FLASH FLOOD WARNING RECOMMENDATIONS FOR FRONT RANGE COMMUNITIES

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT-69

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LETTER OF TRANSMITTAL

The accompanying report, "Flash Flood Warning Recommendations for Front Range Communities," has been prepared to assist local governments in the formulation and implementation of flash flood warning plans. Although the emphasis of the report is on flood hazards in, and at the mouths of canyons, much of the information in the report is applicable to communities in other areas.

The Urban Drainage and Flood Control District is assisting communities within the District in the formulation and implementation of flood warning plans. Communities within the District that are interested in flood warning planning are urged to contact the District. Other communities in Colorado can receive assistance from the National Weather Service, the Colorado Water Conservation Board, and the Colorado Division of Disaster and Emergency Services.

Comments and questions regarding this report will be welcome.

Sincerely,

Scott Tucker

L. Scott Tucker,
Executive Director

WGD/bac

FLASH FLOOD WARNING RECOMMENDATIONS FOR FRONT RANGE COMMUNITIES

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Prepared for the

Urban Drainage and Flood Control District

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The Suggestions contained in this report will, hopefully, help reduce losses from future flash flood catastrophes. They do not necessarily reflect the official views of the District.

INTRODUCTION

Compared with other adjustments to the flood hazard (such as levees, removal of vulnerable buildings, land use regulations), a warning system is a more politically palatable tool for coping with the flood hazard. However, many variables enter into the design of an effective flood warning system. To be effective a warning system must facilitate the saving of lives when a flood does occur. This Report identifies some of the most important variables that must be considered, and offers some specific suggestions for the design of the system. The resources of each community, the number of people exposed to flooding, the nature of flooding, in particular, and the available lead times influence the type and sophistication of the warning systems proposed for local implementation.

This report was prepared as part of a pilot study funded by the Urban Drainage and Flood Control District of Denver, Colorado. That study included 1) an analysis of alternative detection networks for Boulder, Colorado, by Leonard Rice Consulting Water Engineers, Inc. (funded in part by the City and County of Boulder), 2) an investigation of human behavior in the Big Thompson Flood, by Eve C. Gruntfest (1977), and 3) an overview of the warning process, illustrated with four scenarios for Boulder, by Thomas E. Downing (1977).

FLOODS IN THE FRONT RANGE

Floods range from those with a very slow onset, caused by long duration rainfall, possibly coupled with rapid snowmelt at higher

elevations, to flash floods with very short lead times, perhaps less than an hour, caused by intense, short-lived thunderstorms.* In its widest sense, "lead time" refers to the amount of time between the first detection of possible flood conditions and the flood's arrival at a designated location, usually a center of population. Alternatively, "lead time" is used to indicate the amount of time between the first official warning of the flood and its arrival. This can be called the "effective lead time", or the amount of time the population-at-risk has to safely evacuate the area. Lead times are generally shorter in the mountain canyons than on the plains.

The location and rainfall rate of the storm determine which streams flood and the exact timing of flooding at different locations.

Severe floods along the Front Range cause considerable damage. Roads and bridges may be washed out, impeding traffic and isolating areas. Residential, governmental, commercial and industrial buildings in the flood plain may be damaged or destroyed. Numerous cars are likely to be caught in the flood's path. Side gulches may flood, causing damage to structures well above the main stream. Mudslides, landslides and rock falls may also take their toll. The flood waters moving at high velocities undermine the stream banks; as the water slows down east of the canyons, a large amount of debris is deposited.

The highest risk to life is in developed areas of the canyons. In these areas the water is deeper and faster than elsewhere.

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*Although this report deals with naturally caused floods, many of the findings are applicable to floods caused by dam failure.

Although the flood waters are slower and shallower east of the canyons, a severe flood also endangers lives in the flatter parts of the flood plain, particularly developed areas where the streams leave the canyons.

THE POPULATION EXPOSED TO FLOODING

Those who live in flood-prone areas, and workers and visitors in the flood plain when a flood occurs form the aggregate population-at-risk. The total numbers of people, and their vulnerability to a flood vary according to the season, day of the week and time of day. Figure 1 shows the relative variations in vulnerability of the population-at-risk and relative likelihood of a flash flood event.

