Project Number: IQP-PPM-0901

IQP-LDA-0901

Case Studies of Partial Evacuations in the City of Worcester

Under Chemically Hazardous Conditions

An Interactive Qualifying Project Report

Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

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Abstract

Evacuations can occur for many different reasons, but they all have the same objective: to save lives. The most effective way of accomplishing this goal is to utilize all the available resources and plan thoroughly for how to handle situations that necessitate an evacuation. Chemical hazards and fires both routinely merit evacuations, and in this project the procedures for evacuations under these conditions will be modeled and analyzed in order to make the evacuation process more efficient.

Disclaimer

The views, opinions, and conclusions expressed herein do not necessarily state or reflect those of Worcester Emergency Management, Worcester Police Department, Worcester Fire Department, Red Cross, Worcester Regional Transit Authority, Worcester Communications Center, or the employees thereof.

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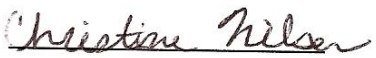
Christine Nilsen 

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1.0 Introduction

This project was performed under the sponsorship of Worcester Emergency Management, with the support of the director Captain Ford. The goal of this project was to conduct a case study analysis of the I-190/I290 chemical spill and examine a similar scenario requiring a partial evacuation in Worcester to see how several different city departments interact in the event of an emergency. The knowledge gained from these scenarios was then used to make a model for emergency evacuation procedure. These models form the foundation of the results, as both incidents investigated for this project are applied to the models and analyzed.

In general, evacuations are used to remove people from a dangerous situation. Fire evacuations are very common, and occur when a building is on fire. Other reasons to evacuate include blizzards, tornados, hurricanes, floods, bomb threats, and other hazards that could injure or kill surrounding people. The Fire Department or a hazardous materials team often carries out dangerous environment evacuations. The police department could handle future threats, such as an upcoming blizzard, as well.

One event that illustrates the importance of emergency management is a chemical spill that occurred in Worcester, Massachusetts in October 1999. This spill involved an overturned tanker truck at the cross-over ramp between I-290W and I-190 N. The emergency response was successful, and the hazard was eliminated without any serious injuries to residents or responders. In this particular response, many of the ICS procedures were executed, contributing to the smooth response by reducing the complexity of the incident. However, a great deal of variables can complicate both the incident and response, and it is therefore important that various agencies involved interact effectively and plan ahead.

For this project the I-190/I-290 chemical spill was researched thoroughly, and a case study analysis was developed; it is included in Appendix A of this report. Through the use of newspapers, incident reports, and personal interviews, an understanding of what occurred at the incident was achieved. This understanding can be applied to future analysis and suggestions. The personal interviews provided information about what happened at the site, but more importantly provided a sense of what could have gone better during the incident.

In addition to the 1999 case study, this project included the investigation of a hypothetical chemical spill. The hypothetical scenario that we developed included a chemical tanker overturning on the eastbound off-ramp of exit 11 on I-290. This exit leads directly to the College of the Holy Cross and Southbridge Street, which leads to the former industrial district of Worcester. It involved the chemical tanker catching on fire, and the surrounding residential homes needed to be evacuated.

To investigate these events, the members of the project team were divided into three sub-groups based on the major components of an evacuation. These components are transportation, communication, and operations. These sub-groups investigated more in-depth how that particular aspect of an evacuation was handled in the I-190/I-290 spill, as well as general information about how each component operates during an emergency.

The group pulled information from three important aspects of an evacuation, and set up a Focus Group meeting based on our hypothetical chemical spill. There were several head of departments present representing each of the three major components of an evacuation. Our scenario was presented to them along with maps and photographs of the site. The meeting then proceeded as if the scenario was a real emergency happening at that moment. Each department explained what their roll was during the emergency, and worked together to discuss the response strategy and solve problems that may occur in the response.

The project included an assessment of how the agencies interacted and made use of Worcester's resources for an evacuation, such as shelters, transportation, and communications. We assessed Worcester's resources for an evacuation, such as shelters, transportation, and communications. Our project was intended to be helpful to Worcester Emergency Management; however, our results will benefit the community as a whole. Our results will be presented in a series of models that serve to illustrate the elements of emergency response, and they can be used in the future to evaluate emergency evacuation procedures. These will be provided to Captain Ford of Worcester Emergency Management at the end of the project in D Term 2009.

Included in this report is background about emergency evacuations, the subsections related to critical components of evacuations, and analysis of the current method of evacuating Worcester.

This project was performed as a partial requirement of the Degree of Bachelor of Science, and is intended to be an educational experience. Under the supervision of faculty advisors, our project team created a proposal and utilized various research methods to achieve our goal. Through this project, the team learned a great deal about the field of emergency Management, but we also gained important experience in research and reporting techniques.

2.0 Background

The field of emergency planning is rapidly expanding in light of recent events such as the September 11th attacks and Hurricane Katrina. Cities are now directing more attention and funds to emergency planning and preparedness. Our research builds upon the basic principles of emergency management as well as existing plans and incident reports prepared by the City of Worcester. Additional background information relating specifically to transportation concerns may be found in Appendix B.

We begin with the definitions of emergency management and preparedness and why they are so important. This section illustrates the perceived current rise in disasters and how communities are being affected, followed by the benefits of emergency management and greater costs due to poor planning. Continuing with our background, a thorough examination of the major principles in emergency management is presented. These principles include mitigation, preparedness, response, recovery and evaluation.

Mitigation is done before any planning begins. It involves efforts to prevent any hazards from becoming disasters or emergencies. Mitigation can be either structural or non-structural methods in addition to vulnerability and risk assessment. Structural methods involve reinforcing homes and buildings as well as structures for flood protection such as dams and levees. Non-structural methods include improving safe practices when transporting hazardous materials or training for preventing small incidents from becoming full scale disasters. Preparedness is the initial planning stage for emergency managers after mitigative efforts have been completed. It involves, among other aspects, plans for communications, multi-agency coordination and training for responders.

Response is the execution of the plans that have been prepared and mobilization of emergency services during an emergency situation. Recovery begins after the initial effects of the emergency are managed and there is no longer any danger to the public. Now, the main focus is on restoring the community to its original state. This means rebuilding and repairing anything damaged in the disaster.

Finally, we have the evaluation stage. After all of the emergency operations have ceased the effectiveness of the planning, response and recovery must be assessed. This is usually done with incident and After Action reports. The conclusions are then used to modify plans and achieve more successful emergency response and recovery operations. Our background section concludes with the history of emergencies in and around the City of Worcester.

2.1 Emergency Management

Emergency management is the responsibility of one person or a team of qualified professionals to ensure that a community is prepared for crisis situations. Each member uses their expertise and experience to elevate the level of preparedness of their district and participate in the response action of a real emergency. To accomplish this emergency managers are trained in the principles of National Incident Management System (NIMS). According to NIMS, emergency preparedness is the preparedness level of responders who will be able to effectively coordinate and execute their operations when required (NIMS Online).

The level of preparedness necessary for communities has grown in the past few decades. This is due to increasing numbers of natural and man-made disasters. Climate changes have amplified the intensity and frequency of hurricanes, earthquakes and other weather related disasters in recent years. Populations have also become more vulnerable due to the large number of urban areas situated in and around disaster zones. Man- made disasters have also risen in past years. As countries become more industrialized the possibility of chemical and biological emergencies are far greater. Additionally, the risk of terrorist attacks is much higher and can be devastating to densely populated regions. Still, the effects of these disasters can be lowered significantly with emergency preparedness. Communities will be able to reduce the immediate impacts of a disaster and smoothly transition from response to recovery. Through greater awareness and mitigation, the effects of a disaster will be lessened, and communities can quickly recover and return to normal development.

2.2 Rise in Disaster Planning

Disaster planning has risen significantly in recent years due to the substantial effects of the latest weather related and man-made disasters. Emergency plans are more important than ever with densely populated cities all over the United States. Our national government saw a need for a national emergency response organization and created FEMA, the Federal Emergency Management Agency, on April 1, 1979. However, FEMA is only called upon when the disaster overwhelms state and local resources. In addition, a federal response cannot be mobilized as quickly as one locally. This is why all large cities must create and continually modify their own emergency plans. Cities in different regions of the United States require unique plans for the distinct disasters they may face. Local governments are now budgeting for emergency planning and spending more time on mitigative measures. According to a 2005 article in the *Boston Globe*, the mayor of Boston announced an $827,500 emergency preparedness plan. The new evacuation plans for Boston are adaptable to all hazards and allow for the entire city to be evacuated in just a few hours. This includes signs for designated evacuation routes and shelters for residents in different areas of the city. All disasters cannot be prevented, however more time spent on planning and preparing will reduce the effects of the disaster and save lives and money.

2.3 Mitigation

The first phase of emergency management is mitigation. By implementing appropriate mitigation techniques a community can either prevent hazards from ever becoming emergencies or minimize the effects of a disaster that occurs. However, before any mitigation strategies are employ, a community must first evaluate its vulnerability. This means completing a risk assessment for hazards that exist in the area. A risk assessment helps to identify and evaluate hazards and can be done using the FEMA model. The FEMA model uses four criteria to evaluate possible hazards and will be further explained in the next section.

Mitigation has become one of the most effective methods for preventing and reducing the effects of disasters and can be done by different means. Mitigative techniques include structural

and non-structural measures. Structural measures use technology to prevent and reduce the effects of hazards. Some examples are dams, levees, and reinforcement of buildings. Non-structural methods mainly deal with legislation and land use and development planning. The value of mitigation strategies to society is exceptionally high. According to a study done by the Multi-hazard Mitigation Council, which is a National Institute of Building Sciences council focusing on reducing the total costs associated with natural hazards to buildings, every dollar spent on mitigation saves society roughly four dollars. Also, with regard to floods, stricter building standards prevent 1.1 billion dollars a year in damage and allow homeowners to recover quickly (Federal, 2008). Because mitigation uses long term measures to reduce and eliminate risk it proves to be one of the most efficient and cost effective phases of emergency management (FEMA, 2008).

2.4 The FEMA Model

There is no "correct" way to prioritize hazards, however, by using the FEMA model emergency managers can gain a better awareness of the hazards they may face and plan accordingly. The FEMA model uses four criteria to rank hazards; they are history, vulnerability, maximum threat and probability. History looks at past emergencies and which hazards triggered them. If these hazards still exist then similar emergencies can occur. Next is vulnerability, which is used to determine the number of people and value of property vulnerable to a particular hazard. This is based on population density, locations of population and valuable properties as well as vital facilities. Maximum threat assumes the worst-case scenario with the greatest impact and is conveyed in terms of casualties and property loss. Finally, probability is the likelihood of a hazard causing an emergency and is expressed in chances per year. To complete the model a scoring and weighting system is used for each category. Each criterion is given a score of one, five or ten for low, medium or high risk. Then based on multipliers for each criterion the final score is determined by summing the weighted score for all four categories. FEMA uses a median weighted score of 100, and hazards with scores over 100 should be given a higher priority (WHO, 2008).

2.5 Preparedness

After mitigation strategies have been put in place, emergency preparedness is the next step. This phase focuses on planning and training for disasters that may take place rather than prevention. When a disaster strikes, the necessary agencies, equipment and resources must be ready to act in an organized manner. A comprehensive plan must be developed for all circumstances that can be followed and modified in real time to meet the needs of the particular emergency.

There are four main areas that must be covered thoroughly to be fully prepared. These are transportation, communications, resources, and training (Preparedness & News, 2009). Transportation involves the movement of emergency responders, evacuees and resources. Maintenance of infrastructure is equally as important as emergency vehicles must be able to get to and from the affected area, and citizens must be able to evacuate. Communications encompasses multi-agency coordination, informing the public and a unified command system to alleviate problems between differences in agency protocol. In the event of an emergency the proper resources must be at hand and ready to use. Shelters, supplies and equipment must all be accounted for during the planning stage to insure availability for distribution. Finally, every agency and responder must be trained to know and carry out his or her responsibilities. Responders must be trained in the Incident Command System (ICS, 2008) to ensure good communication between agencies. They must also be prepared to deal with the stress and uncertainty associated with an emergency. A community will be well prepared with a comprehensive plan that accounts for these main areas (NIMS Online, 2008).

2.6 Response

After an emergency occurs it is time for all the training and preparation to be put into effect. Once a situation has been identified emergency services must be mobilized as quickly as possible. The first responders will most likely be police, firefighters and medical personnel. Depending on the extent of the emergency the first responders may be overwhelmed. They will be forced to act quickly and make decisions with little information. However, all responders

should be trained in the Incident Command System (ICS) and familiar with the community's predetermined emergency plans.

The ICS is an all-hazard incident management concept based on the principles of Unified Command and Mutual Aid. Following ICS protocol an Incident Commander will be appointed, based on experience and expertise, to lead the response operations and coordinate with all emergency services. The first responder at the scene is the initial Incident Commander, and as more knowledgeable personnel and higher-ranking officers arrive, the role of Incident Commander is passed to the most qualified person at the scene. The Incident Commander can modify the existing response plans using the ICS management structure, consisting of an operations branch, planning branch, logistics branch, and finance or administrative branch. A plan of action, decided at the scene based on current conditions and pre-planned procedures, will be drafted and carried out by the responsible agencies. Utilizing the ICS an effective initial response will save lives and prevent further damage. During the early stages of a response, the public will be informed of the emergency, and whether they are required to evacuate or defend-in-place. The Incident Commander will utilize local agencies to control the situation and restore normal order to the community. If the magnitude of the emergency exceeds state and local capabilities then Federal assistance can be requested by the governor of the state where the emergency occurs. At this time the Federal Response Plan (FRP) will be followed. The FRP outlines the process for delivery of Federal support to the affected area. The Department of Homeland Security will coordinate all response and recovery operations. Once Federal assistance is no longer needed, responsibility will be transferred back to state and local agencies (ICS, 2008)

2.7 Recovery

Once the hazard has been eliminated and there is no longer an emergency it is time to assess the damage and begin the recovery process. The affected area should be returned to its original state as quickly as possible. It is important for recovery efforts to begin promptly, while the community will be in favor of otherwise unpopular decisions. Immediately after a disaster the residents will likely come together and feel a sense of patriotism for their fellow citizens. They will feel compelled to help in any way possible and accepts decisions that may not be passed months or even weeks later when the initial sentiment has passed. These unpopular decisions usually involve allocation of funds for recovery that are otherwise used for community services.

Recovery operations will first involve a damage assessment to determine the foremost needs of the area. Citizens that have lost their homes will be temporarily housed in shelters or hotels run or sponsored by the Red Cross. Essential infrastructure and buildings will be rebuilt first, followed by the repair of residential homes. One of the hardest elements of recovery is acquiring the money to pay for the damage. For emergencies within the limits of state and local budgets the costs will be covered by state and local funds. However, for large-scale emergencies, the National Response Plan (NRP) dictates how Federal resources will be provided and used (Homeland Security, 2009). With financial aid readily available from the federal government, recovery operations can proceed without disputes over finances. The community just has to remain active and know that they have prepared well enough to handle the damages they have sustained.

2.8 Evaluation

The final phase of emergency management is evaluation. After every incident there must be an After Action report (AAR) written by the Incident Commander and discussed by the major agencies involved. This report is used to document the performance of agencies during the incident and make recommendations for improvements for future emergencies. Each report includes an introduction and background of the incident followed by the description of the event.

The report must also contain a list of all the agencies involved and a timeline of events during the emergency.

The main goal of every After Action report is to identify mistakes and correct them. To do this, the principal people involved with the incident discuss the response and make recommendations for the future. This is the lessons learned section, which includes a discussion and recommendations for each item. The costs, timetable for completion and follow-up responsibilities are also included to make sure the recommendations are completed. Finally, the report contains sections for training needs and recovery activities if needed. After Action reports are very helpful for evaluating flaws in previous emergency responses and correcting them.

The lessons learned from each incident can be examined and applied to the mitigation phase discussed at the beginning of the process. Emergency management is a continuous process; no community can be prepared for every incident. However by evaluating their performance after each response the community will be better prepared for the next event and consequently save lives and money.

2.9 Worcester Disaster History

The City of Worcester has not seen a vast amount of incidents requiring emergency response. However, there have been a few, and it is important for such a large city to be prepared for the worst. The first major disaster in the 20th century was the Worcester Tornado of 1953. This was the deadliest tornado to ever hit New England and took 94 lives, 60 from Worcester alone. Fifteen thousand people were left homeless, and the tornado totaled fifty-three million dollars in damages. Scientists believe the twister was a category F-4 and ranked it as the fourth worst in American history. If the early warning systems and improved building designs of today were in place in the fifties many lives could have been saved and properties preserved (Pombo, 2009).

One incident, which has an increased probability of occurrence in Worcester due to the industries in Worcester and the surrounding areas, occurred on October 28, 1999. A tanker carrying a dangerous chemical used in the production of plastics overturned on the entrance ramp

to I-190N from I-290W. This spill was hazardous to the surrounding neighborhoods and cars on the highway due to its level of flammability, as well as the toxicity of chemical vapors. The spill was handled well by Worcester fire, police and other responding agencies, as no fatalities occurred and damages were limited (McNamee, 2008)

Another disaster was the Worcester Cold Storage Fire, occurring less than two months after the chemical spill on I-290. On December 3, 1999 six firefighters lost their lives battling the fire. The fire was believed to have been caused by a couple living in the abandoned building. The couple knocked over a candle and fled without alerting authorities. When firefighters reached the scene they thought people were still in the building. Six firefighters entered and were lost in the zero visibility smoke that filled the warehouse. The initial assessment was wrong and likely caused fire fighters to enter unknowing of the true strength of the fire. At first the fire was estimated to be relatively small due to the design of the building composed of brick walls and few windows. The fire burned for six days and reached five-alarm status. At the time it, was the deadliest fire in Worcester since 1978. According to the National Institute of Occupational Safety and Health (NIOSH), which reviewed and reported on this fire, the deaths may have resulted from a lack of pre-planning. This was not to place blame on any person, but to make improvements for responding to future fires. NIOSH is a division of the Centers of Disease Control and Prevention and the Department of Health and Human Services (Firehouse, 10/02).

These three notable emergencies in Worcester prove that emergency management is necessary for the welfare of the public. Lessons must be learned from these events to improve disaster plans for the future. After extensive research, we have created a series of models that can be used to evaluate the emergency evacuation procedures in hopes that the results of future emergencies are less devastating. The following section outlines the methods of research and analysis used in the development of these models.

3.0 Methodology

3.1 Introduction

The following sections outline our methodology for conducting research and collecting data for beneficial results. Many of the methods outlined are typically seen used in most IQP reports and are generally effective means for generating desired results.

3.2 Research Methods

Several methods were utilized in the investigation and research performed for this report, including review of literature published by both federal and non-federal agencies, interviews with personnel directly involved in the emergency response process, and a focus group meeting in which a hypothetical scenario was presented to the supervisors of agencies and parties typically involved in the actual evacuation process.

The review of literature was performed using library databases, library books, and the Internet to search for news articles, reports, and websites that provided relevant information on emergency evacuations. The Gordon Library at WPI provided books on emergency planning and evacuation; however, the selection was limited and many of the available books were outdated. The Worcester Public Library offered a large database of news articles from various local and regional newspapers. These news articles provided concrete examples of emergencies that required evacuation, and helped form a foundation for the case study presented in Appendix A of this report.

The Internet provided a source of updated information regarding the current technologies and procedures used in emergency planning and evacuation. The Transportation Research Board website offered an online database of reports regarding transportation aspects of evacuations. The FEMA website provided online courses in the Incident Command System, which is crucial to the understanding of roles and responsibilities in an incident that may or may not require an evacuation.

The group as a whole conducted interviews with professionals involved in the I-290 chemical spill in order to better understand the events that took place. Chief Michael McNamee

of the Worcester Fire Department and Lieutenant William Trotta of the Worcester Police Department were both interviewed. Additionally, members of each sub-group of this project interviewed professionals involved in the particular aspects under investigation in each sub-section. George Mayo and John Carney of the Worcester Regional Transit Authority, a travel demands forecaster named Ed Bromage, and Professor Suzanne LePage of WPI were interviewed for the transportation subsection. Nicole Valentine, a Red Cross representative, was interviewed for the operations sub-section. David Clemons, director of the Department of Communications in Worcester, was interviewed for the communications sub-section.

3.3 Focus Group

Figure 1

A focus group meeting was held on the WPI campus in order to gain a better understanding of the roles various personnel play in an evacuation, as well as to gain valuable insight into the areas that may cause problems in a particular scenario. The members of this focus group included the WPI students, who served as the hosts of the meeting; Dick Bedard, Captain John Ford, and Lieutenant Tom Gingras of Worcester Emergency Management; Nicole Valentine of the Red Cross; George Mayo of the WRAT, Chief McNamee of the Worcester Fire Department; Lieutenant Trotta of the Worcester Police Department; and David Clemons of the Worcester Department of Communications. Each member was given a copy of the map shown in Figure 3, as well as Figures 1 and 2. The following scenario was presented to the members of the focus group;

It is a cool October night, with a temperature of approximately 50 ℉ and an easterly wind approximately 10 miles per hour. It is midnight on a weekday, with little traffic on the streets. A tanker truck traveling eastbound on Interstate 290 through Worcester is carrying approximately 50,000 gallons of Benzene in liquid form. The tanker truck exits I-290 at exit 11 toward Southbridge Street. College Square and the College of the Holy Cross are located at this exit, as well as a community of triple decker residential housing. The truck overturns at the end of the off-ramp, causing several small leaks in the tanker. The driver is able to escape uninjured

with identification papers for the chemicals being transported. As Worcester Fire Department arrives on-scene, the tanker ignites, creating intense flames.

Benzene is a known carcinogen and is also extremely flammable. Benzene evaporates into the air quickly, and its vapor is heavier than air, causing it to sink in low-lying areas. Benzene is also used in the production of other chemicals to make plastics and resins. It is one of the top 20 chemicals for production volume in the United States.

Figure 2

Figure 1 shows the off-ramp from I-290 described in the scenario. It is here that the tanker truck would overturn, causing a chemical spill and fire. Figure 2 depicts the homes located directly across Southbridge Street from the I-290 off-ramp. These homes would be at close proximity to the flames and toxic fumes produced by the fire, and residents of these homes would be evacuated in the scenario discussed at the focus group meeting. Figure 3 is a map of the area surrounding Holy Cross and the I-290 off-ramp from the presented scenario. This map was supplied to the members of the focus group so that they might have a more accurate understanding of the neighborhood and describe real locations where specific actions, such as establishing a command post, would take place. The red circle on the map denotes the area of the tanker truck rollover. The members of the focus group discussed the primary steps that would be taken in the emergency response to this scenario, focusing on the evacuation aspects as well as the role of the agency each member represents. Through this focus group, the group was able to understand the interaction between each organization during an evacuation, as well as the areas in which problems may arise during an evacuation, including the misunderstanding of responsibilities.

3.3 Methodology Conclusions

Using the information gathered through research, interviews, and the focus group, models of Worcester's emergency systems were created. A detailed model of the process followed in an emergency situation can be seen in the results section. This process was created using input from all of the organizations that have been involved with the group during the project. Models of the transportation and communication subsections were also developed for the analysis of the components of the subsections. The model for the transportation subsection can be found in Appendix C, and the model for the communications subsection can be found in Appendix D. These models served as an important step in the development of the series of models presented in the results section below. The transportation component model and communication functional model provided visual tools that helped illustrate the roles of and relationships between various agencies in the emergency response process.

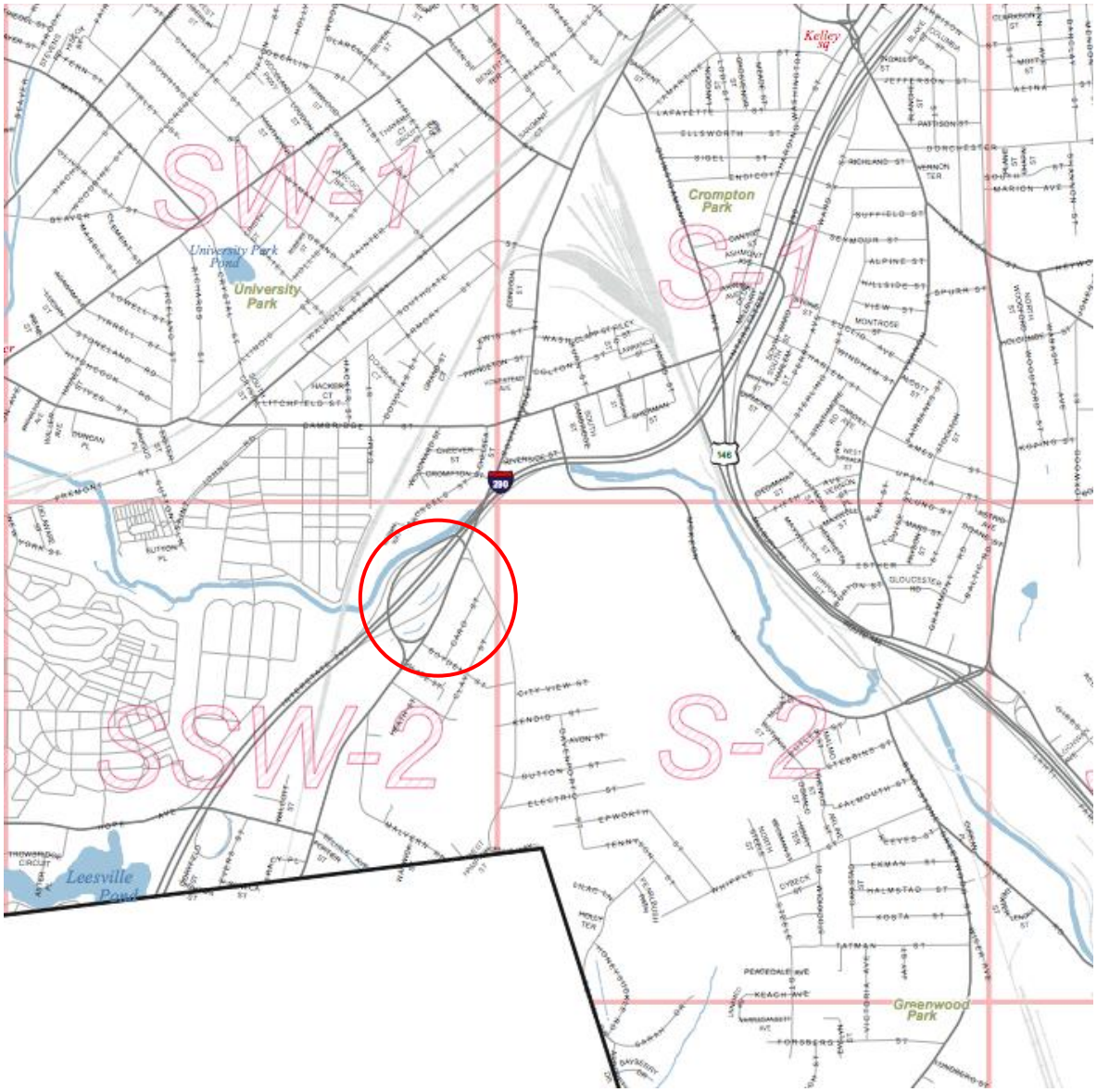

Figure 3: Map of Hypothetical Incident area

4.0 Results

4.1 Introduction

This project was performed under the sponsorship of Worcester Emergency Management and developed models for a systematic approach to emergency evacuations. These models have been designed as tools for the analysis of both historical and future emergency evacuations. These models have been designed for general use in highway incidents involving chemical hazards. As such, they may be used in both the analysis of historical incident reports and in future table-top discussions involving evacuation planning for such incidents. Through their application to these incidents, the models can highlight potential problem areas present in the emergency evacuation process, and changes in the many variables associated with these incidents may lead to potential improvements upon these models.

This chapter presents these models and provides an explanation of the thought process associated with their use. First, an overall explanation of the uses of these models is provided. Then, the "Master Incident Response Model" is introduced and briefly explained. Next, the events of the I290/I190 chemical spill are applied to this model, exemplifying its application to a historical event. A hypothetical incident discussed at a focus group meeting is then applied to the model, exemplifying its application to the planning process and response to a future event. The remainder of the models is then introduced following the same structure as the "Master Incident Response Model" presentation. This chapter concludes with a summary of the key elements discussed in the model applications.

4.2 Model Explanation and Application

Overall Model Explanation

The models developed in this project have been designed for their application to highway incidents involving chemical hazards. In their application to historical incidents, the models provide a skeleton onto which the actual events of the incident may be applied. In their application process, the models clearly identify the actions and events that do not fit cleanly into the emergency response skeleton. These actions and events may then be examined in more detail to determine why they occurred and what purpose they served.

In their application to hypothetical incidents, these models provide a framework for the emergency response process. These hypothetical incidents will generally be presented in a table-top or focus group atmosphere where key agencies are represented and emergency response planning may be simulated. The models provide a visual tool for those involved in the simulation, creating a clearer representation of the relationships between various aspects of an emergency response. Using the models, the members of the focus group or table-top exercise may consider the consequences of particular actions by examining the other aspects of a response that are dependent upon these actions. The models also do not assign responsibilities to any particular parties or agencies, so that those involved in the focus group or table-top exercise can work together to determine how the particular actions will be accomplished.

4.2.1 Master Incident Response Model

Figure 4, shown below, is the master model upon which all subsequent models are based. This model shows conditions surrounding an emergency response, beginning at an incident-free status. At this point, no incident has occurred and the city is considered to be in a “normal” state. The emergency response process begins when the actual incident occurs. The master model then branches down to “highway incidents” and “non-highway incidents”. Our models are specific to highway incident responses, and from here the master model branches down to “increased hazard to the public” and “limited hazard to the public”. In this model, an incident with limited hazard to the public is considered to be an incident that only endangers those immediately involved in the incident, such as the passengers in a car accident. An incident with increased hazard to the

public is considered to be a hazard that could endanger those not immediately involved in the incident. These hazards are further detailed in subsequent models. After the particular conditions of the incident have been established, six major steps of an emergency response are included in the master model. These steps are expanded upon in subsequent models.

