HAZARDOUS MATERIALS AS SECONDARY RESULTS OF FLOODING: A CASE STUDY OF PLANNING AND RESPONSE

By

Elaine J. Denning

QUICK RESPONSE RESEARCH REPORT #49

1992

FINAL REPORT

Hazardous Materials Hazards as Secondary Results of Flooding: A Case Study of Planning and Response

Elaine J. Denning
March, 1992

This paper was undertaken with support from the Natural Hazards Research and Applications Information Center 1990-1991 Quick-Response program for the project "Hazardous Materials Hazards as Secondary Effects of Flooding: A Comparison of Planning and Response." I would like to extend thanks to everyone who was interviewed for this project, and to Dr. Joanne Nigg for reviewing this paper. The ideas expressed are those of the author and do not necessarily reflect the views of the Natural Hazards Research and Applications Information Center.

CONTENTS

I. Purpose of the Research

One infrequently studied problem in the natural hazards area is the secondary effects of flooding with respect to hazardous materials. During a flood, hazardous materials incidents can occur but may be overlooked because of concerns with the primary disaster impacts. These incidents may occur in a variety of ways. Old hazardous materials "dump" sites may be undermined and chemicals spread by flood waters. The integrity of underground tanks which store hazardous materials (e.g., gasoline or oil supplies) may similarly pose a threat. Barrels of stored chemicals or wastes can be moved by simply floating away and, since many of these containers are not labeled, they may constitute an unknown level of hazard. Unexpected hazardous materials problems could emerge in the post-impact period. Lafornara et al. (1978) cite such hazards in their work on the Johnstown Flood. They show that food distributing facilities may face high bacterial counts and hazardous chemicals if their refrigeration systems fail. Gases may collect in the area, causing explosions. Commercial establishments and households that store chemicals pose another threat. Containers may be damaged in the flood, leaving their contents to leak and mix with other chemicals. Also, gases from ruptured tanks or pipelines could accumulate in sewer systems and cause explosions.

Secondary hazardous materials hazards also occurred during a January, 1992 hurricane. The Sunday News Journal of Wilmington, DE (A-1) reported that, "Rising water caused several heating oil tanks to overflow in Bowers Beach...[Director] of the Delaware Division of Air and Waste Management said crews would begin to clean up the oil soon. Environmental officers were also investigating a report of leaking jet fuel in the water off Port Mahon." This incident reinforces that secondary hazardous materials hazards are a recent and serious concern.

Few studies have been completed on this very important problem regarding the potential secondary effects on health, safety, property and the physical environment. Tierney (1980, 1982) has done work on applying the lessons learned in natural disaster response to hazardous materials response. One factor stressed was that communities should be undertaking a planning process, not generating documents based on "model" plans.

The objective of this study is to examine the organizational response to hazardous materials incidents after flooding with regard to the regulations, procedures, and planning that governed affected localities. The problem was framed in terms of organizational theory. Organizational theory holds that organizational actions are affected by the dynamics of both internal and external (or environmental) forces. Organizational boundaries and constraints act upon the ability of the organization to accomplish tasks. In this paper, I will describe the hazardous

materials hazards that occurred in one case study of flooding and how organizations handled them.

II. Research Questions

The following research questions drove this study:

* Are sites routinely tested after a major flood or is the assumption made that no incidents occurred?

* Are there criteria which determine whether or not tests will be done?

* Must testing be performed within a time limit in order to effectively mitigate damages?

* Are testing materials and equipment vulnerable to flood damage?

* Are there factors that facilitate or inhibit testing?

* Do concerned calls from the public facilitate response?

* Does a lack of accessibility to sites hinder tasks?

* Are the employees who test the sites in the area after the flood to do their jobs?

* Are there higher risks to employees involved in checking sites after a flood than in normal times?

* Must hazardous materials responders obtain clearance to test a site? If so, is the authority which grants the clearance available after the flood?

* At what point do higher officials become involved in the local-level response?

* Is there differential response or attention to different hazardous materials?

* Is the public notified of hazards or vulnerabilities?

* At what point is the public warned or evacuated?

* In normal times, how much attention is given to avoiding floodplains when hazardous materials sites are chosen?

* Is there consensus on what kind of hazardous materials response will take place after a flood?

* Are officials aware of what actions are mandated under laws and

regulations?

* Are those involved in the overall community emergency response aware of or concerned about the hazardous materials risks?
* In the response period, do any sites, situations or practices become problems that were not foreseen in planning?

* How are unforseen hazards handled?

As evidenced from the research questions, this study was intended to examine the nature of the planning and response for hazardous materials hazards after flooding. These questions were designed to explore whether involved parties anticipated potential hazardous materials hazards and viewed them as valid concerns.

III. Methodology

The research strategy suitable for this problem was that of face-to-face interviews conducted with an open-ended interview schedule (APPENDIX A). Contacts in the field were treated as "informants" for their organizations. First, key actors in the organizations undertaking the community response to the flood were interviewed. Agencies in which interviews were undertaken include 1) fire departments, 2) police departments, and 3) emergency management agencies. Interviews with the informants were used to understand the general processes of the organizational response to the flood. Second, interviews were conducted with those who have duties with hazardous materials in normal times, such as those working with environmental regulation enforcement. Such informants provided background information concerning state regulations which governed hazardous materials responses, plus information about the quick-response hazardous materials work that was necessary. In all, eighteen face-to-face interviews were conducted. Lastly, document analysis of plans and records was also employed in order to give greater context and verification to the interview materials.

