DEVELOPING AN EVACUATION PLAN FOR PROPANE TRANSPORTATION EMERGENCIES IN THE CITY OF MONTPELIER, VERMONT

LEADING COMMUNITY RISK REDUCTION

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ABSTRACT

The City of Montpelier, Vermont is a small city, a population of around 8,000 in a little over 10 square miles. There was an increased risk to the city because of bulk tanker truckloads of propane being transported through the city. A new rail tanker to bulk truck transfer station was been built adjacent to the city and all trucks that left the facility had to transit through the city.

The problem was that the City of Montpelier did not have an evacuation plan to be used to protect lives from a catastrophic incident involving bulk transport of propane through the city. The purpose of this research study was to develop an initial evacuation plan to be used by emergency responders in the city to protect lives from a catastrophic incident involving bulk transport of propane through the city.

This study used Action Research as the method and answered four Research Questions.

1. What are the legal requirements concerning community evacuation plans?
2. What are the components of an evacuation plan?
3. What are significant issues that have arisen in the past concerning evacuations?
4. What are specific problems that Montpelier faces in responding to a propane transportation accident?

The study researched information concerning evacuations and coordinated a process to write up a draft evacuation plan. The study was able to identify the important elements of a plan, determine the complexity of the issues for Montpelier, and prioritize actions. These priorities were then included in the initial plan to be present to the City for adoption. The study recommends the immediate adoption and implementation of the initial evacuation plan and the continued development of a comprehensive plan.
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INTRODUCTION

The City of Montpelier, Vermont is a small city. It has a population of around 8,000 in a little over 10 square miles. Emergency services are provided by a small career police department and a small combination fire department. The fire department also provides ambulance service. Both departments rely upon mutual aid for assistance in major emergencies.

The last two years has seen an increased risk to the city because of bulk tanker truckloads of propane being transported through the city. A new rail tanker to bulk truck transfer station has been built adjacent to the city. All trucks that leave the facility transit through parts of the city.

The problem is that the City of Montpelier does not have an evacuation plan to be used to protect lives from a catastrophic incident involving bulk transport of propane through the city. The purpose of this research study is to develop an initial evacuation plan to be used by emergency responders in the city to protect lives from a catastrophic incident involving bulk transport of propane through the city.

Action research is the method used by this study.

Four Research Questions need to be answered.

1. What are the legal requirements concerning community evacuation plans?
2. What are the components of an evacuation plan?
3. What are significant issues that have arisen in the past concerning evacuations?
4. What are specific problems that Montpelier faces in responding to a propane transportation accident?

BACKGROUND AND SIGNIFICANCE

A special note is needed here. Duke Energy provided statistics concerning the business they do for the purpose of emergency planning and asked that it be kept confidential within the
department. In respect for their legitimate business needs this report will not use specific numbers concerning the number of loads, the times of day of operation, or the percentage of trips that travel the different routes. General information from their letter may be used. However, emergency planners involved with the actual development of the evacuation plan will have access to full information.

In 2002 Duke Energy opened a propane transfer station at Montpelier Junction in the Town of Berlin. Propane is brought in by bulk railroad tankers, transferred to storage tanks, and then loaded on tractor trailer units for wholesale delivery. There is no retail delivery from that location. The western part of the city is affected by the transfer station itself. However, planning for the location is relatively simple. The location of the hazard and the affected areas are easy to define. The areas at risk are a residential area around State St. and Lague Dr., the City Sewer Plant, and the Public Works garage. In addition, the risk is controlled by the correct operation of the facility.

The transport of propane from the facility is an entirely different situation. All of the loads sent from the facility travel through at least a part of the City of Montpelier. Many of them leave the city by the interstate, but a large number transit through the city. The loads can leave at any time during the day and this is a year round process with a peak in winter time.

The loads that transit the city travel though six major intersections. There have been serious accidents at all of those locations and one intersection has a high number of accidents. Fortunately, most of the accidents there are relatively minor. However, even a minor accident can damage piping, controls, or ignite a fire in vehicle components. A more serious accident could damage the propane tank itself.
The city GIS information was used to get an estimate of the risk to the city. Three buffer zones were considered based on the hazards of propane. These hazards will be detailed under the literature review. The first buffer zone was at 600 feet. This is the radius from a catastrophic tank failure that significant thermal and/or blast damage is probable. The second buffer was set at one half mile. Almost all tank fragments from an explosion should land within this buffer. The third buffer distance was set at one mile. This is beyond the maximum distance that a tank fragment is reasonably expected to travel.

Those buffer distances were set up on all roads traveled by the propane loads. According to the GIS data, the risk to the city is as follows. Within the 600 foot zone are about 920 acres (14% of the city area) and about 670 structures (20% of the structures in the city). Within the half mile zone are about 2,780 acres (42%) and about 1,940 structures (58%). Within the mile zone are about 4,275 acres (65%) and about 2,980 structures (88%). These totals do not include additional acreage and structures at risk in the Town of Berlin.

The problem that propane presents is not well understood. There is a serious flammability problem, but there is also a mechanical explosive potential. It is this explosive potential that presents the possibility of a catastrophic transportation accident. Propane is a gas at normal temperatures and pressures. It is stored and transported as a liquid by compressing it under pressure and then maintaining that pressure. If the pressure should drop to normal air pressure, the propane immediately vaporizes and expands about 265 times. A cubic foot of liquid propane becomes 265 cubic feet of propane gas (Cote, 2003, p. 14-23). The explosion of a propane tank comes from the release of energy as the propane vaporizes and expands. This explosion is referred to as a boiling liquid expanding vapor explosion (BLEVE). Blast effects and projection of tank fragments are the result of this mechanical explosion. The propane does not have to
ignite. Additional explosive effect and thermal damage occurs if the propane subsequently ignites.