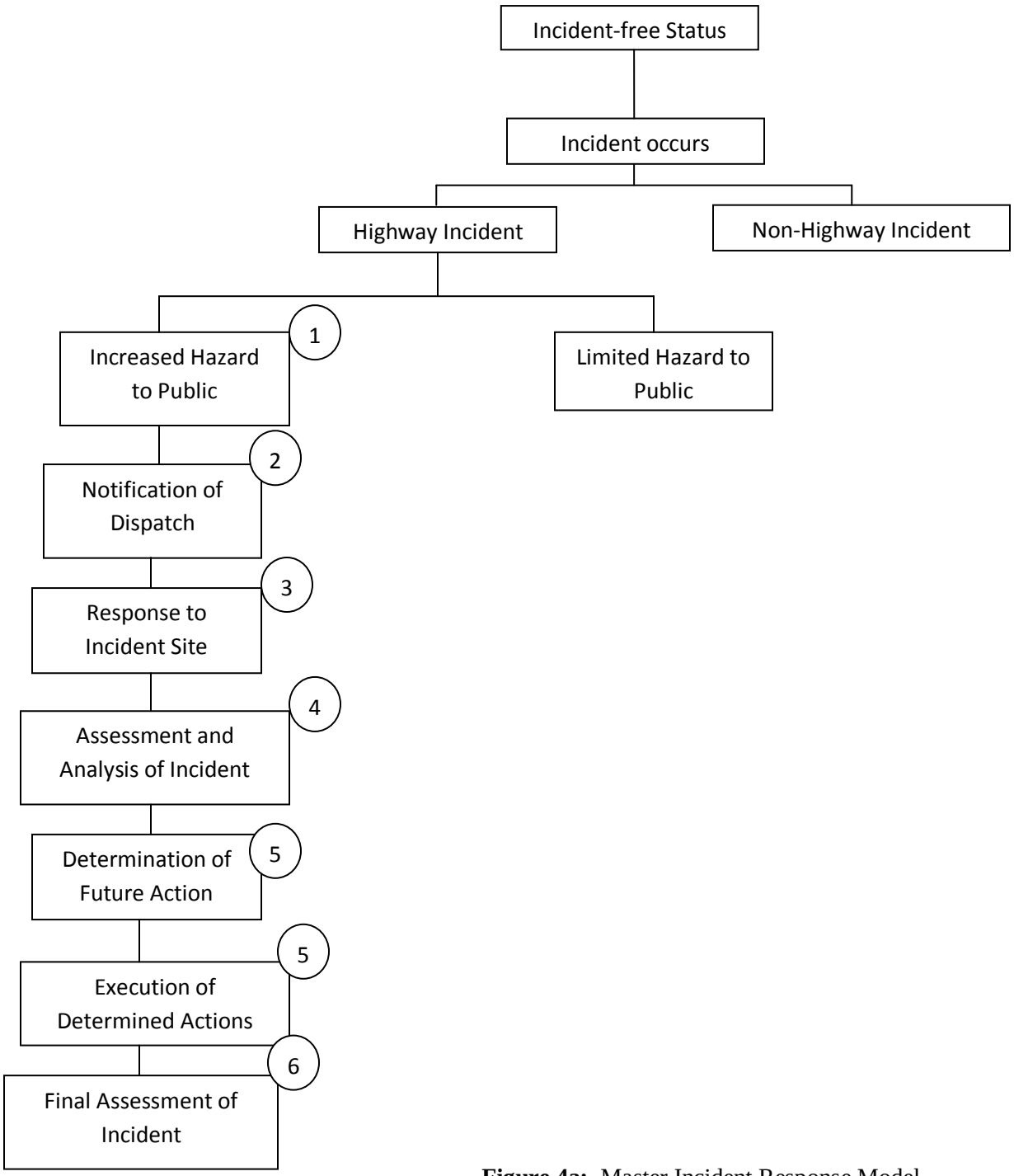

Figure 4a: Master Incident Response Model

Application to Historical Incident

Figure 4b, below, demonstrates the direct application of the historical chemical spill incident to the "Master Incident Response Model". The application of the subsequent models should follow in this manner, with the particular actions of the response corresponding to particular boxes in the model.

At 8:00 am in the morning on October 28, 1999 the City of Worcester was at an incident free status. At approximately 8:30 am a tractor-trailer carrying hazardous chemicals overturned on the ramp from I290W to I190N resulting in a highway incident. Due to the nature of the cargo involved in the incident a full emergency response was required to ensure public safety and return the City to an incident-free status. An eye witness called 911 and emergency responders were dispatched. Initially two fire engines and a ladder truck were sent to the scene. These responders requested further assistance including the State Hazardous Material Team, or Hazmat, based on their initial assessment of the hazard. The chemical was identified as Butyl Acrylate, and a command post was setup for the response. After a complete assessment of the situation, a plan for disposal of the chemical and restoring the highway was determined. This plan was implemented and by 9PM the site was restored to incident-free status. In the month that followed, those involved with the incident filed an incident report as a final assessment of the incident.

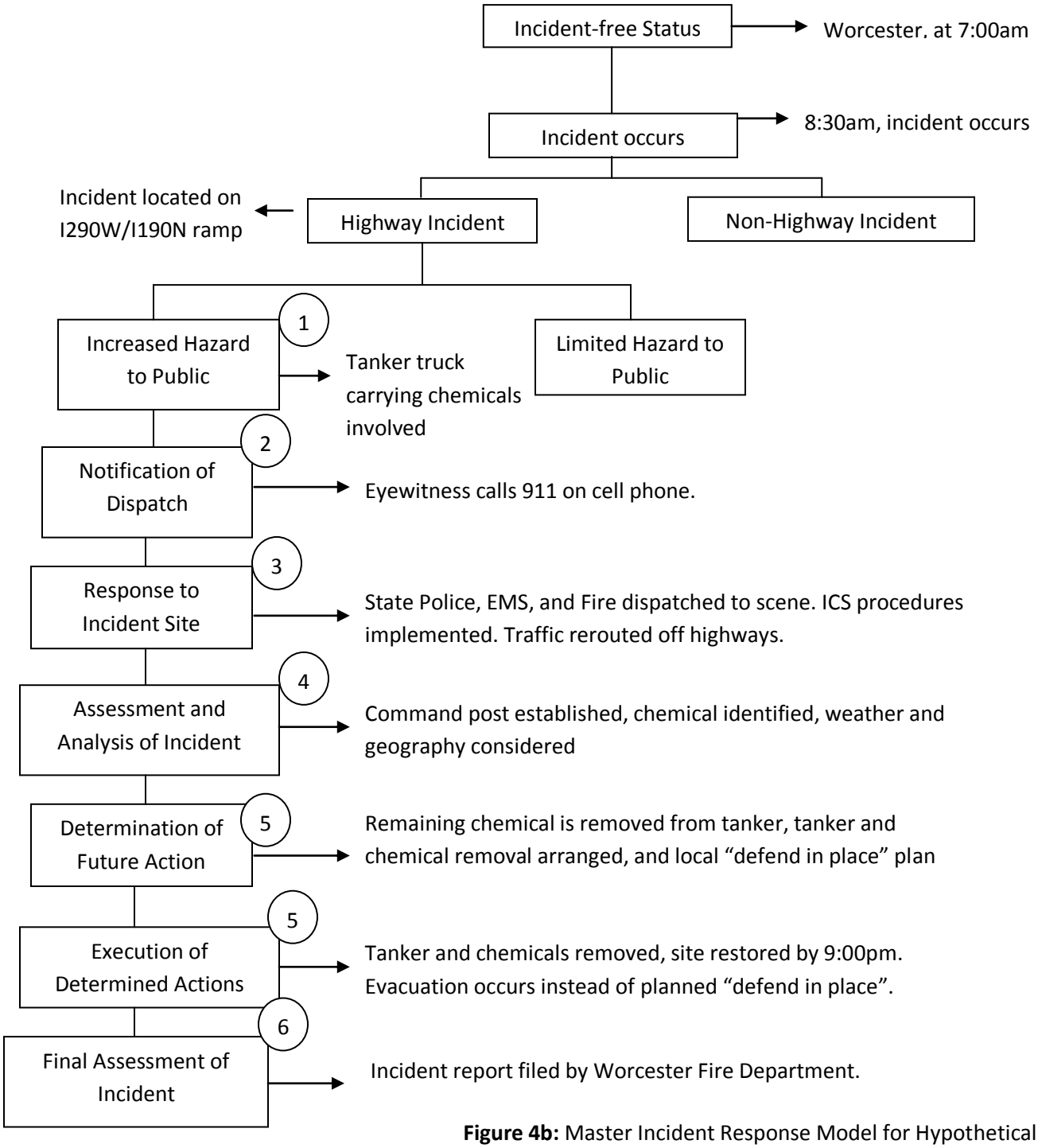

Figure 4b: Master Incident Response Model for Hypothetical Incident

Application to Hypothetical Incident

Figure 4c, below, demonstrates the direct application of the hypothetical chemical spill incident to the "Master Incident Response Model". The application of the subsequent models should follow in this manner, with the particular actions of the response corresponding to particular boxes in the model. Because Figure 4c provides only a brief summary of the hypothetical chemical incident response, a more detailed summary will be provided below. At 11PM on a future October day the City of Worcester is at an incident free status. At approximately midnight a hypothetical incident occurs involving a tanker truck carrying 5000 gallons of liquid Benzene. The truck overturns at the end of the off-ramp of exit 11 from I290 Eastbound, resulting in a highway incident. The chemical nature of the incident poses an increased hazard to the public. An eyewitness calls 911 and emergency responders are dispatched. Initially two fire engines and a ladder truck are sent to the scene. The driver of the truck escapes the accident unharmed with the chemical identification and shipping documents, and the chemical is identified as Benzene. As the emergency responders arrive on scene, the overturned tanker ignites, producing large, intense flames. The responders request further assistance, including the State Hazmat, based on their initial assessment of the hazard. Additional responders representing various agencies arrive on scene and establish a command post. After collecting and analyzing information from the scene of the incident, a plan of future actions is formulated to eliminate the hazards and restore the scene to its original state. The plan requires both a "defend-in-place" and a partial evacuation, as the neighborhood adjacent to the exit ramp is endangered by the fire hazard and the Holy Cross campus is endangered by the toxic fumes from the fire. The plan is put into action and the hazards are eliminated. In the weeks following the incident, an After Action report is filed and the incident is analyzed so that future responses may be improved.

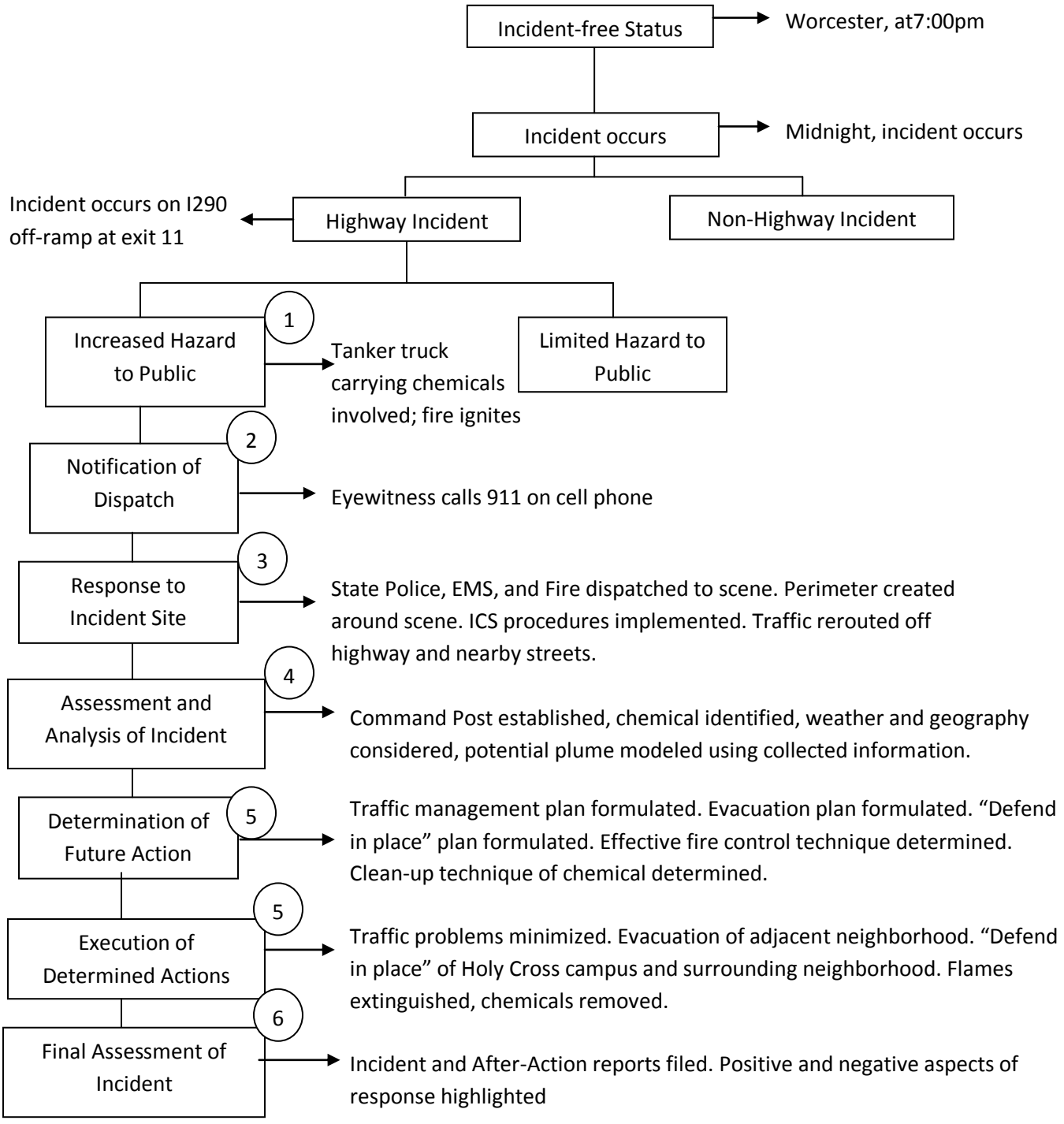

Figure 4c: Master Incident Response Model for Hypothetical Incident

4.2.2 "Hazard Consideration" Model

Figure 5, presented below, is the "Hazard Consideration" model. This model outlines the types of hazards that result in an increased hazard to the public. This model is not used explicitly in the study of historical incidents, as the type of hazard is determined during the incident site assessment. However, this model is an important consideration in the applicability of incidents to the remainder of the models in this system. The models have been designed with the assumption that the incident will involve either a chemical or fire hazard. Other types of hazards, such as nuclear or biological, may pose an increased threat to the public, but these models have not been designed for these types of hazards and may not yield desired results in the application of these types of incident.

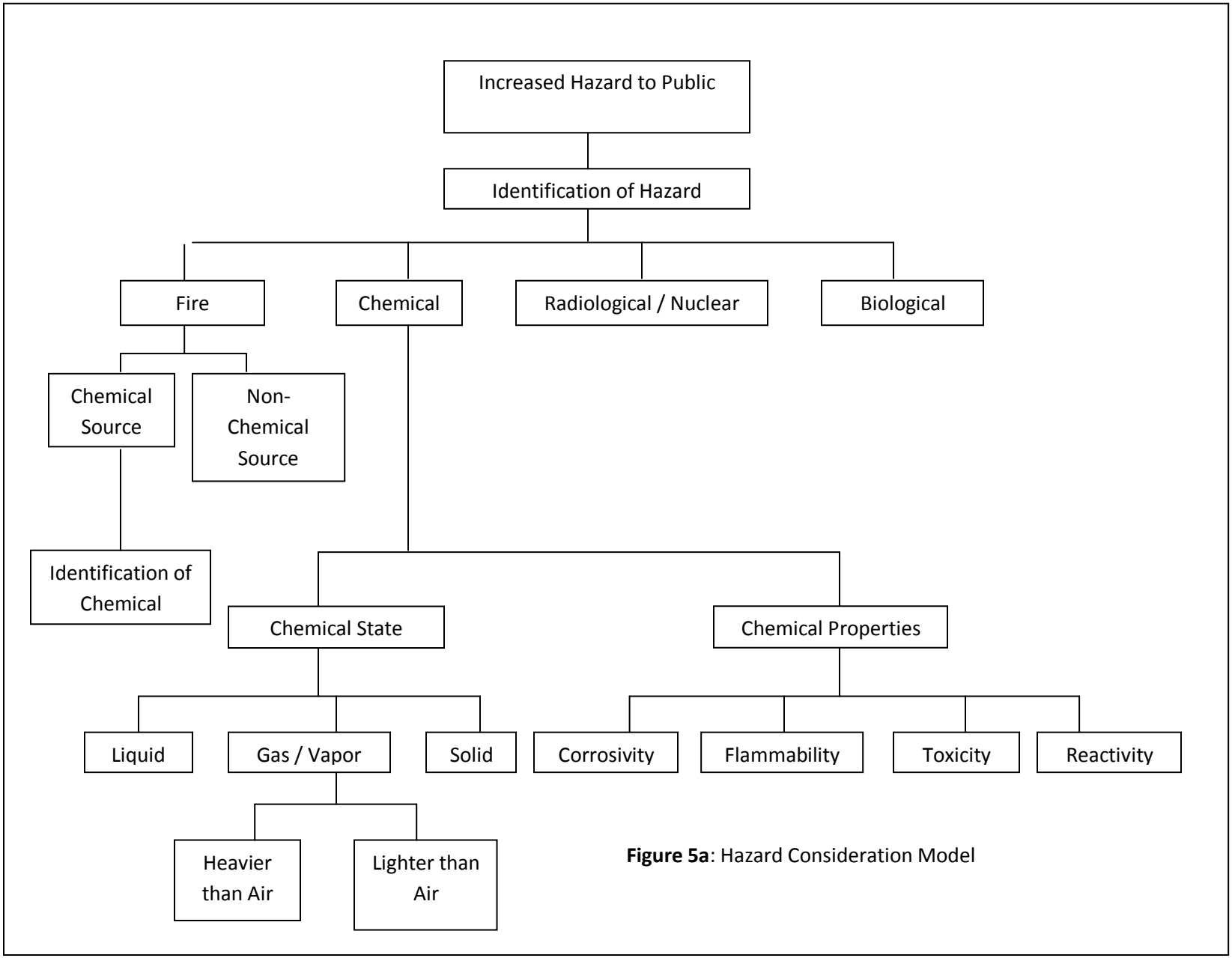

Figure 5a: Hazard Consideration Model

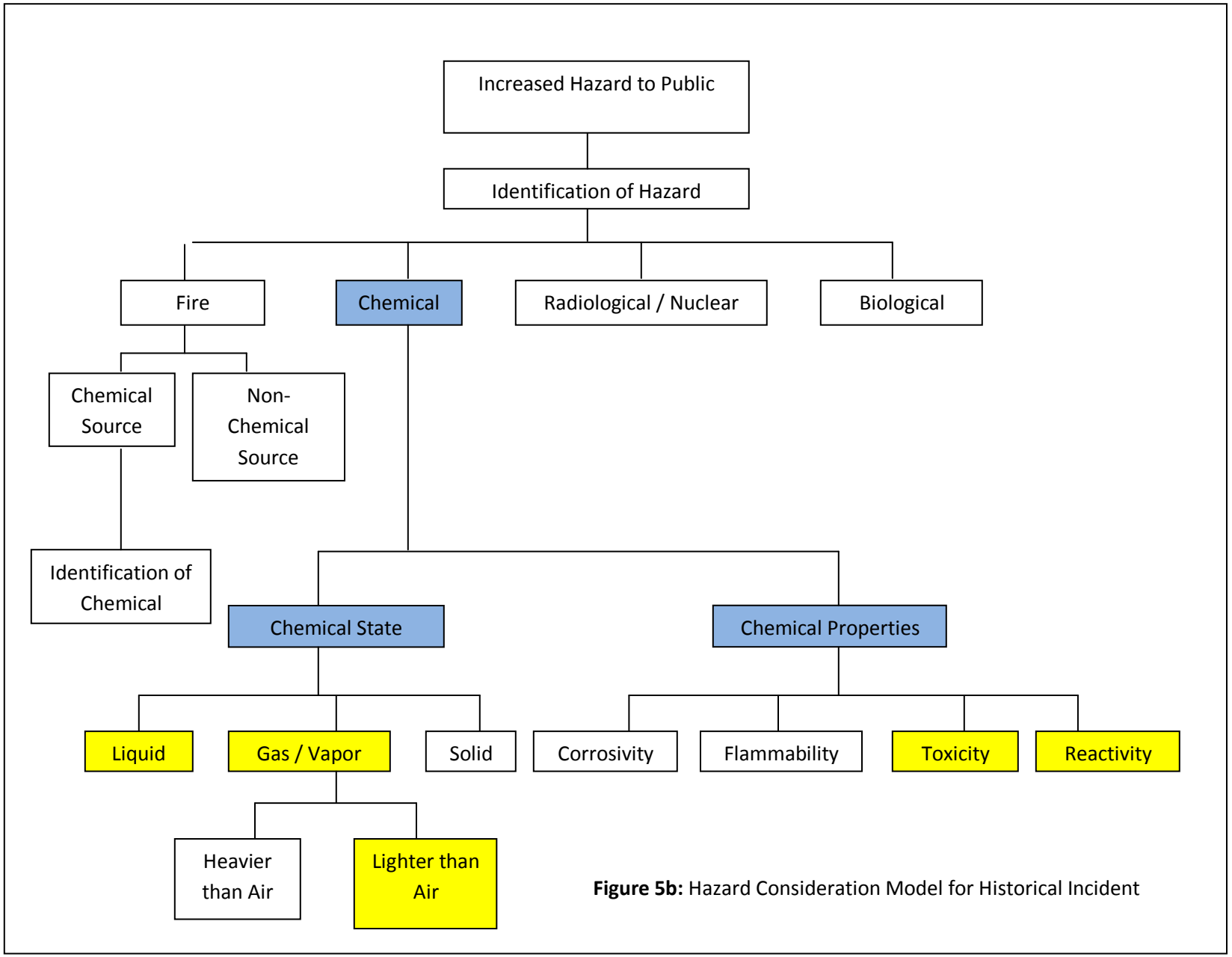

Figure 5b: Hazard Consideration Model for Historical Incident

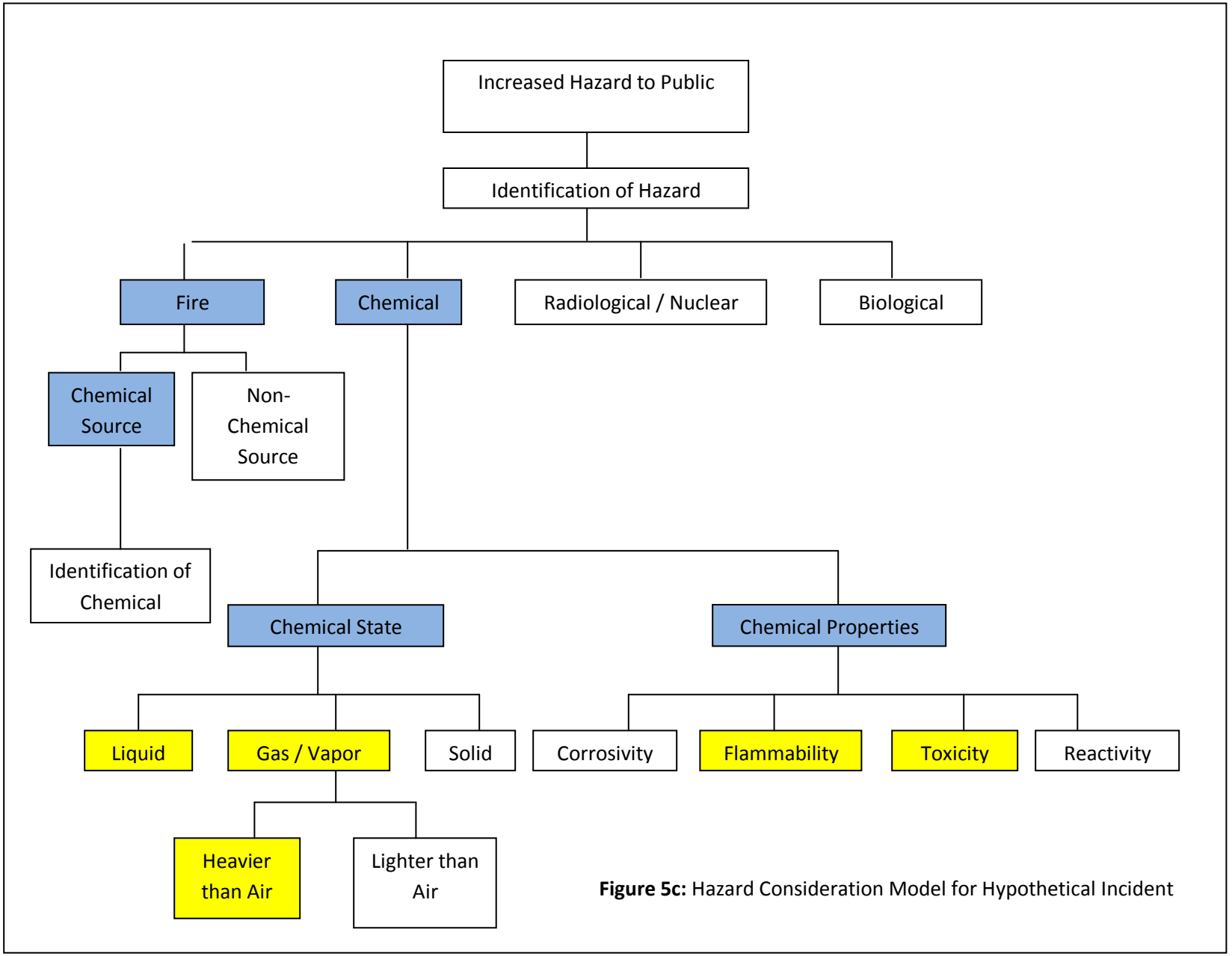

Figure 5c: Hazard Consideration Model for Hypothetical Incident

Application to Historical Incident

In the I290/I190 incident, a vehicular accident involving a tanker truck occurred on the ramp from I290 westbound to I190 northbound. This tanker truck was transporting Butyl Acrylate from New Jersey to Framingham, Massachusetts. The tanker contained approximately 6100 gallons of the liquid chemical. The truck rollover resulted in leaks in the tanker.

This model can demonstrate why the incident posed an increased hazard to the public. The colored boxes are those that apply to this incident. Yellow boxes denote the particular aspects of the I290 incident that could pose an increased hazard to the public. The chemical, Butyl Acrylate, is a clear and colorless liquid and targets the respiratory system, as well as the eyes and skin, resulting in difficulty breathing and eye and skin irritation. Butyl Acrylate reacts with hydrogen compounds, alkalis, strong acids, oxidizers, heat, and sunlight. The chemical is used in the production of plastics and inhibitors may be added to the chemical to prevent spontaneous polymerization. Butyl Acrylate has the potential to evaporate and become airborne. In a vapor state, the chemical could spread easily and affect surrounding communities. For this reason, the I290/I190 incident posed an increased hazard to the public.

Application to Hypothetical Incident

In the hypothetical chemical spill incident, a vehicular accident involving a tanker truck occurs on the off-ramp at exit 11 from I290 eastbound. This tanker truck is transporting liquid Benzene. The tanker contains approximately 5000 gallons of the liquid chemical. The truck rollover resulted in leaks in the tanker. Additionally, the chemical ignites as responders arrive on scene.

This model can demonstrate why the incident can pose an increased hazard to the public. As in Figure 5b, above, the colored boxes in Figure 5c are those that apply to this incident. Yellow boxes denote aspects of the hypothetical chemical spill incident that could pose an increased hazard to the public. The chemical nature of the incident endangered the neighborhoods surrounding the scene of the accident. The chemical, Benzene, is a colorless to light yellow liquid with an aromatic odor and targets the respiratory system, central nervous

system, blood and bone marrow, as well as the eyes and skin. Symptoms include irritation of the eyes, skin, nose, and respiratory system, as well as dizziness, weakness, exhaustion, and headaches. Additionally, Benzene is a carcinogen. Benzene is flammable, reacts with strong oxidizers and nitric acid, and has the potential to evaporate and become airborne. In a vapor state, the chemical could spread easily and affect surrounding communities. After ignition, the fumes from this chemical could also spread easily and affect surrounding communities. The flames could also be intense and pose a hazard to those in the immediate vicinity of the incident. For this reason, the hypothetical chemical spill incident poses an increased hazard to the public.

4.2.3 "Notification of Dispatch" Model

Figure 6a is the "Notification of Dispatch" model. This model shows the sequence of events that occur when someone calls 9-1-1 to report an emergency. If the witness calls from a land line, it will immediately go to the local emergency communications center. If someone calls from a cellular phone or a State Police Officer reports it via their radio in their car, it will be answered by the State communication center and rerouted to the local communication center. In this case, Worcester Emergency Communications (WEC) would be the local communication center for the following scenarios. This model is important because it is essentially the first step in the emergency response process.

Application to Historical Incident

Figure 6b is the application of the historical I-290 chemical spill that occurred in October of 1999. As can be seen, not all of the steps are involved in all incidents. For example, this incident was reported via a cellular telephone from someone driving on the highway. The call was answered by State Police because it was from a cellular phone. Once the caller informed the State Police of the location, the call was rerouted to Worcester Emergency Communications (WEC). The caller informed WEC that the accident involved an unknown chemical, so WEC immediately dispatched Fire and Police to the scene. The caller also informed WEC that the accident was a result of road rage. At the scene, the first person to arrive was a police officer. He

or she immediately rescued the driver, but both were harmed by the chemical. EMS was dispatched to the scene to help the driver and police officer.

