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Highway Routing of Hazardous Materials

Guidelines for Applying Criteria

National Highway Institute

TABLE OF CONTENTS

LIST OF EXHIBITS

Page

PREFACE

This document is a revision of the July 1985 U.S Department of Transportation (DOT) publication entitled *Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials* (DOT/RSPA/OHMT-89-02), and reflects the new regulations regarding highway routing of non-radioactive hazardous materials (NRHM) (49 CFR Part 397).

This document provides guidance to States, Indian tribes, and locals on how to apply and implement the new Federal standards for establishing, maintaining, and enforcing designated NRHM highway routes. It is important to note that there are two types of routing designations: designated routes and restricted routes. Designated routes are those highway routes on which NRHM **must** be transported. Restricted routes are those highway routes on which NRHM **may not** be transported. Restrictions addressed by the new regulations include tunnels, lane restrictions, time of day limitations, prior notice, escort requirements, etc.; jurisdictional restrictions such as "nuclear free zone" are not covered. Both designated and restricted routes are covered in this Guide.

The new Federal standards provide for enhancement of safety; public participation; consultation with others; through highway routing; reasonable routes to terminals and other facilities; reasonable time to reach agreement between affected States or Indian tribes; timely responsibility for local compliance; and thirteen "factors" to consider in the designation process. These factors are:

- **population density** - the population potentially exposed to a NRHM release shall be estimated from the density of residents, employees, motorists, and other persons in the area, using U.S. census tract maps or other reasonable means for determining the population within a potential impact zone along a designated highway route. The impact zone is the potential range of effects in the event of a release. Special populations such as schools, hospitals, prisons, and senior citizens homes shall, among other things, be considered when determining the potential risk to populations along a highway routing. Consideration shall be given to the amount of time during which an area will experience a heavy population density.

- **type of highway** - the characteristics of each alternative NRHM highway routing designation shall be compared. Vehicle weight and size limits, underpass and bridge clearances, roadway geometric design elements[1], number of lanes, degree of access control, and median and shoulder structures are examples of characteristics to be considered. The type of highway can affect the likelihood and severity of an accident, emergency response efforts and cleanup activities, and may be most effectively considered in conjunction with other factors such as terrain, climate, and congestion.

- **type and quantity of NRHM** - an examination shall be made of the type and quantity of NRHM normally transported along highway routes which are included in a proposed NRHM routing designation, and consideration shall be given to the relative impact zone and risks of each type and quantity. Often a routing designation is developed for all hazardous materials classes, using worst case scenarios for the types and quantities of NRHM transported. Specific types and quantities of NRHM should also be considered when features on or along a routing alternative (e.g., a bridge or tunnel) would be particularly susceptible to a release (e.g., toxic gas) or the consequences of a release (e.g., fire or explosion). Routing designations may be needed for one or more classes of hazardous materials, and relative risk comparisons should be made within each class. Evaluations of specific types and quantities of hazardous materials may be made when shipping patterns indicate only certain materials are transported over a specific route.

- **emergency response capabilities** - in consultation with the proper fire, law enforcement, and highway safety agencies, consideration shall be given to the emergency response capabilities which may be needed as a result of a NRHM routing designation. The analysis of the emergency response capabilities shall be based upon the proximity of the emergency response facilities and their capabilities to contain and suppress NRHM releases within the impact zones. Generally, when alternative routings are physically close on similar highway systems, emergency response capabilities should not be a significant factor affecting safety; however, when routings are sufficiently different in terms of highway type, terrain, congestion, and emergency response capabilities, a significant effect on safety may result and should be evaluated.

- **results of consultation with others** - consideration shall be given to the comments and concerns of all affected persons and entities provided during public hearings and consultations conducted in accordance with the Routing Rule.