The BLEVE happens when there is more pressure in the tank than the tank can contain. This can occur because the tank is weakened because of damage from an accident, corrosion of the metal container, or exposure of the metal to heat. In addition, failure of pressure relief devices can allow the pressure to build up. Montpelier had a BLEVE without ignition on February 25, 1985. According to the Montpelier Fire Department (MFD) fire report and recollections of the officer in charge and other responding firefighters, this incident involved three 100 lb. cylinders, one of which had a BLEVE when the sun heated up the tank in the afternoon, building up pressure. The pressure relief system did not function adequately and the tank ruptured. The explosion broke the piping on the other tanks allowing liquid propane to be sprayed on the house and blew the top of the tank several hundred feet onto the roof of a neighboring building. Had the cloud of vaporizing gas ignited there would have been serious fire damage also. A similar process took place in Waverly, TN where damaged rail cars were stable during cold weather following the train derailment. Based on information from the National Fire Protection Association (Cote, 2003, p. 8-106) and the Tennessee Emergency Management Agency (2002) one tank car had a BLEVE more than 40 hours after the accident. The BLEVE occurred at a time when the ambient temperature was increasing and would have increased pressure in the tank. In this case the propane cloud ignited and caused a massive fireball. The explosion and resulting fires killed sixteen people and caused considerable property damage.
Montpelier has had potential problems with propane for years. There have been wholesale and retail transports through the city for years. There are propane tanks throughout the city with regular deliveries. However, the new transfer facility has increased that risk and the City of Montpelier must address the problem. Because of the inherent explosion danger with propane, an evacuation plan must be part of addressing the problem.

The city Emergency Operations Plan has a section concerning evacuations. This section, Annex B (1993), recognizes that evacuation may be a viable action to save lives in an emergency. Annex B also provides for the authority to order evacuations and assigns responsibilities. However the plan does not give specific guidance in dealing with situations. This report will develop an initial plan to provide specific guidance concerning one of the more serious risks facing the city.

The National Fire Academy Executive Fire Officer Program course Leading Community Risk Reduction has as a primary goal to have the local fire department lead or participate in a comprehensive risk-reduction plan for the community. The course goal is similar to the United States Fire Administration operational objective of having comprehensive, multi-hazard risk-reduction plans led by the local fire service organization. This study directly addressed both of these. The fire department took the lead in an area where it has direct responsibility and addressed a serious risk to Montpelier. Both the knowledge gained as a result of the study, and the plan developed from the study, will help make Montpelier a safer city.

LITERATURE REVIEW

The literature review covered relevant laws and regulations, general information on evacuations, and case studies of actual evacuations. The legal review was done in Federal Statutes and State of Vermont Statutes. Other information was located in journals and internet
Federal Law references evacuations related to hazardous materials in Title 42, The Public Health and Welfare. The section on *Comprehensive emergency response plans* (U.S.C. Title 42, Sec. 11003) defines the necessary emergency plan provisions. This section deals with the responsibilities of the local emergency planning committee to prepare emergency plans. The plans are primarily concerned with fixed facilities but do require the “identification of routes likely to be used for the transportation of substances on the list of extremely hazardous substances” (Sec. 11003 (c) (1). Paragraph 11003 (c) (7) says that an emergency plan must include “evacuation plans, including provisions for a precautionary evacuation and alternative traffic routes”.

The Federal Occupational Safety and Health Standards set the legal requirements for employers to protect their employees. There is general guidance for protecting all employees. Section 29CFR1910.38, *Employee emergency plans*, provides for employees to be provided with plans that “address emergencies that the employer may reasonably expect in the workplace” (Exit routes…, 29CFR1910 Subpart E App). In an emergency, employees must know “what type of evacuation is necessary and what their role is in carrying out the plan” (Exit routes…, 29CFR1910 Subpart E App). One of the requirements is that “refuge or safe areas for evacuation should be determined and identified in the plan” (Exit routes… 29CFR1910 Subpart E App). In addition, there is specific guidance for emergency response to hazardous materials incidents. *Hazardous waste operations and emergency response*, 29CFR1910.120, provides the regulations covering response to hazardous materials emergencies. “Based on the hazardous substances and/or conditions present, the individual in charge of the ICS shall implement appropriate emergency operations” (1910.120(q)(3)(iii)). Safety of the emergency responders is the top
priority. The number of personnel in areas exposed to potential or actual hazards must be limited “to those who are actively performing emergency operations” (1910.120(q)(3)(v)). Activities must be monitored and if conditions exist that “involve an imminent danger condition” (1910.120(q)(3)(viii)) activities must be altered, suspended, or terminated. Offensive operations are only permitted by specially trained personnel, Hazardous materials technician (1910.120(q)(6)(iii)) or Hazardous materials specialist (1910.120(q)(6)(iv)). Special situations are recognized by OSHA concerning propane and gasoline fires and incidents. First responder operations level personnel “are trained to respond in a defensive fashion without actually trying to stop the leak” (1910.120(q)(6)(ii)). In an OSHA interpretation letter, 09/20/1991 – Operations level personnel training, provision is made for a technical violation with no citation issued “if a firefighter who took offensive action in the danger area during a propane fire of leak was fully trained and equipped to handle the fire and had first responder operations training” (Operations level….). This letter repeats a second time, with the emphasis in bold print, that the firefighter must be “fully trained and equipped to handle the explosion and fire hazards of propane and gasoline” (Operations level…) because “the fire and explosion hazards of propane and gasoline are very substantial” (Operations level…).

Vermont law has a few specific references to evacuations. They are found in Title 20, Internal Security and Public Safety. The State Emergency Management Division has the specific responsibility to assist state, local, and municipal organizations “in developing, implementing and coordinating emergency response plans” (Emergency management…, 20 V.S.A. Sec. 3a(2)). Emergency Functions include “evacuation of persons from stricken areas” (Definitions, 20 V.S.A. Sec 2(2)) and Emergency management is concerned with preparing to deal with disasters and emergencies which include “hazardous chemical or substance incidents” (Definitions, 20
V.S.A. Sec 2(3)). The Governor of Vermont has the authority “to order the evacuation of persons living or working within all or a portion of an area for which a state of emergency has been proclaimed” (Emergency powers…, 20 V.S.A. Sec 9(9)).