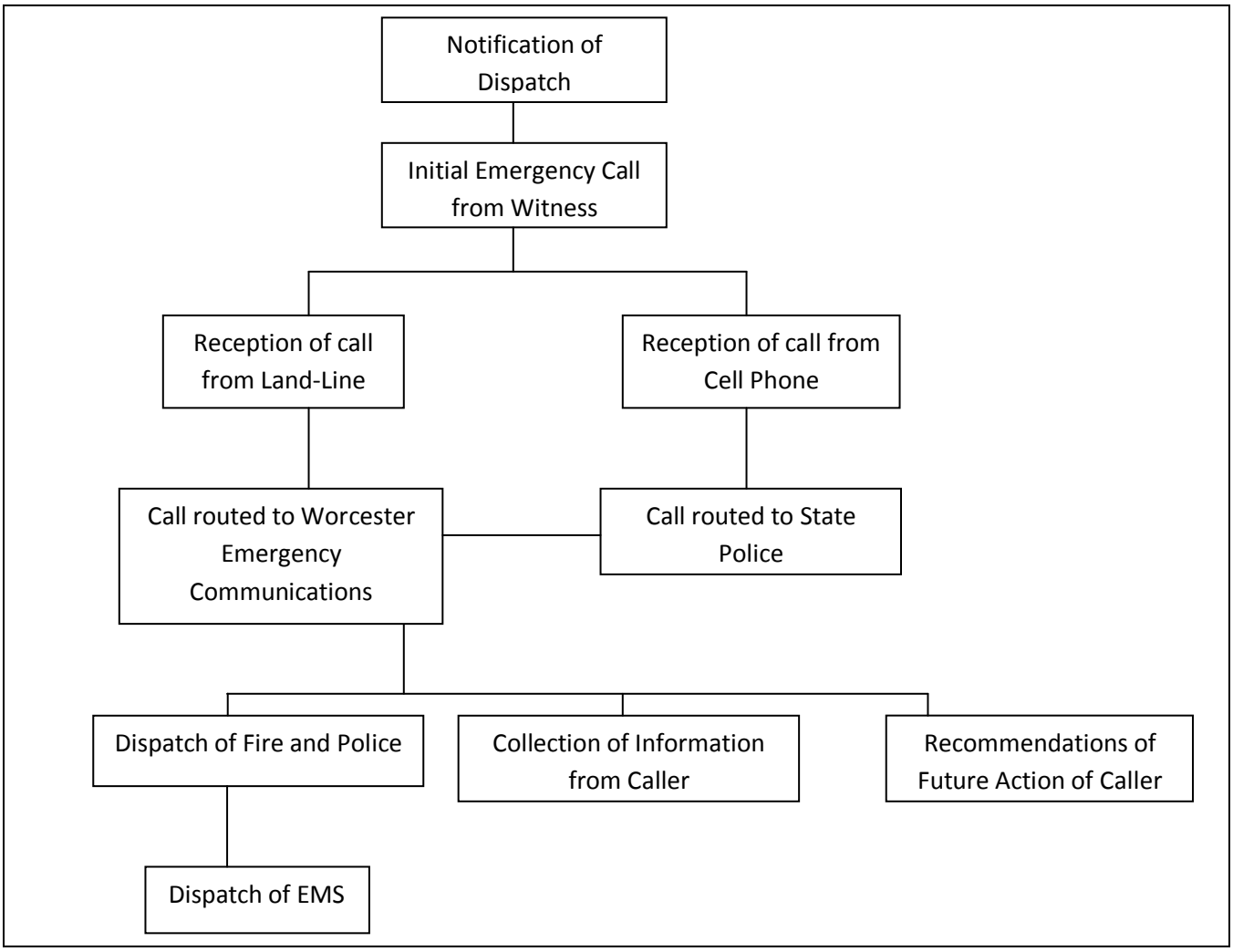

Figure 6a: Notification of Dispatch Model

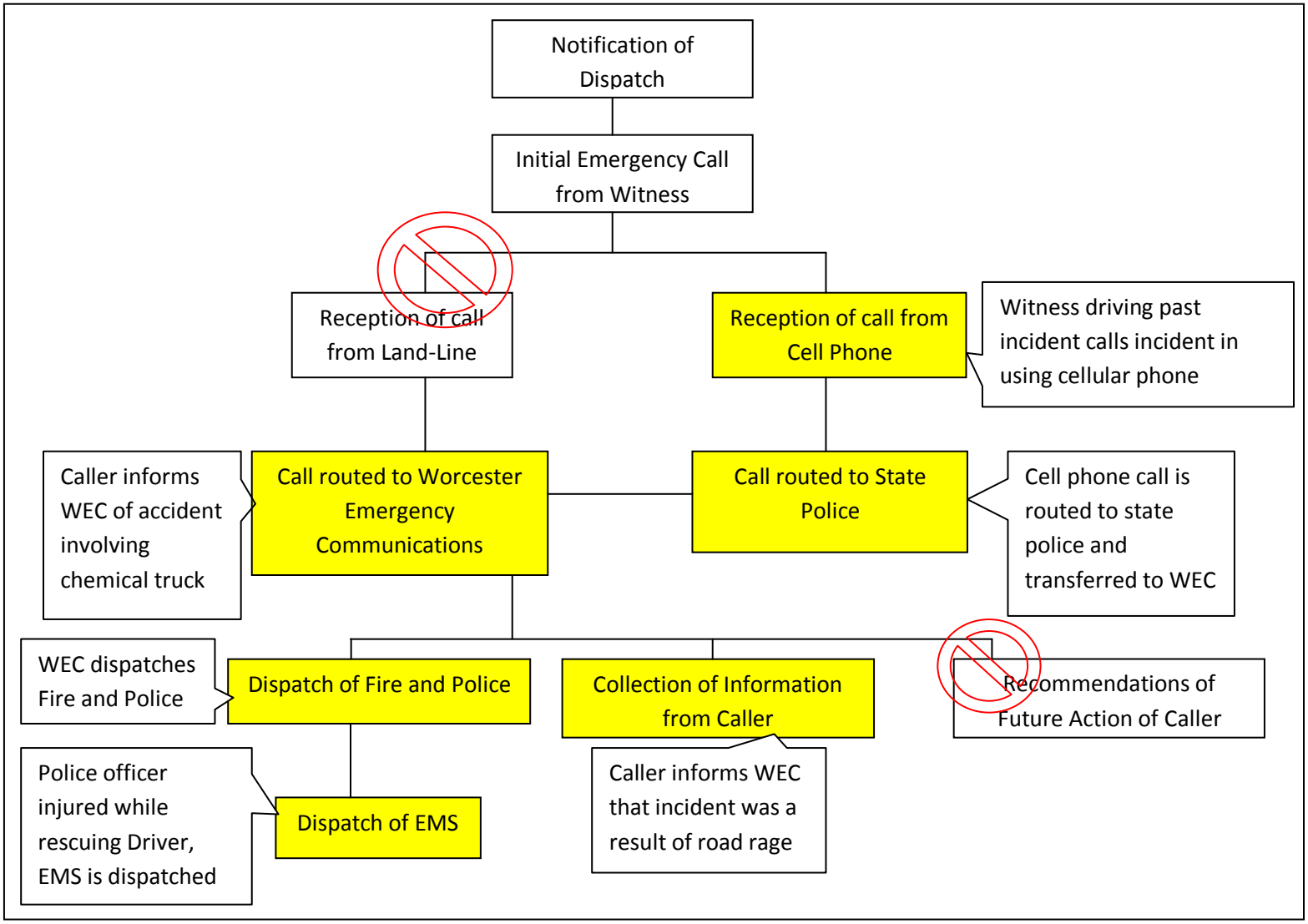

Figure 6b: Application of "Notification of Dispatch" to Historical Incident

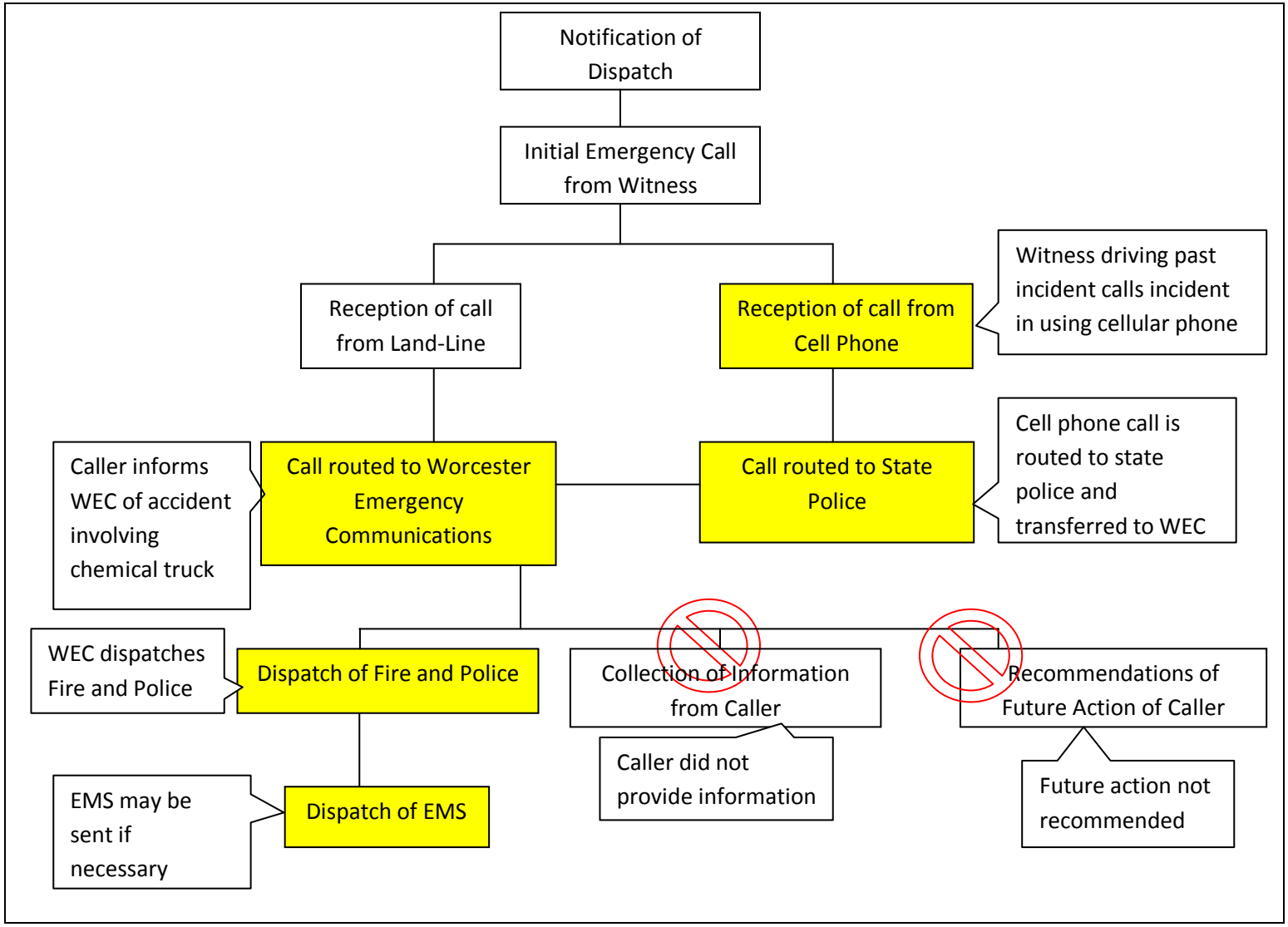

Figure 6c: Application of "Notification of Dispatch" to Hypothetical Incident

Application to Hypothetical Incident

The above figure, Figure 6c, is an application of the model to our hypothetical incident. This incident was also reported from a witness using a cellular phone. The call was therefore answered by the State Police before being rerouted to Worcester Emergency Communications (WEC). WEC dispatched Fire and Police to the incident because it is a chemical spill. Since no one was injured initially, EMS was not sent to the incident. The caller did not have any other information to provide, and was not recommended to do anything.

4.2.4 "Response to Incident Site" Model

The model presented below in Figure 7a represents the initial response to the incident scene for a chemical hazard on a highway. After dispatch has been notified, the initial response is critical to set emergency actions in motion and eliminate the danger created by the chemical hazard. This model, however, is not as hazard specific as the previous. The actions presented in the figure below are applicable to almost any type of hazard. The first step involving the implementation of ICS procedure must always be achieved. Following ICS procedures ensures a swift and efficient start to an emergency response. An important component of ICS is the Incident Commander, who is initially the first responder on-scene. The individual plays an important role in response as he or she is responsible for ensuring that necessary agencies are notified with accurate information.

As the model continues several actions must be completed within a short period of time. As soon as a more qualified responder with experience in the type of hazard at the scene arrives, the command will be transferred to them. This person must quickly determine the location of the command post, implement short term safety measures and determine the future needs required for a complete response. These four actions are on the same level because they can all be taking place simultaneously. Various agencies can handle certain actions. Generally the state and local police along with the fire department can implement short term public safety measures, while the Incident Commander and his or her team can determine the needs of the incident.

The final stages of the incident response require the creation of a perimeter and traffic management plan along with the request for necessary supplies and personnel. Through determination of future needs the essential resources are established and must be requested. Both creation of a perimeter and the traffic management plan are further public safety measures.

The perimeter is dependent on the properties of the chemical hazard that were previously determined in the hazard consideration model. This perimeter provides responders with the areas that must be secured to allow responders in and keep civilians out. The traffic management plan also allows for a steady flow to and from the incident scene and reduces the possibility of gridlock and further vehicular accidents.

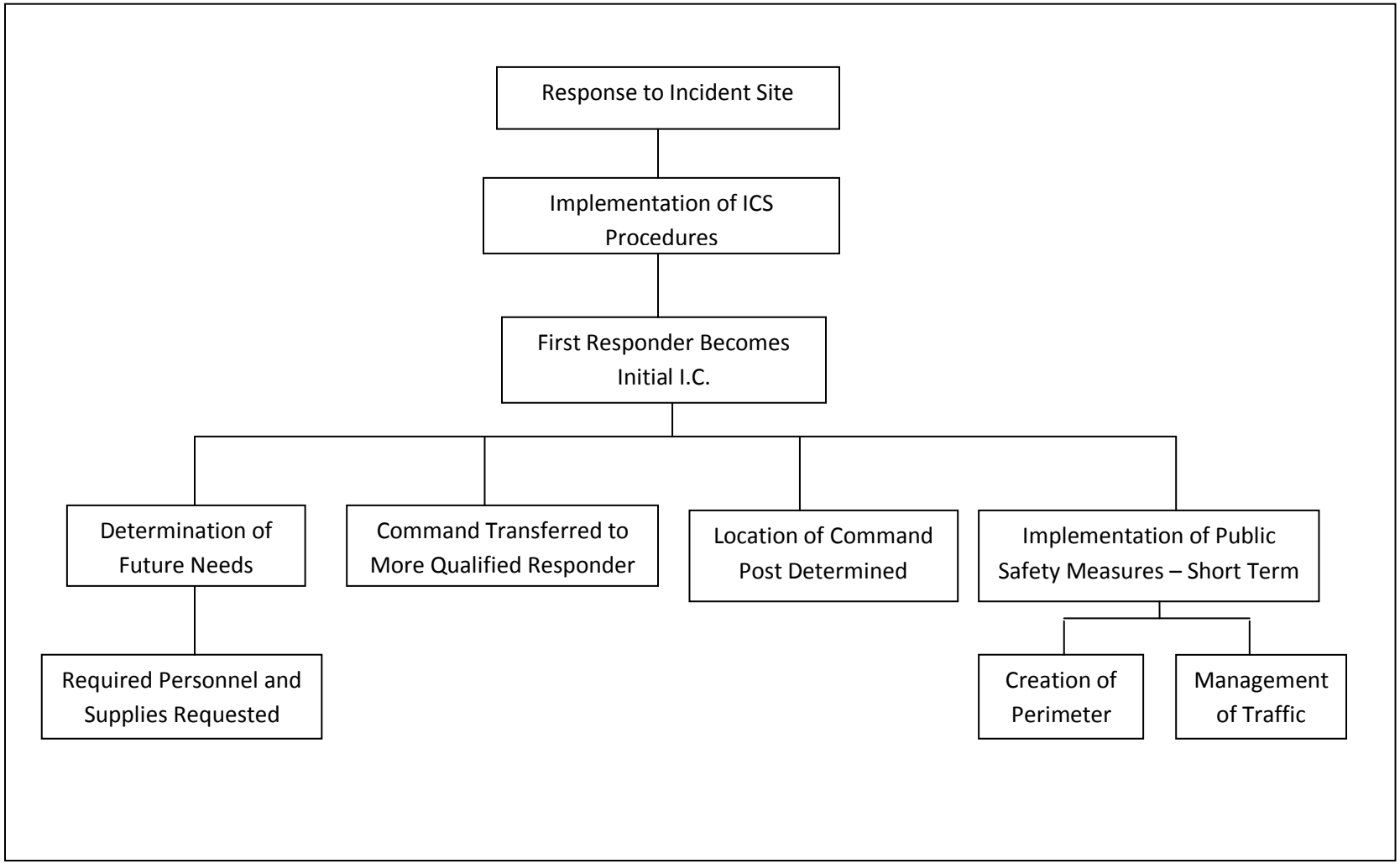

Figure 7a: Response to Incident Site Mode

Application to Historical Incident

The following events are presented below in Figure 7b as a demonstration of the application of this model to a historical incident. The first person on scene was a State Trooper, and by implementing ICS procedures he became the initial incident commander. The police officer immediately provided help to the truck driver, and due to their close proximity to the chemical both men were sent to the hospital for medical attention. This is an example of how certain responders such as police do not have the necessary protective gear required for certain hazards. Therefore it is critical to establish the roles and responsibilities of various responders to ensure their safety as well as the public safety. Worcester Fire Department arrived on scene with two engines and a ladder. Chief Michael McNamee arrived on the scene and assumed control as the Incident Commander because of the chemical hazards present at the scene. Generally, the fire department assumes control of incidents that pose an increased threat to the public because fire fighters possess a greater knowledge of and experience with the hazards involved in these types of incidents.

At the I290 spill, ladder one performed an initial site reconnaissance and identified three leaks in the tanker. Using the information collected from the site recon Chief McNamee determined the future needs of the emergency response including an additional box alarm with two fire engines, a ladder truck and a heavy rescue unit, and a tier two hazmat unit. As a public safety measure additional state and local police were called in to manage traffic and direct it away from the hazard area. The Incident Command Post was established at the 190/Burncoat St. off ramp by following the Department of Transportation Emergency Response Guide. Additionally, the traffic management measures cleared the highway of civilian traffic and allowed for this location to be easily accessible by emergency responder

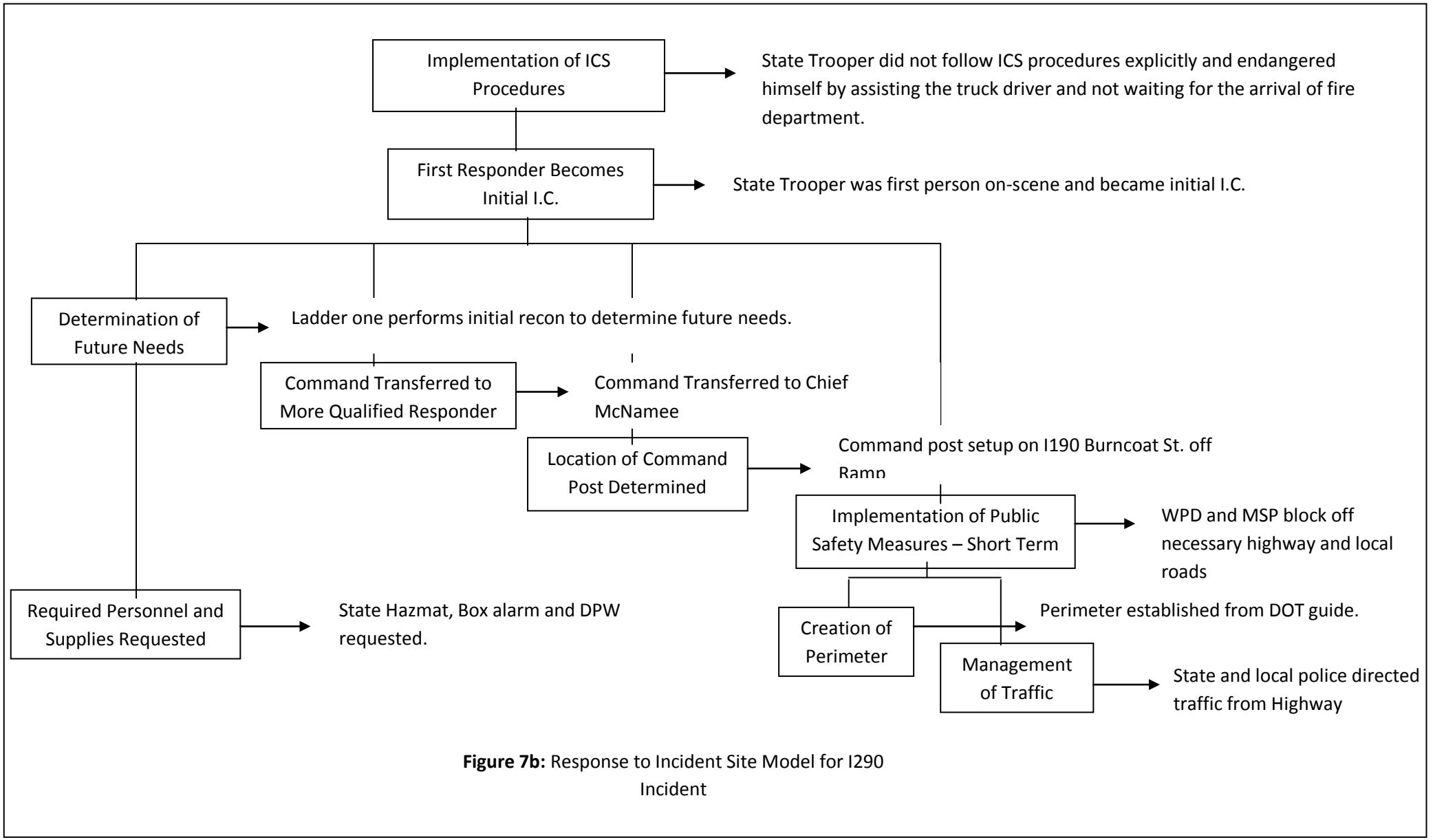

Figure 7b: Response to Incident Site Model for I290 Incident

Application to Hypothetical Incident

The following events are displayed in Figure 7c to show the application of a hypothetical incident to the "response to incident scene" model. The first responder at the scene would likely be a State Police trooper. This responder assumes the role of Incident Commander. In determining future needs, the initial Incident Commander issues a request for a Hazmat team due to the chemical nature of the incident. He or she also receives the chemical identification and shipping documents from the truck driver. Using the shipping documents, the Incident Commander utilizes the ChemTrak hotline to notify the shipper and manufacturer of the chemical that the incident had occurred, and the shipper and manufacturer then initiate a response according to their own standards of procedure.

When the Worcester Fire Department arrives on scene, the fire chief assumes the role of Incident Commander due to his knowledge and experience with the type of incident. The Incident Commander determines the need of Worcester Police officers to form a complete perimeter around the scene at a distance that positions them away from immediate danger. Additional officers are stationed at major intersections to direct traffic away from the incident scene. State Police are stationed on I290 to direct traffic off the highway, as the chemical and fire hazards are located extremely close to the highway. The fire fighters at the scene perform an initial reconnaissance in protective equipment to determine the extent of the chemical hazard, and begin an initial suppression of the flames. Using the information collected from the site recon the Incident Commander determines a safe location of a command post uphill and upwind of the scene, if possible. The command post is setup near I290 and Southbridge Street, in an empty parking lot.

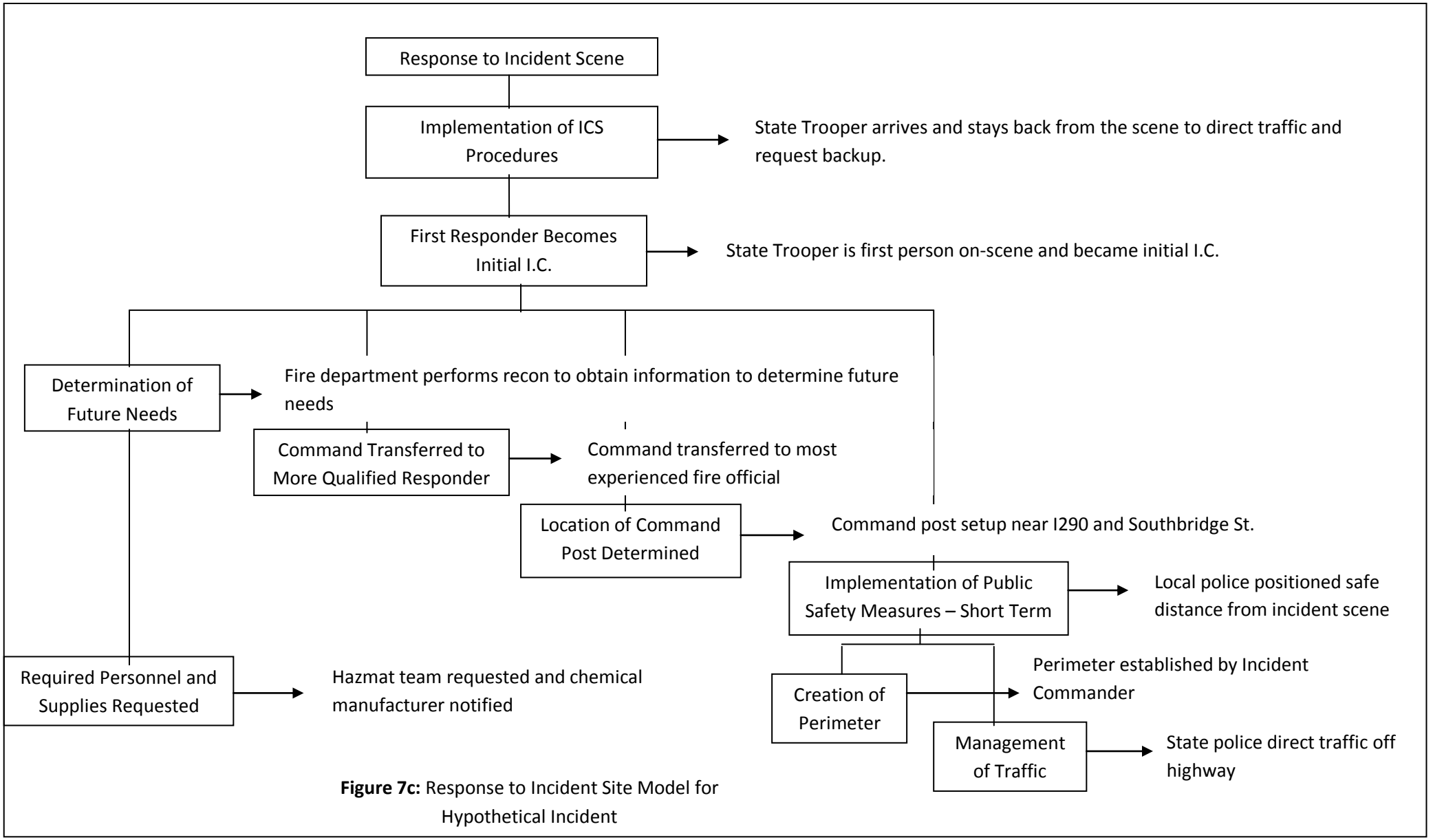

Figure 7c: Response to Incident Site Model for Hypothetical Incident

4.2.5 "Assessment and Analysis of Incident" Model

The "Assessment and Analysis of Incident" model is presented in Figure 8a. This model outlines the information collection process that occurs at the scene of the incident. The assessment and analysis of the incident requires the identification of the variables involved with the hazards and the location. Hazard variables include the type of hazard, for example a fire or a chemical spill, and the consequences of these hazards, such as toxic fumes or local water contamination. The locational variables include the topography and weather conditions, which can affect how and where the hazards spread.

Hot and Cold zones are an important aspect of the emergency response process, because these zones help determine who needs to be evacuated and which responders can take part in the evacuation. The hot and cold zones are determined by analyzing the variable data collected. Areas that are not considered to be susceptible to the hazards are designated as cold zones, and areas that are affected by the hazard are designated as hot zones.

Time constraints should also be considered, because these help determine the priorities of a response. After the hot and cold zones are determined, the Incident Commander must decide the next step in the response. If one hazard must be addressed quickly, these time constraints should be considered in the formulation of a plan of future action.

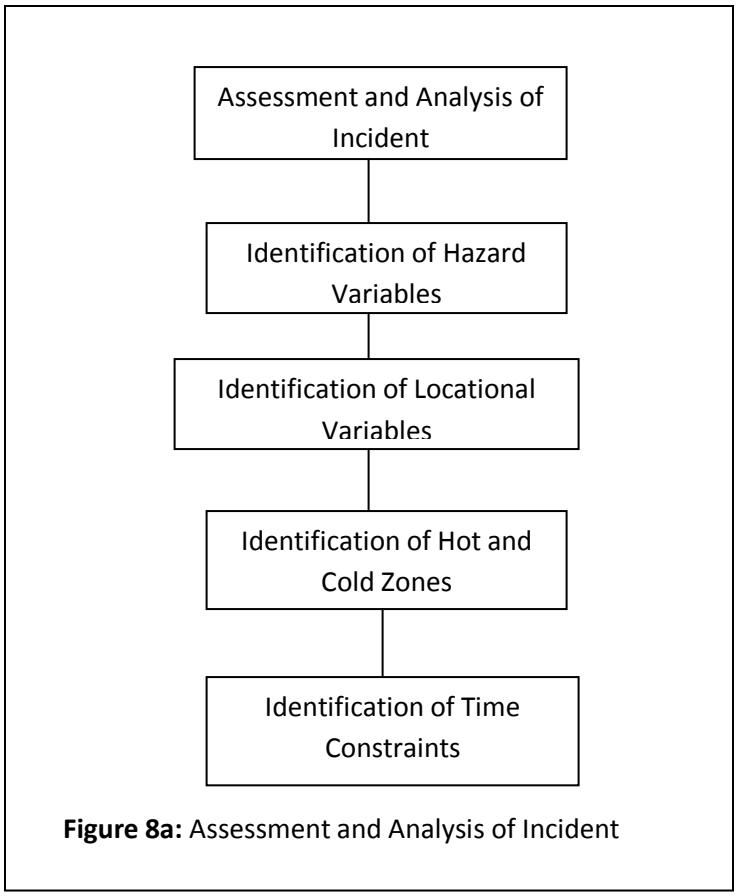

Figure 8a: Assessment and Analysis of Incident

Application to Historical Incident

The application of the I290 incident to the "Assessment and Analysis of Incident" model is demonstrated in Figure 8b. Immediately arriving at the I-290 incident scene, the first responder begins assessment by collecting information from individuals. The driver is found and removed from vehicle. He was able to provide the first responders with the chemical papers before leaving scene. Concurrently with other events, the command post was set at 190/Burncoat Street off ramp split.

