Organizing to Cope With Hazardous Material Spills

D.W. Ryckman and Mark D. Ryckman

The huge quantities of chemicals being produced and transported within the US have become an area of acute concern. The effects that spills of hazardous materials can have on human health and welfare, and the environment have prompted the development of numerous private, state, and federal response systems. Described here is a private system that can be used as a model by water utilities for establishing and evaluating emergency response contingency plans to better cope with hazardous material spills that threaten drinking water supplies.

More than 30 000 chemicals are presently used in commerce in the US, with an additional 1000 being introduced each year. During 1978 18 000 transportation accidents involving hazardous materials resulted in 45 human fatalities and 1411 injuries. The recent increase in the number of reported hazardous material spills may be due to increased production, transportation, storage, and monitoring of these chemicals. Concern on the part of the public, private industry, government, and water utilities for the effects that hazardous material spills have on human health and welfare and on the environment has prompted the development of numerous private, state, and federal response systems.

Each of these systems has been designed to serve a particular mode of transport, a specific region, a particular industry, or a specific regulatory agency. It is critical that the water utility industry be included as a link in these response systems so that the water utility is not the last to know when a hazardous material spill threatens the potable water supply. A unified approach is needed to bridge the gap between technical know-how and "hands-on" spill response procedures.

One such approach has been developed by the authors' emergency action and consulting team (REACT). This system can serve as a guide for the water utility in preparing spill prevention control and contingency plans and in developing individualized hazardous material response systems. Two systems need to be considered when formulating a hazardous material response effort. The first system describes the specific interactions of the constituent with the environment, and the second system deals with the management system employed to respond to the problem. The REACT systems approach is a management system for responding effectively to hazardous material spills. The successful application of this approach will be illustrated by reviewing three REACT case histories.

System Components

The description and function of each of the twelve essential system components of an emergency action response are detailed below.

Fast response. The most important component in dealing with emergencies is a fast response. By prompt action, threats to human health, environmental degradation, and property loss can be minimized. The first few moments of an emergency are the most critical. Human responses to accidents follow an emotional progression from initial fear to secondary reactions of helplessness, followed by a delayed feeling of anger. From the first call, the emergency response center must be prepared to issue emergency directives and provide instruction to the individual in distress until an experienced on-scene coordinator (OSC) arrives. If there is any indication that there is an imminent health hazard, an evacuation press release should be directed to the nearest civil defense or police headquarters in the affected community. It is in this early stage of the emergency that the local water utility should be notified of the imminent threat to the water supply. All material spills released on the ground, into the water source, or into the air pose potential threats of drinking water contamination via direct spillage or runoff, evaporation–condensation, soil percolation, vapor plume water solubility, or direct cross connections. Early notification of the local water utility in the affected watershed allows adequate preparation and response to the hazardous material spill.

Experience. Scientists and engineers who are experienced in the handling of hazardous materials and knowledgeable with respect to the complexities of a hazardous material spill are an integral part of the system. It is not economically feasible to retain every person necessary to respond properly to all types of hazardous material spills as part of a full-time staff. Consequently, it is desirable to have on call part-time experts as specific crisis situations warrant.

In-house personnel should have a multidisciplinary background in environmental systems engineering, civil engineering, industrial hygiene, industrial toxicology, chemistry, and physics. This educational background, combined with in-depth field experience in the handling of hazardous materials from "cradle-to-grave" provides the best experience base for persons involved with responding to hazardous material spills.

Frequently it is desirable to have registered engineers

003-150X/80/040196-05$01.00

and certified scientists on the firing line to protect a client's interests against impending litigation. All things being equal, if a case goes to court, the opinion of a registered engineer or certified scientist may carry more weight than opinions of noncertified parties.

Leadership. During an emergency it is important to have one person in charge. This is necessary to avoid fragmentation, confusion, and duplication of efforts that could result in costly mistakes or the loss of valuable time. An OSC should be dispatched to the emergency scene as soon as possible to direct field response activities. It is desirable that this engineer or scientist be registered or certified and be familiar with environmental systems engineering techniques. This individual should have the ability to rapidly evaluate the situation, make on-the-spot engineering decisions, and supervise all field response activities. For the water supply industry, it is important that there be a designated person in charge, should a hazardous material spill threaten a water supply.

The OSC should receive assistance from a central coordinating body. REACT has designed for this purpose a corporate response center (CRC), described in the system organization section of this article.

