# Hazmat Accident Education - An Integrated Approach


By

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# Table of Contents

**Item** **Page**

## Executive Summary

This project builds upon our previous UTCA study entitled "Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances." The integrated approach used in that study was novel because it linked the traditional accident concerns of material fate and transport with emerging issues such as planning for accidents in routing and the social and behavioral impacts in affected communities. This unified approach must be incorporated into the planning and response to these accidents. In order to do that successfully, professionals and those who are entering the profession must be trained in thinking in this integrated fashion. This project, through the use of classes and an Internet site, developed the material from the previous UTCA report and a related report on using GIS to specify routing and minimize impacts into modules for use in a classroom or workshop setting. The use of case studies has been an integral part of the module development so that students can "see" how the decisions made during planning affect the results/effectiveness of the emergency response. Recent events have dramatically demonstrated the need to provide this integrated information to planners and responders in order for them to both improve their plans and to better inform the public.

This information will be extremely important when planning for accidents involving transportation of hazardous materials. The possible social and environmental consequences of these accidents are often not given the attention that is needed. Also, these overlooked consequences need to be addressed when planning the transportation routes for hazardous materials in the state of Alabama. The Baltimore train derailment and tunnel fire is one recent demonstration of the impacts that these types of accidents can have on a community.

Therefore, the objective of this technology transfer project was to enhance the ability of emergency planners, facility owners, transporters, and consulting engineers to adequately prepare for an emergency involving the transportation of hazardous materials. Recent federal regulations now require specific planning activities to be performed by facility owners and local and state agencies. This is an attempt to help them meet the goals outlined in those regulations.

This project synthesized the information that is currently available on hazardous materials accidents, particularly those involving the transportation infrastructure. This material is available for reference at the following websites: http://www.personal.psu.edu/faculty/s/e/sec16/. Class information for the graduate-level fate and effects class can be found at http://unix.eng.ua.edu/~rpitt/Class/Classes.shtml. This material also has been used in teaching three graduate-level courses in hazardous materials fate and effects – Springs of 2002, 2003, and 2005 at UA. Modules from this project also have been incorporated into the following classes: Environmental Management (UAB), Environmental Science (Penn State Harrisburg), and Occupational Safety and Environmental Health (PSH).

## Section 1.0
## Introduction

The July 2001 train derailment and fire that occurred in Baltimore's Howard Street tunnel served as a powerful reminder of the continuing threat posed by hazardous-materials transportation accidents. The incident caused the closure of all major roads into Baltimore, necessitated the evacuation of the city's baseball stadium, forced many area residents to shelter in their homes, and resulted in substantial damage to roads and other infrastructure, including disruption of electronic communications along the entire U.S. East Coast. Personnel at ALDOT and at DPS have, in the past, expressed concerns about potential hazardous-materials accidents occurring in the Mobile tunnel, even with the restrictions on materials transport through the tunnel. The September 11, 2001 attacks and the threat of further attacks, when coupled with the Baltimore tunnel fire from this summer, also have reminded people of the potential for significant short- and long-term effects of incidents in which hazardous materials are involved.

Since that time, two Birmingham interstates have been affected by hazardous materials accidents – both of which shut down parts of the major freeway interchange in the center of the city and one of which resulted in a fatality. Due to damage caused by high-temperature fires (oil-based products burned in both accidents), both accidents also required the rapid replacement of major sections of highway. Impacts to the City of Birmingham and its residents included the loss of the tanker truck driver, potential release of hazardous smoke in the fire over nearby neighborhoods, and the loss of the major north-south transportation route through central Alabama. The diversion of traffic onto city streets affected residents of the city in all of their commutes in the area and in addition, caused major headaches in setting up and explaining detour routes for people unfamiliar with the city. Large trucks were siphoned onto city streets that were not designed for the frequent heavy loads carried by tractor-trailer trucks. The impacts from these accidents were different from those seen in Baltimore, but were no less severe. In addition, had more people or different chemicals been involved, the results, on a human basis, could have much more tragic.