Fire fighters and Hazmat teams arrive on scene, properly equipped with safety attire and continue assessment of tanker and surrounding area. With metering devices and protection suits, the fire fighters attempted to determine hazard variables. They identified that there were three steady leaks on the tanker. The chemical was also leaking into nearby soil but there was no build up. Mostly normal readings were recorded from metering. Spikes only occurred when the metering device was placed directly over the chemical spill.

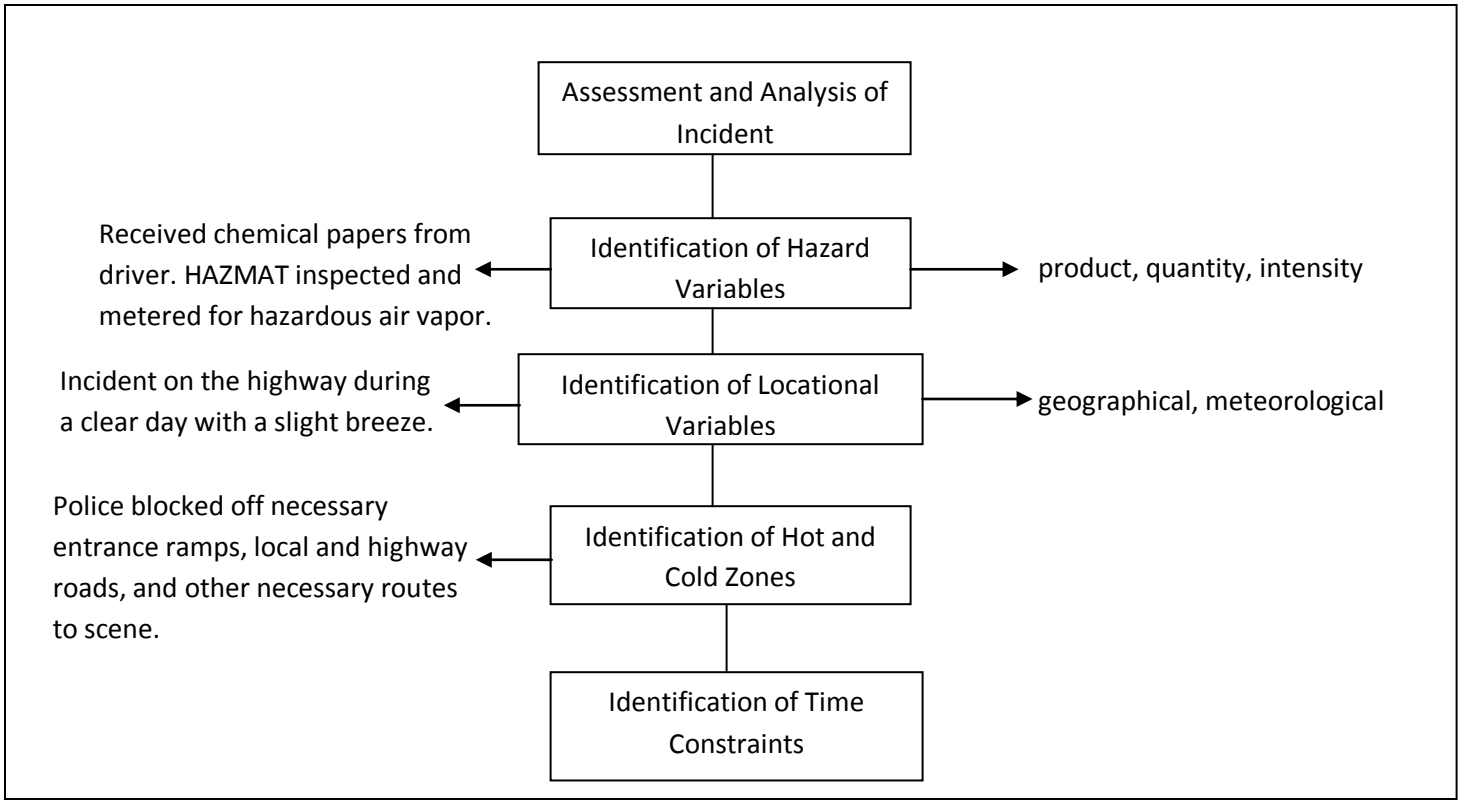

Figure 8b: Application of "Assessment and Analysis of Incident" to Historical Incident

Provided the information they had attained, responders considered how the location could be potentially dangerous. Being that the incident occurred on the highway this caused a traffic problem but arose no potential danger. Roads leading to scene were immediately blocked. It was a clear and sunny October day with a slight breeze so there were no meteorological concerns. A strategic plan was assembled as information flowed into command post.

Application to Hypothetical Incident

The application of the "Assessment and Analysis of Incident" model to the hypothetical chemical spill incident is demonstrated in Figure 8c. The tanker has just flipped and ignited a fire as the first responders arrive on scene. The responders quickly begin their assessment of incident scene. Luckily, the driver was able to escape danger with the chemical shipping papers. The papers will inform the responders of the chemical, quantity, and from/to the chemical was heading. If they were not able to locate the chemical papers, they would look for hazard plaques on the tanker or call the shipping company.

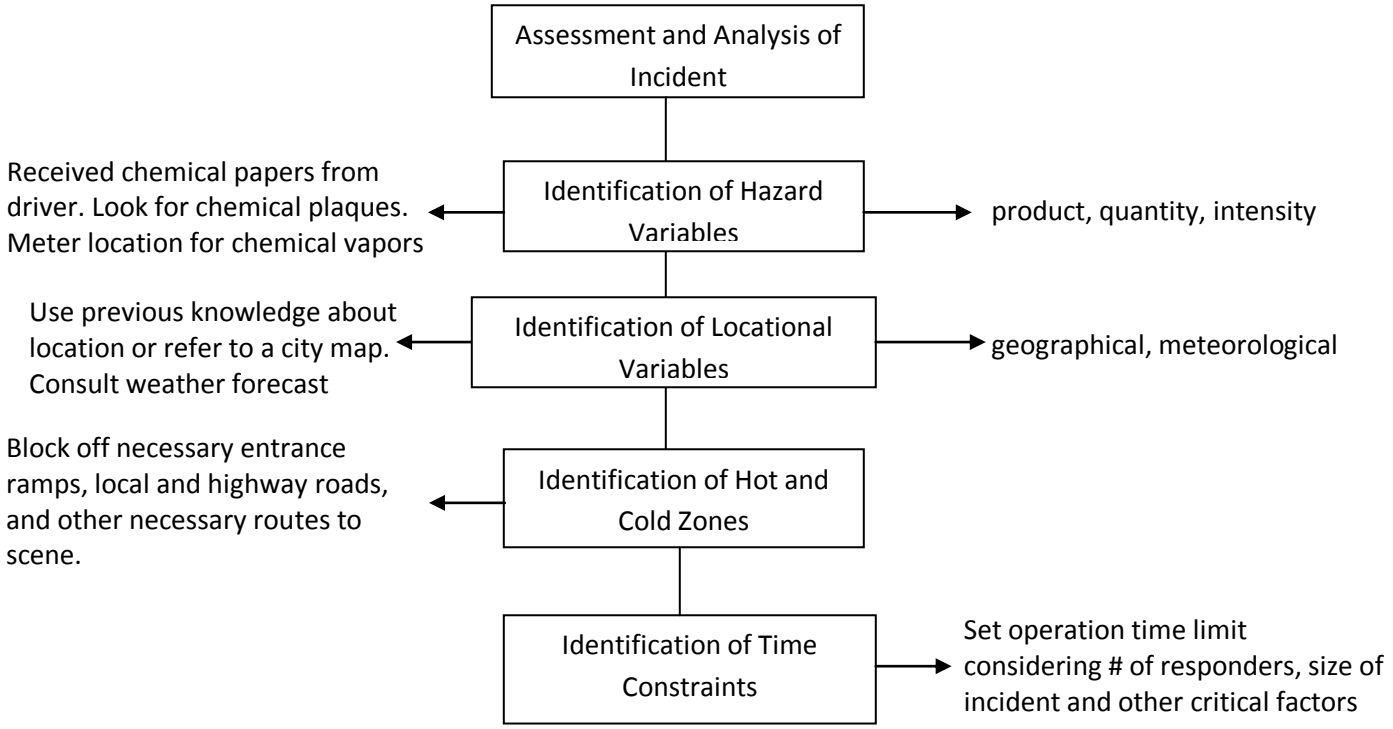

Figure 8c: Assessment and Analysis of Incident Model for Hypothetical Incident

Having the chemical papers allow the responders to focus on other issues such as the fire and leaks. All the while, the fire department would be making sure they could put out the Benzene fire with their usual equipment. If not they must arrange a different safe alternative to fighting the fire.

The responders must now evaluate the current situation and its locational variables. A Hazmat team would arrive nearly 30 minutes later and conduct a recon walkthrough. They would examine the tanker for leaks and meter the surrounding area. Simultaneously, responders should consider the location of the incident. The tanker has flipped nearly centered between a college campus, residential area, and highway. Roads leading to the incident would be immediately blocked off and rerouted. It's a cool night with the wind blowing towards the east as well. The incident team must consider each aspect when deciding on hot/cold zones.

Unlike the I-290 spill, time constraints will be indentified. Considering its nighttime, it will take longer for supplement responders and agencies to arrive on scene. Informing the public of the incident would also be problematic since many will be in bed. A fire would also be regard as a major time constraint. With all mentioned considerations, the operation team should attempt to manage the order of response. Contacting fellow agencies, establishing road blocks, and indentifying the chemical should be done first before more strenuous tasks.

4.2.6 "Determination of Future Action" Model

The "Determination of Future Action" model is presented in Figure 9a, below. This model demonstrates the on-scene planning process that occurs after the assessment and analysis of the incident scene. The Incident Commander must formulate a plan of action that addresses both the hazard and the public safety. Using the data collected in the scene assessment and analysis, the Incident Commander and his team plan restorative

actions and preventative actions. These preventative actions aid in the scene restoration, but also contribute to public safety.

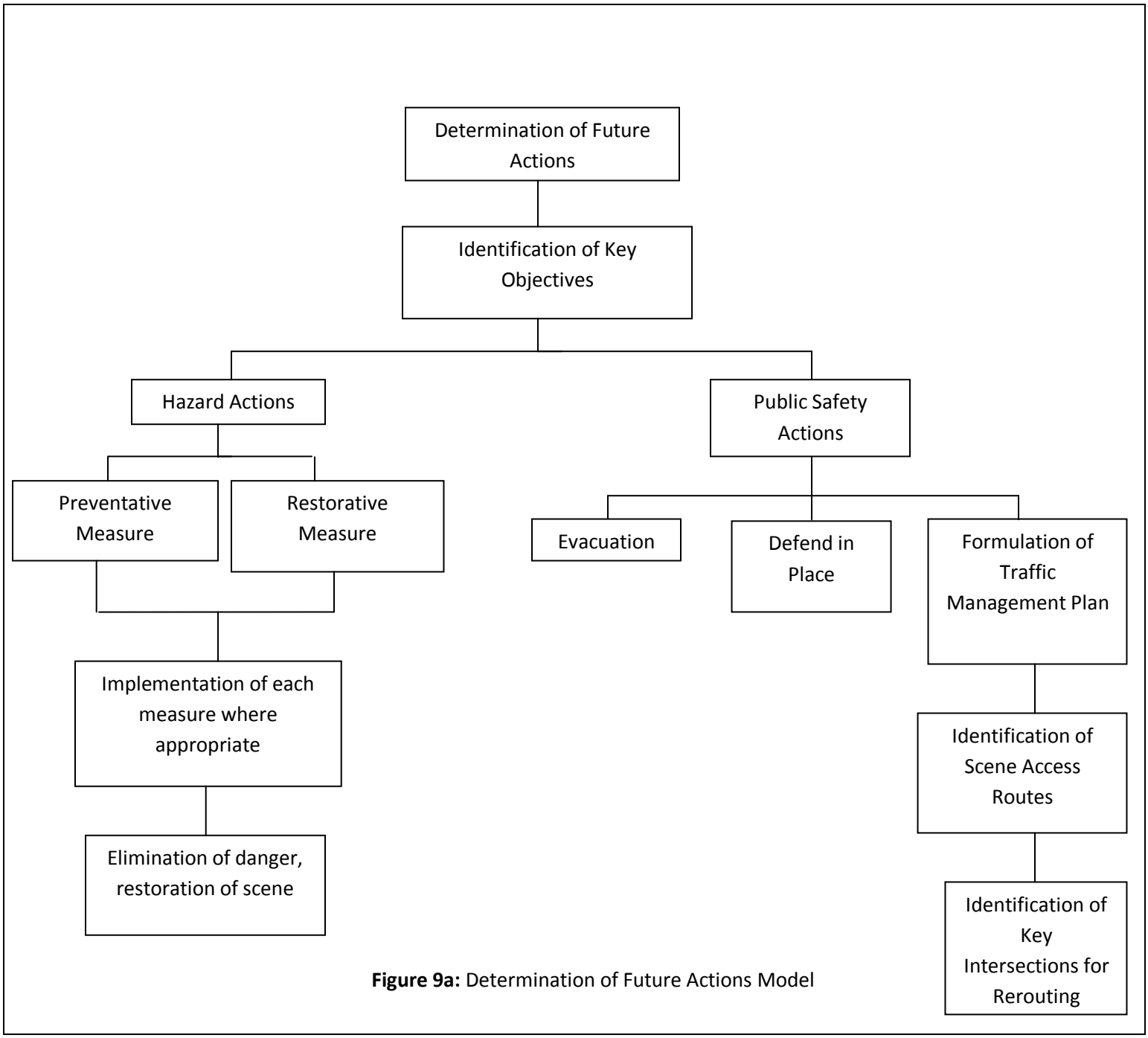

Figure 9a: Determination of Future Actions Model

Public safety actions include evacuation, “defend in place”, and traffic management. It is important to decide quickly whether an evacuation is necessary so that specific evacuation planning can begin. Additionally, a traffic management plan should be formulated so that drivers are not stuck in traffic around the incident scene and risk exposure to the hazard. The traffic management plan also should address routes designated for emergency responders and evacuation vehicles.

Application to Historical Incident

Figure 9b, shown below, demonstrates the application of this model to the I290 incident. The Hazmat team, cleanup crew, specialists from the trucking company, and officials from the chemical manufacturing company were on scene before any specific plan was made. As soon as they arrived, strategic planning commenced regarding different aspects of the incident. Their focused objectives were providing public safety, restoring the location to incident-free status, and rerouting traffic. Departments were assigned different tasks, and they were expected to complete on their own terms.

The responders first identified the problem areas from the information collected. Major problems were the leaking chemicals, small evacuation, cleanup, and road traffic. Preventative measures had to be made to guarantee public safety.

After some discussion, a plan to offload a portion of the truck and slowly raise it right side up was agreed upon. The tank was progressively unloaded as responders inched it back upwards. In fear of chemical build up on the soil, Mass Highway provided sand and built a ditch to hold any chemical flowage. Once unloaded and raised up, the tanker truck was hitched up and towed away, and the cleanup crew began cleaning the area. Fifteen hours after commencing the operation, the scene had been restored to its initial state.

As for public safety, an officer was sent to the nearby Burncoat St. and informed the neighborhood to stay inside until it was determined that safety was restored. In the confusion, residents began leaving the residential area, increasing traffic flow. By then

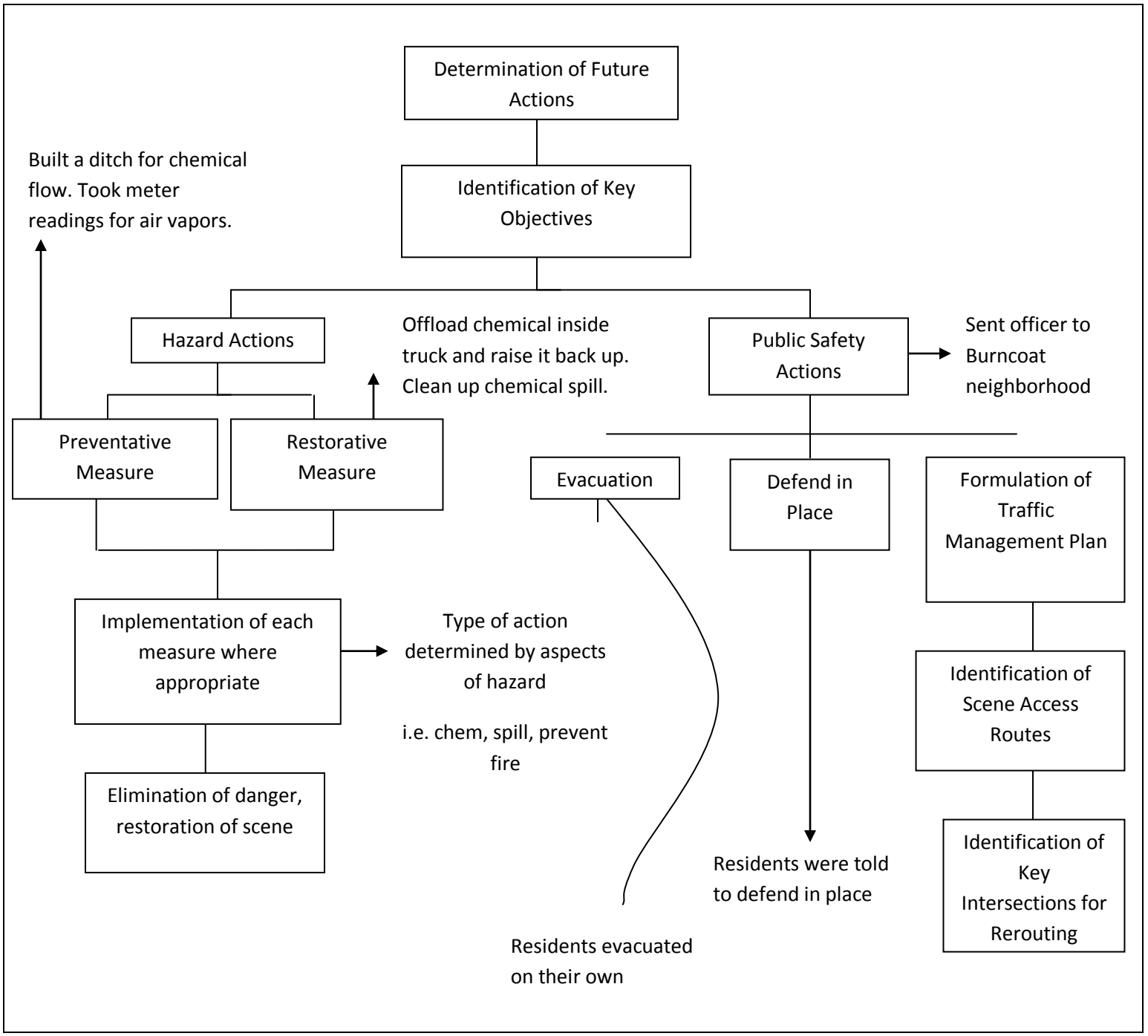

Figure 9b: Determination of Future Actions for Historical Incident

the police had selected and positioned police officers throughout the city at major intersections and possible entry routes to the scene. The streets were quite filled with vehicles as the day rolled along.

Application to Hypothetical Incident

Figure 9c, shown below, demonstrates the application of this model to the hypothetical chemical spill incident. In the hypothetical chemical spill the key objectives include elimination of the fire hazard, cleanup and removal of the chemical and tanker truck, reopening the highways returning traffic flow to its normal patterns, and ensuring the safety of all responders and the public. In the determination of the future actions involving the chemical hazard, preventative and restorative measures are established based on the information collected. In most emergency responses some combination of preventative and restorative measures are used; it is difficult to implement solely preventative or restorative measures. In this scenario, the restorative actions are more critical because the flames are an immediate danger that makes the response more difficult to manage; without extinguishing the fire, further leakage of the chemical and its contamination of the surrounding area cannot be prevented.

Public safety is a major concern in this scenario because there are two significant hazards occurring at the same time. The toxic chemical fumes can, under normal circumstances, merit a “defend-in-place”, as it is too risky to evacuate residents and risk exposing them to these fumes. However, the addition of the fire into this scenario poses an immediate threat to the homes in the surrounding neighborhood, and an evacuation of these homes is necessary. The Holy Cross campus is located far enough from the flames to implement a “defend-in-place”, which reduces the scale of the evacuation and the risk of exposing more residents and responders to the toxic fumes.

Traffic management, in this scenario, is extremely complicated. The Incident Commander is forced to close I290 in both directions for some amount of time due to the

fire and chemical hazards at exit 11. This results in an increased traffic flow on the surface streets, as cars and trucks are rerouted off the highway. Where these cars and trucks go depends directly on where the highway is closed. It may be more beneficial to close I290 at the Mass Pike (I-90) in order to reduce the traffic flow in the incident area. This allows response vehicles to quickly access the scene using either the highway or the surface roads. The problem here is that other towns would be affected by the traffic that is rerouted off the highways, and these towns need to be notified so that a traffic management plan can be implemented there. If only a section of I290 is closed, a detour route must be created for the traffic that is rerouted off the highway. It is critical that this detour route does not create a “spiderweb” effect and cause traffic problems across the city.

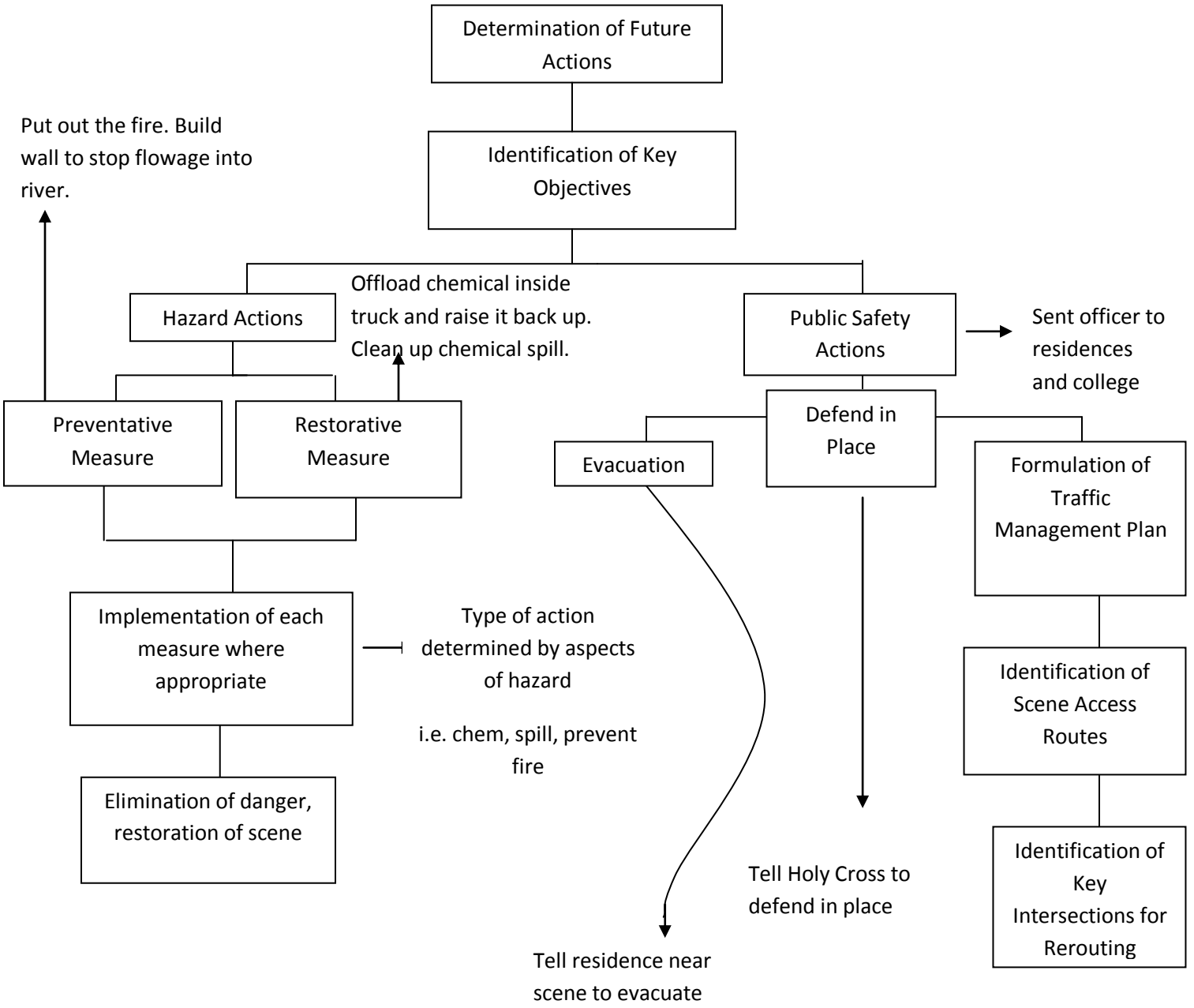

Figure 9c: Determination of Future Action Model for Hypothetical Incident

4.2.7 "Evacuation" Model

The Evacuation model, shown in figure 10a, demonstrates the process of planning and executing an evacuation. In this model, important aspects of an evacuation are addressed. Questions such as "Who is being evacuated?" and "Where will they go?" are considered during this process. Many variables affect, like the size and location of available shelters, can affect the decision making processes associated with an evacuation. The transportation process during an evacuation can be extensive, and is therefore addressed in a separate model. The evacuation process ends when the hazard is eliminated and evacuees can safely return to their homes.

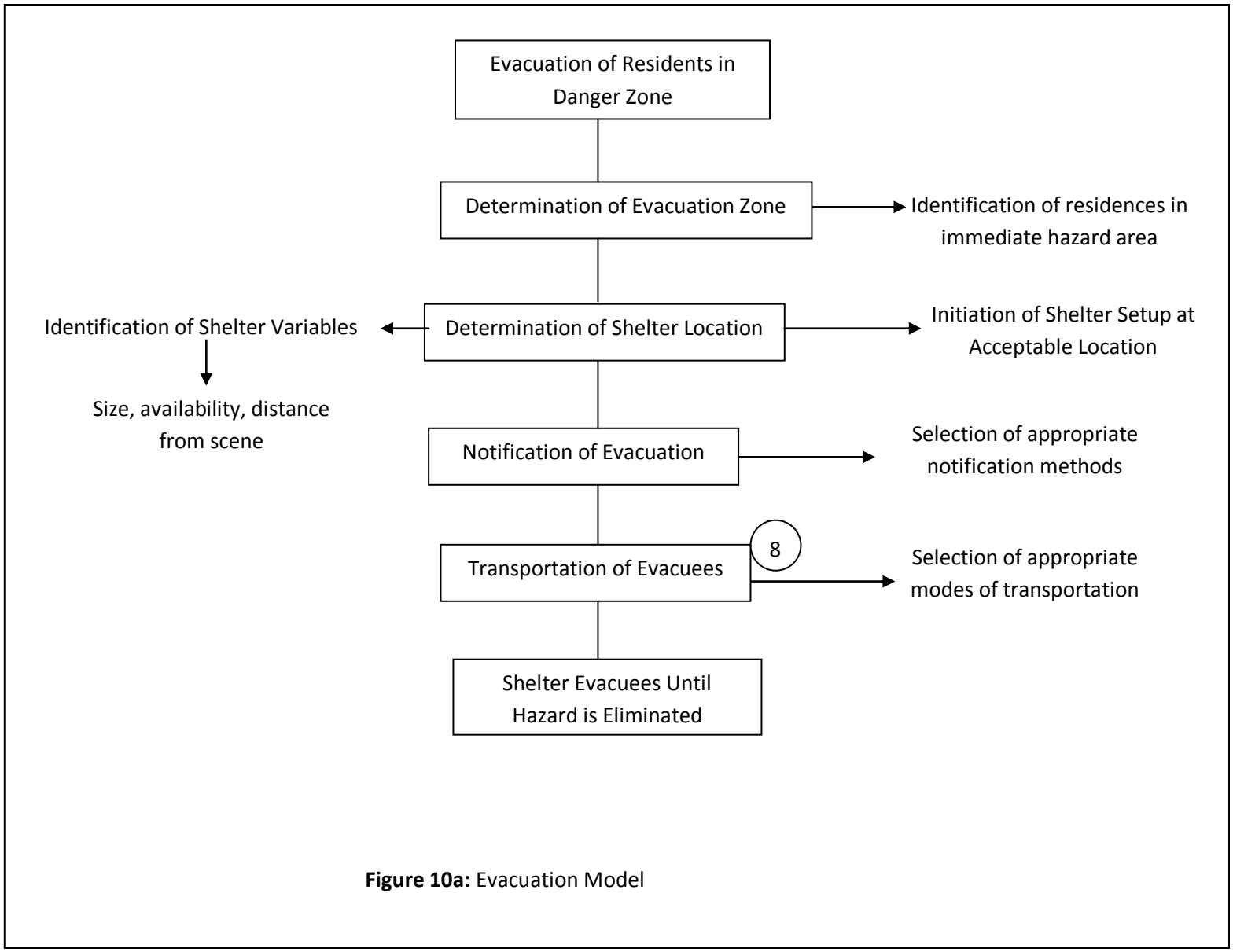

Figure 10a: Evacuation Model

Application to Historical Incident

Figure 10b, below, demonstrates the application of the "Evacuation" model to the I290 chemical spill incident. The responders felt it was necessary to inform those on Burncoat Terrace and Barnard Rd to leave the perimeter due to the incident. An office went knocking from door to door down the neighborhoods notifying the residents. Residents were told to leave just as a precaution and no sever danger was presented to those who stayed. Burncoat Jr High School was established as a shelter for individuals who had no place to go to until the safety was restored. The location was selected since it was within 2 miles away from the incident. No transportation to the shelter was provided to the evacuees, they would have to find their own means of relocating. Those who left their homes drove to a family/friends place or the shelter.