- **exposure and other risk factors** - States and Indian tribes shall define the exposure and risk factors associated with any NRHM routing designations. The distance to sensitive areas shall be considered. Sensitive areas include, but are not limited to, homes and commercial buildings; special populations in hospitals, schools, handicapped facilities, prisons and stadiums; water sources such as streams and lakes; and natural areas such as parks, wetlands, and wildlife preserves. Although public safety is the primary concern in routing hazardous materials, environmental damage can have severe short and long-term effects. Drainage systems are highway components and releases onto a road surface may be quickly carried away to storm or natural drainage channels. This may impair the ability to mitigate and cleanup a release and may be extremely important in areas where streams, lakes, habitats, wildlife preserves or other ecologically sensitive areas are adjacent to the highway.

- **terrain considerations** - topography along and adjacent to the proposed NRHM routing designation that may affect the potential severity of an accident, the dispersion of the NRHM upon release and the control and cleanup of NRHM if released shall be considered. Terrain-related highway features include sharp curves, shoulder widths, grade, climbing lanes and road side characteristics such as side slope rates, height and texture of embankment, clear zones, and water courses. Terrain can affect accident probability and severity, as well as the effectiveness and timeliness of emergency response and cleanup efforts.

- **continuity of routes** - adjacent jurisdictions shall be consulted to ensure routing continuity for NRHM across common borders. Deviations from the most direct route shall be minimized.

- **alternative routes** - consideration shall be given to the alternative routes to, or resulting from, any routing designation. Alternative routes shall be examined, reviewed, or evaluated to the extent necessary to demonstrate that the most probable alternative routing resulting from a routing designation is safer than the current routing.

- **effects on commerce** - any NRHM routing designation made in accordance with the Routing Rule shall not create an unreasonable burden upon interstate or intrastate commerce. Routing designations should be compared with current transportation patterns for the hazardous materials classes being routed to determine any changes in mileage and transport time required. Routing restrictions that may affect commercial operations (e.g., time-of-day restrictions) should also be compared to existing operations to assess whether any additional economic burden results.

- **delays in transportation** - no NRHM routing designations may create unnecessary delays in the transportation of NRHM.

- **climatic conditions** - weather conditions unique to a highway route such as snow, wind, ice, fog, or other climatic conditions that could affect the safety of a route, the dispersion of the NRHM upon release, or increase the difficulty of controlling and cleaning up a release shall be given appropriate consideration. While weather conditions of alternative routings in close proximity can be assumed to be similar, unique features can exist that may affect climatic conditions (e.g., localized blanket fog can be created by large amounts of water vapor released to the air from paper processing plants; heavily shaded highways may remain iced where a parallel highway receives more sun and is relatively ice-free).

- **congestion and accident history** - traffic conditions unique to a highway routing such as traffic congestion, accident experience with motor vehicles, traffic considerations that could affect the potential for an accident, exposure of the public to any release, ability to perform emergency response operations, or the temporary closing of a highway for cleanup of any release shall be given appropriate consideration. Congestion should be considered when there is a significant difference in traffic delays on alternative routings, or when there is similar traffic congestion but different features that could result in increased exposure to motorists following a release. Congestion in tunnels, viaducts or other areas where motorist could be trapped and the effects of a hazardous materials release are confined should be evaluated. Accident histories can be used in conjunction with congestion analysis to determine the likelihood of an accident occurring.

The methodology has been modified to reflect appropriate additional approaches for the determination of accident probability and consequences in the primary risk calculation. The methods have different data input requirements and calculational complexity and are meant to provide optional routing designation approaches for routing designation agencies. This Guide also provides considerations (both quantitative and qualitative) for other factors. The application of the methodology is illustrated in a hypothetical example to assist the user in the analysis and considering all appropriate issues in the routing designation process.

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SECTION I

INTRODUCTION

PURPOSE OF GUIDE

The *Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials* provide a process for evaluating the relative risks associated with alternative highway routes that are used for the transportation of hazardous materials. A hazardous material is a "substance or material, including a hazardous substance, which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce ...".[2] The methodology presented in this Guide may be used to evaluate various roadway types (e.g., Interstates, urban arterials, rural highways) in terms of the risks that hazardous materials shipments on these roadways pose to the travelling public, adjacent populations, and the environs. The results of this process can be used to establish routing designations for hazardous materials transportation in a State, local jurisdiction, or by an Indian tribe. **Remember that these route designation guidelines only apply to non-radioactive hazardous materials.**