The following criteria were used to determine the selection of the research site: 1) the locality had sites where hazardous materials were present; and 2) there were hazardous materials responders for the area who were locally based. Field work was undertaken as soon as it was possible to gain entrance into the flooded area. It was important to arrive as quickly as possible. The more time that passes between the event and an interview, the more likely it is that informants have experienced retelling and social constructions of "truth." Since the field work was undertaken quickly, the event was fresh in the respondents' minds.

IV. Description of the Flooding Event

A serious flooding incident in the southern United States occurred in the spring of 1991 and served as the research site for this study. The flooding, due to torrential rain, was mainly confined to one state. The rain ensued for about one month, from early April to early May. Initially, the first wave of rains impacted the northeastern region of the state. One local newspaper in that region reported that 1,371 homes were damaged. Temporary housing costs were expected to be $900,000. By May 10, 1991, the state's major northeastern city had received 44.42 inches of rain, surpassing its average annual rainfall total of 43.8 inches at the earliest date in recorded history. This was very unusual as the city's average rainfall would be 17.2" at that time of the year. A second wave of rains inundated the north central and northeastern regions. A total of 3,913 homes were damaged there. Temporary housing costs for those regions were expected to be $3.5 million. Successively, 17 counties across the northern part of the state were declared federal disaster areas. This enabled residents to apply for state and federal loans and grants for damages. Grants to individual homeowners were expected to total $9.2 million. In total, 5,284 homes were flooded, resulting in an estimated $46 million in damages.

Though the northern part of the state is largely low river basin land that has a substantial history of flooding, this was not just another flood. This event qualified as a one-hundred year flood, as areas that usually do not become inundated were under water. In some areas, it was considered a five-hundred year event. The only comparable event in the northern region occurred in the 1950s, and this deluge surpassed it. Respondents in a major northeastern city noted one particular bench mark of this flood's importance. The river running through the city reached the level of the city's railroad bridge. The river's crest of 50.2 feet had surpassed the record set in the early 1950s. This was seen as proof that the flood was indeed an unusual event.

Compounding the situation in the northeast, a serious explosion occurred at a chemical plant while surrounding areas were still under water. The plant was located on the bank of an overflowing river and was just miles away from flooded communities. The plant was located within the city limits of a small town of 1500 residents, all of whom were evacuated. Chemical contamination of the air resulting from the plant explosion was a prevalent concern and one reason for the evacuation.

Field work investigating the above events was undertaken in early May, 1991. Interviews were completed at different governmental and organizational levels in several jurisdictions across the northern part of the state. In this study, details were obtained about the hazardous materials related incidents that occurred. Further ideas were also explored about incidents that

could potentially occur, but did not, as a result of this case of flooding.

V. Organizations Involved in Flooding and Hazardous Materials Incidents

A brief description of the organizations at this research site that are involved in flooding and hazardous materials incidents is needed for a complete understanding of the response to the events.

The state regulatory agencies are key actors in hazardous materials incidents. Recently, because of high-level political support, the state environmental regulatory agency was created, and drastically expanded upon functions that had previously been undertaken in other agencies. New laws also empowered them with substantial enforcement capabilities. The state environmental regulatory agency is responsible for enforcing pollution regulations and laws on a variety of counts. That agency is divided into several sections that each have a specific function. There is a specific section to control the operation of underground storage tanks, water quality, air quality, solid waste, hazardous materials, and hazardous waste, for example. The agency also employs the quick-response team which responds to hazardous materials emergencies. Members of each section and the quick-response team are located in different regional offices, to ensure good coverage of the state. The agency was active in investigating the hazardous materials emergencies described in the next section and in testing the air and water quality after the chemical explosion. Another state regulatory body, identified here as the state resource conservation agency, enforces controls on oil drilling operations. They establish regulations on how the oil and gas producers acquire their product and dispose of the associated wastes, for example. They, too, operate in different regions of the state.

City and county fire departments have firefighters trained in hazardous materials responses. Departments were involved in the response to some of the incidents listed in this report and were active at the chemical explosion. Fire departments can also be the repository for information required under the federal SARA Title III mandate, the "community right-to-know" law. Companies are required to provide the repository agency with lists of the chemicals they store on-site and a facility emergency plan to be used in case of an incident. In the case of the chemical explosion, the county fire department held the documents.

Police entities at different governmental levels basically perform the same function. They are to provide security to emergency sites such as the flooded areas or chemical plant, in this case. Their mission is also to control crowds and evacuate people. Some entities, such as the state police, have a cadre of

officers trained in hazardous materials response. Those units act as first responders to various kinds of hazardous materials incidents, including spills on the highways. These officers are assigned to each region to ensure coverage of the state.

VI. Hazardous Materials Incidents, Responses and Procedures

Displacement of Underground Storage Tanks

Incidents

Six underground storage tanks (USTs) floated out of their tank holds at four different locations during the flooding. These six incidents occurred in the northeastern region, which contains a total of 3,000 tanks at 1,100 facilities. The northwestern region contains approximately 1,300 tanks but had no incidents. All of the affected locations were convenience stores that used the tanks for gasoline storage.

Such incidents occur when the water table builds up underneath the tank pad. The pad is usually made up of coarse materials such as peat gravel or sand so it acts as a conduit for water. Since gasoline is lighter than water, it also helps the tank float up. As it rises, it pulls the connection lines. This could cause a breakage in the product line and gasoline could be lost to the environment.

