January 1990

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Quick Response Research Report #42

1990

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QUICK RESPONSE RESEARCH REPORT #42

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This publication is part of the Natural Hazards Research & Applications Information Center's ongoing Quick Response Research Report Series.
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FINAL REPORT
Quick Response Research

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THE ROLE OF EMERGENCY MAPPING IN DISASTER RESPONSE

Maps are a key ingredient in emergency planning for technological disasters. DeLucia (1979) declares that "maps are the fundamental media of communication for planning information." By providing spatial organization of the critical movements in a hazardous event, maps are indispensable tools necessary:

- to coordinate the efforts of emergency groups and services by using a generally accepted model for actions;
- to provide a guide for possible action by the public;
- to aid the flow of resources and services before, during and after an emergency;
- to serve, especially during the event, as the quickest method for locating at a glance all the elements at work in a specific geographic area without having to read large volumes of information;
- to illuminate for emergency managers and for the public the physical constraints of the incident site and the most advantageous choice of actions to take; and
- to serve as educational devices or public relations tools.

Despite the basic role emergency planning maps can play in promoting cross-departmental, cross-agency and cross-jurisdictional coordination of emergency response efforts, review of the cartographic literature revealed few references concerning the use of emergency maps. With support from the Natural Hazards Research and Applications Information Center in Boulder, Colorado, a Quick Response Study investigation of a train derailment in rural Pennsylvania sought to determine what and how many maps were available for use during the emergency and how they were employed. These basic questions shaped the inquiry:

1. What political jurisdictions, government offices, and agencies or private organizations were involved or responded?
2. What kinds of maps were employed by these actors during emergency response efforts?
3. What maps were available for use by the general public and what maps were actually used and owned by evacuees?

The Emergency Event

Map use during a train derailment and subsequent explosive fire was the focus of this research. This technological disaster struck Craigsville on April 22, 1990, at approximately 9:30 pm when 29 cars of a 97-car Buffalo and Pittsburgh Railroad train being pulled by five locomotives derailed on a steep slope in the town. One derailed car carried 2000 gallons of sodium hydroxide, a drain cleaner, but twelve of the derailed tankers held more than 100,000 gallons of crude oil. Over the span of the emergency, four of these tankers exploded, and the coal in numerous open-topped cars caught fire. Caustic sodium hydroxide and particulates from the burning crude oil built a cloud more than a hundred feet high which was kept close to the ground by a temperature inversion. To prevent further dispersal of this cloud, air traffic was forbidden in a 5 mile diameter zone around the accident site. An air advisory was issued warning the elderly, those with respiratory problems and the young to close windows and stay indoors. Fourteen fire companies and five ambulance services under the direction of the Fire Chief of the Worthington-West Franklin Volunteer Fire Company provided emergency services during the first three days of the crisis. The evacuation of approximately 400 residents in the Craigsville area took place the night of the derailment. As stubborn fires continued for two days, threat conditions led to a destructive potential sufficient to cause: fire damage to four homes, extensive contamination of the local water supply, fish kills downstream along the Allegheny River, loss of 12,000 trout hatchlings stocked in Buffalo Creek, a black oil film on structures, health hazards from fouled air for a week or longer and economic loss to several local farm businesses. Two firefighters sustained injuries, but there were no fatalities.

<u>Research Strategy</u>

Two survey questionnaires administered in interviews with emergency personnel and evacuees included questions about residency, educational and career background, map use, map availability and map needs. Followup telephone calls were made to complete 20 interviews with officials and representatives of volunteer agencies and thirty interviews with evacuees. Three foci shaped on-site observations: 1) identifying maps available for use by emergency personnel in the Command Center and in emergency vehicles; 2) determining the extent of map use at the derailment site; and 3) establishing the role of maps in communicating risk to the media.

<u>Research Findings</u>

Results revealed that there was no map showing residences available to guide emergency efforts, and the public was evacuated without the official decision maker consulting a map. Emergency response personnel complained about a lack of maps of the appropriate scale and detail for use in the Command Center and in the office of the Incident Commander, Fire Chief of the Worthington, West Franklin Township, there was not one map on the walls. A USGS topographical map and a General Highway Map, both brought to the Command Center by the Pennsylvania Emergency Management Agency, were referred to, but the impact area was larger than this one USGS quadrangle map showed. Because Craigsville is located near the upper corner of a USGS quadrangle, four USGS topo maps were needed to show all of the land impacted; therefore, even the topo map emergency responders had available to use was incomplete. In his role as water systems manager for Armstrong County, one person used his wetland map of Buffalo Creek to advise Pennsylvania Department of Environmental Resources (PADER) on strategies to protect the surface waters of the area during the night of the derailment.