Vermont law clearly places responsibility for hazardous material incident management on the fire chief. The fire chief or “the assistant highest in rank present at a hazardous chemical or substance incident or fire, shall have charge of the fire apparatus and of the companies and persons attending the hazardous chemical or substance incident or fire for the purpose of containing, controlling or extinguishing the same” (Powers and duties …, 20 V.S.A. Sec. 2673(a)). This authority extends to the “imminent threat of a hazardous chemical or substance incident, fire or explosion” (Powers and duties …, 20 V.S.A. Sec. 2673(b)) excluding bomb threats. The fire chief can only turn an incident over to the State if he has responded and “has exhausted all of the resources, including available mutual aid” (Powers and duties …, 20 V.S.A. Sec 2673(d)).

Phillips (1992) evaluates the evacuation that took place in December 1982 because of a chemical plant incident in Taft, Louisiana. One of the factors in this case is that the community had developed a disaster subculture that had impacts on the residents of the area and the emergency response organizations. Because of previous instances involving evacuations the community was prepared. The residents responded to “a somewhat anticipated situation requiring less adjustive behavior than otherwise would be the case” (Phillips, 1992, p. 104) and the emergency responders implemented actions more easily. A second important factor was that the police secured the overall area quickly. “Sheriff’s department logs indicate that all roadblocks were in place about seven minutes after confirmation of the explosion” (p. 105). Evacuation were done by sounding fire engine sirens followed by a door to door check by
firefighters. The evacuation was started in the area nearest to the plant involved and worked outward. Those closest, within a mile radius were ordered to leave with no exceptions. As the distance from the plant increased less effort was used to persuade the people to leave. Most residents evacuated voluntarily. “Officials attributed this to the fact that the vast majority of the population in the area knew about the hazardous chemicals around them” (p. 106). It is estimated that 17,000 people were evacuated. “About two thousand people went to public shelters; the vast majority of evacuees went to friends and relatives; such behavior is consistent with what disaster research has found repeatedly in studies of evacuation behavior” (p. 106). This evacuation appeared to go smoothly. Some of that was because the timing of the incident was favorable. Occurring at 4:45 AM on a Saturday morning, families were together (children home from school and few people at work) and there was minimal traffic on the roads.

Augustine and De Lorenzo (1996) performed a study of the Miamisburg, Ohio evacuation that occurred because of a freight train derailment and subsequent release of a massive toxic cloud. The incident occurred in July 1986. The study states that “critical elements of the evacuation process are presented with special attention to the lessons gleaned from this incident” (Augustine & De Lorenzo, 1996, p. 270). A number of significant issues are looked at in this report. “The first major issue concerned the safety of sending unprotected fire, EMS, and police personnel into the area to evacuate people and control traffic” (p. 271). Making this decision required knowledge of the material and the possible effects. The public was generally slow to respond until there was a visible cloud. “At that point, panic behavior occurred in some locations as people began moving rapidly away from the cloud. A few citizens insisted on returning to the evacuation areas to close up their homes, and to find family members and pets” (p. 271). Difficulties occurred in five different areas: 1) high population density areas, 2) nursing
homes, day-care centers, and schools, 3) hospitals, 4) individuals requiring assistance, and 5) businesses. In the cases of individuals requiring assistance, the address and nature of problems were reported to EMS command who allocated out the resources as they became available. The general public reacted to that system by raising the nature of the complaints to get quicker service. “The general public quickly educated themselves to that system; soon the requests for assistance were reported as ‘a heart attack’ or ‘a person not breathing’” (p.272). Massive use of the telephone system overloaded it and brought down service for 250,000 people for 8 to 12 hours. This caused problems in calling back emergency personnel.

Communicating the need to evacuate is of prime importance. Rogers and Sorensen (1989) present a study concerning the effectiveness of warnings during two separate transportation incidents. The incidents both involved freight train derailments and studied peoples’ reactions to the warnings. They break down the warning process into two distinct aspects, alerting and notification. Alerting deals with making “people aware of the imminent hazard” (Rogers & Sorensen, 1989, p. 59). The alert often cues them to seek further information. “Notification typically involves providing detailed information on the emergency situation including a recommendation on how to respond” (p. 59). The warning is then evaluated based on the perceived danger, with each person making a decision based on a number of factors, including their own past experience and the credibility of the warning source. In one of the incidents people who were near enough to see and recognize a danger had already started some self evacuation before the decision was made to evacuate. Time is a critical factor. “The major finding from these two incidents and the simulations is that under conditions of rapid onset, people may be engulfed in danger prior to receiving, … The organizational decision to warn, which includes hazard detection, is critical to warning system effectiveness” (p. 72).
Johnson and Zeigler (1986) are concerned with making sure evacuations are effective. “Once an evacuation order has been issued, the most important objective is to clear a well defined area of all human inhabitants in the shortest amount of time with a minimum of fatalities, injuries and property damage” (Johnson and Zeigler, 1986, p. 148-149). Success of a plan will depend on recognizing that peoples’ behavior patterns determine how well it will work. Two important considerations are building the plan “around people’s known reaction patterns” (p. 149) and giving either prior knowledge or detailed instructions. “Plans need to be devised on the basis of how people behave; once devised, people need to be aware of their existence, to be confident in their usefulness, and to be reinforced of their details when emergency conditions exist” (p. 149). In planning and carrying out evacuations it is important to recognize the different patterns of population based on time of day and season of the year.