This Guide does not provide in-depth documentation of the assumptions and processes implicit in the application of the methodology. Rather, it provides a concise description of the criteria that may be applied for hazardous materials highway route selection decisions and illustrates the application of these criteria through examples. It is important to note that the risk analyses described in this Guide are used for comparison purposes, i.e., comparing the relative risk of one route to another. Because the same simplifying assumptions and estimations are applied to feasible alternative routes, the risk values are considered a valid measure of relative risk rather than absolute risk. The risk values are important **only** when compared to similarly derived risk values for other alternative routes. Further, these values are generally conservative; however, if the same assumptions are consistently applied to all routes under consideration, this should have no overall bearing on route choices based on relative risk comparisons.

The FHWA does not consider the Guide as the only acceptable or best method for performing routing analyses. Routing analysis is an evolving discipline in which a large number of complex factors may impinge on a specific routing choice. The Guide is presented as an example of the kind of objective, documentable methodology that may be employed in performing such analyses, and provides an analytical method that is consistent with the Routing Rule. The method in the Guide or an equivalent method shall be used when considering overall risk in the routing designation process.

ORGANIZATION OF GUIDE

The remainder of this Section provides background material on the transportation of hazardous materials, and on routing as one of several measures that can be taken to control risk associated with these materials. The last part of this Section describes the staffing requirements and approximate level of effort required for the routing analysis.

Section II provides an overview of the process for analyzing hazmat routes and describes routing standards and factors and ways to apply and implement them in the routing process. The concept of risk is defined and each step in the process is explained.

Section III discusses the method for determining risk. Section IV presents additional analyses using many of the factors that must be considered when analyzing hazmat routing alternatives. Section V presents a worked example as a simple walk-through of the routing analysis process. The example includes population and property risk calculations and uses "preferred" methods where multiple optional methods have been identified in Sections III and IV.

Appendix A contains background information on managing public involvement, including guidance on how to develop a mailing list and how to conduct public hearings. Appendix B contains information on the public information and Federal reporting requirements regarding designated routes. Appendix C discusses considerations for assessing risk and other factors associated with routes that include tunnels. Appendix D provides background and information on emergency response capabilities. Supporting calculations for the example are in Appendix E. Blank worksheets and forms for structuring and conducting the route analyses are included in Appendix F. References can be found at the end of the Appendices.

At the beginning of each section a box will indicate which of the standards and factors are discussed within that section. This will help the user ensure that **all** standards and factors are considered as required in the Routing Rule.

BACKGROUND ON HAZARDOUS MATERIALS TRANSPORTATION

Growing consumer and industrial demand for products that are, or are based on, flammable, poisonous, explosive, corrosive, or otherwise potentially harmful materials, has resulted in greater movements of these commodities on the nation's highways. Increased transportation of hazardous materials has heightened concerns about the human and environmental consequences associated with the unintentional release of these materials.

This heightened concern stems from several factors, including the increased number and quantity of materials shipped and an increased awareness on the part of elected officials and the public of the risks associated with the transportation of hazardous materials. The highway transport of hazardous materials represents about 62 percent of the volume of hazardous materials transported in the U.S., but contributes only a very small fraction of the annual injuries and deaths attributable to hazardous materials transportation incidents. For the 1982-1983 time period, there were a total of 1.5 billion tons of hazardous materials transported in the U.S., 927 million tons of which were shipped by highway. These 927 million tons of hazardous materials were shipped in a total of 467,000 trucks, which accounted for 93.6 billion ton-miles of hazardous materials traffic. During this time, there were approximately 211 incidents involving a release of hazardous materials, resulting in approximately 121 injuries and no more than 8 deaths. These deaths include those caused by vehicular accidents and other causes, such as faulty valves.

Of the 1.5 billion tons of hazardous materials transported, the majority represent a small subset of hazardous materials and hazard classes. Almost 50 percent of the shipments were gasoline and petroleum products, and approximately 13 percent were chemicals. By decreasing volume (tons), the major hazard classes shipped were flammables, poison B, poison A, flammable compressed gases, and flammable solids. By decreasing volume (ton-miles), the hazard classes shipped were flammables, poison B, flammable solids, combustible liquids, and corrosives.

