is to define and explain, in a general way, each decision point and linkages between organizations involved in these points in the evacuation decision process illustrated in Figure 1. Examples are also given of the kinds of actors and organizations who would typically be involved in the process.

ORNL-DWG 85-14964

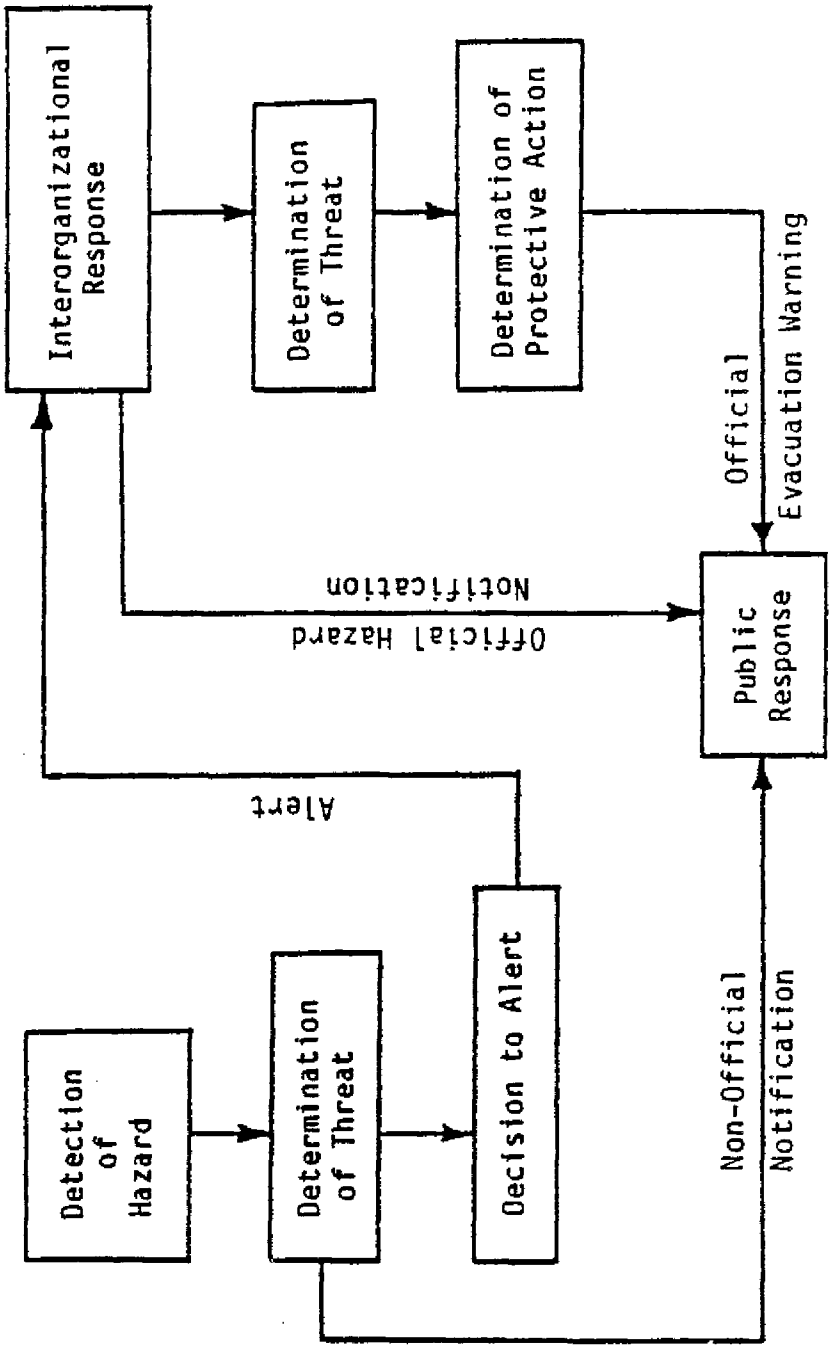

Figure 1. Evacuation decision process

2.1 KEY DECISION POINTS

2.1.1 Detection of Hazard

The initial stage of any public evacuation is the recognition that a particular event or situation constitutes a hazard. In a flood, for example, event recognition may be rain and rising river levels. At a nuclear power plant, it may be a combination of instrument readings and alarms. For an earthquake, it may be unusual animal behavior or swarms of small precursory seismic events. Regardless of the type of hazard, some signs must be read and interpreted to mean that a hazard exists before evacuation is turned to as a possible protective action. Detection may be made by a member of the public (as in the case of a hazardous chemical spill from a truck) or by a complex organization set up to look for and detect hazards. For example, the National Weather Service detects severe storms and tracks hurricanes. The United States Geological Service (USGS) monitors volcanoes for signs of impending eruptions. Some state governments have programs to detect potential landslide hazards. Chemical companies often have monitors at storage facilities to detect releases of hazardous materials.