The first case involved two tanks that were full of gasoline. They were in the process of being installed and workers were preparing to "tightness test" the tanks. There was only a sandy backfill on the top of the tanks at that point. When the tank pit collected storm water runoff, the tanks popped up. No gasoline was lost. In a second case, a 10,000 gallon tank 15% full of product surfaced. It had only been under earthen cover, so when the roof of a nearby building drained rainwater into the tank hold, it rose. The tank's rise was aided by the fact that it only held 1500 gallons, so it was very light. Fortunately, it did not appear to lose any product. The third case occurred at a facility being prepared for closure. The concrete over two tanks had been broken in preparation for the removal of the tanks and all product had been removed. When the rain ensued, rain water flowed into the concrete hole and both tanks surfaced. Since the tanks were empty, this incident was not problematic. The fourth case involved an 8,000 gallon tank under earthen cover. It was empty except for some possible residual amount of 20-40 gallons. In this case, it is not clear why the tank surfaced since the facility was on a hill above the water table. Possibly, rainwater percolated through the sandy backfill and soil and filled up around the tank. Responders observed that the tank's product line was seriously bent but not ruptured. Still, there could have been some product lost in this incident, as there appeared to be gasoline floating in the water.

Such a conclusion is more complicated, though. The lost product that was observed could have been as a result of spillage and overfill that took place at that tank hold in the past.

Response

A state environmental regulatory agency respondent explained that the tank owner must call the fire marshall's office (because of the fire hazard), the state police, and the UST section of the state environmental regulatory agency (responsible for the clean operation of the tanks) when incidents occur. The regulatory agency initially treats it as an emergency situation, and a field inspector quickly responds to the scene in order to remove the tanks and proceed with closure. That way, if any product is present it can be remediated without serious permanent damage. The inspector determines whether it is an emergency situation or not only after arrival on-site. After the inspection, the owner must contract a pump service company to close out the tank. The owner will usually be familiar with the company as they also install and repair tanks.

Following procedure, the regulatory agency required the closing out of all six tanks. The agency respondent explained, "...what we'll do as part of our routine UST closure procedure is have them do some analytical soil testing from beneath the tanks and that will tell us if we have a problem with contamination in the immediate area." The usual closure process involves 30 days notification, but since these were emergency situations, the process was expedited. He continued, "...most of the tanks have been removed or will be removed in the next day or two." This time frame represents up to about a week after they were reported.

Responders had no problem with accessibility to the tanks because of the flood. The field inspector asked one tank owner the best route to take to get to the site, since some roads were closed because of flooding. Good information was received and no problems were encountered in getting to the facility. Also, the pump service companies were available to work on the tanks, even more so than usual because the bad weather had shut down their current projects. Also, since the four tank incidents were deemed emergencies, the regulatory agency and pump service companies dropped what they were doing and attended to the situations. There were no problems with equipment, which is portable, and could be protected from the floodwaters.

Concerning workload, the regulatory agency respondent explained that, "we're overwhelmed before the flood and after the flood." Low budgets have always prevented the hiring of an adequate number of people to deal with the oversight of an entire region. The flood just exacerbated this normal condition.

Experience, Preparedness, and Mitigation

Most of the state regulatory agency's work is done on a case by case basis. Two agency respondents reported that the surfacing of USTs is a rare occurrence that has only happened incidentally in the past.

Precautions that can be taken before flooding include making sure the fill caps and fittings on top of the tank are tight. A regulatory agency respondent further advises that "sand bags can be placed on top of the tank hold areas, probably some on top of the fill ports and maybe some for ballast. They may put some sandbags around them to try to keep the oil back from around the fill point." He warns that there may be several inches of water sitting on top of the concrete, which is on top of the tanks themselves. The respondent noted that the pump service companies told him that they spoke to their clients about precautions before the flooding. They advised that, "...if you have any facilities that look like they're gonna flood, make sure you do these things, make sure your tank is topped off...and keep your tanks topped off, make sure your fill ports are good and tight, the caps, so you don't take on the oil." The respondent reported that a formal plan for outlining precautions did not exist. He said that the precautions taken were the result of the pump service companies' good thinking about potential problems.

Mitigation can be undertaken in the installation phase by strapping the tank down. Retrofitting the tank once it is in place is very difficult. Strapping the tank is desirable in flood prone or shallow water table areas. A concrete pad is poured at the base of the tank hole. The tanks would then be put in on top of the pad, and metal straps secured across the tank. The tank would then be anchored in place.

Regulation of USTs in Normal times

There are two kinds of USTs, chemical USTs and petroleum USTs, which are both regulated by the state. There are very few (less than 10) chemical USTs in the northeastern part of the state, but many are used by industry in the southern part. Petroleum USTs are used by retail fuel distributers but also by industries, which keep them to fuel their fleet vehicles and generators.

Normally, if a leak is suspected at a UST, a soil sample is taken. If the sample shows contamination and evidence that gasoline or another chemical has filtrated into the groundwater supply, then a site assessment is done. One state environmental regulatory agency respondent explained, "We go out and look at the entire area to determine the extent of the damage. That would involve a series of soil bores to the groundwater table and installation of groundwater monitoring wells. That usually doesn't

occur as a result of tanks floating up."