Major accidents involving hazardous materials are rare, but when they do occur, serious environmental health, safety and social problems have been documented. Indeed, depending on the nature and circumstances of an accident, some impacts can be both severe and long-lasting. Social and psychological impacts, for example, can extend well beyond the immediate emergency response phase of an accident. However, these potential longer-term problems are sometimes overlooked after the more dramatic acute problems are addressed.

This project it builds upon our previous UTCA study entitled "Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances." The integrated approach used in that study broke new ground because it examined not only traditional accident concerns such as material fate and transport, but also such emerging issues as social and behavioral impacts in affected communities. For example, the report highlighted the need to address the community impacts of even the smallest accidents. The integrated approach should be incorporated into the planning and response to these accidents. This project, through the use of classes and an Internet site, presents the material from the previous UTCA report to interested parties and incorporates this integrated approach to preparing for and evaluating accidents. As such, it would put Alabama at the forefront of efforts to tie together transportation safety, environmental health, and social policy concerns. Recent events have dramatically demonstrated the need to provide this integrated information to planners and responders in order for them to both improve their plans and to better inform the public.

The project will use the knowledge and methodologies developed in our prior work to pursue two of UTCA's high priority topics: *technology transfer* and *human resources*. This project will also address UTCA's emphasis on *safety* issues. More specifically, we will develop a range of innovative educational tools aimed at providing professionals, students and interested members of the public with the latest information about short- and long-term environmental, safety and community impacts of these accidents. The project also fostered intercampus collaboration by incorporating a team of professionals from diverse backgrounds at UA and UAB.

This information will be extremely important when planning for accidents involving transportation of hazardous materials. The possible social and environmental consequences of these accidents are often not given the attention that is needed. Also, these overlooked consequences need to be addressed when planning the transportation routes for hazardous materials in the state of Alabama. The Baltimore train derailment and tunnel fire is one recent demonstration of the impacts that these types of accidents can have on a community.

The second part of this project involved using the material in classes taught at the campuses and preparing the materials for inclusion in workshops. The classes that focused specifically on this material were several graduate-level Fate and Effects of Hazardous Materials that were taught at UA in the Department of Civil and Environmental Engineering. In addition, specific modules that were developed for the project have been incorporated in many other classes both in Alabama and outside of the state. While at UAB, Dr. Clark used the modules on fate prediction and psychosocial impacts in a School of Public Health course entitled Environmental Management. This course contained students from a variety of graduate majors on the campus: medicine, public health, and engineering. In addition, modules on fate and on the problems of transport (including case studies) were used at Penn State Harrisburg in two undergraduate courses: Environmental Science, and Occupational Safety and Environmental Health. These courses required students to perform analyses on the available data in terms of frequency of spills and what materials are most frequently spilled. In addition, the courses required the students to prepare case studies on several accidents each. The guidance required that the student research the accident from the available information (accident reports, newspaper accounts – personal interviews not requested [they were discouraged since the students were not skilled in interviews]), determine from the accident reports the amount of the material spilled, and determine where it went. The students also had to prepare a section on impacts – both environmental and community.

## Section 2.0
## Organization and Conduct of the Project

This project builds upon our previous UTCA study entitled "Environmental Health, Public Safety, and Social Impacts Associated with Transportation Accidents Involving Hazardous Substances." The integrated approach used in that study was novel because it linked the traditional accident concerns of material fate and transport with emerging issues such as planning for accidents in routing and the social and behavioral impacts in affected communities. This unified approach must be incorporated into the planning and response to these accidents. In order to do that successfully, professionals and those who are entering the profession must be trained in thinking in this integrated fashion. This project, through the use of classes and an Internet site, developed the material from the previous UTCA report and a related report on using GIS to specify routing and minimize impacts into modules for use in a classroom or workshop setting. The use of case studies has been an integral part of the module development so that students can "see" how the decisions made during planning affect the results/effectiveness of the emergency response. Recent events have dramatically demonstrated the need to provide this integrated information to planners and responders in order for them to both improve their plans and to better inform the public.