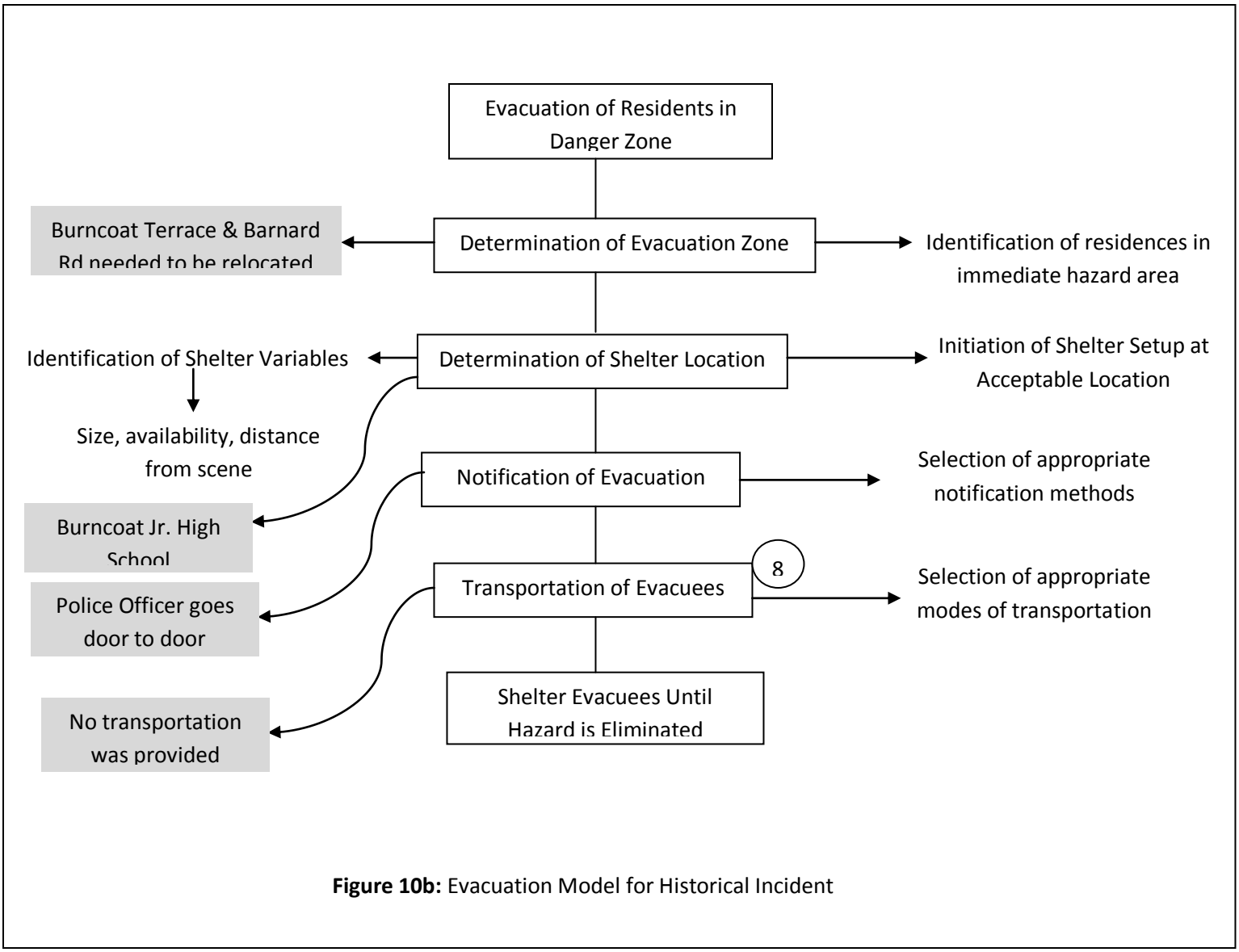

Figure 10b: Evacuation Model for Historical Incident

Application to Hypothetical Incident

Figure 10c, below, demonstrates the application of the "Evacuation" model to the hypothetical chemical spill incident. Responders would first have to determine those areas that would defend-in-place and those which have to be evacuated. In the scenario presented the Holy Cross campus is far enough to defend-in-place. There is the risk of exposing Holy Cross residents to toxic fumes released from the flames. However, residential area near the scene would have to be considered for an evacuation.

Before starting to notify and evacuate the residents a shelter must be established. Responders would determine the number of possible evacuees and begin searching for a shelter close and large enough to accommodate the evacuees. The shelter must also be open throughout the night and into most of the next morning. Under these conditions, Gates Lane School is the best option for a shelter. Red Cross would arrange the location of the shelter, but there is an hour wait for the volunteers to arrive at the shelter.

Residents in the evacuation zone would need to be notified of the evacuation. A reverse 911 call would be sent out to all landlines informing the residents of the evacuation, transportation, and shelter location. Due to the toxic fumes, police officers would not be allowed to inform the residents and fire fighters with protective gear would have to go door to door. The fire fighters would have to first fight the fire before trying to alert the evacuees. A breathing apparatus would be necessary if the chemical vapors in the air are too high. The safety of responders and evacuees are the primary concern of the operation.

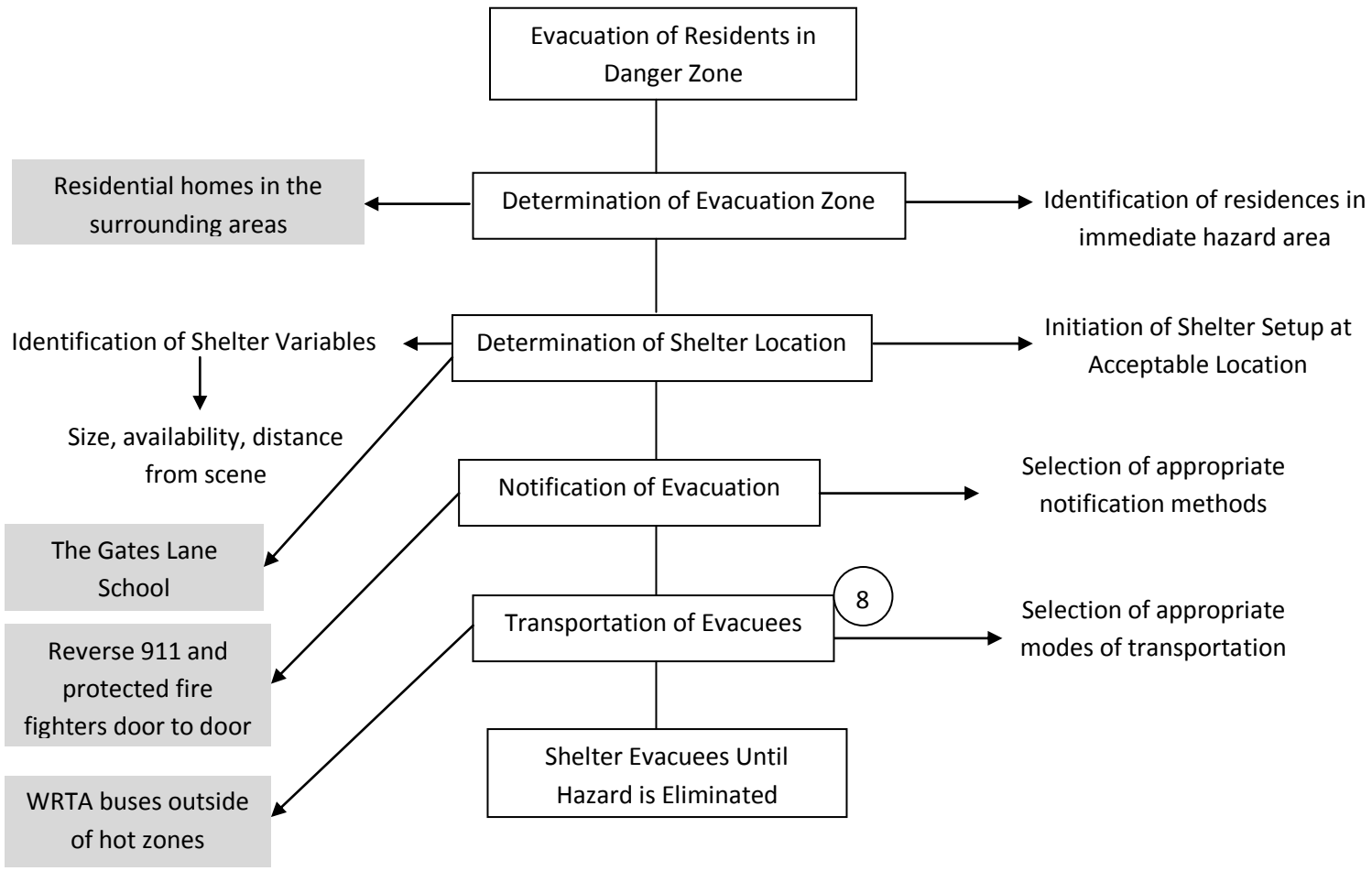

Figure 10c: Evacuation model for Hypothetical Incident

4.2.8 "Transportation of Evacuees" Model

The "Transportation of Evacuees" model, shown below in Figure 11a, focuses on the transportation needs of the evacuees during an evacuation. The evacuees are categorized into four main groups, including "Elderly/Disabled", "Foreign Language Barrier", "Transportation Required", and "Transportation not Required". The elderly and disabled may require medical assistance in an evacuation and the general transportation provided may not sufficiently meet these needs. Non-English speaking residents are initially considered separately so that the transportation needs may be determined. Once these needs are determined, non-English speaking evacuees may be categorized into one of the other three groups.

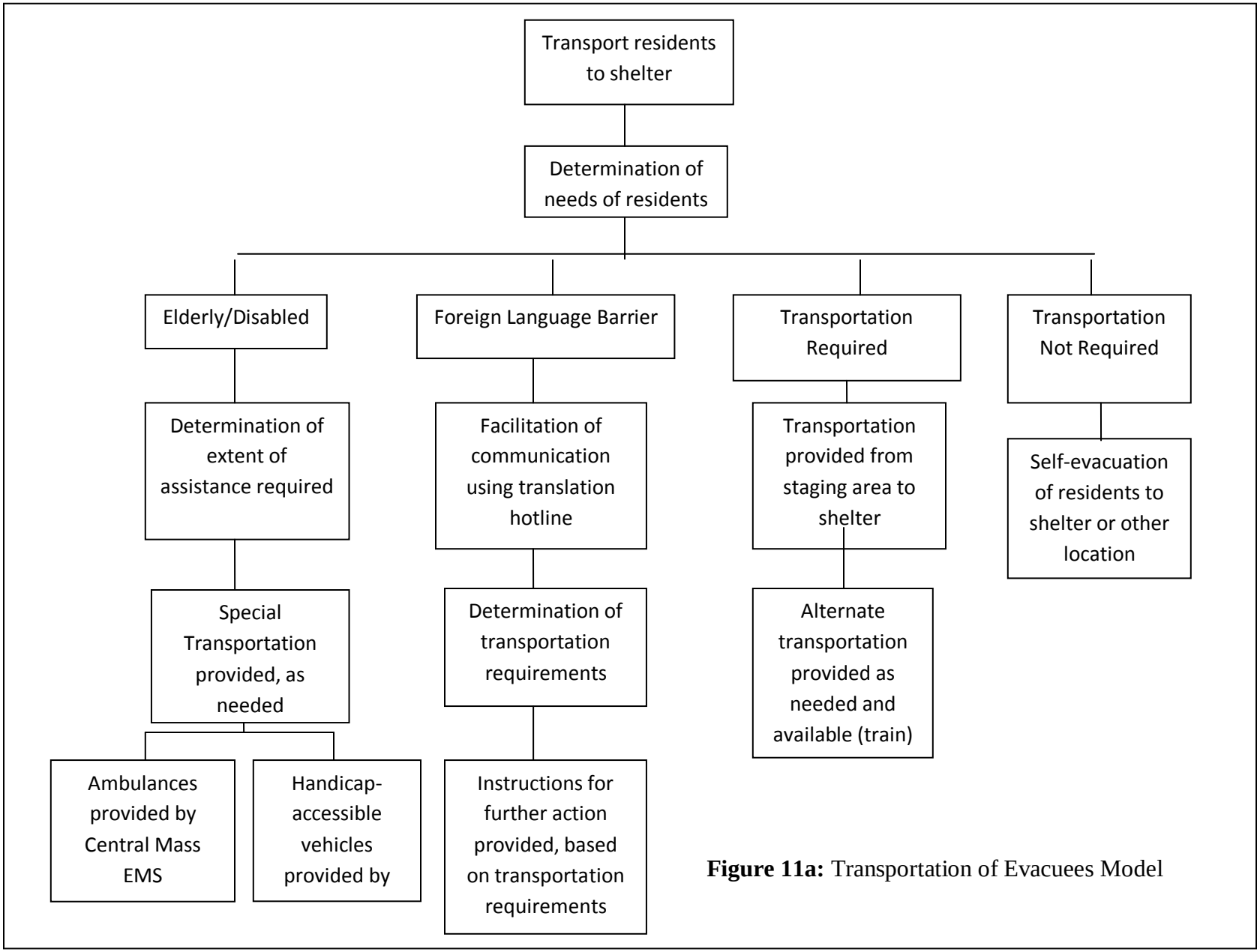

Figure 11a: Transportation of Evacuees Model

Application to Historical Incident

In the application to the I290 incident, the model shows that only two of the four categories of residents are present. Those speaking a foreign language and those requiring transportation do not factor into the I290 incident evacuation. The primary transportation involved in this evacuation, which was not planned, was the cars owned by those being evacuated. Secondary transportation was present in the form of ambulances for the elderly that required special assistance.

Because the evacuation was not initially planned, there was a potential for serious problems in the transportation aspect of the evacuation. Had this evacuation been in a densely populated area where residents are less likely to own a car, or had a nursing home been located within the evacuation area, the evacuation could have failed. During the evacuation planning process, the transportation needs are estimated so that the transportation providers may be alerted. The WRTA, in the case of the I290 incident, would likely have had problems arriving at the staging area quickly due to traffic congestion from the closed highways. Had an evacuation been planned, the WRTA would have been notified earlier and would have had more time to send buses for an evacuation. If these providers are not given adequate time to respond to the incident, the evacuation may not run smoothly. It was fortunate that the evacuation occurred in a neighborhood where residents had the means to self-evacuate

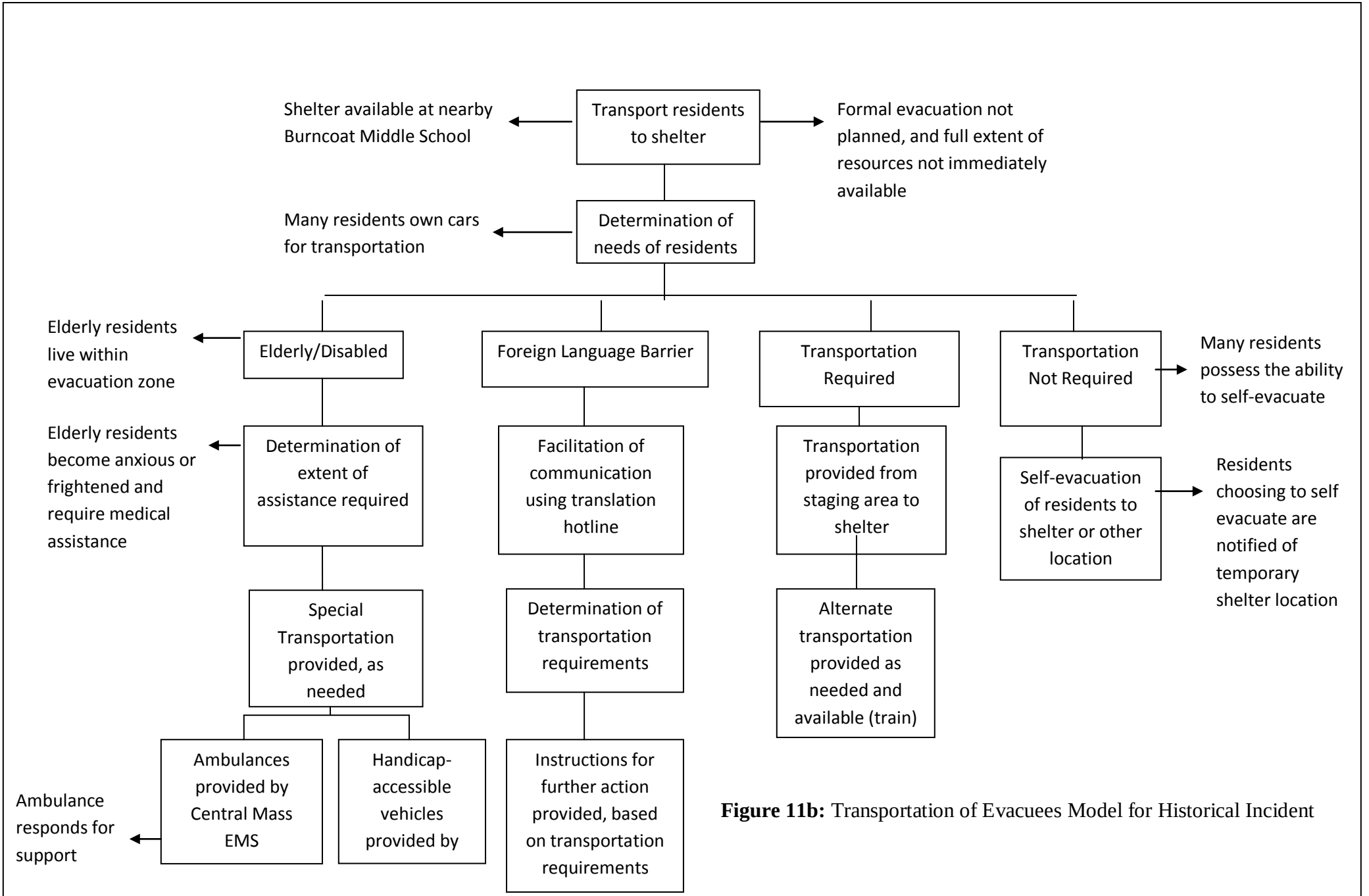

Figure 11b: Transportation of Evacuees Model for Historical Incident

Application to Hypothetical Incident

In the application to the hypothetical chemical spill incident, the model shows that all four of the categories of residents would be addressed. The consideration of all four groups is typical during a planned evacuation because, in general, the Incident Commander and those involved in the planning process do not initially know the full extent of the transportation needs of those being evacuated. If an evacuation is planned without addressing any of these four groups, serious problems could occur during the execution of the evacuation plan.

The evacuation planning process for the hypothetical chemical spill incident is made more complex by the presence of toxic fumes at the incident scene. Evacuation of those whose homes are threatened by the fire hazard could expose those residents to the toxic fume hazards. Additionally, responders without proper personal protective equipment could be exposed to the toxic fumes. The fire department is most prepared to handle these types of hazards, but fire fighters likely could not be spared to aid in the evacuation due to the high priority of extinguishing the fire. A problem is therefore encountered in transporting evacuees from their homes to a temporary shelter. Planning for events such as these is critical because important decisions must be made quickly, and there is little time for debate.

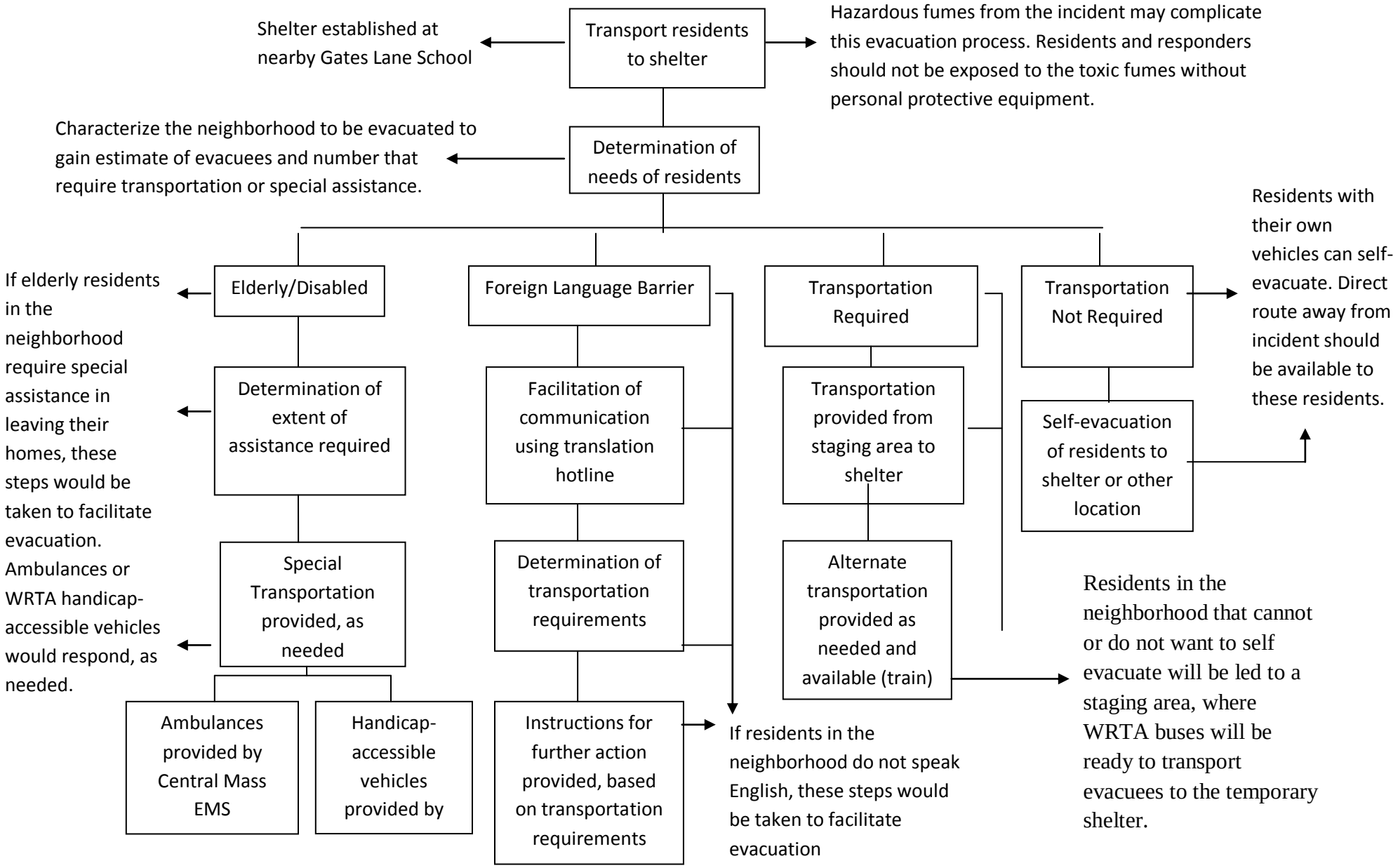

Figure 11c: Transportation of Evacuees Model for Hypothetical Incident

4.2.9 "Final Assessment" Model

Figure 12a, the Final Assessment of Incident model, is displayed below. This model reveals the necessary items that must be completed to contribute to the improvement of future incident responses. The first step is most critical and if not completed the lessons learned may not be acknowledged and any difficulties that may have been exposed can be forgotten. The After Action report gives all responders and agencies a chance to reflect on their own and other's actions during the emergency response. From this exercise key contributions are identified, and general responsibilities for specific positions or agencies can be recognized. Additionally, well executed and poorly executed actions are scrutinized for further improvement or new strategies. Finally this report is distributed amongst the agencies and responders for feedback. Lessons learned are highlighted, and it is then the responsibility of specific agencies to correct their mistakes or improve upon procedures to achieve the ultimate goal of this model.

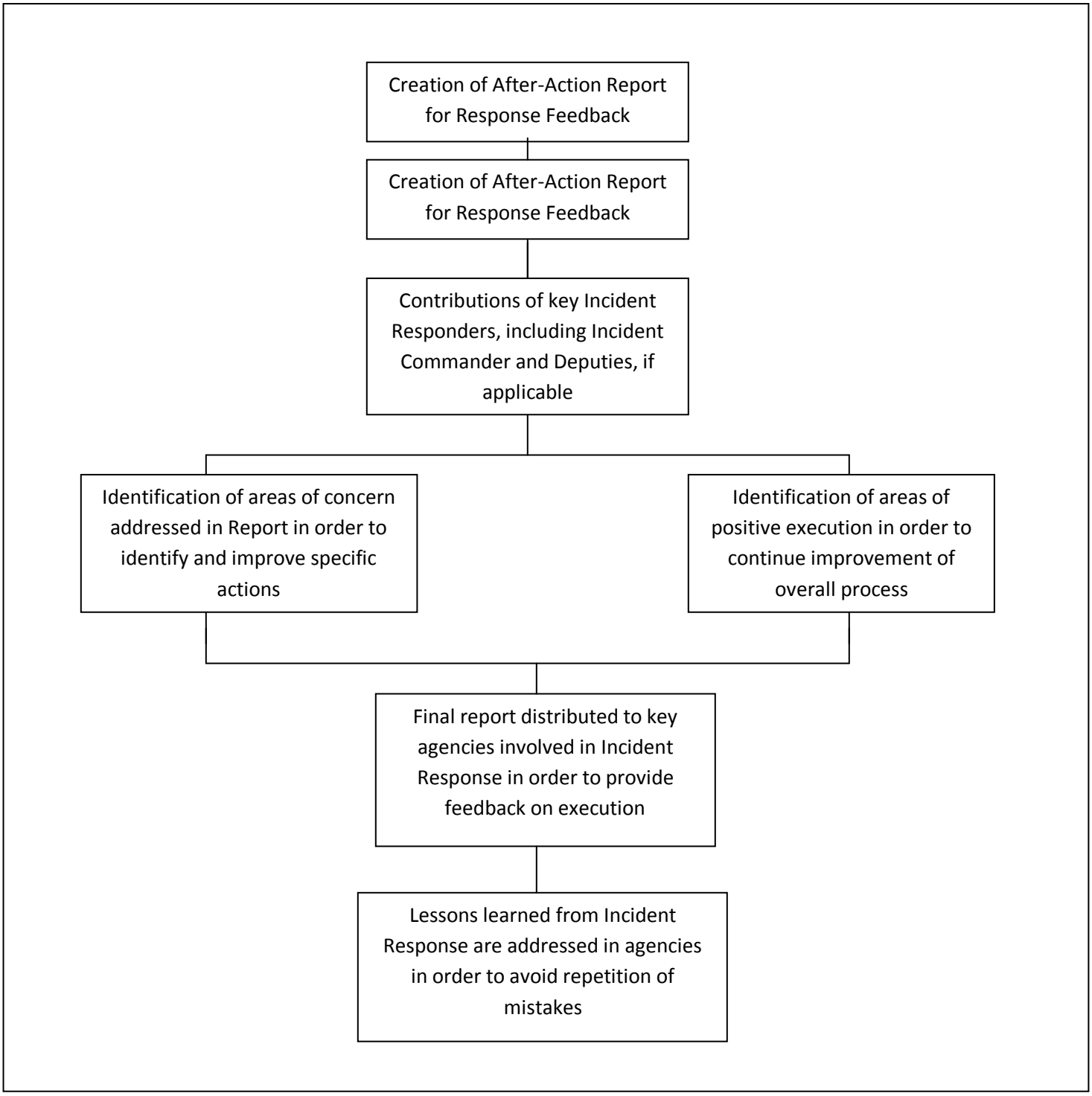

Figure 12a: Final Assessment of Incident Model

Application to Historical Incident

In Figure 12b, the following events can be seen applied to the Final Assessment Model. In the weeks following the I290 incident an incident report was filed by the Worcester Fire Department detailing the events of October 28, 1999. The report was descriptive in nature and included contributions of key responders, but did not critically analyze the response. This analysis is normally completed in an After Action report as shown in the model; however, at the time of the I290 incident these reports were not consistently filed. As a result areas of concern were not addressed formally, though the responders involved likely gained knowledge and experience for future incidents. A formal report that identified these areas of concern as well as areas of positive execution should have been distributed to all agencies involved. Through this report all involved in the response can learn from the mistakes and strive to improve upon future responses. By failing to complete an After Action report the I290 chemical spill does not follow our model. As a result, the chemical spill occurs without any valuable lessons being recognized and discussed.