Fickes (2002) details the need for good communication procedures and using multiple methods. There is Reverse 911, Internet, and radio and television, the traditional media. However, street by street canvassing is still necessary, especially in communities with non English speaking residents. GIS and mapping technologies are becoming important planning tools. They can also be of value in decision making during transportation incidents.

Carlson and Isman (1988) are concerning with the elements of an evacuation plan necessary to ensure and efficient evacuation. Several specific decisions have to be made. One is who will carry out the actual evacuation work. Fire department personnel will probably do the immediate danger area while other agencies will have to assist elsewhere. One “major question for the incident commander is whether to leave people in place or to evacuate them” (Carlson & Isman, 1988, p. 38). Another decision is the extent of an evacuation. Planning for evacuations should include all agencies that will be involved. Management of evacuation sites should be
planned in advance. “Information on where evacuees go is important, especially for children who were not with their parents at the initiation of the evacuation” (p. 38).

Roberts (2000) presents an analytical method for predicting the effects of a BLEVE. He states that there are three effects: an overpressure blast wave, thermal radiation if the propane ignites, and fragments of the container being propelled as missiles. He has revised some of the formulas for predicting the effects and performed a case study analysis of a BLEVE event on a 10,000 gallon propane tank filled to 80% capacity. A summary of his analysis showed the following effects are likely:

- **Blast effects.** Depending on building type damage can occur up to 270 feet from tank. Personnel in the building may be injured. There would be a 1% likelihood of eardrum rupture up to 177 feet.

- **Thermal radiation.** Direct exposure to the fireball could result in second degree burns up to approximately 600 feet. There would be a 1% chance of fatal third degree burns at about 450 feet from the tank. At about 300 feet from the tank personnel would be engulfed by the initial ground flash as well as exposed to the radiation from the fireball. At that distance fatal injuries are to be expected.

- **Container fragment travel.** 80-90% of fragments should fall within 1,800 feet. However maximum travel under extreme conditions could be up to 6,740 feet.
This information can be used in the planning process to predict the consequences of a BLEVE.

The U.S. Department of Transportation produces an emergency response guidebook to be used during the initial phases of a hazardous materials incident. The 2000 Emergency Response Guidebook recommends “if tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions” (GUIDE 115).

The literature review demonstrated the complexity of the issue. Evacuation plans are multifaceted and require a considerable effort to coordinate. The planning process must eventually address all aspects, but each planning process must prioritize activities to ensure an effective product at each stage of development. The reading also made it clear that the planning is never completed, there was always a need to practice, evaluate, and update the plan.

PROCEDURES

Research Questions.

An internet search is done to locate Federal Laws. They are located in a web site run by Cornell University, http://www4.law.cornell.edu, with links to the Federal codes, URL=/uscode. The Federal Code is searched for references to “evacuation”. Thirty nine matches to “evacuation” are found. Review of the matches narrows down to Title 42 of the Federal codes, The Public Health and Welfare, where references are found which are relevant for this study.

An internet search is done to locate Federal regulations. They are located on a web site, http://frwebgate3.access.gpo.gov, maintained by the Government Printing Office. Searches under “evacuation”, “evacuation plan”, and “evacuation plans” do not produce any results.
Relevant Federal Occupational Safety and Health Standards are retrieved from the OSHA web site, [www.osha.gov](http://www.osha.gov). The sections dealing with Employee emergency plans and Hazardous waste operations and emergency response are of specific interest for this study.

An internet search is done to locate State of Vermont statues concerned with evacuations. A site maintained by Matthew Bender and Company, Inc, a member of the LexisNexis Group is located. A key word search on “evacuation” is done and the matches evaluated for relevance to this study.

The Learning Resource Center at the National Emergency Training Center is used as a source of research materials for general information. Searches were made through the directory on “Evacuation Plans”, “Hazardous Chemicals”, “Hazardous Materials Accidents”, and “Warning Systems”. Articles and Executive Fire Officer Program papers were then reviewed and those having relevant information were selected for this study. In addition, general searches were made on the Internet for information on propane emergencies and evacuations. Several works were selected to be used for this study.

An e-mail is sent to the State of Vermont Director of Emergency Management requesting that office’s interpretation of laws and regulations concerning community evacuation plans and requirements. A letter requesting information is sent to the manager of the propane transfer station to get specific information concerning the operation and its effect on Montpelier.
GIS information from the City of Montpelier system is used to map specific information. Buffer zones of 600 feet, one half mile, and one mile from the transportation routes are determined to locate facilities and hazards within those areas. Mapping of those same distances are done from the six intersections most likely to be locations of incidents. These maps will be used for specific incident location planning.

**Evacuation plan development.**

Successful development of the City Evacuation Plan will require the cooperation of various city departments. Open communications are critical. A memo is sent to the Police chief and the Director of Public Works to inform them of the research study. The City Manager and Fire Chief receive copies of the memo. An immediate response was received from the waste treatment plant which has specific hazardous materials and is directly on the route taken by the propane tankers.

Preliminary work on the literature review and answering the research questions is completed early in November, 2003. That work is then made available to the City Manager, the Police Department, and the Public Works Department. Those departments are requested to review the information, gather any relevant information, and participate in a meeting to be scheduled after December 15, 2003.

A planning meeting was held with the Police Department and Public Works on December 19, 2003. At this meeting it was decided to narrow the focus of the report and the preliminary plan to include the following four items: 1) Educate city employees to the risks involved with bulk propane transport, 2) establish the basic criteria that would trigger an evacuation and activation of the EOC, 3) educate city employees to potential evacuation areas and identify specific hazards in each area, and 4) plan for the Police Department to secure an initial perimeter.
city by denying all access into the city. The plan developed for this report is based on those four items.

Limitations

The plan presented with this report is not a comprehensive evacuation plan. The scope of the task requires that it be a continuing work in progress. There is a need to include many more community and service organizations in a final plan. However, the knowledge gained from this study will have an immediate impact on the handling of an incident that could occur now.