There is a good working relationship between the pump service contractors and the state environmental regulatory agency. The companies cooperate by reporting leaks from USTs. State law requires that a person aware of a leak from a UST must report it in 24 hours. Anyone can be held responsible for failure to report. The pump service contractors report more leaks than the owners themselves.

In normal times, the major oil companies are the group that is most in compliance with regulations concerning the proper operation of USTs. They want to keep a favorable corporate profile so they stay current with the laws. The ones that are the most affected by the laws are the small company owners, and the individual tank owners. For instance, the "mom and pop" grocery store owners usually aren't aware of the state regulations governing USTs. When the state undertakes a routine inspection of their tanks and finds out they are not in compliance, the owners are usually not aware of the fact. When they realize the costs of upgrading to be in compliance, they close the system down.

Actual and Potential Incidents at Oil Fields Regarding Reserve Pits, Tanks and Wells

The most evident impact from rain and flooding on the oil and gas business is that it slows down. Locations become inaccessible, equipment can't be moved since the ground is soggy, and wells are taken over by water. The rising water causes more of a problem than rain. The northeastern part of the state was investigated for oil well problems concerning hazardous materials. In this area, there were 300 fields, some small and some large, containing 30,000-40,000 wells. Small, independent companies operate these wells, as opposed to the "majors" such as Exxon, Mobil and Chevron.

Responses

The state resource conservation agency for oil fields reported that a few wells had to be shut in because the flooding would make them inaccessible. An agency respondent said that when the operators of the oil wells, the "pumpers", see that the location is getting too wet, they relocate the oil that they have already extracted. This entails trucking out the oil that is usually stored in a 210-barrel tank on the lease. The pumpers usually know the history of their wells, which can be 50-60 years old, and can tell which will be affected by flooding. They know they need to go shut them down and drain the tanks, or put water in the tanks and balance them to prevent them from tipping because of the rising water. Because of the rain, the pumpers were watching for

problems, the resource conservation agency respondent said. He added, though, that some pumpers might not aware of the flooding hazards, and tanks could have toppled over.

The state resource conservation agency had reports of drilling pits and reserve pit muds being inundated. The muds were leaking through natural drainage, but normally are not released into the environment. As a well is being drilled, the cuttings from the earth are circulated into a large pit about 100' x 200' and 6-8' deep. In three instances, flash flood waters in creeks rose above their banks and inundated these pits. Some of the contents flowed out as a result. Most of the products associated with oil and gas are non-hazardous oil field waste. These drilling muds are not as harmful to the environment as are the oil and salt water extracted in the process. Even salt water and oil are considered non-hazardous wastes by the state regulatory agency in this context. Potential hazards are contingent on what else the oil and gas operators are doing in practice, for instance, if they have anti-corrosion well treating chemicals they are injecting into the mud. If a 55-gallon drum containing such a chemical was open, and flipped over and leaked, it could be a problem. It could contaminate flood or ground waters and a cleanup would be necessary. The resource conservation agency respondent noted that smaller operators could have a barrel sitting on the lease and if water got to it, that could happen. A case such as that would probably go unreported, however.

As far as response to the reserve pit problem, once reported, an inspector from the state resource conservation agency will go out and document the case by completing an inspection report. Notes will be made so that next time, a pit won't be located in the flooded area. Initially, when the drilling rig moves into a location, the operator is to assess the best location for the pit. It must be remembered, though, that when there is a one-hundred flood such as this event, there will be pit overflows that were not expected.

The resource conservation agency respondent noted that "I'm sure there are some well heads underwater." A well head might extend 4-8 feet above ground but wells are a closed system that are not prone to leaks at the well head. Oil travels to the surface through lines to the storage tanks. It is a closed system until there is a leak in the tank or the tank flips. A well head submerged is not a problem.

Accessibility to the oil field installations is a problem in flooding events, so it cannot be known if there are spills on a lease. Neither resource conservation agency responders or operators can get to the locations. One environmental regulatory agency respondent notes that it is useful to remember, though, that any leak would be diluted to a great extent by the floodwaters.

Mitigation and Experience

There has been experience with these problems before. Many of oil and gas operators are located near the banks of one large northeast river. One year before the event, in another flood, the river overflowed its banks into an operating area. Two spills occurred, both similar in nature. In one of the incidents, a 210-barrel tank 1/4 full of oil became buoyant and turned over. Between the two tanks, about 20-30 barrels of oil spilled. All tanks are open at the top as a vent, so the contents spilled out the top. There were reports of the oil on the water, as it is noticeable as the oil spreads out very thinly. By the time these incidents are reported, the product is usually down the river and dispersed so there is not much that can be done.

Because of these experiences, the resource conservation agency respondent said that the county emergency manager and he learned their lessons and took action. They taught operators that if there was a threat of high water again, they should either empty their tanks or fill them with water. Water can be added to the oil without separating it, and is needed to weigh down the tank so it sq it does not become buoyant. This precautionary advice was spread through the resource conservation agency's file room. As the operators came in, they were told to do these procedures. There is good rapport between the agency and the operators, and they frequently go over procedures. For instance, the agency respondent noted that in the event of an oil or salt water spill, the operators know that the resource conservation agency and the state police must be contacted.

Interruption of Cleanups in Progress

Flooding and heavy rain interrupted the following ongoing hazardous materials cleanups in progress.