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Preparation of the Manual and Internet Site

Drs. Becker, Pitt and Clark reviewed the federal requirements and guidelines for emergency planning and response, as well as the existing literature and databases on accident statistics, preparedness training, prediction of pollutant fate, and psychosocial impacts of these accidents. This material was synthesized into a class reference site that is currently housed at the University of Alabama (Dr. Pitt's website). In addition, supporting documentation and updated references can be found on Dr. Clark's website (http://www.personal.psu.edu/faculty/s/e/sec16/). The Internet site has been organized into the following modules:

Module 0: Overview and Introduction
Module 1: Basic Concepts of Chemical Fate and Transport
Module 2: Surface Water Processes
Module 3: Subsurface Water Processes

Module 4: Atmospheric Processes
Module 5: Accidental Releases
Module 6: Basic Prediction Procedures
Module 7: Case Study for Hydrocarbon Spills
Module 8: Case Study for Ammonia Spills
Module 9: Case Studies of Long-term Community Impacts

The material was taught as a class first at the University of Alabama. The units on Accidental Releases and Community Impacts were incorporated into the Environmental Management course at UAB and into the Occupational Safety and Health course at Penn State Harrisburg.

The class by itself has definitely raised the awareness among the students about the potential for substantial short- and long-term problems due to an accidental release of hazardous materials. The accidents in Birmingham, when combined with the train accidents in Baltimore and South Carolina, highlight the problems when these accidents are transportation-related and occur in areas where the population density is either high and/or is near the transportation infrastructure in question. In addition, the authors hope that the classes and project material have raised the awareness of land-use and community emergency planners about growth issues in terms of transportation infrastructure, especially given that the lack of land-use planning led to many communities being situated near that very infrastructure that is carrying these potentially-dangerous materials from one location to another.

# Section 3.0
# The Internet-Based Manual

The reference sites contain materials that enable an integrated approach to preparing for hazardous materials accidents. The background information is readily available for the public at the Department of Homeland Security website under Emergencies and Disasters, at http://www.dhs.gov/dhspublic/display?theme=14. The website is organized into sections, depending on the area of interest of the reader (see below for a list of areas).

- Emergencies & Disasters
- First Responders
- Planning & Prevention
- Hazard Mitigation
- Natural Resource Protection
- Marine Safety
- Response & Recovery
- Declared Disasters & Assistance

This Internet-based resource incorporates the planning and evaluation work that has been done under the auspices of several past UTCA projects. The two primary projects of interest for developing these materials were the one focusing on developing GIS methods for planning the transport of hazardous materials and the report by this research team on the impacts of transportation-related hazardous materials accidents.

Specific sections on the website currently include twenty years of accident data – available for statistical analysis as to which materials the profession should be planning to most likely find in a hazardous-materials accident – and workshop material supporting the use of GIS (and reviewing other planning tools and models) for predicting the likelihood of a transportation-related hazmat accident for various routes of transport. In addition, the modules listed below are incorporated (and they have been used in a standalone course on Fate and Effects of Hazardous Materials).

Module 0: Overview and Introduction
Module 1: Basic Concepts of Chemical Fate and Transport
Module 2: Surface Water Processes
Module 3: Subsurface Water Processes
Module 4: Atmospheric Processes
Module 5: Accidental Releases
Module 6: Basic Prediction Procedures

Module 7: Case Study for Hydrocarbon Spills
Module 8: Case Study for Ammonia Spills
Module 9: Case Studies of Long-term Community Impacts

Rather than strictly use a textbook that may be quickly out of date, it was decided as part of the proposal to put this material onto an Internet site. This would allow for regular updating of the material to ensure that it remained current. Also, this site would be accessible to professionals both in Alabama and out of state, who may not be aware of any published manual.

The two URLs for the reference material are http://www.personal.psu.edu/faculty/s/e/sec16/ and http://unix.eng.ua.edu/~rpitt/Class/Classes.shtml.

## Section 4.0
## Course Delivery and Evaluation

This material has currently been vetted through incorporation of the material, in part or as a whole, in courses in several undergraduate and graduate campuses both within and out of the state of Alabama. In particular, several semesters of a graduate course entitled Fate and Effects of Hazardous Materials has been offered by Dr. Robert Pitt at the University of Alabama. This course is advertised as focusing on not only the general topic of hazardous-materials accidents, but as focusing class time on the development and evaluation of transportation-related case studies. Dr. Clark has incorporated individual units from the project materials into one of her past offerings – a graduate-level course in Environmental Management offered through the UAB School of Public Health; in addition to incorporating units into two of her current undergraduate offerings – Environmental Science (course designed for non-engineering majors) and Occupational Safety and Environmental Health (designed for environmental engineering seniors).