RESULTS

The research done during this study provided the information to answer the research questions. Analysis of that information allowed the development of the initial evacuation plan. This plan, while limited in scope, focuses on the most important decisions that need to be made and actions that will have the greatest immediate impact.

Research Question #1: What are the legal requirements concerning community evacuation plans?

A review of the Federal and Vermont laws shows that two separate approaches indicate the need for the community evacuation plans. The first approach is to consider the various hazardous materials laws and the mandates in them for planning to protect the community. The second approach looks at the occupational health and safety laws and the need for the employer to protect employees. When combined together it is clear that the community must have an evacuation plan, especially for a known hazard.

The State of Vermont Director of Emergency management summed up one part of the legal issue in a memo to the author of this study. “I am not aware of any specific references that a city must have a plan entitled ‘evacuation plan’ but there are a number of Vermont and Federal requirements that each community have an emergency plan and one of the common protective
actions that public officials can order for many emergencies is evacuation” (A. Lewis, Personal Communication, September 15, 2003). Federal law requires planning to include the identification of routes used for transporting hazardous materials and that emergency plans must include evacuation plans (Comprehensive emergency response plans, 42 U.S.C. Sec. 11003). Vermont law has general provisions that emergency functions include evacuations when hazardous materials are involved (Definitions, 20 V.S.A. Sec 2). The city has a responsibility to be involved in preparing for evacuation when a known hazard exists.

The second reason for having an evacuation plan is that the city is responsible for providing for the health and safety of its employees. Employees must be trained and equipped to safely perform their job. If their job involves an emergency response to hazardous materials then there are specific training and response responsibilities that must be met (Hazardous waste …). According to OSHA, propane presents a very substantial explosion hazard (Operations level …) and employees must be protected from that risk. If the risk can not be controlled, then the employee emergency plan must identify areas of refuge that employees will be evacuated to (Exit routes …). According to Roberts (2000) there are three primary effects of a catastrophic failure of a propane tank leading to a BLEVE and ignition of the gas cloud. These effects are blast effects, thermal radiation, and container fragment travel. Roberts based the following results on a hypothetical BLEVE of a 10,000 gallon tank filled to 80% capacity. Blast effects up to 300 feet from the tank, serious thermal effects up to 600 feet, and fragments up to 6,740 feet with 80-90% falling within 1,800 feet. These figures are supported by the supervisor of the propane transfer plant (Collins, Personal Communication, September 26, 2003) who reported that blast and thermal effects would be a concern within a radius of 800 feet and that tank pieces have been known to travel up to three quarters of a mile. He would recommend an evacuation
distance of one mile. His information was based on a BLEVE of a tanker load of 9,747 gallons. Based on this information from two different sources, employees must be evacuated about a mile from a potential BLEVE of a tank containing 8,000 to 10,000 gallons of propane. The U. S. Department of Transportation is in agreement with this figure, recommending isolating an area of one mile radius from an incident where a propane tank truck is involved in a fire (2000 Emergency Response …).

However, responding city employees, primarily firefighters and police, are faced with two conflicting duties. They must try to protect endangered civilians and they must get outside the danger area themselves. The city can help assure the safety of employees by reducing that conflict between duties by having an evacuation plan for the civilian population prepared in advance.

There is a clear need for the city to have in place an evacuation plan. Under Federal and Vermont law the community has to be prepared to deal with emergencies. Evacuation planning is a part of emergency planning. Under Federal regulations, administered through the State of Vermont, the city must protect its employees from harm, evacuating them if necessary from reasonably expected emergencies.

**Research Question #2: What are the components of an evacuation plan?**

The components of an evacuation plan are based on an evacuation being used within the context of some specific action plan. According to OSHA hazardous materials response regulations an emergency response plan must have a minimum of eleven elements (Hazardous waste …, 1910.120(q)(2)). Of the eleven, six have a direct impact on evacuations. These six are “personnel roles, lines of authority, training and communication” (1910.120(q)(2)(ii), “emergency recognition and prevention” (1910.120(q)(2)(iii)), “safe distances and places of
refuge” (1910.120(q)(2)(iv), “site security and control” (1910.120(q)(2)(v), “evacuation routes and procedures” (1910.120(q)(2)(vi), “emergency alerting and response procedures” (1910.120(q)(2)(ix). Expanding on these six elements gives a good foundation of what is necessary in the evacuation plan.

The first element concerns roles, authority, training and communication. This can be broken down into two segments; incident roles and authority and pre-incident preparation and communications. The incident commander must make the critical decisions whether to evacuate and how much to evacuate (Carlson & Isman, 1988). In Vermont, by statute, the incident commander at a hazardous materials incident is the fire chief or his assistant highest in rank (Powers and duties …, 20 V.S.A. Sec. 2673). Personnel at the scene work for the fire chief. Those personnel are likely to be from non fire department sources (Carlson & Isman, 1988; Augustine & De Lorenzo, 1996) and good cooperation between different agencies will be critical. However, the public also has a role. Phillips (1992) describes how important it was that the community had what he describes as a disaster subculture. In that case the community was aware of the danger and was prepared to react. In contrast, Rogers and Sorensen (1989) found that the most frequent initial response to a warning in the two train derailments was to disregard it. Any plan needs to be communicated to the people involved and those people need to be trained on it.

The second element is emergency recognition and prevention. Obviously prevention has failed when the incident occurs, but early recognition of the potential can avert a disaster. Rogers and Sorensen (1989) concluded that people can be engulfed by dangerous conditions before warning when there is a rapid onset of emergency conditions. Augustine and De Lorenzo (1996) found that people were slow to react until there was a visible cloud and then panic behavior
occurred in some locations. The emergency services must recognize the potential of the hazard and be prepared to act even before there are obvious visible signs.