2.1.2 Determination of Threat

Once a hazard is detected the second key decision in the general process is whether or not it poses a threat to human health and safety. In a flood, this may be defined as waters exceeding flood stage elevations. At a nuclear power plant, it may be defined as some off-site

release. In an earthquake, threat may be indicated by an expected Richter magnitude of energy release and associated shaking intensities in populated areas. Often the determination of threat is done by the same person or organization detecting the hazard; at other times, different actors and organizations may be involved. A private citizen or company of any level of government may determine that a threat exists. The U.S. Geological Survey is, for example, formally charged with issuing hazard watches and must detect and assess threats from geologic hazards. The State of California determines whether or not an earthquake prediction is valid and constitutes a threat to the public. Local governments often must determine whether a derailed train carries hazardous materials. Public and private utilities must determine dose projections in the event of a nuclear power plant accident. Threat determination is judging that an event is or is not hazardous to the public.

2.1.3 Decision to Alert

Once a threat is judged to be a significant one, the detector/assessor must decide whether or not to alert others of the risk and potential damages. Part of this decision includes determining who should receive the alert. In an earthquake, a scientist would need to decide whether or not to make an announcement to the governor or keep silent. For nuclear power plant accidents, guidelines and requirements usually spell out when and who should be alerted. Clearly, for some hazards the alert decision is spelled out in plans while for others it remains discretionary.

2.1.4 Interorganizational Notification

Following an alert, that person or organization receiving the alert must decide which other parties will be involved in the decision to evacuate or implement other types of protective actions. This decision is more important than it may appear on the surface because the number and type of actors involved will affect the timing and outcome of the decision, particularly if a distinct or clear-cut threatening situation is not present.

The actors involved will depend on the hazard, the location and existing emergency plans. In some cases, notification is fixed and automatic; in others, it is largely ad hoc and may depend on who is available at the moment. Often participation emerges during the onset of the hazard with both the formal and informal involvement of actors and organizations in the process.

2.1.5 Determination of Threat

An official decision first must be reached as to whether or not the event poses a hazard to the public. The decision includes determining the magnitude and characteristic of the threat, the locations that would be impacted, and the nature of human exposure to the threat. This decision may be made by a single organization or may be made by a group that forms following the inter-organizational notification.

2.1.6 Determination of Protective Action

Once a hazard is judged to be a significant threat to the public, a decision must be reached as to whether public protective actions are necessary, and what protective action to recommend or implement. This will be determined, in part, by the severity of the threat and the amount of time to its impact. Other factors may also play a role which may not relate to the threat per se. As in the case of threat-assessment, a variety of groups or persons can be involved in this determination.

2.2 KEY COMMUNICATIONS LINKS

2.2.1 Detectors to Officials: Alert

Following the detection of a hazard, information is usually passed on to an agency with emergency powers or responsibilities. This may be a phone call to a police dispatcher, an automatic ring-down to a civil defense director, activation of a tone-alert radio in the mayor's home, and so forth.

2.2.2 Detectors to the Public: Non-Official Notification

Information about the threat may also go directly to the public either simultaneously, before, or after the officials are alerted. The NWS may flash a severe storm warning on television. A person discovering a chemical spill may run door-to-door notifying neighbors.

2.2.3 Interorganizational Alert

This communication link ties together those that will be involved in the official evacuation decision. It may be a series of telephone calls to people on a list in an emergency plan, a siren or whistle in an industrial plant, or informal word-of-mouth communication between people.

2.2.4 Officials to Public: Notification

Prior to a protective action decision, the public may be alerted by officials about an approaching or impending hazard. This alert may be through a media report, activation of an emergency broadcasting system, the sounding of a siren, or interpersonal communications.

2.2.5 Officials to Public: Evacuation Warning

Finally, if evacuation is recommended, officials must inform the public to evacuate and supply them with the details about the evacuation. This may be done over electronic media, with bull horns, or by door-to-door contact.

2.3 AGENCY INVOLVEMENT

A variety of private, local, state, and federal organizations participate in evacuation decision making. The presence, level, and nature of involvement will vary according to the hazard causing the evacuation, the jurisdictional setting and the peculiarities of the event. Table 1 lists agency involvement for generalized evacuation circumstances for

Table 1. Examples of agency involvement in evacuation decision-making

Decision point	Nuclear power plant	Hazard situation		
		Hurricane	Chemical plant	Earthquake
Detection of hazard	Utility	National Weather Service (NWS)	Private company	U.S. Geological Survey (USGS)
Determination of threat	Utility	NWS	Private company	USGS, State Geologists, etc.
Decision to alert	Utility	NWS	Private company	USGS, Governor
Interorganizational Notification	Utility State Highway Patrol	Local NWS office Local Civil Defense (CD)	Local police department	Governor
Determination of threat	State Health Dept., utility, NRC	Local NWS office Local CD	Local CD, CHEMTREC, private company	Board of experts
Decision to evacuate	Utility, State Health Dept., local CD director	Local CD Local mayor	Local CD	Local mayors

four different hazards. These entries are based on legislation, current plans and recent experiences. A review of historical involvement, in general, shows that it is often impossible to predict prior to an evacuation which levels of government and which types of agencies will be involved.

This section has provided a generic model of evacuation decision making and some notion of the agencies involved in that process. The following section will provide a more detailed account of the uncertainties in decisions and parties involved with specific historical evacuations.