The Incident Commander directed the evacuation without the use of one map to show the location of residents. Emergency response personnel operated solely from their own mental maps of the area resulting in the application of a system of collective mental maps.

The videotape shot by the fire company's photographer and comments from Craigsville residents point to the dangers of conducting an evacuation without appropriate residency maps. Fire company radio communications captured on the official videotape reveal that emergency personnel discussed street location directions at length. If they had been able to reference identical town maps, less vital time at the peak of the crisis would have been wasted. Evacuee interviews revealed that there were indications two isolated and unusual locations of residences resulted in oversights during evacuation. Had town maps been available, these homes need not have been overlooked. Finally, the fact that this derailment emergency and evacuation were handled successfully was due to the relatively limited area impacted. Had the cloud been more toxic or the fire area larger, the lack of maps for evacuation and control of the physical agent could have had even more critical consequences.

Evacuee interviews revealed the following: 1) no maps other than mental maps were used by the public during the evacuation; 2) nearly one-fifth of the people interviewed, all new residents in the community, said they could see the advantage of having a map available for use during an evacuation; 3) even if they had wanted to use one, thirty percent of the interviewees own no maps at all; and 4) the majority had Pittsburgh and Pennsylvania road maps both in their homes and in their cars. Already published maps were not viewed by the evacuees as essential for emergency evacuations.

"Crisis mapping," a new genre of mapping for decision making and risk communication, was found to exist during this emergency. At least six of the federal and state agencies or companies operating out of the command center prepared hand drawn site sketches to facilitate decision making and risk communication during the emergency. This new type of cartographic tool served various functions. One taped to the wall of the Command Center the morning after the event was used to organize water sampling efforts by the Pennsylvania Department of Environmental Resources. Another crisis map was faxed overnight by the PEMA staff at the Command Center to their Harrisburg office to provide the basis for phone consultations the next day. The most important crisis map prepared during this incident was a sketch of the zigzagged, derailed railroad cars drawn on a 17" x 24" posterboard. The Fire Chief postponed making critical decisions about controlling potential exlosions on Monday until this crisis map was available. At a news conference on Tuesday, this same roughly drawn crisis map provided the chief means for communicating to the media in a news conference the degree of potential risks remaining. Crisis maps were produced by the EPA, NSTB and Buffalo and Pittsburgh Railroad to mitigate and to reconstruct the accident.

A truism that characterizes this disaster is "the closer you get to the incident, the fewer the maps that are available." At the state level in Pennsylvania, a comprehensive computer mapping system provides detailed emergency maps. Part of this mapping capability is a one million dollar "TAGAVAN" that can perform chemical analysis and produce plume maps at the emergency incident site. Conditions in the Craigsville case prevented use of this van. Before the derailment, requests went out to each county in Pennsylvania to submit to the state county data to be incorporated into the statewide Geographical Information System (GIS). This mapped data then became available to individual counties in a form whereby they could add information to produce updated maps. The skills necessary for use of this GIS by county and state employees are still being acquired, and updating of the county data is not yet complete.

Conclusions and Recommendations

In emergency planning, the role of detailed maps in disaster management has been neglected. In the Craigsville case, emergency personnel expressed a strong need for blownup topographical maps and residency maps. By producing crisis maps, they were able to document the details of spatial relationships and the changing elements of the emergency to control and mitigate the consequences of the disaster. In both the response and recovery periods of this technological disaster, crude crisis maps helped emergency managers: grasp the geographic facts necessary to deal with the physical agent, explain risks to the media, document better records of the history of the incident, and reconstruct the disaster to establish what lessons were learned. Crisis mapping is filling a void and should be recognized as a critical part of emergency management that needs to be integrated more fully into planning.

More specific recommendations based on insights gained from this Quick Response research include the following:

1. There is a need for funding to produce local town maps which include residences.
2. The important role of crisis maps needs to be acknowledged by emergency planners so materials for their

production are taken to the sites of technological disasters.

3. To improve the effectiveness of crisis maps, guidelines for their necessary content and design should be developed. This would include standardization of methods for showing accurate locations of sampling sites, tracing dynamic conditions during the event, portraying relationships to other geographical locations and phenomena, and indicating directions and scale.
4. By determining the person who is tasked with drawing crisis maps, training can be provided.
5. Research is needed to establish whether implementation of computer mapping capabilities for crisis mapping in the field is warranted.
6. Emergency mapping, especially crisis mapping, deserves special attention on the part of cartographers, decision makers and emergency managers.

Emphasis was put on the mapping aspects of this incident. For a more detailed report, including analysis of the social factors existing in this community through application of Quarantelli's model of evacuation, a journal article has been prepared and will be supplied upon request.