Communications. Communications are vital to an effective emergency action response. It is important to be able to send and receive information without delay. A breakdown in communications can cause serious dangers and mistakes when dealing with hazardous substances. Areawide mobile telephones, marine radios, paging systems, and facsimile transmission equipment provide effective means of field-to-response center and field-to-field communications.

Availability. Emergency situations, unfortunately, do not keep regular business hours. Consequently, information, equipment, and personnel must be available 24 hours a day, seven days a week. Frequently, emergency responses are initiated after working hours or on weekends or holidays.

Coordination. Emergency action response for hazardous substances requires the coordination of people, information, and equipment. It is necessary to coordinate cleanup operations, public health and safety measures, liaison with regulatory agencies, information flow to the local water utility, and information to and from the emergency site. Often, coordination of all of these agencies and operations is more difficult than the response effort itself.

Manpower. Successful emergency action response will generally utilize three types of personnel: leaders, operators, and researchers. The importance of having experienced engineers and scientists on the scene has been stressed. Operators, under the supervision of the OSC, provide the necessary manpower for labor intensive cleanup operations. Researchers provide the necessary data for decision making.

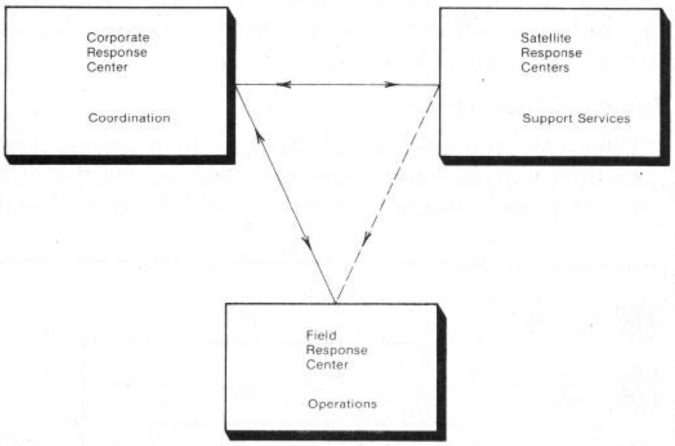


Fig. 1. System Organization Depicting Directional Response Logistics and Information Flow

Fig. 2. REACT Hazardous Material Response Network

Tank farm spill of monononylphenol, 810 alcohol, and solvents contaminated groundwater and leached into a nearby stream.

Equipment and supplies. Each hazardous spill situation presents a unique set of circumstances requiring specialized equipment for treatment, recovery, and disposal. Therefore, it is desirable to establish a system of warehouses and suppliers of various equipment and materials and incorporate them into the response system. In an emergency situation, it is necessary to make the best use of the materials at hand. Water utilities usually have available some of the required equipment and supplies. Additional resources should be located, and arrangements made for their rapid acquisition under emergency conditions.

Transportation. Efficient means of transportation are necessary to mobilize personnel and equipment to and from emergency scenes. Air transportation is generally the most efficient means of dispatching an OSC to the accident site and for aerial surveillance. Land transportation is generally utilized for local emergencies and for transportation of heavy duty equipment; water transportation is used to deploy the equipment and transport personnel. The specific mode of transportation will depend on the location of the accident with respect to the response network and the accessibility of the accident scene.

Data resources. A computer assist program (CAP) has been developed by REACT to immediately provide pertinent information to an experienced engineer or scientist so that the appropriate response measures may be implemented. Information contained within the system includes physical, chemical, and toxicological properties of some 250 000 materials; technical information on appropriate containment, removal, recovery, treatment, and disposal practices; more than 2000 hazardous material experts classified by discipline and location; the location of equipment and material suppliers, including mobilization equipment; the location of staging, disposal, recovery, and waste exchange facilities; medical clinics specializing in pulmonary medicine, cardiovascular medicine, and other specialized fields of industrial medicine; EPA- and FDA-certified analytical testing laboratories; a complete system of maps of the entire US, including US Geological Survey maps and Army Corps of Engineers maps; government agency contacts; a listing of water utility companies; and emergency telephone numbers including but not limited to poison centers, press outlets, ambulances, and medical, fire, and police services. The REACT CAP system is maintained by CRC personnel and continually updated and fine-tuned to incorporate the latest technology and information. (It should be noted that information is only as good as the individuals who are interpreting and trying to apply it.)