Flash floods are most likely to occur in the late afternoon or early evening from late spring to early fall; at those times more tourists and visitors are in the flood plain. Many of these visitors are unfamiliar with the flood hazard. The most vulnerable time of day is during the evening rush hour, when normal traffic problems would interfere with evacuation. Although late at night fewer people are in the flood plain, many may be sound asleep. There may also be fewer emergency personnel on duty at that time. A warning system must recognize these problems.

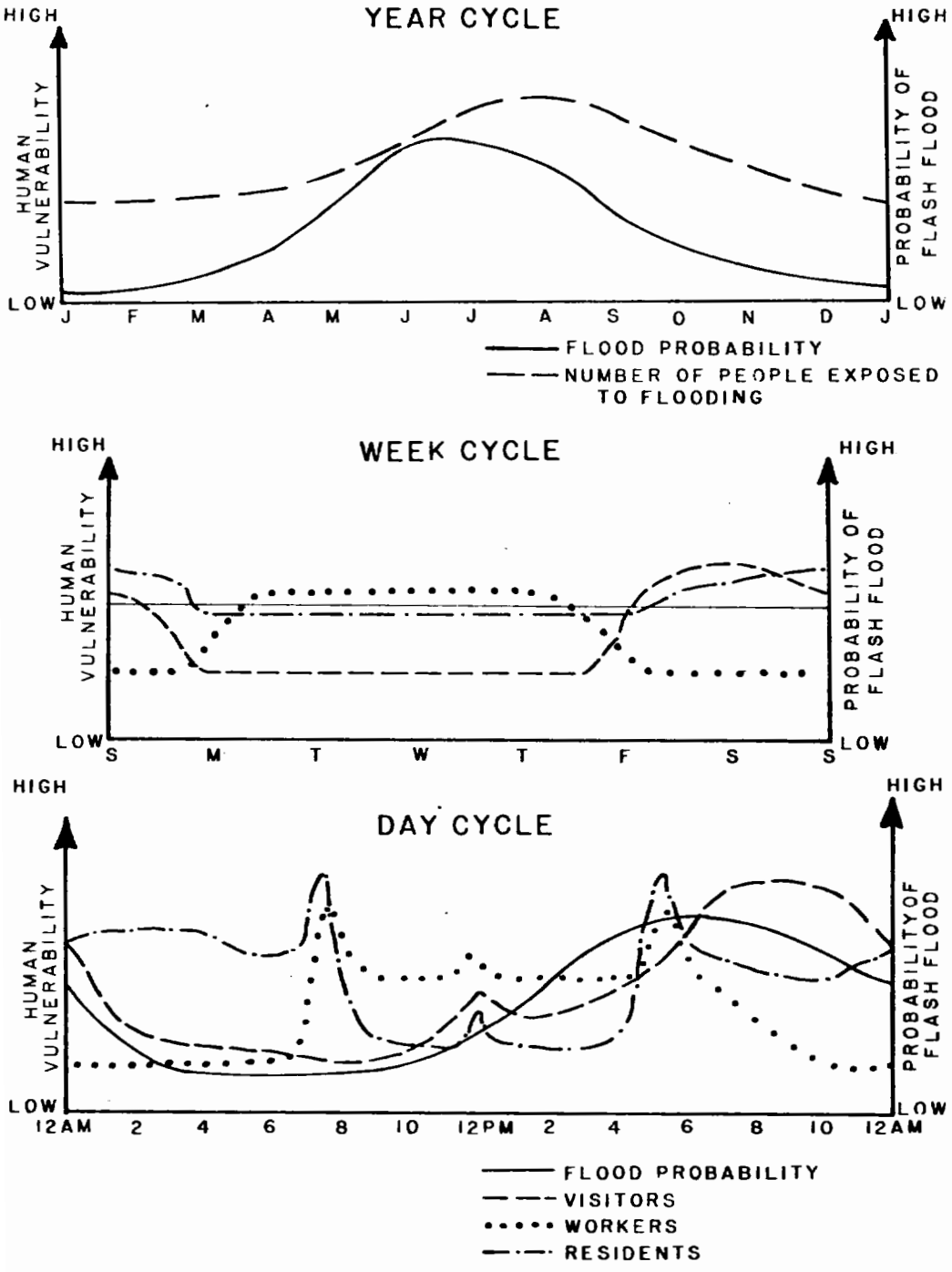

FIGURE 1. PROBABILITY OF A FLASH FLOOD AND HUMAN SYSTEM VULNERABILITY. Based on observations for Boulder City and adjacent canyons.