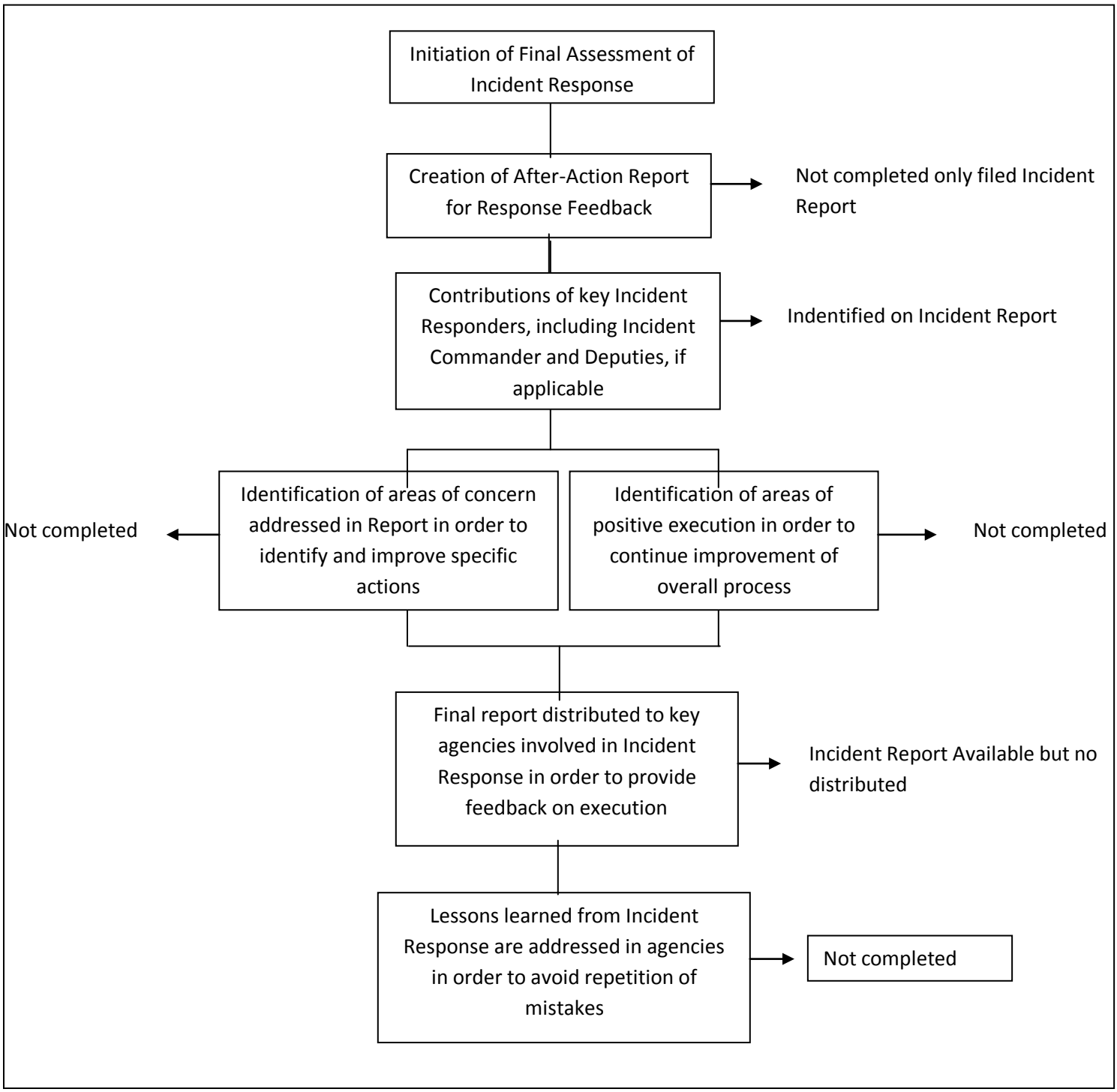

Figure 12b: Final Assessment of Incident Model for I290 Incident

Application to Hypothetical Incident

In Figure 12c, above, the following events can be seen applied to the Final Assessment Model. After the scene has been restored, and the City of Worcester regains an incident-free status, the final assessment of the incident response begins. An incident report is filed by the Worcester Fire Department, and other agencies may also file reports. An After-Action report will also be created by all the key agencies involved. Key contributions are reported and discussed during the formation of the After Action report. Areas of concern and good execution are identified to discuss options for improvement. Through this discussion the response is analyzed and lessons learned are recognized. Since emergency management is a growing field, and its importance has been recognized more after major events such as Hurricane Katrina, the final assessments have become more critical. Improving upon a response is always a consideration. This After-Action report is then distributed to all agencies involved in the incident, so that each agency can improve upon their own actions and adjust their standards of procedures. By completing the After Action report and following the actions outlined in the model constructive results can be achieved from incidents that seem to only cause turmoil.

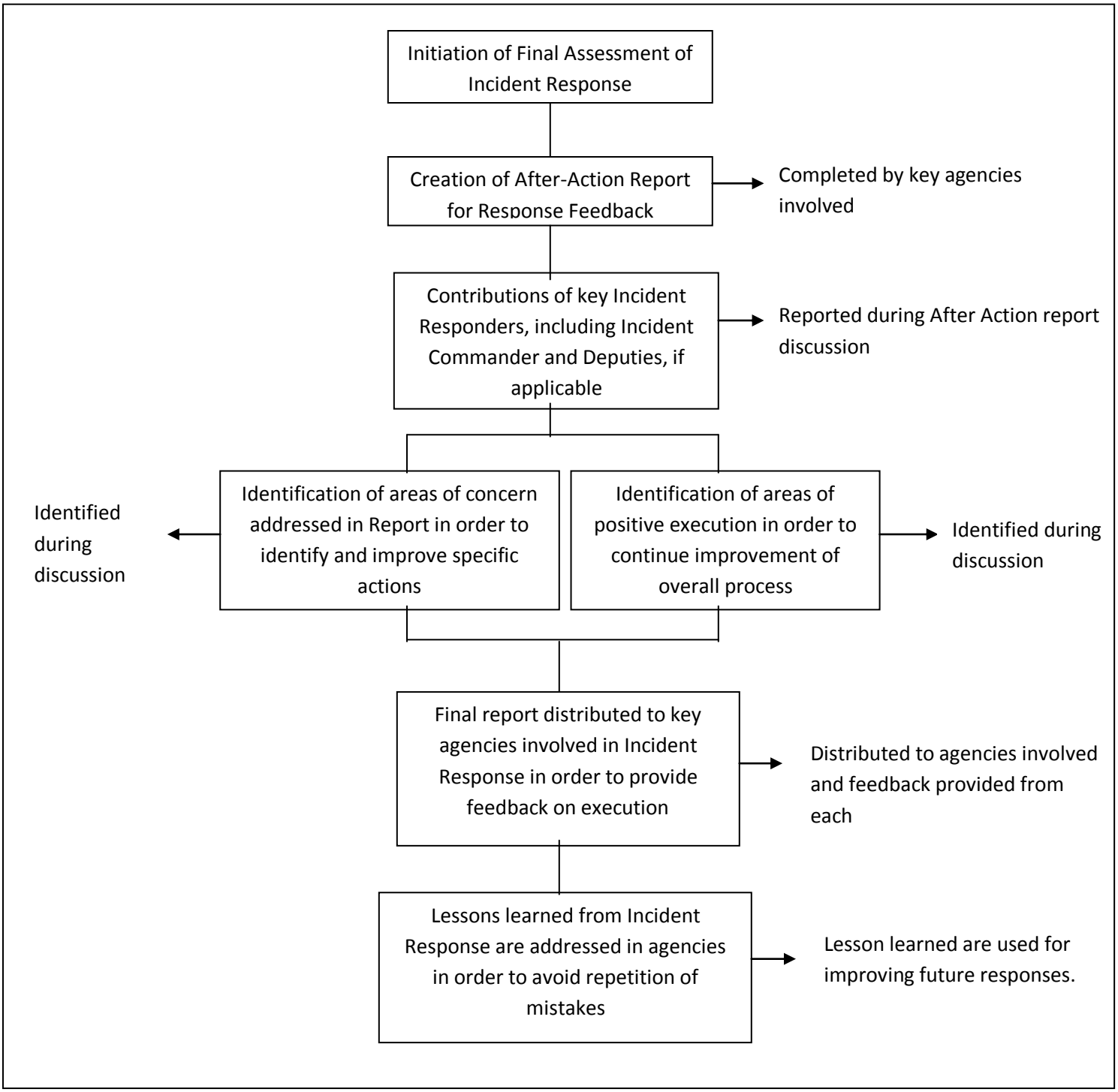

Figure 12c: Final Assessment of Incident Model for Hypothetical Incident

4.3 Summary of Key Points

The application of these models to both an actual and a hypothetical incident has demonstrated that several are important to consider for a future highway incident involving a chemical hazard. The first consideration is the responsibilities of the first responder at the scene. This responder plays a critical role in the emergency response process, and in many incidents he or she will arrive on scene without understanding the full extent of the hazards present.

The second consideration is the traffic management in an emergency response. Managing the traffic and creating access routes for emergency responders can play a critical role in an evacuation, but this aspect of planning can be overlooked at times.

The third consideration is the notification of residents to let them know that they will be evacuated. In both the actual and hypothetical incidents, there were challenges at this junction in the evacuation process. This is one of the most important aspects of an evacuation, and it must be planned and executed effectively.

The fourth consideration is the transportation of evacuees under hazardous conditions. This demonstrated in the "Transportation of Evacuees" model for the hypothetical chemical spill incident, is caused by the toxic fumes present in the incident and is closely related to two other areas. The notification of residents who would be affected by toxic fumes, and the difficulty for responders to provide face-to-face instruction at the residents' homes could make an evacuation more difficult. The management of manpower, discussed below, can also be a factor because fire fighters are equipped to handle the toxic fume hazards, but because of the high priority of extinguishing the fire, they likely cannot assist in an evacuation.

The fifth consideration is the effective management of resources and manpower at an emergency response. The Incident Command System (ICS) was created, in part, to aid the organization of resources and manpower in an emergency response. The application of these models shows the importance of clarity regarding the responsibilities of the various responders and the importance of making sure that all responsibilities are assigned.

5.0 Conclusions

The models presented in this report are meant to be used as tools for examining and analyzing an emergency response. It is important to consider that, though they have only been used in the analysis of the two incidents presented above, they have been designed to accommodate a wide range of highway incidents involving chemical hazards. The Master Incident Response Model outlines the general process, and the subsequent models provide greater detail while still allowing for the introduction of new variables. These models are meant to be fluid, and modifications may be made to them to better analyze a wide range of incidents. They are not meant to be a finished product, but rather a framework for incident analysis.

To aid in the emergency planning process the application of these models to hypothetical incidents, demonstrate how a vast number of variables can affect the results. Several variables were addressed in the scenario that was presented to the members of the focus group meeting so that an appropriate response could be established. Variables such as weather, time of day, day of the week, location, and many others can affect how a particular emergency response is carried out. Evacuations can be made more complex with the addition of variables such as wind and location, as shown in the hypothetical incident above. By adjusting and incorporating new variables into an incident, more may be learned about the evacuation process, and other areas of concern may be identified. In the future, the models presented above may be used or modified to apply to more complex incidents for further analysis.

In the application of our models we first observed that the responsibilities of initial responders are not very well defined. This responder is general unfamiliar with all the details of the incident, and likely does not understand the full extent of the hazards present at the scene. In the I290 chemical spill, the first responder to the scene must be taken to a hospital for medical attention because he was not properly equipped to be in close proximity to the chemical hazard. The model gave no indication that this responder should take certain actions to protect themselves at the scene. The models do, however, outline the importance of the first responder in the overall emergency response process. It is therefore important that the first responder be informed of the potential hazards that may be present at an incident, and a new action protocol should be created for this initial responder.

The models also emphasized the importance of traffic management in an emergency response and evacuation. Traffic management is part of the public safety measures, as existing traffic must be rerouted away from danger, and roads must be managed to prevent the exposure of future traffic to the incident hazards. Additionally, the increased traffic that results from the closure of highways often overwhelms the surface roads. These roads have not been designed to handle such increased traffic volume, and the problems tend to "spiderweb" across the city as frustrated drivers seek the least congested route. These traffic problems can thereby hinder an emergency evacuation by delaying the arrival of resources and responders to the scene of the incident.

It is critical to identify strategies for traffic management is addressed in the preplanning stages of an emergency response so that, during an actual emergency, an appropriate traffic management plan can be chosen and implemented quickly. Several resources exist that may aid in the preplanning process, including traffic forecasting, traffic modeling, and Geographical Information Systems (GIS). These resources, discussed at greater length in Appendix B, can be used to predict expected traffic flow at a given time during the day. Some traffic forecasters develop plans for emergency evacuations and can be hired to engineer an emergency evacuation route or test the feasibility of an evacuation plan. However, these services can be costly and generally are performed for full evacuations of cities and not the partial evacuations of neighborhoods that have been the focus of this report.

GIS can be used to identify the types of populations living in particular areas, and the usefulness of this knowledge cannot be underestimated. GIS is composed of statistical data, such as median income or ethnicity that corresponds with actual locations in a map. By understanding how to use this information and draw conclusions from it, an emergency responder can be better prepared for handling an evacuation. For example, if an incident occurs in a densely populated area of the city with a high rate of non-English speaking residents, an emergency responder can expect an increased need for transportation during an evacuation and an increased importance in communication between responders and residents. In a densely populated part of the city, very few residents are likely to own a car and have the ability to self-evacuated. Residents that don't speak English may have trouble understanding the directions they are given by the emergency

responders, and it may take time to effectively communicate with these residents. By anticipating these factors, and planning for them early, a more effective evacuation is possible.

The addition of these resources in the emergency response process could lead to a new model depicting the traffic management process. A model incorporating traffic forecasting and GIS for traffic management may serve as an important tool for the state and local police, who are primarily responsible for directing and rerouting traffic during an evacuation.

The notification of residents to evacuate is another area of consideration. In both the actual and the hypothetical incidents that were applied to the models, this area proved to be problematic. In the I290 incident, a breakdown in communication at this step in the emergency response process resulted in an evacuation that was not planned. In the hypothetical incident, a method for executing this step in the evacuation process was a point of debate in the focus group meeting, and a clear solution could not be reached. Effective communication between responders is necessary, and the ICS procedures generally streamline this communication by utilizing a chain of command and designating particular responsibilities to particular responders. However, it is important for the responders to adhere to these ICS procedures and to constantly be informed of the plans for the response so that events such as the one in the I290 incident can be avoided.

Instructing the evacuees is a critical step in the evacuation process, and it must be planned and executed properly for an effective evacuation top take place. Methods of notifying residents of an evacuation must be planned and the implementation of these methods must be effective. Methods such as the Reverse 911 call can be effective at times, but in this day and age, more people are beginning to abandon their land-line telephones in favor of cell phones, which cannot receive the reverse 911 call. Therefore, new methods, such as those used by local colleges in notifying the student body of emergencies via cell phone, may be considered in future evacuations.

Another consideration that was highlighted by the models is the transportation of evacuees under the hazardous conditions in the hypothetical chemical spill incident. An evacuation of several homes is necessary due to the fire hazard, but this evacuation could expose residents to the toxic fumes of the fire. This point was discussed at length during the focus group

meeting, and no clear solution was determined. Potential solutions could include extended training and equipment for WRTA operators so that buses can enter into the hot zone without risking the exposure to toxic fumes. This solution would also require an extended public awareness program that would provide residents with instructions and equipment, such as respirators, for handling airborne toxins. When considering the various hazards associated with the hypothetical chemical spill incident, the "Transportation of Evacuees" model is critical because a method of transporting evacuees under hazardous conditions is not addressed.

The final consideration addressed in this report is the management of resources and manpower during an emergency evacuation. The scale of the incident influences the level of resources required for an effective emergency response. In some situations few resources and relatively few responders are required. However, for large scale operations the number of responders and resources employed during the response can be extremely difficult to manage. The Incident Command System (ICS), displayed in Appendix E, was developed in part to address this problem; however, these procedures are not always followed closely and may not be known to certain responders.

To address this problem the key responders that will be leading or serving during emergency responses should be required to continually familiarize themselves with and be tested on ICS procedures. This will ensure that responders will be able to utilize their knowledge gained from ICS during the stressful situations encountered in emergency responses. Successful application of ICS procedures allows the Incident Commander to manage all necessary resources and maintain an awareness of the status of each.

Through the identification of the areas of concern mentioned above, those involved in an emergency response may improve upon the evacuation process. These common problems that arise during an emergency response can be addressed now to better prepare the City of Worcester's emergency response for future incidents. Although our application of the models to the incidents mentioned previously have resulted in four areas of concern they can be used to encompass additional hazards and analyzed further.

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Appendix A

Case Study of the I-290/I-190 Chemical Spill

Introduction

On October 28th, 1999, a tractor-trailer transporting a hazard chemical overturned on the ramp from I-290 West to I-190 North. An investigation into this event was performed through a series of interviews with emergency responders involved in this event, as well as through the review of news articles and after-action reports written about the incident. The resulting case study presented here focuses on three main aspects of an emergency evacuation. The first aspect is transportation, which includes transporting evacuees to safety and responders to the scene. The second aspect is communication, which is crucial to the execution of orders and conveyance of important information to civilians and the media. The third aspect is somewhat broader, consisting of evacuation operations such as the establishment of shelters and processing facilities, as well as the acquisition of supplies for those being evacuated. These three aspects serve as the foundation of this case study

This case study has been performed in order to provide greater detail of chemical spill incidents and the actions that must be taken to protect the citizens in the affected areas. The information presented here will be used as the basis of further investigation on the evacuation process associated with chemical spills in a densely populated area.

Summary

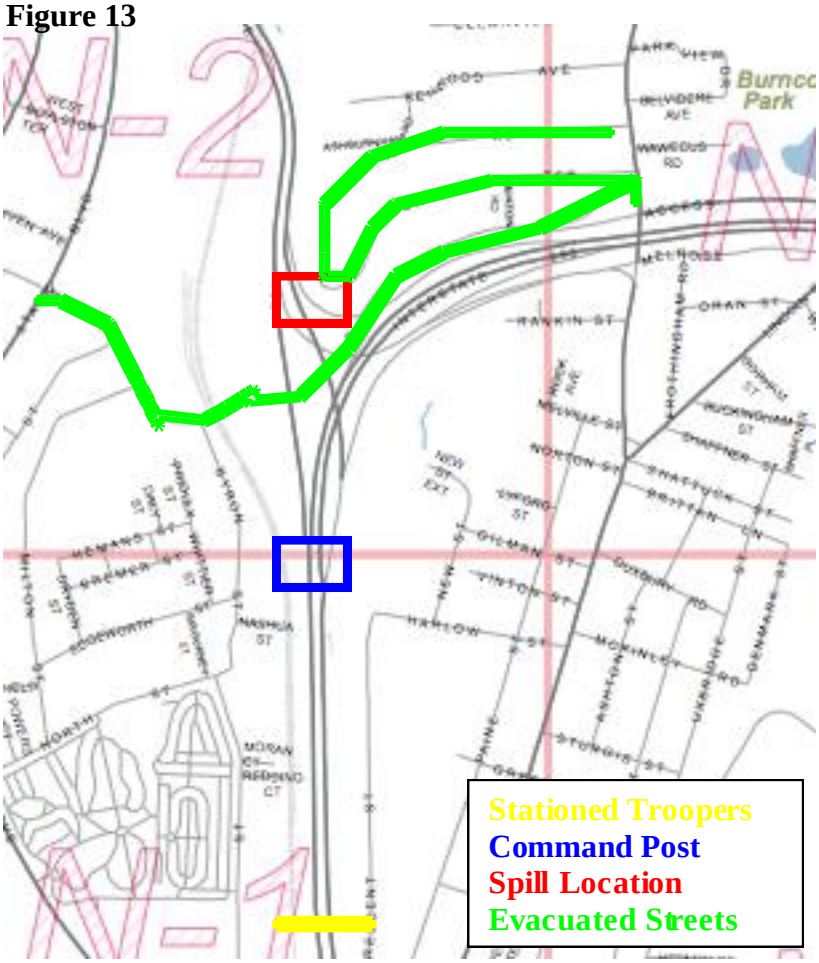
At approximately 8:30am on October 28th, 1999; a tractor-trailer truck rolled over onto the grassy area next to the on-ramp to I-190 North from I-290 West and slid about 100 feet before coming to a stop. The red rectangle on the map marks the area where the truck overturned. The truck was traveling to Fitchburg, and came from Pennsylvania. The accident was caused by road rage, and was reported by an eye-witness. The truck was carrying over 6,000 gallons of Butyl Acrylate, which is a very hazardous liquid. It is flammable, can explode upon heating, and is toxic to come into physical contact with or to inhale the fumes from. The driver of the truck and the responding police officer were sent to the hospital to be treated.

The chemical was leaking steadily from three different locations on the truck. The initial responders, which included 2 engines and 1 ladder truck, requested more assistance. The incident was reported to all necessary agencies, such as the Department of Environmental Protection and the Department of Public Works, and the Department of Public Health. Chief McNamee was appointed Incident Commander. Hazmat was contacted to respond to the spill, and 16 members of the Fire Departments of surrounding towns were called in to assist. They took approximately 30-45 minutes to arrive on site.

Once a command post was set up, agencies continued to arrive on site. The blue rectangle on the map marks the location of the command post. Agencies sent their top representative to receive instructions from the Incident Commander. This communication is normally done face-to-face. If communication cannot be done face-to-face, then there is a citywide radio system managed by the Communications Officer that all departments use daily. There is a channel that all city departments can access to communicate with each other. ChemTrak was notified by the 9-1-1 Dispatch Center to identify the chemical in the truck, as well as contact the chemical manufacturer. ChemTrak is a 1-800 telephone number that can supply the caller with information about chemicals, as well as contact the shipping company and the manufacturer so that representatives can be present at the scene. Representatives from the chemical company flew to Worcester from New Jersey in order to be present during the clean-up.

I-190 was blocked off, along with several local roads. I-290 had troopers stationed approximately half a mile away from the incident in either direction to discourage travel on the road. The yellow line on the map marks the location of State Troopers stationed on I-290. Lieutenant William Trotta returned to Worcester from Framingham, Massachusetts to aid in controlling the press and to dictate police involvement. At the time of the Spill, Lieutenant Trotta was the director of Emergency Management in Worcester. Hazmat teams evaluated the air quality and deemed the levels of the chemical in the air to be negligible.

Figure 13



Notification to the public during an incident such as this is crucial, but it is very difficult. It is important to release the necessary information at the right time. A firefighter was sent to tell people to shelter in place. The officer misunderstood, and told local citizens on Burncoat Terrace, Millbrook Street and Barnard Road to evacuate. The green lines on the map indicate the streets previously listed. The citizens then added to the confusion of the incident and many panicked.

The incident caused substantial traffic jams on both the interstate highways as well as the city streets. The rerouting of the traffic on the city streets was done by Worcester City Police. Officers were called in from off-duty to help direct and reroute traffic. Lanes were kept open on

major roads so that supplies could be delivered to the incident location. The traffic was backed up until about 8:30pm.

Sand with a plastic lining called a “Geo-membrane” was provided by the Department of Public Works (DPW) to create an earthen berm to keep the liquid chemical that had leaked from the truck from spreading over the surface of the ground. The trucking company that owned the leaking truck hired a cleanup company to take care of the spill, and the cleanup company was approved by the Department of Environmental Protection (DEP). The trucking company can choose a clean-up company, but it must be approved by the DEP, or the DEP can suggest a company if the trucking company has no preference.

Between 2pm and 3pm, the chemical was offloaded from the truck, using gravity to drain it. There were three cranes and several air bags that were used to right the truck so that the chemical could be drained. This remaining chemical that was pumped out was moved to a new truck.

The truck involved in the road rage incident was then impounded and the driver was fired. The incident was cleaned up by a chemical company, which vacuumed up the chemical that had spilled, and helped to take down the dike. The site was cleaned up and personnel were free to leave around 9pm.

Analysis

The analysis of this case study of the chemical spill that occurred on the I-190 to I-290 on-ramp will consist of three major categories. These categories arose from our investigation of this chemical spill and of evacuations in general, and are major aspects of an evacuation. The first is transportation, which will include the transportation of responders to the scene of the spill and the traffic concerns that stemmed from the spill. The second point is communication, which will include communication between responders and citizens, as well as between responders themselves. The third point is primary response operations, including the decision-making processes of those in charge of the response, and the measures taken to control the scene and protect the citizens in the area.

Transportation

Transportation at a chemical spill is a very important aspect of the response. The ability of responders to reach the scene of the spill is critical in containing its effects and ensuring the safety of local residents. In order to ensure the safety of commuters and residents, I-290 West was temporarily blocked off, and actions were taken to greatly reduce the traffic flow on I-290 East, including public warnings and police barricades. In this particular case, responders were able to quickly reach the scene via I-290. This highway acted as a direct route for responders to transport themselves and critical supplies to the Incident Command post, which was located on I-290 West. The blue rectangle on the map indicates the location of the command post. State police were responsible for blocking off on-ramps to the highway and succeeded in transforming the highway into an emergency responder route. One example of the effectiveness of I-290 as a transportation route for responders was the efficient delivery of sand and geo-membranes from the Worcester DPW in order to create an earthen berm near I-290 West to block any liquid chemical from reaching the highway.

The other primary transportation concern in this particular response was the re-routing of traffic from I-290 to local streets. The city of Worcester has two police Lieutenants, and one or two sergeants for each of four sectors. These sergeants take orders from one of the two Lieutenants, and in emergencies they assign important intersections to nearby officers on duty. These officers generally receive instructions to keep the traffic moving in a particular direction, though these instructions can lead to a spider-web effect, where traffic problems spread across the city because of the increased volume of cars on local streets. This problem tends to arise from cars seeking the least congested route once they have been directed through intersections where police officers are stationed. This commuter tactic leads to smaller streets being overloaded with cars, and the traffic "spider-webs" to more and more streets. In the I-290 chemical spill, police followed the standard procedure, and local officers were stationed at various intersections. State police generally did not help direct traffic on the streets. The traffic problem from re-routing cars off the highway was the most notable effect the spill caused in Worcester. Traffic was backed up throughout the day, causing traffic jams and much longer commutes for those driving in Worcester during the day.

Communication

Communication is another crucial aspect of emergency responses. Communication can take many different forms, including radio, face-to-face, and television broadcasts. Communication between responders and the media and local residents primarily took the form of radio and television broadcasts. The local police were responsible for controlling the press at the scene in this particular case. Currently, Worcester employs a public information officer to handle the media at the scene of an incident. According to Chief McNamee, the incident commander for this chemical spill, the responders utilized the media to deliver the correct information to local citizens. The responders cooperated with the media and periodically met with reporters to give updates on the situation. One of the benefits of this cooperation was the significant decrease in the traffic flow on I-290 East. The media was able to convey the status of the clean up to citizens and advise them to avoid using the highway. Utilization of the media to report the traffic

conditions can also help to contain the traffic problems by advising those who do not need to leave their homes to stay off the roads.

Communication between responders is also critical to coordinating actions in an emergency. Most of the critical communication between responders at the I-290 spill was face-to-face due to the convenient location of the established incident command post. As a result, many of the instructions and orders given were clearly understood and accomplished. The most notable exception was the order given to a firefighter to alert surrounding neighborhoods that a "shelter in place" was in effect. The incident commander chose this "shelter in place" tactic as the most appropriate manner of protecting the local residents. However, the firefighter did not carry out this order, perhaps due to a misunderstanding or personal decision. As a result, residents were told to leave their homes and seek shelter somewhere else. This action created a significant problem because no shelter had been established to receive the evacuees. Also, older residents often become anxious and panic when told they must leave their homes. Occasionally, these elderly residents refuse to leave their houses. In this particular response, at least one elderly resident became upset because of the evacuation and required medical attention.

Communication errors, such as the one described above, are generally avoided through the Incident Command System (ICS) procedures used across the nation for emergency responses. This system creates a well-defined command structure that places ultimate control in the hands of the most qualified and experienced responder. The ICS consists of five main components; command, operations, planning, finance, and logistics. Each component generally has its own branch of personnel, with a Deputy at the head of each branch. Depending on the situation and the conditions, the Incident Commander can choose not to utilize particular branches for a response. In this response, Chief McNamee was the incident commander because of the chemical nature of the emergency. The incident commander delegates tasks and responsibilities to his deputies, allowing the incident commander to remain focused on the overall response. Examples of the incident commander's deputies could be a logistics deputy to manage the needs of the responders, or the public information deputy to handle the media. These deputies can then delegate their tasks to their subordinates. For example, the incident commander could tell the police lieutenant at the scene that the traffic must be re-routed in a particular direction to avoid

cars entering a chemical plume. It is then the responsibility of the police lieutenant to create a plan for re-routing this traffic, and send his officers to accomplish the task. Generally, this system streamlines the response by creating a clear chain of command that simplifies communication.

Operations

The final aspect that will be examined in this case study is the evacuation operations. In this particular response, no true evacuation was planned, so any evacuation operations that occurred had to be improvised. It was reported that the Burncoat Middle School was quickly transformed into an evacuation shelter, though the extent of its utilization and effectiveness is unclear. The necessity for this shelter was caused by the communication error of the firefighter who was ordered to alert the citizens of the shelter in place", and as a result, the incident commander could not properly plan for this shelter. The improvised "evacuation" is not a normal part of most emergency responses, and in this case a "shelter in place" was chosen as the most effective evacuation operation. It protected the public from exposure to chemical fumes, which can be the most dangerous part of a chemical spill. "Shelter in place" is a common tactic in chemical spills, unless the chemical is highly flammable and could result in dangerous fires near residences. When evacuations are planned, the Red Cross generally handles most of the operations regarding the needs of the evacuees. The incident commander plays a role in choosing the location of the shelter, and for alerting the local residents of the evacuation plan and the method of transporting these evacuees. In the I-290 spill, evacuation operations were perhaps the least organized and planned of the three main aspects of this investigation.

Conclusion

The investigations into the transportation, communication, and evacuation operations aspects of the I-290 chemical spill that occurred in October 1999 have demonstrated areas that the response team handled well, and areas that could be dealt with more effectively. Throughout our investigation into this chemical spill, these three aspects presented themselves as primary areas of an evacuation. They will serve as the framework for a study of a hypothetical scenario and analysis of its response.

The Worcester Police Department responded quickly to the scene to help direct traffic and contain the traffic effects of the closed highway. However, there may be more efficient methods of re-routing traffic to keep the traffic problems from spreading throughout the city. Communication was mainly efficient due to the excellent location choice for the incident command post and the thorough execution of the ICS procedures. Communication did break down at one point and created a major problem. New methods of alerting citizens of the surrounding neighborhoods may help to avoid future problems like the one that occurred at this response. Evacuation operations had not been planned, but lessons can still be learned from this event. Planning an evacuation, even if a “shelter in place” is chosen, may prove to be beneficial. The areas of each aspect that could be more efficient will be the subjects of a further investigation.

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Appendix B

Model Explanation and Presentation

In this appendix each model is briefly summarized to demonstrate the thought process involved in creating them. Following the explanations are the models that were created for analysis of the historical and hypothetical scenarios.