Laboratories. Two types of laboratory facilities are required during an environmental crisis. A network of main frame laboratories are utilized to conduct sophisticated air, water, and solid waste analytical evaluations that cannot be conducted in the field. Mobile testing facilities are used to obtain rapid field information. The importance of obtaining first-hand information from the point of material identification, monitoring, and surveillance to the ultimate fate of the material in the environment is of the utmost importance to document the integrity of cleanup operations.

Clinics. Medical clinics are an integral part of the REACT response system. Specialists in industrial medicine provide assistance in the fields of industrial (emergency) surgery, occupational medicine, internal medicine, and general practice. This allows REACT to provide the best possible medical assistance in the form of specialist referrals or treatment of individuals exposed to toxic substances.

System Organization

Effective organization is required to integrate and coordinate emergency response activities. REACT's organizational diagram (Fig. 1) depicts directional

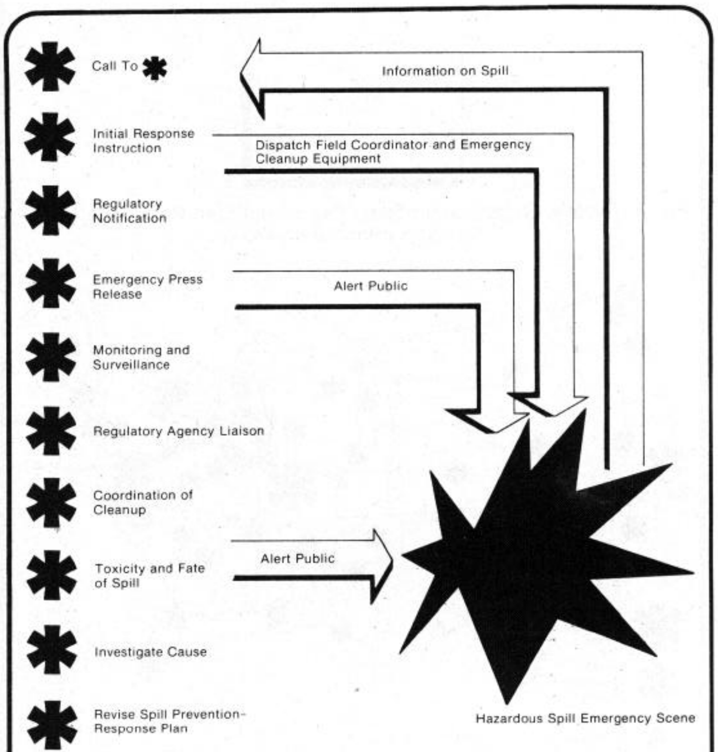


Fig. 3. REACT Response Logistics and Tasks Completed During Typical Hazardous Material Spill

response logistics and the flow of information to and from the accident scene.

The principal function of the CRC is to coordinate all response activities. All communications and information flow are directed to the CRC. Depending on the geographic location and the nature of the accident, the CRC may receive technical assistance, manpower, or equipment and supplies from one of 47 strategically located satellite response centers (Fig. 2).

The role of the satellite response centers (SRC) is to provide support services to the corporate response center and to the field response center (FRC) after receiving authorization from the CRC.

The FRC is established at the accident scene. It is important that all information be channeled through the CRC to the FRC to avoid confusion and fragmentation and to optimize field response efforts. An on-scene coordinator dispatched from the CRC or one of the SRCs directs all field operations and documents all response activities.

This organizational structure provides an effective vehicle for utilization of the twelve essential system components in solving hazardous materials crises.

System Operation

Three case histories illustrate application of the REACT systems approach to hazardous material crises. The case histories were selected because of the particular hazardous material involved and the potential threat that this material posed to a water supply. Figure 3 shows the response logistics and tasks completed during a typical hazardous material spill.

Phenol, alcohol, and solvents spill. Residents' complaints of foul odors coming from a nearby stream prompted state officials to investigate the source of the problem. A government investigation traced the problem to a nearby specialty chemical company, where a spill of an estimated 38 kL (10 000 gal) of 810 alcohol and mononomylphenol had occurred on the company grounds. These chemicals had leached into the groundwater aquifer beneath the company's property, which discharged into a stream. The company was directed by the regulatory authorities to take immediate steps to rectify the situation. The company elected to try to solve the problem by using straw to soak up the materials from the creek. This effort proved to be futile, and several company employees received minor skin burns from contact with the mononomylphenol. Management then decided to seek outside assistance.