THE WARNING SYSTEM

There are three primary benefits from a flood warning system: 1) fewer lives lost; 2) fewer injuries, with those treated more promptly as hospitals and emergency personnel are warned and prepared; and 3) possibly, less damage to the contents of buildings, especially in a slow flood. Gas and electricity can be turned off. Depending on how much time is available between the first warning and the flood's onset (the "lead time"), some of the contents of buildings, including office equipment and records, furniture, and personal papers, can be either removed from the flood plain or elevated above the flood's expected height. With longer lead times, and with prior planning, openings in stronger buildings can be sealed shut. Cars and other vehicles can be driven out of the flood plain.

The implementation of an effective flash flood warning system necessitates certain costs for

conceptual planning of the system,
detailed hydrologic and engineering studies,
drafting a preparedness plan,
flood detection hardware, purchase and installation,
communications hardware, purchase and installation,
maintenance of equipment,
personnel to coordinate warning responsibilities,
public information costs,
revisions of the preparedness plan, and
drills, simulations, and training programs.

Some of these activities represent initial investments and some need to be funded on an annual basis. Federal or state agencies may assume some of the costs. The planning of the warning system should include representatives from the involved agencies and the public. Appendix A summarizes the steps involved in planning an effective warning system.

Although an effective warning system is complex, it can be simply modeled (see Figure 2). An alert may be issued predicting the potential for meteorological conditions conducive to flash flooding. The flood-producing storm is monitored by the detection network. With information provided from the detection network, the warning agencies must formulate the warning messages and disseminate them to the users, i.e., the population-at-risk. The population's response to the warnings of imminent danger determines the efficacy of the warning system. Each component of the process will now be discussed, with special attention to variables that influence the system's effectiveness.

Alert of Potential

Warning agencies may be alerted by the National Weather Service or private meteorologists of the potential for flash flood-producing storms to develop over the region. The agencies can then "gear up" to monitor the storm if and when it occurs.

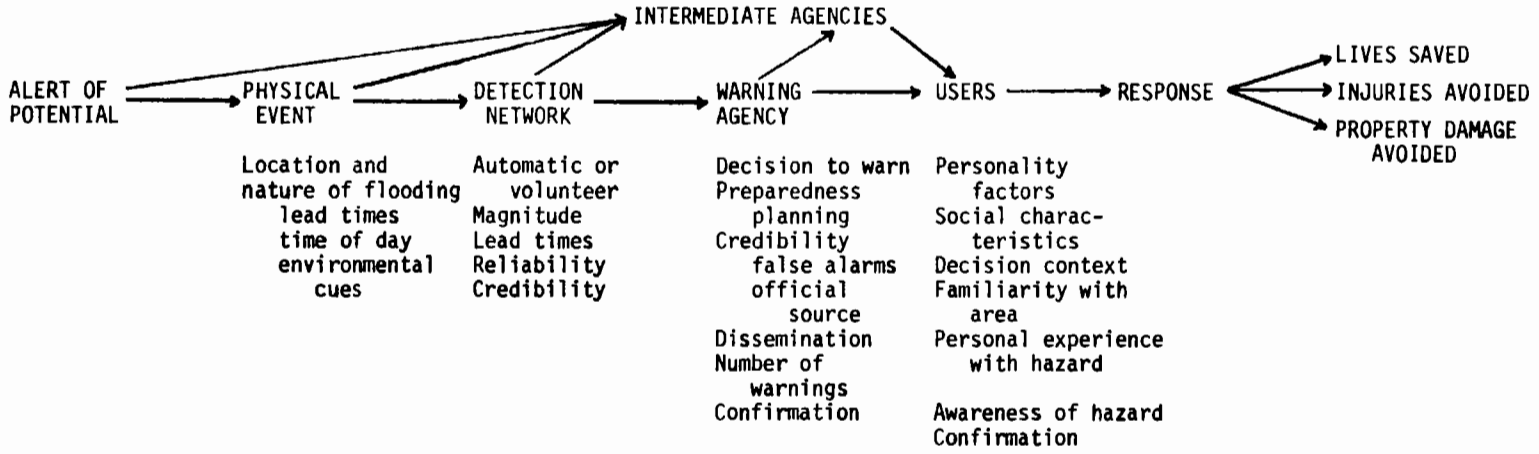

FIGURE 2. THE WARNING SYSTEM
(Adapted from a model by
Gilbert F. White.)