1. Mitigation at a Boat Dock Cleanup

One cleanup operation that was disrupted involved a gasoline line leading to a boat dock that had sprung a leak. The leak occurred on the edge of the lake and the soil had to be excavated as it was contaminated with gasoline. So far in the operation, the line was excavated. Workers had already started to remediate that area by removing and replacing the line and removing the contaminated soils. When the rain began, the lake started to rise. The operation had to be delayed because of the high water, which flooded the area that was excavated. That is where the job stood as a state environmental regulatory agency respondent replied, "until the lake begins to subside." Precautions were taken to avoid any further damage to the site. The area was barricaded with

a petroleum absorbent boom to prevent any gasoline from reaching the lake.

2. Interruption of a Battery Acid Cleanup

There was another incident where severe weather increased a hazardous materials hazard, although there was no flooding involved. The ongoing cleanup involved a vehicle that was carrying a load of electrical storage batteries for electrically operated vehicles such as golf carts and go carts. The acid that was leaking from the batteries was of concern. Any water that hit the affected area could cause dilution of the battery acid and contaminate runoff. Fortunately, because the cleanup had progressed far enough, that situation did not occur. The job was virtually complete before the bad weather struck.

The bad weather halted the cleanup for about 30 minutes. Everything was very quickly secured and workers returned to their vehicles to check the weather report. Fortunately, the worst part of the storm did not go through the area of the cleanup. The crew got back out and finished the cleanup.

Concerning the initial response to the incident, the quick-response hazardous materials team, contractors, and other responders did not experience accessibility problems when responding to the site.

Airplane Hanger Event Resulting from Heavy Rains and Wind

A weather-related hazardous materials incident took place at a local regional airport. Due to winds that were between 85 and 90 mph, one of the hangers collapsed. Some of the aircraft that were trapped inside had to be removed in an environmentally safe manner, so that no fuel was allowed to leak.

Parties moved to avoid a potential leak. A contractor was called to remove the craft. Also, fire departments and the state hazardous materials quick-response team were notified. The operation was very tedious because of the bad weather, which continued throughout the process. The operation was completed without any environmental impact. One respondent from the quick-response team suggested that luck was on their side, as the outcome could have been worse. Since the weather had gotten so bad, most of the cleanup crews in the area around the airport had stopped working. That meant that they were available to respond to this particular situation. Another benefit was that there normally is good coverage for environmental cleanups in this area by private companies. One particular crew kept on working and finished the job in a safe manner. There was no problem with workers not being

able to respond to the site. The company was able to quickly get to the location without any accessibility problems, and was even there before the hazardous materials quick-response team.

Inundation of Landfills as a Result of Flooding

The northwestern region contains at least 8 landfills and 75-100 surface impoundments (operated at industrial facilities). There were problems with the inundation of one landfill which accepts industrial and municipal refuse, but not hazardous waste. The problems arose because of rain water rather than rising flood waters. There was no problem with accessibility to the site, and two people from the state environmental regulatory agency, one from the solid waste section, the other from the water quality section, inspected the landfill at different times. The piping at the site was not adequate to remove the eight million gallons of water that were entering. The storm water came in contact with cover material in two cells of the landfill, but not with waste. A six foot boom was laid to segregate the contaminated water. Permission was granted to use a portable pump to discharge water off-site. Whenever a landfill or surface impoundment deviates from their discharge permit, they must notify the water quality section. In this case, an accidental discharge permit was granted by the water quality section.

The state environmental regulatory agency's solid waste section has only permitted these landfills and surface impoundments to include flood standards for 5 or 6 years. Approval for design and construction must be granted by the section before the facility is built. This is the only time that precautions can be taken. The facility must employ structural mitigation to withstand inundation from a twenty-five year or one-hundred year flood, depending on location. The regulations also state that the plan for the facility must be signed by the Core of Engineers to ensure that it is not located in a flood prone area. In the past, the regulatory process halted the construction of one landfill because it was found to be in a flood prone area. Routine inspections also help keep the facilities in check. All landfills are inspected quarterly, while surface impoundments are inspected semi-annually. Unfortunately, as changes in drainage occur from increased development of roads and neighborhoods, facilities may flood. Usually such changes are gradual and the effects can be recognized before a major incident occurs.

Inundation of Sewage Systems and Wastewater Treatment Plants

Several municipal sewage treatment systems were inundated by the flood. They were the source of most of the sewage problems.

Refineries which operate their own wastewater treatment systems and have treatment ponds on-site were also inundated by flooding. Since their ponds are located at the lowest elevation on the plant grounds to ensure flow by gravity, they are easily flooded. A number of spills occurred at one refinery, which had a history of flooding after heavy rain.

Calls to the state environmental regulatory agency water quality section from residents concerned about water contamination doubled or tripled during the flood, a respondent in that section reported. Tests for drinking water contamination from sewage are mainly the responsibility of the state health department (as addressed in the next section), but the water quality section also checks the waters. The section planned to investigate the situation during their next regularly scheduled check, instead of an emergency check. Accessibility problems due to closed roads were preventing water quality personnel from getting into some of the flooded areas right away.

Precautions to be taken for the sewage and wastewater problem are few. One water quality section respondent commented that there was not much one could do about the problem except to document that it had occurred. He noted that there is little that can be done, "not when they're inundated 7 feet." It wasn't justifiable or possible to "spend double the money" to protect sites that may not even be in such a rare one-hundred year flood. He did mention that the formulation of a plan for downstream sampling of floodwater could be useful. Concerning municipal sewage treatment problems, another water quality section respondent noted one precaution that can be taken so sewage stations are not overrun. In some low areas, manholes have been elevated so water cannot invade them as quickly.