Course enrollments for the full-semester offering at UA have consistently been approximately 10 students. The School of Public Health class had 15 enrollees while the Occupational Safety class has had between 5 and 10 students.

*Short Course Instructors*

The full-semester course was taught by Dr. Robert Pitt at the University of Alabama. During his last offering of the course, the class was also offered by Interactive Television to students at The University of Alabama at Birmingham. Drs. Clark and Becker have guest-lectured in Dr. Pitt's classes. Drs. Clark and Becker have taught the Public Health Environmental Management class and Dr. Becker offers regularly a course in Environmental Disasters.

Dr. Pitt is the Cudworth Professor of Urban Water Systems at the University of Alabama. He has over 20 years experience in the fate and transport of materials in the natural environment. During 15 years in industry, Dr. Pitt participated on a variety of hazardous material management planning projects as the task leader for the air and water quality modeling of hazardous conditions. These hazardous conditions included toxic and explosive concentrations of many materials in water and air. He has calculated the spread of material on and in water and the air quality effects of many accidents spills (including downwind photochemical oxidant and hydrocarbon increases in Southern California associated with major oil field accidents). He has also analyzed the probabilities for the losses to occur and estimated how much of the material may be spilled. He has analyzed the effects of these various materials in urban areas, especially if the material affected storm drainage.

Dr. Becker is Associate Professor of Environmental Health Sciences at the UAB School of Public Health. Becker, who is also a Scientist at the Center for Disaster Preparedness, is a leading authority on the social, psychosocial, public health and public policy implications of hazardous material accidents. He has conducted on-site fieldwork at range of chemical and radiological accident sites in North America, Europe and Asia. In 1997 he developed the "Environmental Disasters" course at UAB. Dr. Becker also serves as a member of a national panel on nuclear/radiological incidents, and he is a member of the International Working Group on the Psychosocial Aspects of Ecological Disasters.

Dr. Clark is an Assistant Professor of Environmental Engineering and was formerly an Assistant Professor in the Department of Civil and Environmental Engineering at the University of Alabama at Birmingham. Prior to pursuing her Ph.D., Dr. Clark worked for several Northeast U.S. consulting firms, focusing on remediation projects (primarily for asbestos). Her training is in the field of chemical engineering and her graduate work focused on the fate and transport of pollutants in the natural environment. She currently teaches classes in Environmental Engineering, including the aforementioned class on Occupational Safety and Environmental Health.

*Scheduling Class Sessions*

The full course has traditionally been offered as an elective in the graduate program at the University of Alabama, and has been offered in the spring term. The Occupational Safety and Environmental Health class is also a spring offering. These classes usually are offered in the late afternoon or evening to allow part-time students to take the class.

*Class Assignments*

The original assignment for the mid-term in the graduate class was to analyze the data available on transportation-related hazardous materials spills in Alabama for a particular assigned year. The students would be required to cull from the National Response Center database the appropriate accidents, separate out the accidents that occurred in the state of Alabama, and determine the materials spilled most frequently and in the greatest quantities. In addition, for a final project, the students were required to develop preliminary case studies for future revision. The development of the modules under this project scope provided the background material for current students to do in-depth development of several transportation-related case studies. Each student is assigned several accidents and are given directions that require them to answer the following questions:

1. What happened?
2. How much material was spilled?
3. What are the environmental hazards of the material spilled?
4. Based on the modeling covered in class, where is the material expected to end up?
5. What are the consequences of the dispersion of this material into the environment?
6. What community impacts resulted from the accident?
7. What were the lessons learned from the accident (including those recorded by the accident inspectors and those developed by the student after compiling this information)?

*Course Reviews*

The conclusion of the PIs, based on course reviews, is that these classes and modules have been very helpful to their education. It provided an opportunity to see how many different areas/specialties should be brought to bear on issues such as planning for, preventing and coping with the aftermath of transportation-related hazardous materials accidents. The students used their chemistry, their knowledge of pollutant dispersion, and their education in psychology and sociology to prepare these case studies. Students comments were typically in the range of “eye-opening” to describe what they felt they learned in the class.