The Physical Event

The nature of flooding in the Front Range has been discussed above. The physical event determines the magnitude of the flood, its location, the time of day when it occurs, the speed of onset, and the presence of environmental cues. The awareness of environmental cues, such as heavy rain or a rising river, may prompt people to evacuate, particularly if they have learned to recognize nature's warning (Mack and Baker, 1961).

The Detection Network

The detection network is the system of radar, rain and river gages, and weather and flood observers that is responsible for predicting and monitoring a flood event. The National Weather Service and the sheriff's department are typically involved in this network, aided by the police and fire departments and Civil Defense and volunteer observers. In a flash flood situation along the Front Range, the National Weather Service cannot be relied upon to give a timely warning, due to the short lead times and lack of data. Procedures for detecting a flood should be established at the local level in cooperation with the National Weather Service. The detection network should be designed to provide an adequate amount of time (about 45 minutes, minimum, if possible) between the first warning of a flood and its impact on a designated population center.

A detection network may include automatic rain and river gages and flash flood alarms connected to a central, continuously manned communications center. Radar may provide the earliest indication of a

possible flash flood situation. Several cities or counties may join together to operate a local radar station that could provide better coverage than the National Weather Service's Limon station. Such a station might also benefit local farmers and the highway department in monitoring other severe weather patterns. Several entities might contribute to the support of such a radar unit.

The automatic network should be supplemented with volunteer observers. In some locations, the volunteers may be relied upon in place of the automatic network. In either case, the volunteers must be organized so they will know when and to whom to report heavy rain or a rising river or reservoir. (The observers need to know how much rain or stream rise is significant enough to report to the emergency flood coordinator.) One method of monitoring the observers' interest is to require them to record daily rainfall amounts on preprinted postcards to be mailed to a designated office at the end of each month. Those who do not send in their postcards can be contacted to freshen their interest. These reports will also provide a detailed hydrologic record. Acknowledgement of observers' reports in news releases during or after the flood will help to maintain their involvement.

After detecting a potentially serious situation, the central agency coordinating the detection network must make some estimate of the flood's expected magnitude (minor, moderate, severe; or keyed to flood elevations above the streambed) and the lead times. These estimates can be adjusted as more information becomes available. The National Weather Service can provide charts which correlate, roughly, rainfall and flood threat. The subsequent warning activities will

have to be carried out within the time limits determined by the physical event and the detection network.

Two aspects of the detection network are particularly important: 1) the system must be reliable; 2) the prediction must be credible. Although it is best to err on the side of safety, if too many false alarms are issued, subsequent warnings of imminent danger may not be heeded (Anderson, 1970).

The Warning Agencies

The prediction of a flood is transmitted to the agencies responsible for formulating the warning message and disseminating it to the population-at-risk. The agency responsible for predicting the flood may also be responsible for warning the public. Involved in issuing and disseminating warnings may be the sheriff, police and fire departments; Civil Defense; volunteer emergency groups; radio and TV stations; citizen's band and ham radio groups; and other government and private groups or individuals. With so many people involved, warnings need to be transmitted accurately between agencies. In an emergency, rumors can be easily started. The first reports of an imminent flood threat must be confirmed to insure an accurate warning.

The lead warning agency must decide whether or not to warn the public. Several levels of warning may be used: 1) an alert notifies the appropriate emergency personnel of the potential danger (but is not disseminated to the public; 2) a watch is disseminated to the public and indicates meteorological conditions are conducive to a flood

event; and 3) a warning tells everyone that flooding is imminent or occurring. If the lead time is short, the warning may not be preceded by both a watch and an alert.

To issue alerts, watches and warnings effectively, procedures and criteria must be established before an emergency exists. Effective decision-making in a flash flood situation is related to the extent of preparedness planning. An emergency plan must be formulated and kept current and should be practiced yearly, at a minimum. Situations such as faulty telephone lines, blocked highways and absent officials need to be considered. A list of steps to be taken in a flood emergency is provided in Appendix B.