The third element is safe distances and places of refuge. For the propane truck emergency there are two major safe distances to be considered. The first distance is where blast effects and/or thermal radiation are expected to have significant effects. That appears to be between 600 feet (Roberts, 2000) and 800 feet (Collins, Personal Communication, September 26, 2003) from the tank. Within these distances property is expected to be destroyed and people injured or killed. The second distance is concern over fragments of the tank propelled by the explosion. The propane transfer facility recommends an evacuation distance of one mile because tank pieces have been known to travel about \( \frac{3}{4} \) of a mile (Collins) while Roberts (2000) calculates a maximum distance under extreme conditions of 6,740 feet, well over a mile. However, he does state that 80-90\% of fragments should fall within 1800 feet. When you look at the area covered by a mile radius, it is clear that the chance of any particular location being hit by tank fragments becomes very small. However, there is significant chance of damage or injury where the fragments do land and where the fragments will land can not be predicted.

Places of refuge must be outside of danger area. While most people will go to friends or family (Phillips, 1992) there is still a need for public shelter locations. Those “evacuation sites and there management should be established in advance” (Carlson & Isman, 1988, p.38) and need to be prepared to provide all services, including feeding, sleeping, hygiene, medical services, communications, social services, pet control, and entertainment (Augustine & De Lorenzo, 1996; Carlson & Isman, 1998). Carlson and Isman (1988) stress the importance of maintaining information on where evacuees go. This is especially important when children are evacuated separately from their parents.
The fourth element is site control and security. Controlling the perimeter of an incident is important to keeping non-affected people from getting into the hazard area. In the Taft, LA evacuation police roadblocks were in place immediately and had a positive effect on the evacuation (Phillips, 1992). In Miamisburg police had to reroute rush hour traffic and deal with people insisting on returning into evacuated areas “to close up their homes, and to find family members and pets” (Augustine & De Lorenzo, 1996, p. 271). Johnson and Zeigler (1986) state that planners have to take into effect human behaviors, especially families that are separated and people with special needs. This is supported by Rogers and Sorensen (1989) who report that “social dynamics of location by time of day and day of week are a contributing factor in the apparent difference in the warning and associated response” (p. 67) for the two railroad incidents they studied.

The fifth element is evacuation routes and procedures. According to Johnson and Ziegler (1986) evacuation plans for transportation incidents must be more flexible because of the inability to predict the precise location and circumstances of an incident. The hazard zones extend linearly along the whole transportation corridor. Fickes (2002) reports that in Denver, emergency managers have to do much of their planning “on the fly” when something happens. Denver is expanding its computer mapping capabilities to give better information of hazardous materials transportation routes. Evacuation routes have to be designated and the evacuees must know where to go.

The sixth element is emergency alerting and response procedures. The “pro-active response required to protect or avoid is impossible without alerting the public to the potential for hazard and notifying them about appropriate response(s)” (Rogers & Sorensen, 1989, p. 58). They break the warning process into two separate parts, alerting and notification. Alerting cues
people to an emergency situation. Notification typically gives information on the emergency and a recommendation on how to respond. People respond to a warning based on prior experience and the social environment they are in. People evaluate a warning and make a personal perception of their risk. They then act based on the perceived risk. This evaluation of people’s behavior is supported by Augustine and Lorenzo (1996) and Phillips (1992). There is indication that prior awareness is effective in making the warning effective. Phillips (1992) concludes that prior experience with planning and evacuations made the process flow smoothly in Taft, LA. Referring to the same incident, Johnson and Zeigler (1986) credit planning for a nuclear plant allowed the process to go smoothly during a chemical plant emergency. Rogers and Sorensen (1989) report that the content of the warning heavily influences the public response. Some of the specific factors they list that help shape the public response are “credibility of the warning source; clarity, consistency, accuracy, and detail of the information; and frequency of the message issuance” (p.61).

An effective evacuation plan will have to incorporate all six elements listed above.

Research Question #3: What are significant issues that have arisen in the past concerning evacuations?

The issues that have been reported in past evacuations are “people issues”. They are primarily concerned with the warning of people and the willingness of people to comply with instructions. A review of these issues indicates areas that need special attention.

The first problem is warning people that a problem exists and informing them what they should do. Rogers and Sorensen (1989) break the warning down into two separate parts, alerting and notification. Alerting makes the person aware of a problem and notification gives them information about the emergency and what they should do. While other potential evacuation
situations may have days or even weeks to prepare (Fickes, 2002), when hazardous materials are concerned, the warning time may be very limited if exposed people are expected to evacuate or take other protective measures (Rogers & Sorensen, 1989). There are a number of options for alerting and notifying. These include radio and television, reverse 9-1-1 systems, internet connections, portable sirens, bullhorns, and house to house canvassing (Fickes, 2002; Rogers & Sorensen, 1989). However, sometimes nothing seems to work. “Former Vermont law School staffer and Montpelier resident John Friesman slept through anxious pounding on his door, flashing lights on police cars and even a phone call from a neighbor as fire crept up on his rented Southern California townhouse” (Palmer, 2003).

Getting people to comply is an issue in evacuations. People react to an alert and notification by making a personal risk assessment. If they perceive no risk they will not react. Rogers and Sorensen (1989) found that disregarding the warning was the initial action most often taken. However, in one of the two incidents they studied, where people in the immediate area of the incident recognized the potential of danger, they started evacuation on their own. Similar results were found by Augustine and De Lorenzo (1996) where the “general public was notified of the emergency, but was slow to respond until the cloud was visible. At that point panic behavior occurred in some locations as people began moving rapidly away from the cloud” (p. 271). Phillips (1992) found that prior experience with evacuations and general public awareness of the potential danger was a factor in having a smooth evacuation. Another situation occurs when people perceive a greater risk than the authorities report and, not trusting the authorities, evacuate on their own. Johnson and Zeigler (1986) report that when a precautionary evacuation of about 3,400 pregnant women and pre-school age children was announced for a five mile radius around the Three Mile Island nuclear plant, “an estimated 200,000 people from within 25
miles of the plant left their homes” (p. 153). As Rogers and Sorensen (1989) report, the credibility of the warning source is a critical factor.