Possible Contamination of Wells

Trailer park and individual wells were inundated by floodwaters. When distribution lines become washed out as they did in this flood, they must be repaired, chlorinated and flushed. Also, water samples must be taken. Owners were advised on how to flush the wells, a task that can only be done when the water goes down. Some areas were inaccessible, so the department had to wait a few days to follow up on complaints. The state health department issued voluntary boil orders for several areas.

Past experiences with such inundation have taught the health department how to effectively carry out boil notices. The department now also issues information on food cleanup and health tips during the flooded conditions. The department also attends civil defense department meetings to be updated on preparedness. In the past, there has been no hazardous materials interaction with wells due to flooding, but a spill of hazardous materials has

entered a well system without flooding present. In that case, the wells had to be closed and new wells drilled. A state police respondent warned that there is always the possibility of harmful chemicals in the soil drifting into wells, so they must be monitored if there is a concern.

Inundation of an Automobile Junkyard

During the flooding, there was a problem with a wrecking yard going under water. The gasoline left in vehicle tanks was spilling out of the wrecked cars. Originally, when the cars are brought into the yard, all fluids are not drained. The oil plus whatever gas is left in the tank is still in the car. If the gasoline cap is removed, when the floodwater inundates the yard, it fills the tank and the gasoline is released. The gasoline is lighter than water, also, so that aids its distribution. A respondent from the state environmental regulatory agency water quality section noted that they would have to address that problem in the future as at present, it is an unregulated activity.

Potential Release of Transformer Fluids in Floodwaters

During the flooding, a resident called the state environmental regulatory agency and reported that a transformer had been hit by lightening. A transformer and pole fell on a property adjacent to the home of the caller. The caller was concerned that the water that was washing across their yard might contain contaminated material. The power company involved took care of the incident quickly and there was no problem with a loss of fluids from the transformer.

The resident was correct to anticipate such a hazard. It is not unusual for a transformer to be struck by lightening, and the problem with the release of PCB fluids is possible. In this particular region, the majority of transformers have been remediated in that all of the PCB contaminated transformer oils have been removed. There are some older transformers still in use, though, that still have the old configuration. Nevertheless, the power company would check all transformers that are involved in such incidents.

Potential for Transportation Related Spills of Hazardous Materials

1. Barge Accidents on Waterways

A state police respondent warned that barge incidents should be expected in times of heavy rains and river rise. In the past,

there have been such barge incidents in the northeastern region, but none occurred in this flooding event. The respondent described an incident where a barge ran into bridge pilings and was turned over in the river. A city fire department respondent reported an incident where a barge that was carrying ammonia struck a bridge. There were some problems with what jurisdiction was responsible for such an incident on the river. After the event, the county civil defense director discussed the plan again, which clearly stated jurisdictional responsibilities. This was done so it would be clear what jurisdiction would act as the primary responder in a future incident.

As this case suggests, there could be a hazardous materials/oil spill associated with such an incident depending on what kind of chemical the barge was carrying. According to one county plan, river traffic is highest on the local river during the spring and summer months. At that time, there are about 6-8 tows with 3 barges per tow (6000 tons per barge) of anhydrous ammonia moved per month. In the winter months, the threat is lessened, but there are still two tows per month of caustic soda. In case of an accident of this type, it is the state environmental regulatory agency water quality section's mandate to test the river water.

The barge accidents are related to high water. When the current is swift, tugboats cannot push the heavy barges, which weigh as much as a few train loads. The work on the tug's engines increases as the current gets swifter. The state police respondent remarked that on the day of the interview a barge could not be allowed to traverse on the river because the water level was so high. There would be the possibility of damaging a levee as well if one did attempt the trip.

2. Trucking Accidents and Associated Spills in Bad Weather

A state police respondent mentioned that trucking accidents, and their potential associated hazardous materials spills, are more likely in times of bad weather and flooding. He reported that in the northeastern part of the state, on any given day, about 5,000-10,000 trucks crossed the interstate scale. Probably 17-20% of them would be carrying some kind of chemical. This fact is addressed in one county hazardous materials plan studied. These respondents emphasize that accidents are not usually flood-related, but weather-related. Also, more accidents occur when it is raining than when it is not.

VII. The Added Threat of a Chemical Plant Explosion

While localities were still enduring flooded conditions, another disaster event occurred -- an explosion at a chemical plant which had principally manufactured anhydrous ammonia, an extremely

toxic substance. The plant had many other hazardous materials onsite, according to the county disaster plan's annex on hazardous materials. Under extremely toxic substances, the plant reported to have formaldehyde, nitric acid, sulfuric acid and chlorine on-site, in addition to others. The facility was in compliance with SARA Title III requirements; it had filed its appropriate Material Safety Data Sheets and had also submitted a facility emergency plan and resource list.

The plant employed approximately four hundred workers, eight of whom were killed by the blast. Over one hundred employees were injured by the explosion. The powerful blast shattered windows of neighboring homes and a school, and downed telephone poles and trees. A gas station located across the street from the plant sustained heavy damages. The surrounding town of 1500 residents was evacuated after the explosion because it was not known if the fire would emit toxic fumes. The evacuation included a local hospital which held 20 patients.