Warnings from official sources encourage a more adaptive response than those from unofficial sources (Drabek and Boggs, 1968; Mileti, 1974). The content of warning messages should include:

* mention of who made the prediction if that person is known to be credible;
* an appropriate sense of urgency;
* the most accurate estimate of the size of the expected flood possible (minor, moderate, severe; or elevation above stream bed) relating it to known landmarks and historical flood heights;
* an estimate of when the flood will arrive;
* specific instructions about what to do, where to go and how to get there (including the location of safe and vulnerable areas);

number of warnings issued in that particular area;

confirmation of the threat from other sources, e.g., the mayor;

examples of others taking adaptive actions;

mention of environmental cues, if present; and

advice to stay clear of the hazard zone to reduce convergence problems.

If there is sufficient time, the warnings can encourage emergency flood-proofing measures. In the canyons, safe evacuation should be emphasized. The messages could be in two parts. The first, a concise warning including the items starred, could be easily repeated. Subsequent messages could incorporate the more detailed descriptions of the threat.

Sample messages are given in Appendix C. A standard form can be prepared, with only a limited number of words to be filled in during the emergency. If each agency had copies of the standard form, warnings from different sources would be more similar in content. Increasing degrees of specificity are desirable as more becomes known about the flood.

Warnings disseminated through personal communication modes, such as telephones, bull-hornes, loudspeakers, and face-to-face, are more effective than those received through impersonal modes (Drabek, 1969). Although sirens are often misinterpreted they may be useful in campgrounds and mobile home parks, and at night when many are asleep. The warnings should be disseminated through as many channels as available. Two-way or tone-alert radios can be particularly useful. Large establishments (schools, factories) should be directly linked to the warning dissemination network.

If a false alarm should be issued, the warnings will have to be cancelled or modified as soon as the lack of danger is realized. Favorable news coverage, highlighting what might have happened, will help minimize the effects of issuing a false alarm.

TYPICAL BEHAVIOR IN A FLASH FLOOD

A number of behavior patterns have been found to be typical in a flash flood.

Panic is not typically a widespread phenomenon. It tends to be confined to individuals trapped by the flood with no escape route open (Quarantelli, 1964). Apathy is a more likely initial response.

People will normally try to confirm the warning of imminent danger by calling officials or friends, or checking to see what their neighbors are doing. In Rapid City, less than 20% of the people evacuated after receiving the first warning. Subsequent warnings are needed to confirm the previous messages (Mileti, 1974).

Many people will warn others of the danger. Although not always reliable, the unofficial, unplanned communication networks spread the warning.

Convergence on the danger zone by volunteers, onlookers, and families trying to reunite before evacuating is common. The resulting traffic tie-ups may seriously hinder evacuation if they are not controlled (Drabek and Stephenson, 1971). Early placement of officials to watch the traffic and blockade the streets, if necessary, is desirable as are radio and television messages telling people not to enter the hazard area.

Telephones may be overloaded by people checking on the safety of friends or relatives (Drabek and Stephenson, 1971). Operators must be advised to connect calls by emergency personnel.

Driving out of the hazard zone seems to be a first impulse in many cases, especially when the weather is inclement. In the canyons this may be fatal. There, the proper action is to climb the side of the canyon. Those who stay where they are are most likely to die. A good rule is, "Always keep yourself between the rising water and high ground." Trying to cross the river is extremely dangerous. The force of the water and its rate of rise are often underestimated. It may be difficult to tell if bridges or a roadway are washed out, especially at night.

PUBLIC RESPONSE TO WARNINGS

A number of characteristics of the population exposed to flooding influence how they respond to the warnings of danger. Certain personality traits have been related to warning response. However, these are difficult to incorporate into the design of a warning system, and are not discussed here.

People of middle age and middle socio-economic levels have been found to be more likely both to receive a warning and to respond in an adaptive manner. In several disasters the elderly have made up a disproportionately high percentage of the victims (Mack and Baker, 1961; Hutton, 1976). Where there are high concentrations of elderly, special arrangements for evacuation should be made.