Master Incident Response Model

Figure 14, shown below, is the master model upon which all subsequent models are based. This model shows conditions surrounding an emergency response, beginning at an incident-free status. At this point, no incident has occurred and the city is considered to be in a "normal" state. The emergency response process begins when the actual incident occurs. The master model then branches down to "highway incidents" and "non-highway incidents". Our models are specific to highway incident responses, and from here the master model branches down to "increased hazard to the public" and "limited hazard to the public". In this model, an incident with limited hazard to the public is considered to be an incident that only endangers those immediately involved in the incident, such as the passengers in a car accident. An incident with increased hazard to the public is considered to be a hazard that could endanger those not immediately involved in the incident. These hazards are further detailed in subsequent models. After the particular conditions of the incident have been established, six major steps of an emergency response are included in the master model. These steps are expanded upon in subsequent models.

"Hazard Consideration" Model

Figure 15, presented below, is the "Hazard Consideration" model. This model outlines the types of hazards that result in an increased hazard to the public. This model is not used explicitly in the study of historical incidents, as the type of hazard is determined during the incident site assessment. However, this model is an important consideration in the applicability of incidents to the remainder of the models in this system. The models have been designed with

the assumption that the incident will involve either a chemical or fire hazard. Other types of hazards, such as nuclear or biological, may pose an increased threat to the public, but these models have not been designed for these types of hazards and may not yield desired results in the application of these types of incidents.

"Notification of Dispatch" Model

Figure 16 is the "Notification of Dispatch" model. This model shows the sequence of events that occur when someone calls 9-1-1 to report an emergency. If the witness calls from a land line, it will immediately go to the local emergency communications center. If someone calls from a cellular phone or a State Police Officer reports it via their radio in their car, it will be answered by the State communication center and rerouted to the local communication center. In this case, Worcester Emergency Communications (WEC) would be the local communication center for the following scenarios. This model is important because it is essentially the first step in the emergency response process.

"Response to Incident Site" Model

The model presented below in Figure 17 represents the initial response to the incident scene for a chemical hazard on a highway. After dispatch has been notified, the initial response is critical to set emergency actions in motion and eliminate the danger created by the chemical hazard. This model, however, is not as hazard specific as the previous. The actions presented in the figure below are applicable to almost any type of hazard. The first step involving the implementation of ICS procedure must always be achieved. Following ICS procedures ensures a swift and efficient start to an emergency response. An important component of ICS is the Incident Commander, who is initially the first responder on-scene. The individual plays an important role in response as he or she is responsible for ensuring that necessary agencies are notified with accurate information.

As the model continues several actions must be completed within a short period of time. As soon as a more qualified responder with experience in the type of hazard at the scene arrives, the command will be transferred to them. This person must quickly determine the location of the command post, implement short term safety measures and determine the future needs required

for a complete response. These four actions are on the same level because they can all be taking place simultaneously. Various agencies can handle certain actions. Generally the state and local police along with the fire department can implement short term public safety measures, while the Incident Commander and his or her team can determine the needs of the incident.

The final stages of the incident response require the creation of a perimeter and traffic management plan along with the request for necessary supplies and personnel. Through determination of future needs the essential resources are established and must be requested. Both creation of a perimeter and the traffic management plan are further public safety measures.

The perimeter is dependent on the properties of the chemical hazard that were previously determined in the hazard consideration model. This perimeter provides responders with the areas that must be secured to allow responders in and keep civilians out. The traffic management plan also allows for a steady flow to and from the incident scene and reduces the possibility of gridlock and further vehicular accidents.

"Assessment and Analysis of Incident" Model

The "Assessment and Analysis of Incident" model is presented in Figure 18. This model outlines the information collection process that occurs at the scene of the incident. The assessment and analysis of the incident requires the identification of the variables involved with the hazards and the location. Hazard variables include the type of hazard, for example a fire or a chemical spill, and the consequences of these hazards, such as toxic fumes or local water contamination. The locational variables include the topography and weather conditions, which can affect how and where the hazards spread.

Hot and Cold zones are an important aspect of the emergency response process, because these zones help determine who needs to be evacuated and which responders can take part in the evacuation. The hot and cold zones are determined by analyzing the variable data collected. Areas that are not considered to be susceptible to the hazards are designated as cold zones, and areas that are affected by the hazard are designated as hot zones.

Time constraints should also be considered, because these help determine the priorities of a response. After the hot and cold zones are determined, the Incident Commander must decide

the next step in the response. If one hazard must be addressed quickly, these time constraints should be considered in the formulation of a plan of future action.

"Determination of Future Actions" Model

The "Determination of Future Action" model is presented in Figure 19, below. This model demonstrates the on-scene planning process that occurs after the assessment and analysis of the incident scene. The Incident Commander must formulate a plan of action that addresses both the hazard and the public safety. Using the data collected in the scene assessment and analysis, the Incident Commander and his team plan restorative actions and preventative actions. These preventative actions aid in the scene restoration, but also contribute to public safety.

Public safety actions include evacuation, "defend in place", and traffic management. It is important to decide quickly whether an evacuation is necessary so that specific evacuation planning can begin. Additionally, a traffic management plan should be formulated so that drivers are not stuck in traffic around the incident scene and risk exposure to the hazard. The traffic management plan also should address routes designated for emergency responders and evacuation vehicles.

"Evacuation" Model

The Evacuation model, shown in figure 10a, demonstrates the process of planning and executing an evacuation. In this model, important aspects of an evacuation are addressed. Questions such as "Who is being evacuated?" and "Where will they go?" are considered during this process. Many variables affect, like the size and location of available shelters, can affect the decision making processes associated with an evacuation. The transportation process during an evacuation can be extensive, and is therefore addressed in a separate model. The evacuation process ends when the hazard is eliminated and evacuees can safely return to their homes.

"Transportation of Evacuees" Model

The "Transportation of Evacuees" model, shown below in Figure 21, focuses on the transportation needs of the evacuees during an evacuation. The evacuees are categorized into four main groups, including "Elderly/Disabled", "Foreign Language Barrier", "Transportation Required", and "Transportation not Required". The elderly and disabled may require medical assistance in an evacuation and the general transportation provided may not sufficiently meet

these needs. Non-English speaking residents are initially considered separately so that the transportation needs may be determined. Once these needs are determined, non-English speaking evacuees may be categorized into one of the other three groups.

"Final Assessment" Model

Figure 22, the Final Assessment of Incident model, is displayed below. This model reveals the necessary items that must be completed to contribute to the improvement of future incident responses. The first step is most critical and if not completed the lessons learned may not be acknowledged and any difficulties that may have been exposed can be forgotten. The After Action report gives all responders and agencies a chance to reflect on their own and other's actions during the emergency response. From this exercise key contributions are identified, and general responsibilities for specific positions or agencies can be recognized. Additionally, well executed and poorly executed actions are scrutinized for further improvement or new strategies. Finally this report is distributed amongst the agencies and responders for feedback. Lessons learned are highlighted, and it is then the responsibility of specific agencies to correct their mistakes or improve upon procedures to achieve the ultimate goal of this model.