Local, state, and federal entities such as the Occupational Safety and Health Administration and the Environmental Protection Agency responded to the scene. Police organizations evacuated residents, closed roads and controlled access. Fire departments added their resources to fight the blaze. The local civil defense organization also responded and an Emergency Operations Center was established. The state environmental regulatory agency, including the hazardous materials quick-responders, was on-site to test air quality and the quality of the runoff water.

Main hazardous materials concerns regarded air quality around the plant and the quality of the runoff water, which was resulting from both the internal fire suppression system and the fire departments. There was initial concern with asbestos being knocked out of the nearby high school auditorium ceiling. A plant representative resolved the issue, though, by meeting with school board representatives about a management plan for cleanup. Air quality around the plant was found to be within acceptable standards. With regard to runoff water, although the plant was designed to contain this water in its own piping system, there were some problems. One water quality agency respondent explained,

> "They lost some of their chemicals when the vessels exploded...Their fire system went on immediately spreading water and the water has to go somewhere. Since they lost their power, it went down the storm water drain. We've been monitoring, taking some samples, as well. I understand they had barely reportable quantities of TMP propane and possibly some formaldehyde problem. Other than that...OSHA is not letting them take the water off, so its water brought on to the propane tank. So that's a source of runoff. So until that's settled, they're going to have runoff problems. As soon as they get the flow down to manage it with the flood,

they're going to divert it to their treatment system..."[There is] a slight organic pollution problem. But again its flowing into the flooded area and I don't consider it a problem. Its going to some lake more or less. The runoff will go into surface drainage and get into a drainage system. Part of it goes into the river but since the river's so high, it will flow back. You probably couldn't detect it a 1/4 mile from [the plant], but we're still concerned about it."

Fortunately, there was little interaction between the explosion and the flood. The flood in no way caused the explosion. Responders did not report any problems in gaining accessibility to the site because of closed roads or floodwaters. One environmental regulatory agency air quality section respondent noted, though, that sections of a major highway were closed because of flooding only days before the explosion. The potential for hazardous materials hazards was also very real. Although the area around the plant was not under water, plant property was less than a block away from an overflowing river. If the river water had been higher, the response could have been much more difficult to carry out, and chemical hazards entering this water might have been more of a concern. There were not hazardous chemical releases into the floodwaters, although they were anticipated and discussed by citizens and responders. One rumor warned about the possibility that contaminated runoff water could be entering the floodwaters. This rumor prompted calls from citizens to the environmental regulatory agency. Another rumor about the explosion warned that the impact of the blast would weaken a levee and the floodwater would push through to flood more homes. Two days after the event, a local newspaper addressed both rumors with the following statements:

"'Runoff water used to fight the fire is being contained on the plant site, eliminating the threat of ground contamination.'...'There are no chemicals leaking on the ground or into the water used on the fire. But, just in case somebody is worried about it, the plant is designed to contain that water, and its doing just that.'... 'Officials from the EPA and [the state regulatory agency] will continue to monitor the site for the release of hazardous chemicals. Chemical fire experts, including the head of [the corporation's] firefighting division, have been called in to help with the cleanup...'...He said the levee holding back the swollen [local] river was not damaged or weakened by the blast, as some residents feared. 'We have inspected the levee and it was unaffected by the blast. There is no threat of it breaking,' he said."

Some organizations reported no organizational strain from responding to both the flood and explosion, but others did. For instance, one sizable city fire department reported that their organization was strained by the flooding event and the explosion

as they had to call in off-duty people. There was a lot of overtime and employees that worked many shifts became fatigued. The Red Cross and Sheriff's office were reportedly "stretched to their limits."

VIII. Conclusions

Secondary hazards after flooding were viewed as real concerns by responders at this research site. Overall, everyday planning and response techniques for hazardous materials incidents were used as hazards were identified. Experience with hazardous materials incidents on a day-to-day basis made these responses not unlike any other, even though there were flood causes. For example, responses to some incidents by the state environmental regulatory agency followed everyday procedures but were carried out with more quickness and priority. In some cases, responders went to the site quickly, dealt with the involved party, and found out what happened, but the response mostly consisted of documenting the occurrence. In other cases, an accident was cleaned up or contained. In most cases, the response to hazardous materials problems during flooding did not have a discernable "emergency period." These were rather small events. The agencies normally involved in hazardous materials incidents responded, and other agencies did not emerge into the picture because of the flooding aspect. There were no difficulties observed regarding coordination between agencies.

This study described preparedness and mitigation techniques that could be employed to lessen the probability of flood-related hazardous materials incidents. Underground storage tanks can be strapped in with steel bands during construction or sandbagged as heavy rain ensues. Oil well fields can be shut in when waters rise or their on-site tanks can be weighed down. Concerning sewage hazards, manholes can be built up a few feet so that floodwater cannot as easily enter municipal sewage systems. Permitting standards are used to site landfills away from flood prone areas. Mitigation for landfills and industrial facilities takes the form of structural measures to withstand floods up to certain levels.

Regarding the chemical explosion, the potential interaction of hazardous materials with floodwaters was a concern of officials and citizens, which also caused it to be addressed through the media. Overall, the organizational response to the explosion was more elaborate than the responses to the hazardous materials incidents caused by flooding, although many of the same groups were involved.