ALTERNATIVES FOR IMPROVING PUBLIC SAFETY

Routing is not necessarily the only or the best strategy available to enhance public safety in the transportation of hazardous materials. Many of the risks associated with transporting hazardous materials may be addressed by safety programs that affect the packaging of the material, the design and operation of the vehicle, the training of the driver, the methods in which materials are handled, roadway designs, and emergency response procedures to accidental releases. Both the public and private sectors have responded by developing programs for most of these safety issues. For example, the Federal Government regulates vehicle safety and driver training requirements through FHWA's Office of Motor Carriers (OMC). Regulations on the packaging, handling, and placarding of hazardous materials shipments are promulgated by DOT's Office of Hazardous Materials Transportation (OHMT) within RSPA, and are codified in Title 49 of the Code of Federal Regulations (49 CFR). Private industry has developed and actively promotes a number of safety programs, which include hazardous materials awareness and training seminars for local emergency response teams, a real-time emergency response information system (CHEMTREC) maintained by the Chemical Manufacturers Association (CMA), and industry transportation planning guidelines set out in The Transportation Community Awareness Emergency Response Program (TRANSCAER), also supported by CMA.

The Hazardous Materials Transportation Act of 1975 (HMTA) vests the ultimate routing authority for interstate carriers of hazardous materials with the Secretary of Transportation and expressly preempts "any requirement, of a State or political subdivision thereof, which is inconsistent with any requirement" of the HMTA or regulations issued thereunder. The law also authorizes the Secretary to waive the preemption if the State requirements provide an equal or higher level of safety and do not unreasonably burden interstate commerce.

The Hazardous Materials Transportation Uniform Safety Act (HMTUSA) of 1990 was enacted and amended the HMTA. The FHWA was delegated the responsibility by the Secretary to implement the rulemaking for hazardous materials highway routing. HMTA, as amended by section 4 of the HMTUSA, requires DOT to establish by regulation, standards for States and Indian tribes to use in establishing, maintaining, and enforcing these routing designations. These Federal standards are promulgated in 49 CFR 397 Subpart C.

STAFFING REQUIREMENTS FOR ROUTE DESIGNATION

This Guide and the routing method it describes are designed to allow individuals with little knowledge of hazardous materials safety issues to conduct routing analyses. The lead agency in routing designation should be the agency identified as having primary responsibility for highway routing. Providing opportunities for participation in the analysis and route selection process to shippers, carriers, and the public, is also required by the routing regulations. The routing analysis methodology presented here has been applied by persons with limited experience in the field but who are comfortable with mathematics and data analysis.

Experience to date indicates that approximately 40 to 80 person-hours are entailed in the analysis of several highway route alternatives ranging in length from 50 to 100 miles. Factors that will alter these estimates include the depth of the analysis (for example, how many routing criteria are applied), the availability of local data, and the characteristics of the routes evaluated. (Routes with fairly uniform accident rates and nearby population densities typically require less time to evaluate.)

The analysis may be conducted by one individual or by a group of people representing various agencies and interests. If more than one agency conducts the analysis, it is recommended that a lead agency or individual be designated to coordinate activities and ensure that responsibilities are fulfilled in a timely fashion. The size of the project team will depend upon the level of resources that are committed to the project. Although more person-hours are typically expended in a group analysis, the opportunity to assemble several perspectives on the issue will likely enhance the quality of the analysis and the validity of any routing recommendations. Particular attention should be given to assembling a broadly representative team in controversial cases. Perhaps the most cost-effective approach is to assemble a project team for the initial scoping of the problem and structuring of the analysis. The technical work may then be performed by one or two individuals and the project team re-convened to discuss the findings before the selection of preferred routes is made available for public comment.