The status of family groups appears to be another important factor in getting people to respond as desired in an evacuation. Phillips (1992) reports that one of the reasons for the smoothness of the evacuation in Taft, LA was the fact it occurred at 4:45 AM on a Saturday morning. Family members were together and evacuated together. Rogers and Sorensen (1989) also report that time of day (one incident at noon and the other at 4:20 AM) was a factor in differences they observed in the warning and associated response. Families being together caused different social dynamics. Augustine and De Lorenzo (1996) also report that some citizens insisted on going back into evacuated areas “to close up their homes, and to find family members and pets” (p. 271).

A successful evacuation plan is going to recognize that you are asking people to leave the comfort of their normal surroundings. They are going to lose control of their lives at that point. There needs to be a credible reason along with assurance that their lives, family, and property will be protected and taken care of.

Research Question #4: What are specific problems that Montpelier faces in responding to a propane transportation accident?

There are a number of specific issues that Montpelier needs to address in developing an evacuation plan for the propane transportation incident. These include the terrain, the road network, the location of emergency response facilities, the location of public facilities and buildings, the location of possible evacuation centers, and the number of and training level of emergency responders.
The terrain presents problems for responders. The center of the city is located in a flat area at the confluence of two rivers. The propane transportation route is on the southern edge against a hillside. The hillside could reflect and direct blast effects toward the city center. The route to the east is in a valley. This valley could direct and increase blast effects along the valley, but the hills could limit the projection of tank fragments to the sides. The route south climbs a steep hill above the city. In an incident there the added elevation could increase the travel distance of tank fragments.

The road network presents a number of difficulties. There are very limited alternative approaches to most locations along the routes taken by the propane tankers. A long detour would be necessary in almost every case to get to opposite sides of an incident. Where a shorter route is available it would take responders right along the edge of a 600 foot buffer from the truck route. There are very limited detour routes to channel traffic away from danger areas or to bring responders into the area. Until roads are shut down they would continue to funnel traffic into the danger area. Once shut down the traffic will continue to back up. This incoming traffic will block access of emergency responders and compound any efforts to get residents out of the danger areas. The hospital is outside the city and not directly affected by these transportation routes. However, access to the hospital could become very difficult depending on an incident location. An incident involving the interstate through Montpelier will have incoming traffic backing up and through trucks will be facing up to 50 to 100 mile detours. Depending on the location of the incident citizens will have to be evacuated by foot, driven close to the incident, or sheltered in the danger zone because of no alternative roads out of areas.
The public safety facilities are all in the potential evacuation zones. These facilities include the fire station, the police station (including the regional fire dispatch center), the county sheriffs office, and the public works garage. The fire station and police station are within several hundred feet of each other and the sheriffs office is two blocks away. The public works garage is remote from the other locations.

There are a number of public facilities and buildings in the potential evacuation zones. The water treatment plant is right next to the travel route for all the propane transports. The plant has Chlorine and Sulfur Dioxide on location. A power company maintenance facility is located within the 600 foot zone. A major transmission substation is located within the 600 foot zone. State office buildings and the State House are located at the edges of the 600 foot zone and well within the half mile zone. City Hall is located just beyond the 600 foot zone. The high school is located within the 600 foot zone. Two elementary schools are located within the half mile zone. The middle school is located just beyond the half mile zone. A college campus is located within the half mile zone. Most of the churches are within the half mile zone.

Planning for evacuation centers is difficult. All buildings and locations with good facilities are located within the one mile danger zone. Most of those locations are located within a mile of each other and very likely all be unusable at any one time. Evacuation would then rely on several communities between eight and ten miles away in four directions. There are very limited transportation routes connecting those communities if traffic can not transit through Montpelier. Inclement weather can further restrict that travel.

The number of available responders will have an effect on the planning. The MFD has between three and six people on duty depending on the time of day and day of week. Call personnel and off duty career personnel respond in on a call. The department can plan on 12-15
people on scene within 10-15 minutes. About 40 mutual aid personnel from four departments can be expected in 15-20 minutes. These departments will all face problems with the road network and traffic. The MFD is going to be very limited in the tasks that can be accomplished in the first 15 minutes. Priorities will need to be determined early and certain aspects of the incident left uncontrolled. The actions taken will be affected by the fact that the MFD and neighboring departments are only trained to the OSHA operations level. Sufficient technical resources will take an hour or more to arrive. The Montpelier Police Department (MPD) has limited personnel on duty. They also depend on off duty personnel and mutual aid from neighboring departments. Public works is available depending on time of day and the specific jobs they are performing at the time.

Propane Incident Evacuation Plan.

The Propane Incident Evacuation Plan is developed from the information gained in this study. The plan is attached as Appendix A. The plan provides for the initial actions to be taken by the City of Montpelier. These actions will provide immediate benefit in case of an incident. The plan provides for educating city employees to the hazard, identifying circumstances that will trigger an evacuation order, identifying the most likely areas to be evacuated, and preparing to seal off the City to prevent additional people converging on an incident.

There are major benefits for the Montpelier for adopting the initial plan and devoting the resources to develop it over time. A major risk to the city is addressed. In addition, a bulk transportation incident involving propane represents a “worst case” scenario for Montpelier. Therefore, the plan will be adoptable for both smaller propane incidents and for any other hazardous situation which may require evacuation. The primary limitation is that it is only the initial plan. It will need further work over a period of several years.
DISCUSSION

This study showed the complexity and scope of planning necessary for some emergency situations. Propane transport had always been of concern in the city, but factors outside the city have greatly increased the risk to the city. The majority of the city is within a one mile radius of some point along the routes regularly traveled by the bulk propane tankers. That mile radius is an established industry standard (2000 Emergency Response …; Collins, Personal Communication, September 26, 2003) supported by theoretical work (Roberts, 2000). Everything within that mile radius is considered a hazard zone. Not only must the city be concerned for the safety of citizens within the mile radius, but the city has an obligation under hazardous materials and occupational safety regulations to remove its employees from the danger zone (Hazardous waste operations …, Exit routes, Emergency …).