This study identified factors that could facilitate or impede responses to hazardous materials incidents after flooding. Factors that facilitated the response were identified by the respondents as the following:

* Organizational experience and previous lessons learned about flood related hazardous materials incidents often helped preparedness and response, as in the cases of underground storage tanks and oil fields.

* Strong legal requirements on spill reporting and discharge notification ensured reporting by parties and response by regulatory agencies.

* In the airport cleanup and underground storage tank cases, bad weather had already halted the cleanup contractor's regular work, so they could devote extra attention to the emergency situations.

* Concerned calls from the public helped in identifying the transformer problem and the flooding of certain drinking wells.

Respondents also identified factors that can impede response as the following:

* Accessibility can impede responses to certain incidents, depending on the nature of the hazard to be investigated.

* Tanks or barrels could topple on industrial sites, oil fields, or other locations and go unreported.

* Small company owners, such as those who operate oil wells or underground storage tanks, are often not aware of regulations. They might also be caught unaware by a flood and not know how to take precautions.

This study identified new evidence on potential hazards:

* Agents other than flooding, such as incessant rain and high winds, acted as catalysts in these incidents.

* There is mixed evidence that bad weather can halt or slow down a hazardous materials cleanup in progress. The effects would depend on what stage the cleanup had entered.

* Transportation spills, such as barge accidents and highway hazardous materials spills from trucks, may be more likely in times of bad weather and flooding.

* The vehicle oil and gasoline leaks into the floodwaters at the junkyard presented an unforseen hazard that could be addressed in future regulations.

LITERATURE CITED

Lafornara, Joseph P., Howard J. Lamp'l, Thomas Massey and Ralph Lorenzetti.

1978 "Hazardous Materials Removal During 1977 Johnstown, Pennsylvania, Flood Emergency," Information Transfer. 156-160.

Sunday News Journal. Wilmington, DE. "Briefs - Oil Tanks Overflow," January 5, 1992, p. A-10.

Tierney, Kathleen J.

1980 A Primer for Preparedness for Acute Chemical Emergencies. Newark, DE.: Disaster Research Center, University of Delaware.

1982 Developing a Community-Preparedness Capability for Sudden Emergencies Involving Hazardous Materials. DRC Articles #154. Newark, DE: Disaster Research Center, University of Delaware.

APPENDIX A

Interview Guide

THE FLOODING

1. To begin, could you give me just a brief description of this agency's response to the flooding that has occurred over the past few weeks?

2. Have there been any hazardous materials hazards that have surfaced during the time of the flooding?

3. Have there been any hazardous materials checks that have taken place during the flooding? How about after the flooding?

- Employees available?
- Accessibility?
- Authorization?
- Equipment?

4. Have there been any calls or other notifications about hazardous materials during the time of the flood?

5. Have there been any rumors or scares about hazardous materials hazards during the time of the flood?

6. Have there been any problems with the quality of drinking water during the flood?

7. How have the industries, including the fertilizer plants, been effected by this flood?

8. Have there been any problems concerning chemical hazards in houses, commercial establishments, or industries during this flood?

9. When do you think the flooding situation will be back to normal?

THE PLANT EXPLOSION

We're also interested in the plant explosion,

10. Was there been any connection between the flooding and the explosion of the plant?

11. Has the explosion exacerbated the flooding situation in any way?

12. Was there any problem with chemical hazards after the explosion?

13. Was there any testing or checking of floodwaters, air or land for hazardous materials safety hazards after the explosion?

Criterion for safety?
When checked?
What sites checked?

14. Have the resources of this organization been strained between the two emergencies?

DISASTER EXPERIENCE

The next few questions are about the disasters this community has undergone in recent history.

15. What flooding has occurred in the past?

16. What hazardous materials incidents have occurred in the past?

17. Has there every been any interaction between flooding and hazardous materials incidents in the past?

HAZARDOUS MATERIALS SITES

Now, I'd like to ask you about the hazardous materials sites and industries that use such materials in this community.

18. What hazardous materials dump sites are located within your jurisdiction?

SITE	LOCATION	TYPE	HISTORY	PROBLEMS
1				
2				
3				
4				
5				
6				

19. Could you point out these sites on this map?
20. Were any of these sites underwater in the flood?

21. What industries in this community house hazardous chemicals?

SITE	INDUSTRY NAME	LOCATION	HISTORY	TYPE	PROBLEMS
1					
2					
3					
4					
5					
6					

22. What records or documents exist about hazardous materials in this community?

Superfund sites in the area?
Title III documentation of chemicals housed?
Maps of dump sites?

HAZARDOUS MATERIALS/FLOODING PLANNING

Now I'd like to ask you some questions about emergency planning.

23. Does this community undertake planning for flooding?

24. Does this community undertake planning for hazardous materials emergencies?

25. Could we have a copies of these plans?

26. Are there areas of the floodplain which contain hazardous materials? [If so, does that cause any safety hazards?]

27. Are any precautions for hazardous materials sites needed before floodwaters come?

28. What organizations are involved in hazardous materials tasks in this community?

1
2
3
4

ORGANIZATIONAL

Now we would like to ask for some information about your agency.

29. How many employees work for this organization?

    Divisions?

30. Is there an organizational chart that I could copy?

31. Could you describe the chain of command in this agency.

32. Who or what level of the organization makes decisions about hazardous materials sites?

33. Who or what level of the organization, if any, makes decisions about flood emergencies?

34. How does information get passed in this agency? Did that change during the flood?