REACT was contacted and advised of the situation. Company management authorized REACT to contain and remove the material from the creek and to conduct an investigation to determine the source of the problem. Men and equipment were immediately dispatched to the scene, arriving within one hour. A series of booms, both containment and sorbent, were set up along an 8-km (5-mi) stretch downstream of the aquifer outcropping to prevent the spill from entering a major river used as a water source for a large city.

Samples collected from the creek were analyzed, revealing the presence of kerosene in addition to the reported alcohol and mononomylphenol. Two response teams proceeded to construct activated carbon sandbag dams that served as the primary containment and

Polypropylene sorbent barriers contain gasoline residues and direct plume migration toward the toe of the roadbed.

adsorption systems. Next, an activated carbon "blackout" of the entire 8-km (5-mi) stretch of creek was completed within one day. This arrested the odor problem and stopped residents' complaints.

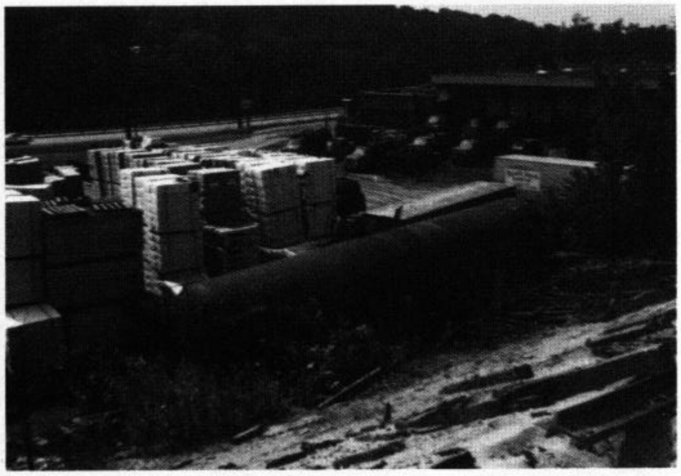
Monitoring at the outcropping revealed that the aquifer still contained significant concentrations of pollutants. A decision was made to construct a coffer dam at the groundwater outcropping to collect and pump the pollutants back to the chemical company's property for subsequent treatment. This operation ceased after monitoring indicated no further pollution discharges from the aquifer system for five consecutive days. This was 25 days after the initial call for assistance.

Response efforts were conducted 24 hours a day for a 25-day period. During this time, in-plant audits and recommendations were made to update the facility's spill prevention control and countermeasures plan. The recommendations included moving all underground process lines above ground, providing concrete paving and secondary containment structures for bulk storage and transfer facilities, and redesigning the storm water facilities.

Gasoline spill. As the result of a gasoline tank truck's overturning, and subsequent emergency fire hose washdown, 26 kL (7000 gal) of gasoline were spilled into a marshy area of the Gibbon River in ecologically fragile Yellowstone National Park. The spill was of special concern not only because of the pristine quality of the national park environment but also because of gasoline's toxicity to fish, waterfowl, flora, and aquatic life, and the threat to downstream water supplies.

REACT's corporate response center quickly dispatched an on-scene coordinator to the spill site. Support personnel, equipment, and supplies were provided through satellite response centers in the spill area. All operational directives were coordinated through the CRC. Because of the remote location of the spill, communications were a persistent problem.

Three sorbent containment structures and sorbent sandbag dikes were constructed to prevent gasoline-contaminated groundwater from migrating to the Gib-



A midwestern railroad derailment released 57 kL (15 000 gal) of lubricants into a tributary of the Missouri River. The confluence of the tributary and the Missouri River was immediately downstream from a water utility.

bon River. A plan was developed to release the gasoline from the saturated soil using desorption agents, thereby preventing a persistent leaching problem. Gasoline-saturated sorbent materials were contained in 210-L (55-gal) drums and taken to an approved landfill for ultimate disposal.

Labor Day weekend oil spill. An unstable track bed resulted in the derailment of four tank cars which rolled down a 15-m (50-ft) embankment. The belly valve of one of the cars was sheared off and more than 57 kL (15 000 gal) of its 79-kL (20 800-gal) payload were spilled from the car. The spilled lubricant made its way through a storm sewer outfall and into a stream that flowed through a busy commercial and residential area, ultimately discharging into the Missouri River just downstream from intake structures for a major midwestern water utility company. The Coast Guard was alerted, and the railroad was instructed to take immediate and effective action. The time was 4:00 PM, the Friday before Labor Day weekend.