Developing a plan for a transportation risk is much more difficult than for a fixed facility. When the specific location of the hazardous situation is known, very specific plans can be drawn up, especially concerning evacuation routes and areas of refuge. In Montpelier’s situation the problem is magnified in that all major public facilities are in the area at risk and until the incident occurs no location can be depended upon to be available. Evacuation is going to require people moving four to ten miles in all directions with very few connecting roads between locations. The chance of families being separated is very high and because of that, difficult situations could arise, especially early in an evacuation. These are the significant human issues discussed by several of the authors referenced in this study (Augustine & De Lorenzo, 1996; Johnson & Zeigler, 1986; Phillips, 1992; Rogers & Sorenson, 1989). As the plan develops and the community begins to be educated these problems will be addressed and solutions found. This
will derive partially from the development of a “disaster subculture” that Phillips (1992) described.

There are several major advantages to planning for this issue. The first is that the city as a whole will be better prepared for this type of incident. The second is that a bulk propane transportation incident can be considered a “worst case” situation for the city. Preparation for this type of incident will provide the framework for successfully responding to any incident requiring evacuation. The effort put into preparing personnel, developing procedures, protecting facilities, etc, will be of general use in protecting against any hazard.

The initial evacuation plan developed from this study provides the greatest benefit for the resources available to develop it. The plan concentrates on educating the responders on the hazard and the area at risk. This will allow for good basic decisions to be taken immediately when an incident occurs. These immediate decisions will concentrate on the decision to evacuate and the area to be evacuated. The plan can then be more fully developed to fill in the other areas that need to be addressed.

**RECOMMENDATIONS**

This study produced an initial plan for evacuating people placed at risk because of a possible catastrophic bulk propane transport failure. This framework is primarily concerned with defining the hazard and ensuring that all responders are aware of the risk to the community. The plan also gives some basic guidelines for starting the evacuation process in a timely fashion. In addition, because the propane transportation hazard presents a “worst case” scenario, this basic plan provides the framework to be used in any situation requiring evacuation. This report recommends the following be done.

1) The City adopt the *Propane Incident Evacuation Plan* as an initial plan.
2) All departments will start the training required by the plan.

3) All departments will make contacts with mutual aid to coordinate the initial response and expected actions.

4) Planning will start with community groups, neighboring communities, and non-governmental agencies to fully develop the plan.

5) Planning at all stages should be accompanied by drills and exercises designed to test and evaluate the plan.

Acceptance and implementation of the plan will go a long way toward making the City of Montpelier a safer community. There is a current risk that has not been adequately addressed. By addressing this risk the city will be better prepared to react and control the harmful effects of an incident.
REFERENCES


Powers and duties during hazardous chemical of substance incident, fires; threat of fires or explosions. 20 V.S.A. Sec 2673. Retrieved October 9, 2003 from http://www.leg.state.vt.us/statute


Appendix A

Propane Incident Evacuation Plan

Purpose of this Plan

This plan will provide direction and guidance for City personnel to use to assess and respond to an incident involving the bulk transportation of propane.

Additional applications of the plan:
1) Because the plan addresses the most serious propane incident in the city, the plan also provides the framework to respond to a smaller propane incident.
2) Because the recommended evacuation radius from a bulk transport incident is a “worst case” scenario, the plan provides the framework for any emergency situation requiring evacuation.

The plan is an initial plan to allow immediate, effective action to protect the city. The plan will need to be developed and expanded over the next few years in order to be a comprehensive plan.

Plan Outline

1) Education Component
2) Support and Resources
3) Initial Operational Actions

Educational Component

Employee Training Goals
1) All City Employees will have awareness training annually on the hazards of propane transport.
2) All Police, Fire, and Public Works employees will have annual training reviewing the potential evacuation areas based on possible locations of an incident.
3) Police and Fire will share basic planning information with their primary mutual aid on an annual basis.
**Support and Resources**

1) Identify the Mutual Aid: Police, Fire, and EMS that will be called initially. Ensure that they are aware of the basic plan.
2) Identify the specific resources available to deal with a propane incident. Arrange for methods to contact and authority to authorize their activation.

**Initial Operational Actions**

**Command and Control**

1) Fire Department will have Incident Command as required under State Law.
2) EOC will be activated immediately if there is any possibility of an evacuation beyond the immediate area of the incident.
3) The following conditions will trigger the start of evacuation. Police Officers may be first on scene and need to be prepared to start the process.
   1 - Major damage to the propane tank.
   2 - Fire impinging on the propane tank.
   3 - Compromised pressure relief system. Tank rolled over or on end or damage to the relief valve area.
   4 - Terrorism, sabotage, or other deliberate damage.

**Initial Areas of Responsibility**

1) Fire Department to scene. Coordinate control of incident and start of evacuation in area nearest to the scene. Montpelier Fire / Ambulance personnel and incoming Fire Mutual Aid will need to sector the area and start removing people.
2) Police Department will act to seal off the City of Montpelier to prevent additional people converging on the incident.
3) Public works as available will assist the Police with barricading roads unless the Public Works Facilities are at high risk and need to be evacuated.

**Special Operational Concerns**

1) The EOC and Dispatch could be in a relatively high risk area and a catastrophic failure could disrupt communications and control.
2) Public Works could be rendered totally unavailable if an incident occurred in certain areas.
3) All operational personnel need to understand that their job is to remove any civilians in the area to be evacuated and then **exit the area and stay out.**