When these modules have been incorporated as parts of other classes, the students have found them to be very interesting and applicable. They have commented on seeing trucks on the highway and wondering what they were carrying. They comment on living near chemical companies or railroads. They feel that, as they graduate and pursue careers which might need this material, they are better educated to view the entire scope of the issue rather than the very narrow focus of either transportation-route planning or of hazardous spills cleanup. With this, the project PIs feel that their goals for the development of curricula material was met.

## Section 5.0
## UTCA Technology Transfer Policy Requirements

UTCA has an administrative policy with specific requirements for preparing and conducting technology transfer projects. This section of the report constitutes the required course-end report, and addresses the ten required topics in the following text:

1. *Course announcement/brochure* – The courses were sponsored by the respective academic institutions at UA and UAB. The module material has also been used in courses at PSH. Announcements for the courses have been done in the typical manner as for all academic courses. PSH attempts to solicit non-degree seeking graduate students with specific academic interests through advertising of upcoming semester offerings in the local ASCE newsletter.

2. *Attendance list, with names, addresses and telephone numbers* – Student attendance was tracked in accordance with the attendance policies of the respective universities.

3. *Date, time and location of the course offerings* – The courses were scheduled in the late afternoon or evening in order to accommodate the schedules of working engineers. Courses have been held in previous years during the spring semester, allowing the graduate students the time in the fall to take any basic courses that could be helpful in this course.

4. *Copy of the agenda/syllabus* – The syllabus is distributed to the students at the beginning of each term and is available on the course website on the Internet.

5. *Copy of the course notes* – Course materials are located on the two websites referenced in this report – one at UA and one at PSH.

6. *Copy of visual aids* – PDF copies of the visual aids are available on the websites referenced above.

7. *Evaluation of the class* – The reviews found the instructors to be very knowledgeable about the topic but that the some of the topics were not directly applicable to their current or future careers. However, those students who have been or are currently employed in industry have found this class to be particularly relevant. Most students said that they had never thought about the community ramifications of a hazardous material accident, and if they had, they had focused on the fixed facility, not on the transportation route. For students in older areas of the country where industrial and residential facilities are intermingled, this was a particularly important lesson. They see tractor trailers and rail cars carrying many different types of materials passing through city streets and often through neighborhoods. As they ponder employment in the local industries or with

consulting firms who prepare emergency plans for industry, they feel that they have a broader knowledge of emergency preparedness and of how to assist their employer in preparing a more useful emergency response plan.

8. *Other pertinent materials* – There were no other pertinent materials.

9. *A financial summary of all sources of income, amount of registration fee, total collected from participants, itemized costs, and balance of income less expenses* – Since the courses and modules were taught as part of the current academic load, there were no participant registration fees, and there is no separate financial report of instructional revenues and expenses for this project.

10. *A short written summary of successes and lessons learned* – The course was considered an "eye-opener" by many participants. They had not considered the issue of hazardous materials except in the industrial context where it is assumed the material is on-site. They had not considered how the material was transported to a facility – routing, types of transportation and storage – or what the ramifications were to the community if an accident were to happen. Most students also expressed that they did not realize how much hazardous material is transported in the United States in an average year. They also did not realize the number of accidents and the variety of materials spilled. They thought the use of case studies allowed them the opportunity to begin planning from start to finish of a potential accident. Occupational safety and health students said that this was an area that they had not considered and that was not touched on in any other class in their educational experience. They felt that this topic definitely needed to be incorporated somewhere in the curriculum since someone owns the hazardous material at any given time. They also learned from the case studies that not all accidents were the transporter's fault although generally the transporter had to help pay cleanup costs. In general, they thought it was very useful and very interesting.

## Section 6.0
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## Section 7.0
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## Section 8.0
## Appendix

The following attachments are included as part of this appendix:

A: Example handout page for the morning workshop ("Introduction to Highway Construction Erosion and RUSLE")

B: Example handout page for the afternoon workshop ("Site Hydrology's Impact on Erosion and Selection of Appropriate Controls")

A: Sample handout page from Module 4.