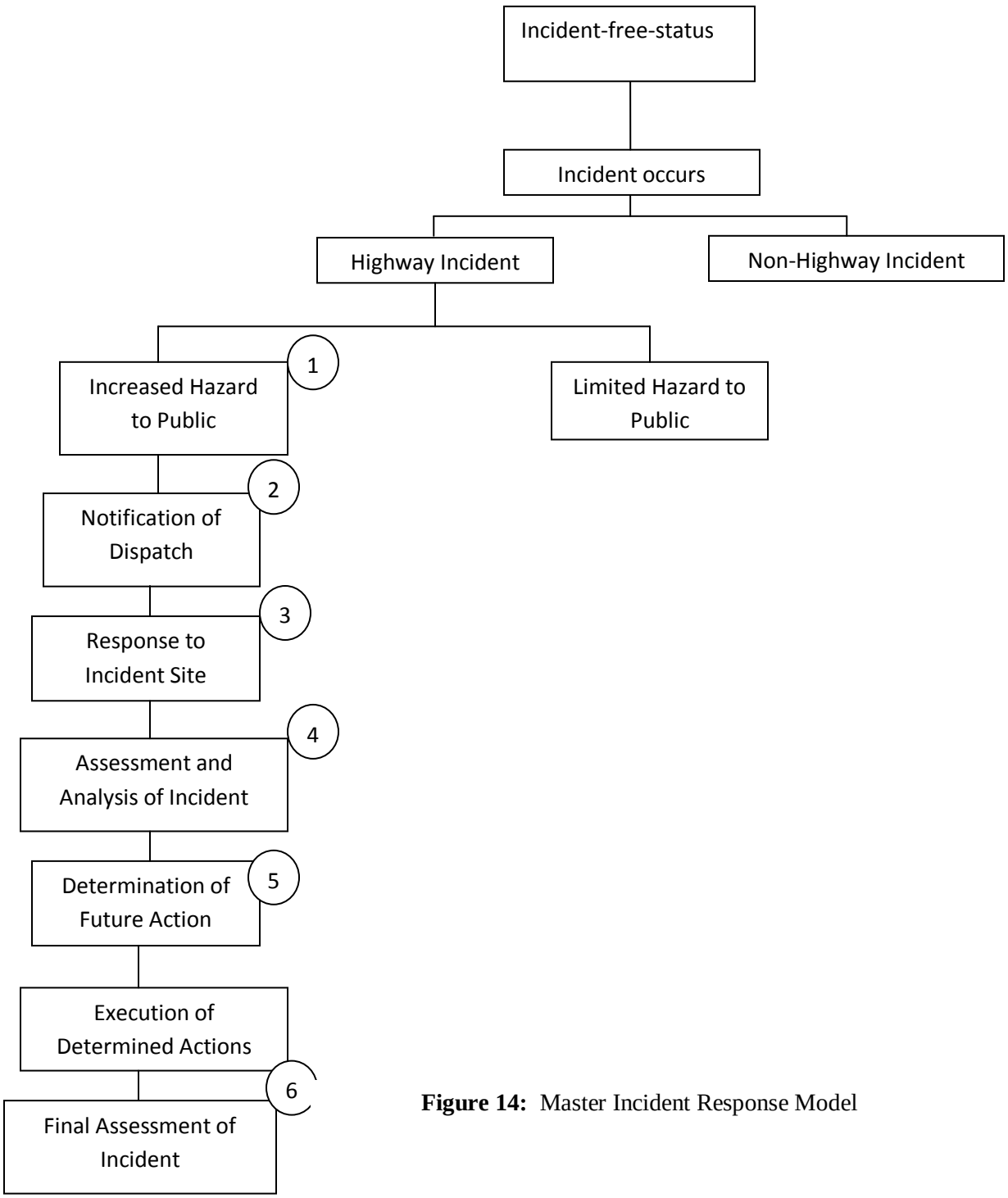

Figure 14: Master Incident Response Model

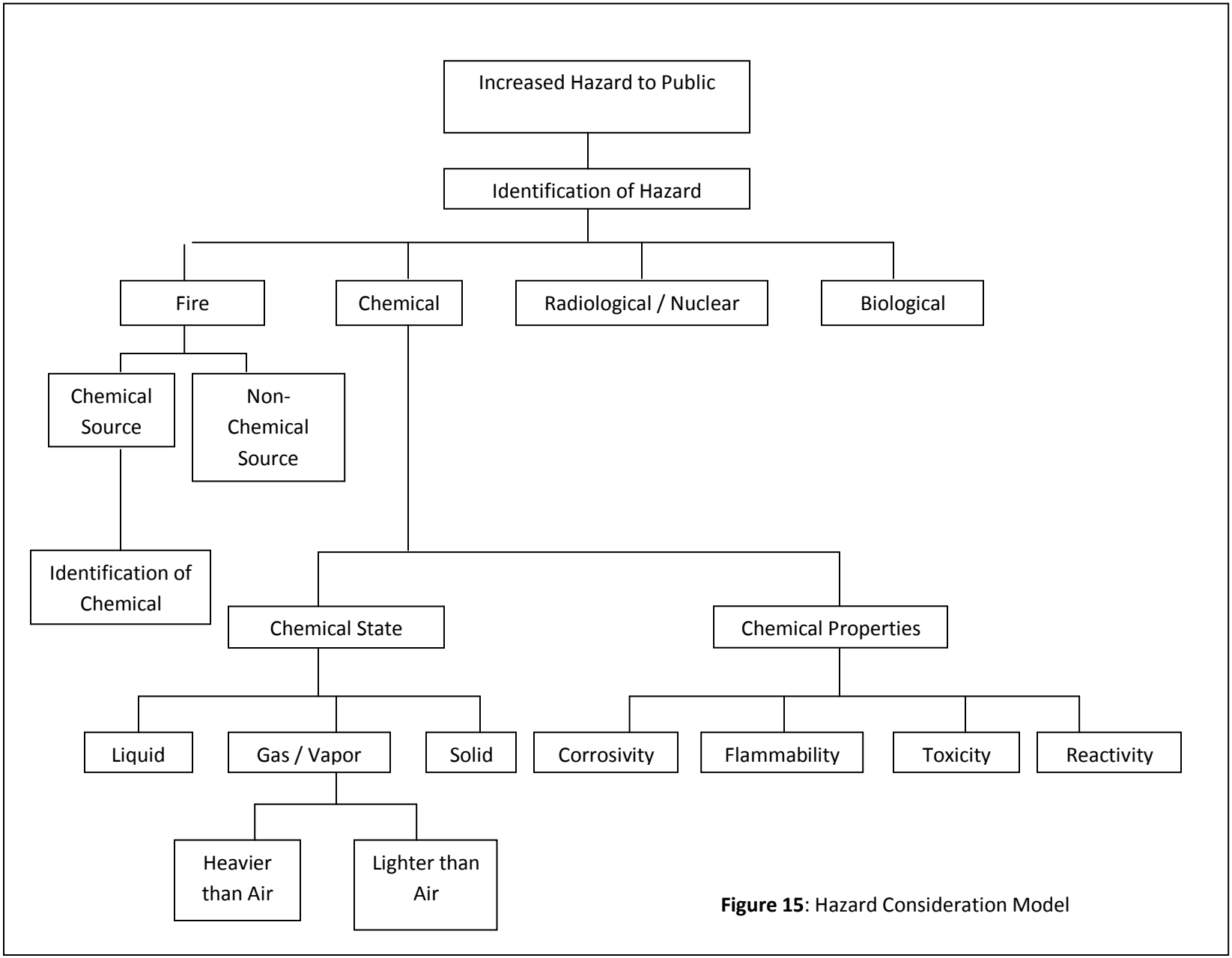

Figure 15: Hazard Consideration Model

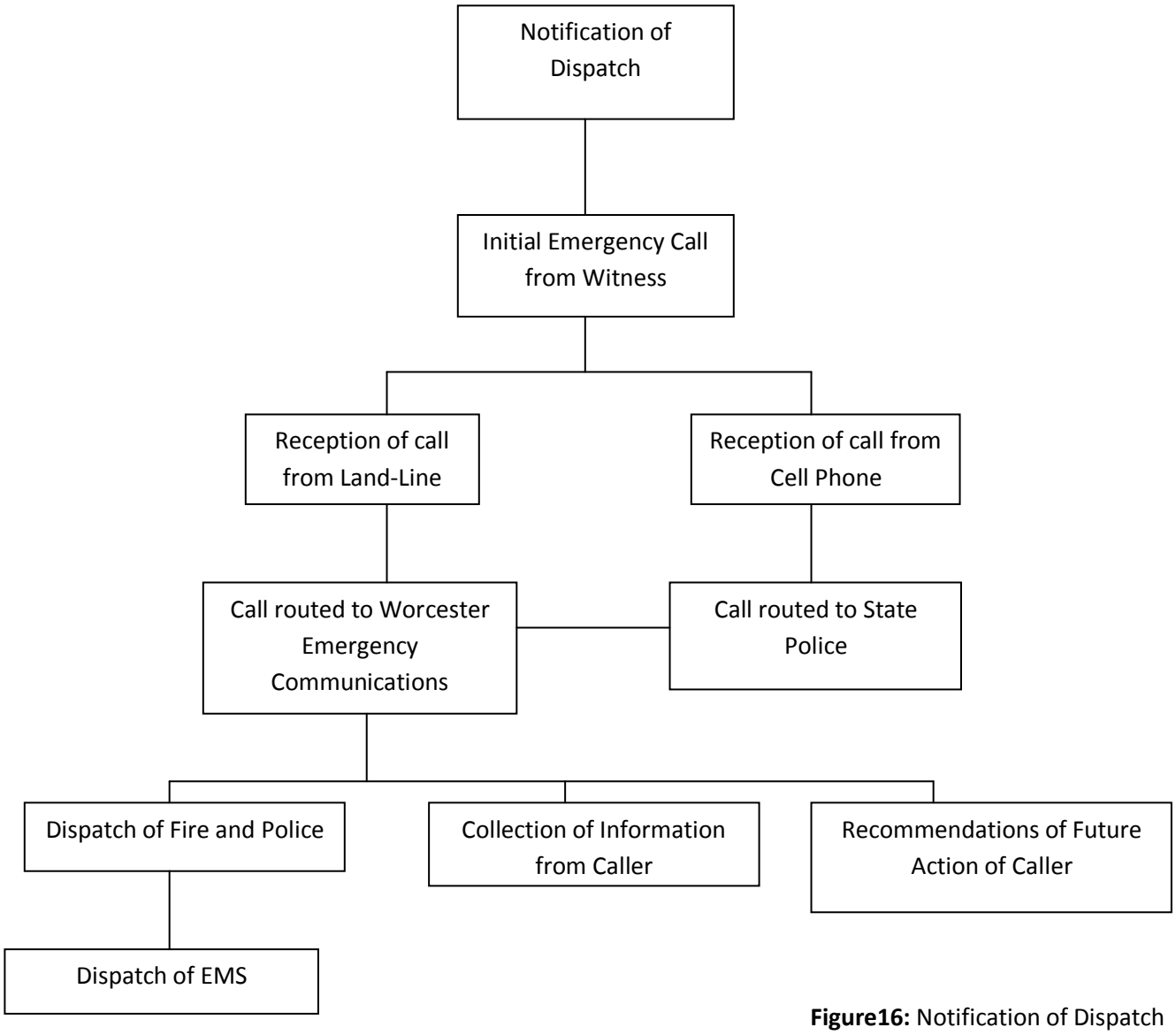

Figure16: Notification of Dispatch

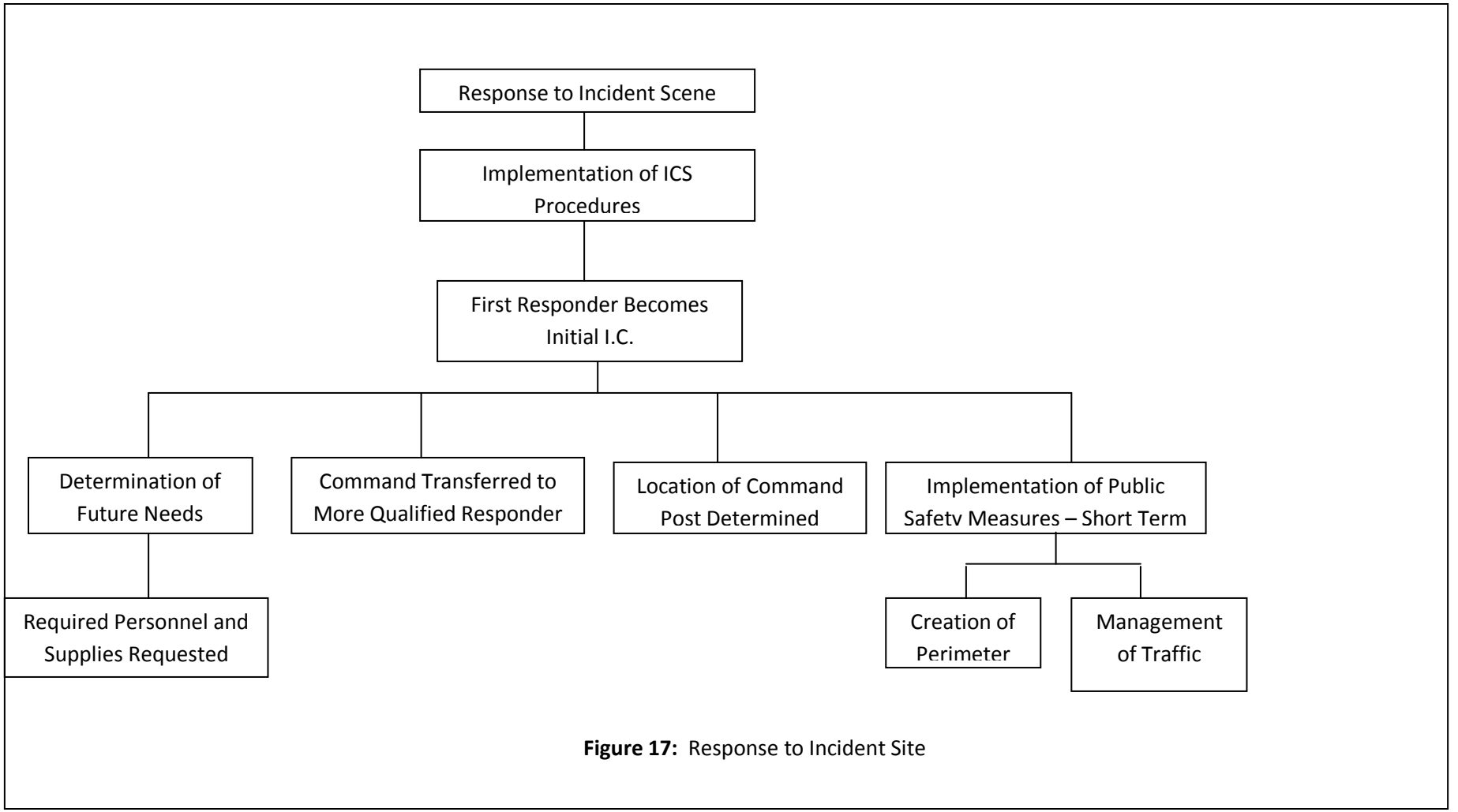

Figure 17: Response to Incident Site

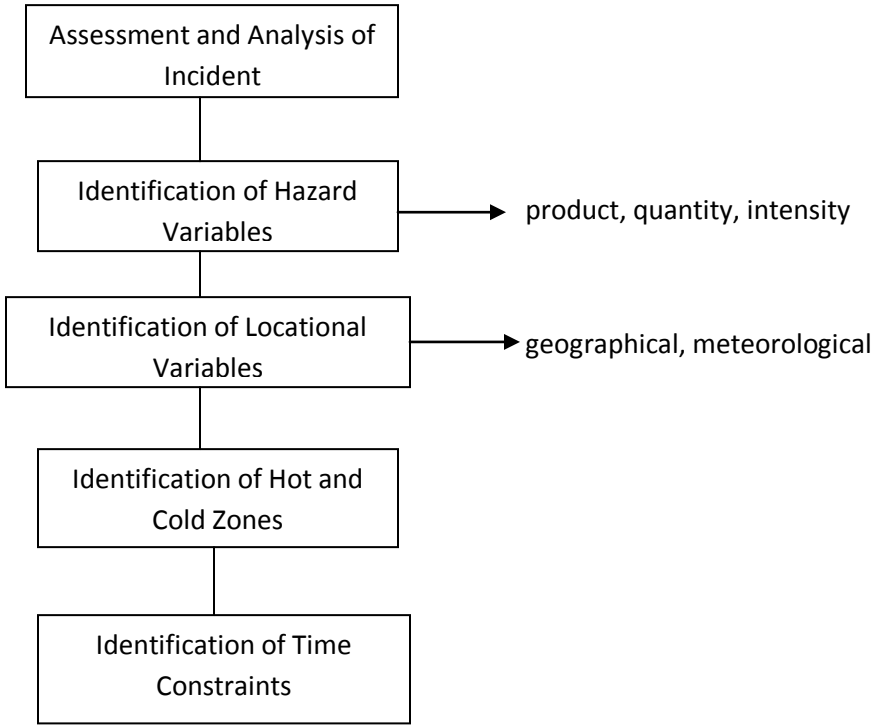

Figure 18: Assessment and Analysis of Incident

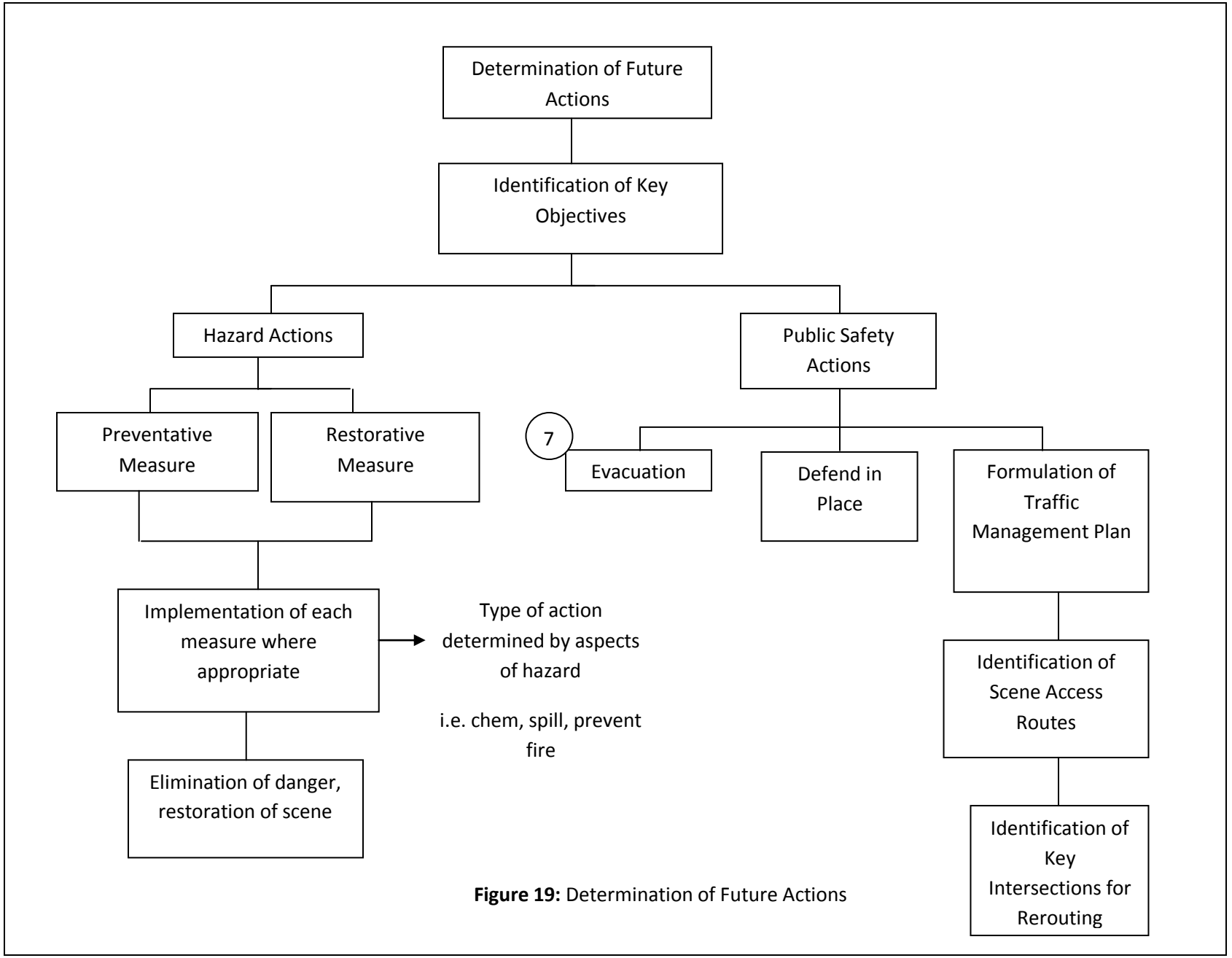

Figure 19: Determination of Future Actions

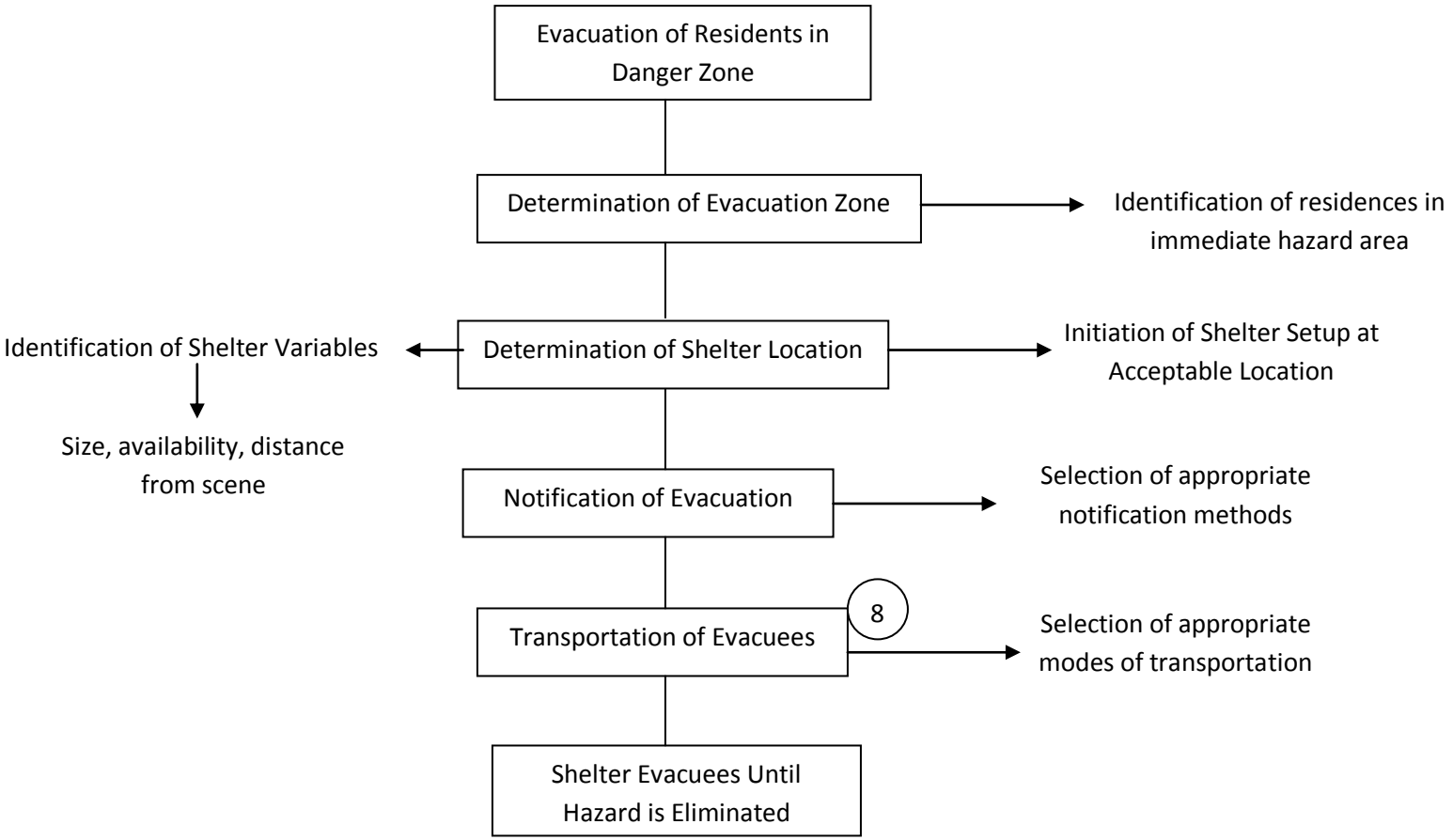

Figure 20: Evacuation of Residents in Danger Zone

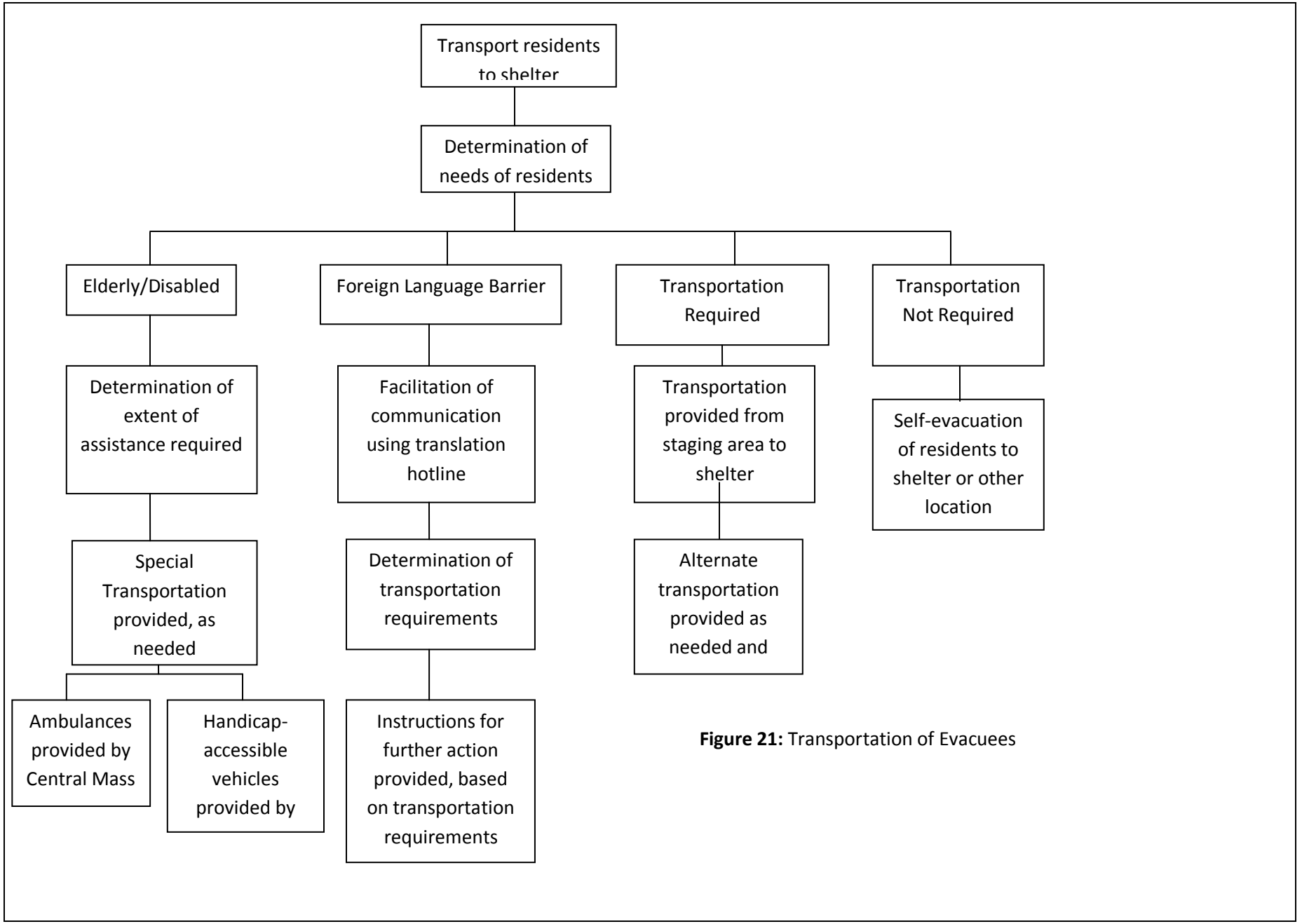

Figure 21: Transportation of Evacuees

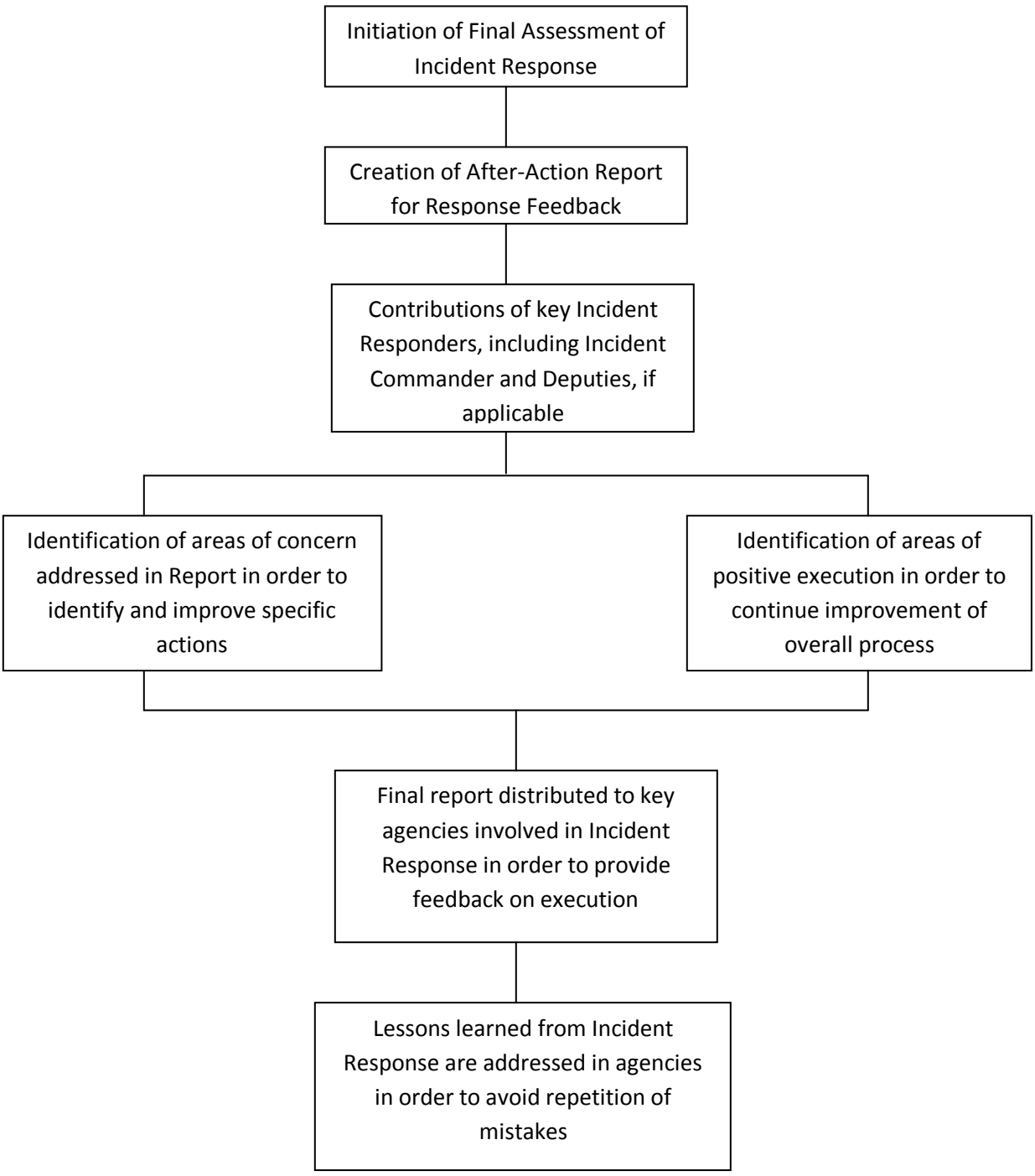

Figure 22: Final Assessment of Incident

Appendix C

Transportation Background

Technology

Over the past decade, significant advancements have been made in the field of emergency management. Many of these technological advancements have benefited the planning and preparedness of emergency management agencies. Technology can now be successfully used in many different aspects, especially in estimating the various populations that will be affected in an emergency.

Information technology systems (ITS) and geographic information systems (GIS) are two of the most important technological tools pertaining to transportation. Both tools can be used to locate particular populations that require special assistance or planning. (Federal Transit Administration, 2008) These populations will be discussed in greater detail under the "Special Transportation Considerations".

GIS is used for "Capturing, managing, analyzing, and displaying all forms of geographically referenced information" (GIS.com, 2008). People often only think of GIS as a series of maps. In reality, there are three different views of GIS; the database view, the map view, and the model view. The database is the foundation of the geographic information system. Maps serve as windows into this database, supporting the analysis and organization of GIS information. Models apply analytic functions to GIS data to create new datasets from existing ones. GIS can incorporate various types of information from the U.S. Census Bureau into interactive maps. Examples of these types of information include resident employment status and education level, household size, age, and race.

Traffic models and simulations are other potential tools for emergency management agencies. Generally, the modeling process consists of four basic steps. The first step is "trip generation". Trip generation requires population and employment data that could be collected from GIS. This step yields the number of trips by purpose. Step two is the calculation of trip distribution patterns. Some of the considerations of this step include where the trips begin and end, and the time of day the trips are made. Step three splits the trips between transportation modes. Typical modes are automobiles and transit. Step four is the assignment process. This step

is how one person gets from home to work. For example, a person may drive to a "park & ride" lot, walk from there to a mode of public transit, ride that transit to a particular station, and walk from the station to the destination (Martin, 1998).

Traffic models have two primary structures. The first is known as the common aggregate model. This type of model does not simulate individuals. Instead, it simulates groups of people or employers. The number of trips is estimated by groups and by destinations. The groups are then assigned to a type of transport system.

The second type of structure is the individual model. These models take into consideration the individual interactions in households. It also accounts for "tours", or trips with multiple stops. The travel demand forecast industry is shifting toward this type of model as the primary modeling tool.

Special Transportation Considerations

Evacuating residents from the area of an emergency is critical, but sometimes residents do not own their own cars and cannot transport themselves to safety. The most common groups affected by this problem are elderly, low income, disabled, minority, and limited English proficiency (LEP) persons. Often times, these people are also susceptible to other problems related to emergency preparedness. The elderly and disabled can be overlooked in the emergency evacuation planning process because they may require special vehicles or equipment to transport them. Minorities and low-income household may not have the means or capabilities to plan for emergencies in the same manner as other local residents. Limited English proficiency people may have problems receiving directions from emergency responders. Throughout the planning process, these groups should be considered.

Those who do not own cars have several alternative transportation options. These alternatives include walking and cycling, public transit, ridesharing, and ferries. Ridesharing is commonly referred to as "carpooling", and occurs when one or more persons ride with a relative or neighbor in an empty seat in the car. Some of these options may be inappropriate for different types of emergencies. The chart above shows the different forms of transportation and their uses in an emergency.

Public transit is crucial for evacuating people, especially those without cars. The Nationwide Plan Review, a 2006 report from the Department of Homeland Security, noted that previously, many evacuation plans focused primarily on transportation by personal vehicle and few public transit operators had emergency evacuation plans. Some of the roles public transit can fulfill in an evacuation include:

- Evacuating people, primarily those without cars
- Transporting emergency responders between staging areas and the scene of the emergency
- Transporting supplies throughout the city
- Serving as temporary shelters for responders and evacuees. This role is primarily for buses and trains.
- Communicating with other vehicles, if equipped with radios.

For many carless populations, transit may be the only option for evacuation. It is therefore crucial for governments and emergency management agencies to work closely with transit agencies in order to maximize the effectiveness of transit during emergencies. In Worcester, one of the most important transit agencies is the Worcester Regional Transit Authority, known simply as the WRTA.

The WRTA was created in September of 1974 in order to "develop, finance, and contract for the operation of mass transportation facilities and services within its territory" (WRTA, 2009). The day-to-day affairs of the WRTA are managed Stephen F. O'Neil, the Administrator of the WRTA. This position is appointed by an Advisory Board consisting of the City Manager or Mayor of Worcester and the town manager, town administrator, or chairman of the Board of Selectman of each town. Members of this board can appoint others to act on their behalf. The WRTA is a political subdivision of the Commonwealth of Massachusetts and is funded by federal, state, and local money, as well as advertising revenue and fare money. Fare money covers approximately 15-30% of operational costs, and state funding covers approximately 75% of the net service cost. Federal funds must be spent on tangible items, not salaries, advertising, or marketing.

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Appendix D

Transportation Component Model

The model presented below was created in the preliminary stages of the emergency evacuation modeling process. It was created in order to determine the various agencies that are directly involved with transportation in an emergency evacuation. Each agency has particular responsibilities in an emergency evacuation, and these responsibilities are also included in the model.

The Worcester Regional Transit Authority (WRTA) and the Central Massachusetts EMS are mainly responsible for providing the vehicles and drivers to transport evacuees from the incident to the shelter. The EMS are less likely to be utilized for mass transit of evacuees, and are mostly used only to transport evacuees that need medical attention to a nearby hospital. The EMS can also be used to transport elderly or disabled evacuees that need special considerations or attention in an evacuation.

The police are primarily involved in managing traffic. Traffic management is an important aspect of an evacuation, especially if the initial incident occurs on a major road or highway. Traffic will need to be routed away from the incident and emergency response vehicles must be able to gain access to the staging areas at the incident scene. In order to avoid a spiderweb effect of traffic congestion across the city, traffic in the immediate vicinity of the incident scene must be managed effectively. Police should be stationed at the most important intersections, and some roads can be turned into temporary one-way routes to manage increased traffic flow.

The Department of Public Works and Mass Highway take on a support role in evacuations. They generally provide resources that are critical in managing traffic and protecting those on the roads. These agencies provide signs, blockades, and other materials used in rerouting traffic. Additionally, these agencies can also provide materials to protect roads and highways from the effects of the incident, such as sand and geo-membranes for a berm to block the flow of liquid chemicals onto a highway.

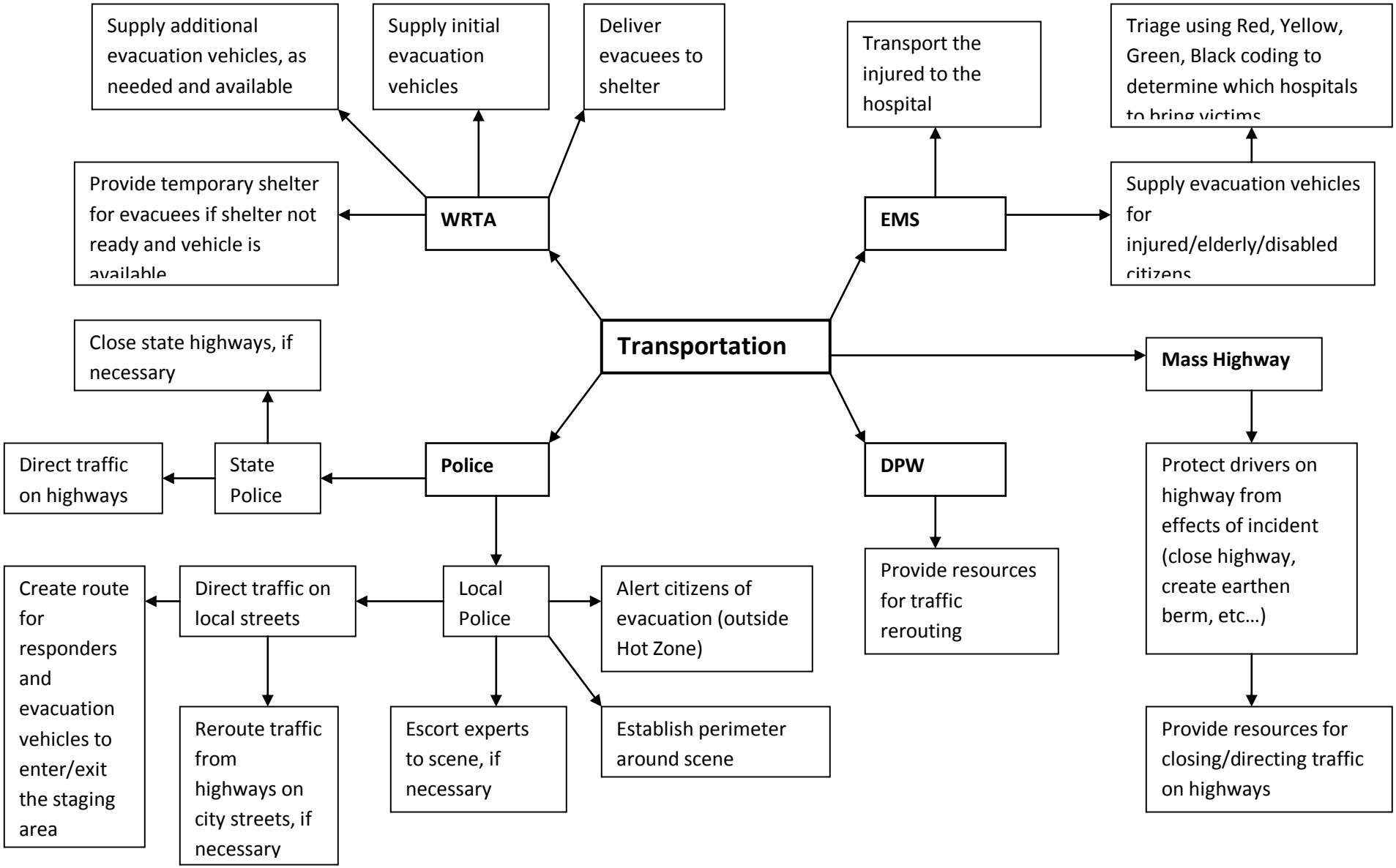
Transportation
WRTA
Supply additional evacuation vehicles, as needed and available
Supply initial evacuation vehicles
Deliver evacuees to shelter
Provide temporary shelter for evacuees if shelter not ready and vehicle is available
EMS
Transport the injured to the hospital
Triage using Red, Yellow, Green, Black coding to determine which hospitals to bring victims
Supply evacuation vehicles for injured/elderly/disabled citizens
Police
Close state highways, if necessary
State Police
Direct traffic on highways
Local Police
Direct traffic on local streets
Create route for responders and evacuation vehicles to enter/exit the staging area
Reroute traffic from highways on city streets, if necessary
Alert citizens of evacuation (outside Hot Zone)
Escort experts to scene, if necessary
Establish perimeter around scene
DPW
Provide resources for traffic rerouting
Mass Highway
Protect drivers on highway from effects of incident (close highway, create earthen berm, etc…)
Provide resources for closing/directing traffic on highways

Figure 23

Appendix E

Communications Functional Model

This is a functional model showing the components of communication during an emergency evacuation. There are three main types of communication: communication between departments, communication with organizations and agencies, and communication with the residents. The model shows how each type of communication is carried out and by whom. For example, the public would be notified door-to-door knocking, which would be conducted by either the police department or fire department, depending on the situation. The model helps show how communication in an emergency evacuation is accomplished in a straight-forward, easy to understand manner. It shows what needs to be done, how it needs to be done, and who needs to do it.

Interdepartmental communication relies on the use of radios, cellular phones, automatic alerts, and face-to-face communication. Radios are operated by individual officers in communication with the 9-1-1 Dispatch Center. There is frequently a radio truck at incident command manned by the communications officer. The radio truck is used to communicate between the personnel at incident command and the Dispatch Center. Cellular phones are frequently used for convenience purposes for direct communication between two parties. Automatic alerts are sent out to the first responders by the 9-1-1 Dispatch Center after receiving the initial emergency call. Also, if two parties are in the same location, for example, at incident command, they can also talk to each in person.

The public, or residents, are notified in several ways. When it is first determined what action needs to be taken, the 9-1-1 Dispatch Center uses the Reverse 9-1-1 system to call the land line telephones with a message containing instructions for what to do during the emergency. If there is enough warning ahead of time, Television Broadcast may be used. The communications department can broadcast on Charter Cable, antenna television, and Broadcast Media. If it is essential to evacuate, door-to-door notification will need to be used. This will be carried out by the Police Department, unless there is an environmental hazard which needs special equipment.

In this case, the Fire Department will be responsible for evacuating the residents. If there is a university or college involved, the communications department will notify the campus police, who will in turn use the Connect-Ed, or a similar system, to notify the students.

Agencies are notified through automatic alerts as well as telephone. Automatic alerts are sent out by the 9-1-1 Dispatch Center to notify first responders. Agencies that are less essential at the scene are notified by telephone. They will be notified by either Incident Commander or Worcester Emergency Management.

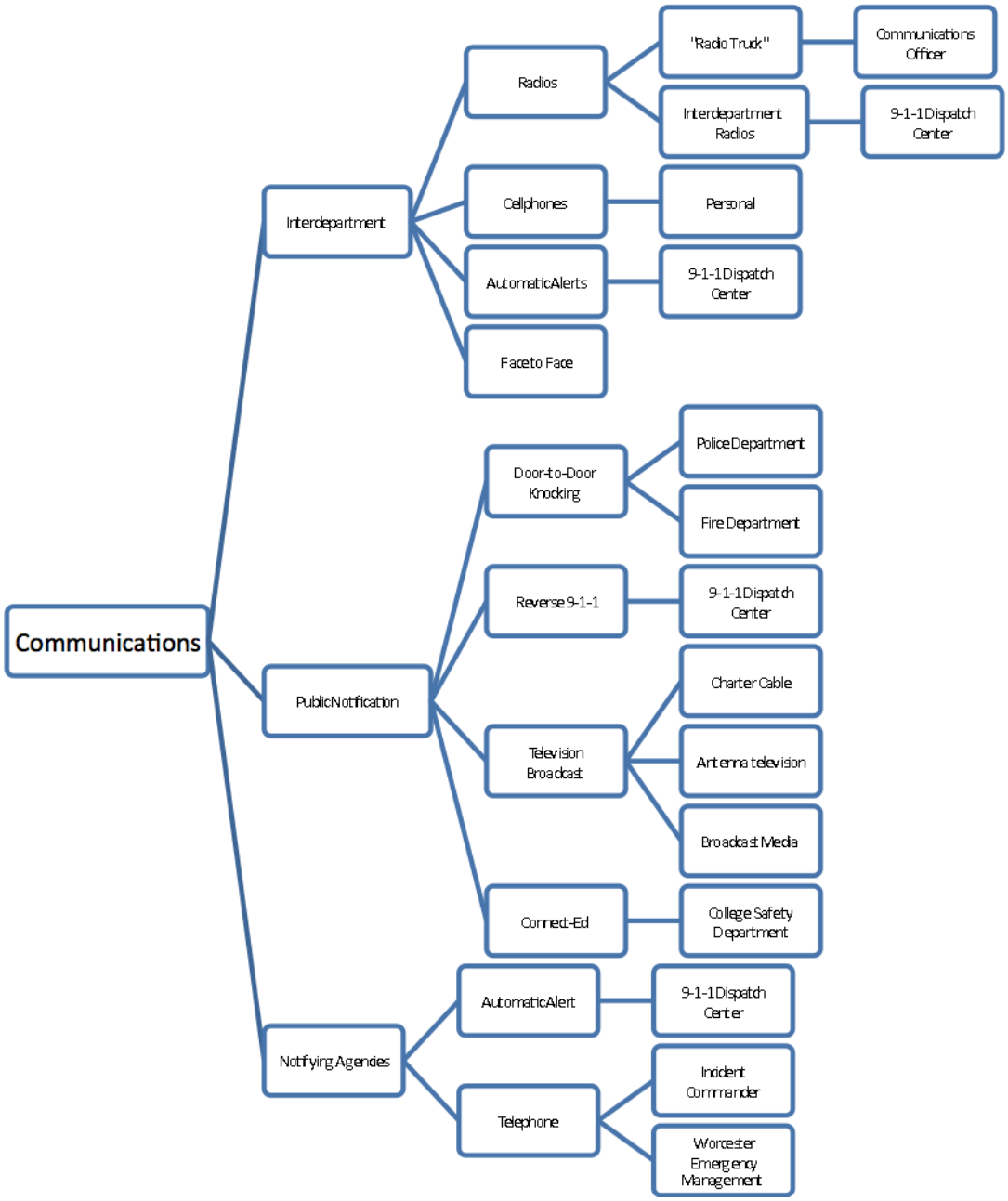

Figure 24

Appendix F

Incident Command System Overview

The Incident Command System, or ICS, is a component of the National Incident Management system (NIMS) and the standard for emergency management throughout the United States. It is a proven management system for on-scene response to any hazard. ICS was designed to overcome the weaknesses of previous incident management techniques and provide a comprehensive structure for emergency response. Now emergency responders can use the basic structure of ICS and adapt it to simple and complex situations without concern for jurisdictional boundaries. ICS structures four main areas, they are, management, communication, resource management and command (ICS 100).

The management structure can be very simple or complex depending on what the incident requires. For every incident there is an Incident Commander (IC) who is responsible for managing the incident and delegating responsibilities to other agencies and staff. Following the Incident Commander is the Command Staff which includes a public information officer, safety officer and liaison officer. The Incident Commander has a General Staff with four sections, operations, planning, logistics and finances. Each section has a Chief which has one or more Deputies under his command. Finally each section may be broken into Divisions, Groups and Branches to maintain the span of control. Span of Control is the number of personnel a supervisor can manage effectively. ICS dictates that an effective span of control may vary between three and seven but recommends a ratio of one supervisor to five supporting elements. Using this management structure the Incident Commander can increase or reduce the size of his response team based on the size of the incident (ICS 100).

Communication is very important during emergencies and greatly affects the response. First of all communication between agencies is to be done in plain English. It allows for effective coordination between different agencies without creating confusion through individual codes or jargon. For effective communication ICS uses three elements, hardware, planning and networks. Planning needs to be done so the hardware systems for transferring information are available, and a network is setup to handle communication internally and externally. The network needs to be able to link the Operations section personnel to each other and the Incident commander, as well as provide communication between Branches, Divisions and Groups (ICS 100).

Even with strong communication and a solid management structure a good response relies on resource management. ICS provides this with two categories, tactical and support resources. Tactical resources are personnel and major items that are available or can be made available for the incident. All other resources are in the support category. These include food, water, equipment, supplies and any other resources that are not tactical. Tactical resources can be either assigned, available or out-of-service. Assigned resources are currently working on a task while available resources are assembled and ready for assignment. Out-of-service resources are not prepared to be assigned or available. ICS also includes the processes for categorizing, ordering, dispatching, tracking and recovering resources. With proper resource management the Incident Commander and his Command Staff will know which resources are currently in use and available to deployment at any moment. This knowledge is critical for a well organized response and will eliminate any confusion as to what resources are available for the incident ICS 100).

Finally, the command structure for any incident is crucial for maintaining order during the response. ICS incorporates Chain of Command and Unity of Command. Chain of Command creates a line of authority where lower levels are subordinate and connected to higher levels. Unity of command means that each individual is accountable to only one supervisor. The response can then be carried out using a single command where the Incident Commander assumes all responsibility for the response or a Unified Command where agencies share responsibility for managing the incident. A Unified Command is usually used when the incident involves multiple jurisdictions and agencies that must work together to get rid of any boundaries that might otherwise slow down the incident response. ICS also outlines when a transfer of command may take place. Transfer of command may be required if; a more qualified person arrives, it makes sense to change command; the incident changes and requires a transfer legally or because of work and rest accommodations during prolonged incidents (ICS 100).

These are the main principles of the Incident Command System and when followed properly any hazard can be managed efficiently and effectively. ICS has been developed through studying the organization and management of previous incidents and represents organizational “best practices”. The knowledge gained through analyzing incidents around the country has been put into a comprehensive system to aid all emergency managers in the difficult task of emergency

preparedness and response. It is the standard for emergency management in the U.S. and has significantly improved the nation's response to disasters (ICS 100).

Works Cited

IS-100a (ICS 100) Introduction to Incident Command System (ICS) Online Course, FEMA, http://training.fema.gov/EMIWeb/IS/is100HC.asp

Appendix G

Focus Group Overview

Date Performed: Wednesday February 11, 2009

Location: Kaven Hall 115

Start Time: 4:00 PM

End Time: Approximately 5:00 PM

Attendees: Evan Guarino, Jeff Root, Walter Canuto, Ted Kalbach, Chrissy Nilsen, Leonard Albano, Paul Mathisen, Robert Fitzgerald, Dick Bedard, Captain John Ford, Lieutenant Tom Gingras, Nicole Valentine George Mayo, Chief Michael McNamee, Lieutenant Trotta, and David Clemons.

Summary: At this meeting a hypothetical scenario of a chemical spill was presented to the attendees listed above. For the next hour an emergency response for the incident was established. Each member of the focus group had ample time to discuss the necessary actions that would be taken by the agency they represented. During this discussion the WPI students present, observed and noted important comments to better understand the thought process of the individuals and agencies at the time of an incident. The results of this meeting can be seen in the models presented in chapter 4 and their application to this hypothetical scenario.