REACT was contacted immediately and authorized to take whatever measures were necessary to remove the product from the creek before the resumption of normal business activities on Tuesday morning. Within 30 min a REACT coordinator arrived on the scene to evaluate the situation. Forty-five minutes later, three response teams with complete containment equipment arrived. By 6:00 PM a sorbent boom had been placed across the stream, 5 km (3 mi) downstream from any visible product, and a containment underflow dam had been constructed just downstream from one of the major product pockets. Simultaneously, a crew was dispatched to the accident scene to construct a damage control plug to seal the damaged tank car, thus preventing further leakage or the contamination of the 19 kL (5000 gal) of lubricant remaining in the tank car.

Two more response teams were then dispatched to construct additional containment underflow dams and begin removal operations.

Weather information revealed a high probability of rain later in the day. This was of particular concern because the creek was known for flooding during moderate rainfalls. Consequently, two additional flotation booms and one additional containment dam were constructed to prepare for high water conditions. This action proved well advised: an early rain on Monday morning caused the water level to rise, allowing the product to break through the first two containment dams. The product was effectively trapped by the two added containment booms.

The bulk of the product was removed by using vacuum trucks and considerable amounts of sorbent materials. By Sunday morning the entire city's supply of sorbent material was exhausted. The CRC then contacted a manufacturer in Chicago and had a special shipment flown in and delivered to the site that same afternoon. By 8:00 PM Monday evening all but 76 L (20 gal) of product had been accounted for and removed from the creek.

Labor intensive operations spared the railroad adverse publicity, and by the time normal business activity resumed early Tuesday morning, all visible signs of the accident were gone.

As a postscript, a REACT laboratory analyzed the product remaining in the bottom of the damaged tank car for contamination. Results indicated that the product was uncontaminated, and arrangements were made to sell the product back to the originally scheduled customer. This saved the railroad more than $5000, in addition to potential fines and civil liabilities that would have resulted if flooding had caused heavy oil tc surcharge from the creek onto an adjacent highway.

Bibliography

ANDREWS, J.F. Application of Some Systems Engineering Concepts and Tools to Water Pollution Control Systems. Dept. Envir. Engrg. Course Notes, Clemson University, Clemson, S.C., (1975).

ELLISON, T. Industrial Toxicology Course Notes. The Center for Professional Advancement. New Jersey (1977).

Hazardous Materials Spills Emergency Handbook. AWWA, Denver, Colo. (1975).

Hazardous Materials Transportation: A Review and Analysis of the Dept. of Transportation's Regulatory Program. Com. on Commerce, Science, and Transportation. US Senate (Apr. 1979).

METZLER, P. Personal communication.

Polluting Incidents In and Around US Waters, US Coast Guard Publication C6-487 (for calendar year 1976) (1977).

Quality Criteria for Water. US Environmental Protection Agency, EPA 44/9-72-023 (1976).

RICH, L.G. *Environmental Systems Engineering.* McGraw-Hill Book Co., New York (1973).

RYCKMAN, D.W. ET AL. Hazardous Material Handling, Spills, & Decontaminations. Industrial Hygiene Course, Univ. of Illinois Medical Center, Urbana, Ill. (1979).

RYCKMAN, D.W.; RYCKMAN, M.D.; & MILLER, D.B. Emergency Action Response for Hazardous Substances. Am. Defense Preparedness Assn. Energy Envir. Conf., Kansas City, Mo. (1977).

RYCKMAN, D.W. & MILLER, D.B. Case Histories of Emergency Action Reports from Men on the Firing Line. AWWA Hazardous Materials Spills Seminar, Anaheim, Calif. (Jul. 1977)

RYCKMAN, M.D. ET AL. REACT's Response to Hazardous Material Spills. Proc. 1978 Natl. Conf. on Control of Hazardous Material Spills, Miami, Fla. (Apr. 1978).

A conference paper selected by the JOURNAL and authored by D.W. Ryckman (Active Member, AWWA) and M.D. Ryckman (Active Member, AWWA), both of Ryckman's Emergency Action & Consulting Team, St. Louis, Mo.

28498 3600, 4110