## "Transport of Chemicals in the Atmosphere"

### Module 4: The Atmosphere, Lecture 2

*Chemical Fate and Transport in the Environment*, 2nd edition. H.F. Hemond and E.J. Fechner-Levy. Academic Press. London. 2000.

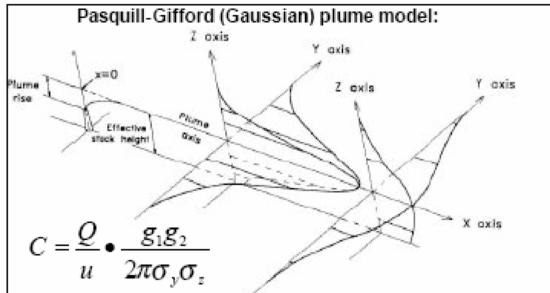
## 4.4 Transport of Chemicals in the Atmosphere

- Physical transport and chemical reaction rates are both needed to predict downwind concentrations of air pollutants.
- It is important to compare chemical reaction rates with advective velocities and mixing rates.
  - If chemical transformations are relatively slow compared to mixing rates, it may be appropriate to use simple box models in which air volumes are considered well mixed.
  - When chemicals are transported significant distances in the time it takes for the chemical reactions to reach equilibrium, then advection-dispersion-reaction equation solutions are most useful.

## 4.4.2 Local-Scale Outdoor Air Pollution

- The smallest spatial scale at which outdoor air pollution is of concern corresponds to the air volume affected by pollutant emissions from a single point source.
- Chemicals are carried downwind by advection, while turbulent (Fickian) transport cause the concentrations to become more diluted.
- Possible to predict the distance to and the concentration at which the plume from an elevated emission reaches the ground (classically considered the worst-case scenario).

**Pasquill-Gifford (Gaussian) plume model:**




Hemond and Fechner-Levy 2000

$$C = \frac{Q}{u} \bullet \frac{g_1 g_2}{2\pi\sigma_y\sigma_z}$$

$$g_1 = \exp\left(-0.5y^2/\sigma_y^2\right)$$

$$g_2 = \exp\left(-0.5 \bullet (z-H)^2/\sigma_z^2\right) + \exp\left(-0.5 \bullet (z+H)^2/\sigma_z^2\right)$$

B: Sample handout page from Module 6: Accidental Releases

## Steps for Performing Analyses

***Worst-Case Analysis for Toxic Gases***

To conduct worst-case analyses for toxic gases, including toxic gases liquefied by pressurization:
**Step 1:** *Determine worst-case scenario*. Identify the toxic gas and quantity released.
**Step 2:** *Determine release rate*. Estimate the release rate for the toxic gas.
**Step 3:** *Determine distance to endpoint*. Estimate the worst-case consequence distance based on the release rate and toxic endpoint. Select the appropriate table based on the density of the released substance, the topography of the site (urban or rural), and the duration of the release.

***Worst-Case Analysis for Toxic Liquids***

To conduct worst-case analyses for toxic substances that are liquids at ambient conditions, or for toxic gases that are liquefied by refrigeration, alone:
**Step 1:** *Determine worst-case scenario*. Identify the toxic liquid and quantity released.
**Step 2:** *Determine release rate*. Estimate the volatilization rate for the toxic liquid and the duration of the release.
**Step 3:** *Determine distance to endpoint*. Estimate the worst-case consequence distance based on the release rate and toxic endpoint. Select the appropriate reference table based on the density of the released substance, the topography of the site (rural or urban), and the duration of the release. Estimate distance to the endpoint from the appropriate table.

***Worst-Case Analysis for Flammable Substances***

To conduct worst-case analyses for all regulated flammable substances (i.e., gases and liquids):
**Step 1:** *Determine worst-case scenario*. Identify the appropriate flammable substance and quantityreleased.
**Step 2**: *Determine distance to endpoint*. Estimate the distance to the required overpressure endpoint of 1 psi for a vapor cloud explosion of the flammable substance. Estimate the distance to the endpoint from the quantity released.

***Determining Worst-Case Scenarios***

A worst-case release is defined as:

- The release of the largest quantity of a substance from a vessel or process line failure,
- The release that results in the greatest distance to the endpoint for the regulated toxic or flammable

End of Handout