The context in which the evacuation decision is made influences response. Families tend to respond in a more adaptive manner than other groups; this is probably related to a greater sense of responsibility between members of a family (Drabek and Stephenson, 1971). The attitude of peer groups is also important. In one motel on the Big Thompson, the proprietor showed little concern about the rising river. Evacuation then had to be accomplished by knocking a hole through the ceiling because the outside staircase was under water. One of the visitors led the way (Gruntfest, 1977).

The presence of environmental cues, such as heavy rain or a rising river, lends credence to the warnings (Mack and Baker, 1961).

Familiarity with the flood-prone area may include the knowledge of safe locations for evacuation. Experience with floods is related to knowledge of the area. Experience with only minor floods may inhibit an adaptive response to a major flood; this is expressed in the statement, "The water

never got that high before." On the other hand, in the Big Thompson flood, one family which had been in Rapid City during the 1972 flood promptly climbed the side of the canyon when warned of the coming flood (Gruntfest, 1977).

Public information, one of the more important aspects of a warning system, can be used to expand the population's experience of the hazard. Education efforts need to be conducted at frequent intervals, particularly where the population turnover is high. Possible methods of heightening awareness of the flood hazard are:

signs in strategic locations warning people of the hazard and what to do in a flood situation;

markers showing the height of historic floods, or the expected height of the 1% (100-year) and 0.2% (500-year) floods;

markers showing the boundaries of the designated 1% or 0.2% flood plain;

signs showing evacuation routes and procedures;

brochures distributed through the mail, by sheriff or police officers, other public agencies, or volunteers, as a part of real estate sales or leases, and available in public locations;

hazard advisories printed on state travel maps;

news media coverage, including a short television movie on the flood hazard; and

talks to schools and citizen groups.

Some of the information measures can be included with other adjustments to the flood threat or to other hazards, such as fire, landslide, and avalanche. Scenarios can be used to heighten awareness of the flood threat and to illustrate how various warning systems may function in an emergency. The public information efforts will be more widely accepted if citizens, realtors business interests and politicians are involved in the early stages of planning for the flood hazard.

OUTCOME OF THE WARNING EFFORTS

How people respond to the warnings of the flash flood determines the numbers of deaths and injuries. In a slow flood, particularly, some property damage can be avoided. However, in areas where the risk to life is greatest, warnings should emphasize safe evacuation. Evacuation routes should not cross streams. Many people have lost their lives trying to cross flooded roads or bridges.

Flash floods have axacted a high toll in recent years: 237 dead in Rapid City, South Dakota in 1972; 139 dead in the Big Thompson canyon in Colorado in 1976; 9 in El Dorado Canyon, Nevada in 1974. Property damage has totaled hundreds of millions of dollars. At the same time, the numbers of people and buildings occupying flood-prone areas continue to increase.

A number of Front Range communities face serious flood hazards. The Colorado Geological Survey has identified the flood-prone areas of Colorado. The top ten on their list of potential flood disaster locations are (areas named include tributaries):

1. Boulder Canyon, Boulder County
2. Bear Creek, Jefferson County
3. San Miguel River, San Miguel County
4. Arkansas River from Parkdale to Salida, Fremont and Chaffee Counties
5. Animas River near Durango, La Plata County
6. Fountain and Monument Creeks, El Paso County
7. St. Charles River near Beulah, Pueblo County
8. Clear Creek and Tucker Gulch, Jefferson and Clear Creek Counties

9. Grand Junction Area Tributaries, Mesa County

10. North Fork of the Gunnison River, Gunnison and Delta Counties

Other canyons with serious flood hazards include South Boulder Creek, Lefthand Creek, Big Thompson Canyon and Poudre Canyon. A number of other communities are also subject to flooding, as are numerous undeveloped areas. Continuing development of vulnerable locations increases the potential for disaster. In the absence of an effective warning system, many residents, workers and visitors may get no warning of the danger.

Despite the sophistication of the detection network, if planning for the flood hazard does not include careful consideration of warning dissemination, of warning content, and of other variables that influence response to warnings, the system may fail its major purpose: safe evacuation of vulnerable areas. In the next flood's wake there will be destruction. Can we afford not to be prepared?

BIBLIOGRAPHY

Anderson, William A.
1970 "Tsunami Warning in Crescent City, California and Hilo, Hawaii." Pages 116-124 in National Academy of Sciences, The Grest Alaska Earthquake of 1964: Human Ecology. Washington: National Academy of Sciences.

Downing, Thomas E.
1977 Warning for Flash Floods in Boulder, Colorado. Natural Hazards Research Working Paper 31. Boulder: University of Colorado Institute of Behavioral Science.

Drabek, Thomas E.
1969 "Social Processes in Disaster: Family Evacuation." Social Problems 16, #3, (Winter): 336-349.

Drabek, Thomas and Keith Boggs
1968 "Families in Disaster: Reactions and Relatives." Journal of Marriage and the Family 30 (August): 443-451.

Drabek, Thomas E. and John S. Stephenson, III
1971 "When Disaster Strikes." Journal of Applied Social Psychology 1, #2: 187-203.

Gruntfest, Eve C.
1977 What People Did During the Big Thompson Flood. Natural Hazards Research Working Paper 32. Boulder: University of Colorado Institute of Behavioral Science.

Hutton, Janice R.
1976 "The Diffeerential Distribution of Death in Disaster: A Test of Theoretical Propositions." Paper presented at the Joint Meeting of the Society for the Study of Social Problems and the American Sociological Association, New York City.

Mack, Raymond W. and George W. Baker
1961 The Occasion Instant. National Academy of Sciences, National Research Council Disaster Study #15. Washington: National Academy of Sciences.

McLuckie, Benjamin F.
1970 The Warning System in Disaster Situations: A Selective Analysis. Research Report #9. Columbus, Ohio: The Ohio State University Disaster Research Center.

1973 The Warning System: A Social Science Perspective. National Oceanic and Atmospheric Administration.

Mileti, Dennis S.
1974 A Normative Causal Model Analysis of Disaster Warning Response. Unpublished dissertation. Department of Sociology, University of Colorado.

1975 Natural Hazard Warning Systems in the United States: A Research Assessment. University of Colorado Institute of Behavioral Science.

Mileti, Dennis S., Thomas Drabek and J. Eugene Haas
1975 Human Systems in Extreme Environments: A Sociological Perspective. Boulder, Colorado: University of Colorado Institute of Behavioral Science.

National Oceanic and Atmospheric Administration
1971 Arizona Floods of September 5 and 6, 1970, A Report to the Administrator. Natural Disaster Survey Report 70-2. Rockville, Maryland.

1976 Big Thompson Canyon Flash Flood of July 31-August 1, 1976, A Report to the Administrator. Natural Disaster Survey Report 76-1. Rockville, Maryland.

1977 Flash Flood Preparedness Planning Guide. By H. James Owens. (Forthcoming from the National Weather Service).

Quarantelli, Enrico L.
1964 "The Behavior of Panic Participants." Pp. 68-81 in D. P. Schultz (ed.) Panic Behavior. New York: Random House.

White, Gilbert F.
1939 "Economic Aspects of Flood-Forecasting." Transactions of the American Geophysical Union.

1964 Choice of Adjustment to Floods. Department of Geography Research Paper #93. Chicago: University of Chicago Press.

1966 Flood Hazard Reduction and Flood Plain Regulations in Boulder City and County, Colorado. Report requested by Planning Department, City of Boulder and County Planning Commission, Boulder.

Williams, Phillip, Jr., et al.
1972 Flash Flood Forecasting and Warning in the Western Region. NOAA Technical Memorandum NWS WR-82. Salt Lake City, Utah.

APPENDIX A

DESIGNING AN EFFECTIVE WARNING SYSTEM

The National Weather Service can provide assistance in planning a warning system. The key steps are to determine the following:

What is the nature of the flood hazard in this area?

- size of expected floods
- delineation of flood plain
- probable lead times to key areas
- location of population-at-risk
- location of safe areas and evacuation routes

What are the existing resources in the community available for flood warnings?

- flood prediction and detection
- possible flood emergency coordinators
- warning dissemination and evacuation and capabilities
- resources for emergency flood proofing (in a slow rising flood)

How can the existing resources be organized and improved to provide the desired level of warning?

- radar facilities
- automated rain or stream gages
- volunteer observers
- communications equipment
- preparedness plans
- public information programs

How will the warning system be maintained to ensure its continuing reliability?

- updating names
- revisions
- practices

APPENDIX B

ELEMENTS OF THE WARNING PROCESS

This is a partial list of the activities that might be included in a warning system. A complete list could include identification of responsible officials for each decision.

PRE-FLOOD ACTIVITIES

- Public Information
  - post signs indicating:
    - height of historic floods
    - evacuation routes and procedures
  - prepare and distribute local brochures
  - prepare regional brochures and distribute
  - require warning on state travel maps
  - enact hazards disclosure law or agreements
  - solicit news media coverage of hazard
  - incorporate hazards curricula in school
- Emergency Preparedness
  - prepare detailed flood plans and distribute to each involved official
  - conduct periodic practices
  - update plans periodically
  - stockpile appropriate emergency supplies

PREDICTION OF FLOODING

- Monitor Weather with Radar
- Obtain Precipitation Amounts
  - automatic rain gages
  - volunteer observer reports
- Obtain River Stage Data
  - automatic river gages
  - volunteer observer reports
- Assess Expected Magnitude of Flooding
- Assess Expected Lead Times
- Confirmation of Rainfall, Flooding

NOTIFICATION OF OFFICIALS OF POSSIBLE FLOODING

- Fire Departments
- Sheriff and Deputies
- Police
- Local Hydrologists
- Radio Personnel
- TV Stations
- Ambulances

Search and Rescue Groups
Parks and Recreation Personnel
Highway Departments
Public Works Personnel
City Manager, Mayor
Hospitals
Military
Relief Groups
Emergency Communications Groups

FORMULATION OF WARNING MESSAGE

*Mention Who is Giving the Warning
*Degree of Urgency (Alert, Watch, Warning)
*Expected Magnitude, Related to Known Landmarks
*Expected Lead Time
*Proper Actions
*Location of Safe Areas
*Evacuation Routes
Number of Warnings Issued in Area
Confirmation of Flooding from Other Sources
Reports of Others' Taking Adaptive Action
Reference to Past Floods, Here or in Other Areas
Emergency Flood Proofing
Precaution Against Convergence

EVACUATION DECISION

Exact Areas to be Evacuated
canyons
city
county

WARNING DISSEMINATION TO PUBLIC

Methods
radio
phonecalls
loudspeakers
Civil Defense sirens
television
door-to-door
sirens on patrol cars, emergency vehicles
tone alert radios
Special Warning To
commercial establishments
theaters, restaurants
hotels, nursing homes

*Indicates items that should be included in first warning messages.

Close Highways
Bridge Clearing Patrols

POST-FLOOD ACTIVITIES

Notification of State and Federal Agencies
relief groups
Federal Disaster Assistance Administration
Governor
President
Urban Drainage and Flood Control District
Department of Housing and Urban Development
Corps of Engineers
United States Geological Survey
State Geological Survey
Federal Insurance Administration

APPENDIX C

SAMPLE FLASH FLOOD WARNING MESSAGES

FLASH FLOOD ALERT (Time & Day) NOT FOR PUBLIC RELEASE

The (warning agency) reports possible flash flood conditions for (communities and canyons). Report severe weather and change in stream level to (communications center). This is an alert of possible flooding, intended for emergency personnel only. Stand by for more information.

FLASH FLOOD WATCH (Time & Day)

The (warning agency) has received numerous calls reporting heavy rain in (storm area). Residents and visitors of (communities and canyons) should be ready to evacuate these areas if the stream continues to rise. Collect your valuables and emergency supplies. If the stream does flood --climb immediately to high ground, do not try to cross the stream and do not try to drive out of the flood.

This is not a warning of an actual flood. This is a watch for possible flooding; check the stream frequently the next (several) hours.

FLASH FLOOD WARNING (Time & Day) FOR IMMEDIATE RELEASE

The (warning agency) has received confirmed reports of extreme amounts of rainfall and flash flooding in (communities and canyons). A severe flash flood is imminent. Water at high velocities will be well above the stream bank; the road will be washed

out. Climb to high ground immediately. Do not try to cross the stream and do not try to drive out of the canyon. (other areas) _____ has already flooded. This is your (number of warnings) _____ warning.

(This is an abbreviated message, a longer warning could include specific details of where to go in each area, how high the flood is expected in relation to specific landmarks, when the flood is expected to arrive, when key bridges may become impassable, warnings about reentering the hazard zone or convergence onto the flood plain.)