SECTION II

PROCESS FOR HAZARDOUS MATERIALS ROUTING ANALYSES

Section II discusses the following Standards and Factors:

Standards	Factors
✓enhancement of safety	✓population density
✓public participation	type of highway
✓consultation with others	types and quantities of NRHM
✓through highway routing	emergency response capabilities
✓burden on commerce	✓results of consultation
✓reasonable routes to terminals and other facilities	exposure and other risk factors
✓reasonable time to reach agreement between affected States or Indian tribes	terrain considerations
✓timely responsibility for local compliance	continuity of routes
	✓effects on commerce
	✓alternative routes
	delays in transportation
	climatic conditions
	congestion and accident history

This section describes the procedures for analyzing and comparing alternative hazardous materials routings. The section begins with a brief overview of the route selection process (a schematic flow-chart of the process is presented in Exhibit 1) and concludes with a description of each component used in the analysis. Each box in Exhibit 1 represents an activity (or related activities) in the routing designation process.

METHOD OVERVIEW

Sequence of Activities

The routing process is designed to identify and evaluate roadway and community characteristics that make one route preferable to another from the perspective of improving the overall public safety associated with the transportation of hazardous materials. The sequence of tasks and decision points in the method allows the analysts, early on in the process, to eliminate alternative routes that are clearly unacceptable. Exhibit 1 presents an overview of the routing process and identifies the issues to be addressed (as indexed to the sections of the Routing Rule).

The analysis starts by clearly identifying (1) the role(s) of the performing agency(ies), (2) the affected parties, and (3) the State or community's goals and objectives for managing shipments of hazardous materials that originate from, or are destined to, or pass through the community. After political, legal, and jurisdictional issues are addressed, alternative routings that are consistent with State and community objectives can be defined. Factors that affect hazardous materials routing decisions then are investigated and criteria applied to determine which routes are most or least preferred.

Exhibit 1
Overview of Routing Process

DEFINE OBJECTIVES AND RESPONSIBILITIES

Identify participants
Define objectives
Establish jurisdiction

↓

DEFINE ALTERNATIVES FOR ANALYSIS

(7)	Reasonable routes to terminals and other facilities
(9)(viii)	Continuity of routes
(9)(ix)	Alternative routes
(9)(xi)	Delays in transportation

↓

SEEK PUBLIC INPUT

(2)	Public participation
(3)	Consultation with others
(5)(ii)	Agreement of other States
(6)	Timeliness
(9)(viii)	Continuity of routes

↓

ANALYZE RISK

(9)(i)	Population density
(9)(ii)	Type of highway
(9)(iii)	Type and quantity of NRHM
(9)(vii)	Terrain considerations
(9)(xii)	Climatic conditions

↓

APPLY THROUGH ROUTING CRITERIA

(4)	Through routing

↓

CONSIDER ADDITIONAL FACTORS

(5)(i)/(9)(x)	Burden/effects on commerce
(9)(iv)	Emergency response capabilities
(9)(vi)	Exposure and other risk factors
(9)(xiii)	Congestion and accident history
Optional	Property risk analysis

↓

IDENTIFY ROUTING

↓

REVISE (if needed) AND PUBLICIZE ROUTES

(8)	Responsibility for local compliance
(9)(v)	Results of consultations with affected persons

Application of Standards and Factors

The standards that must be applied when establishing, maintaining, and enforcing routing designations correspond to four levels of decision-making. Each decision level endeavors to identify characteristics and circumstances that would preclude the use of a particular route. This procedure is used to successively reduce the number of potential alternatives and ultimately to select a preferred route.

Route characteristics and physical and legal constraints are considered at the outset to eliminate routes with obvious impediments. These constraints generally apply to all motor carriers and include such items as size and weight restrictions.

The second level of decision-making is based on the relative risk to public safety of transporting hazardous materials on each alternative routing. Risk is a measure of the probability of occurrence of a specific consequence or loss due to a failure or external event. Total risk is the product of the probability and magnitude of a consequence or loss, or the sum of such products over all possible consequences or losses.

Risk, as used in this Guide, is an overall measure of the potential exposure of a community to a release of hazardous materials from a highway transportation accident. It is derived by multiplying the probability that a vehicle will be involved in a highway accident that results in a release along a given highway route by a measure of the population potentially exposed beside and along that route. Relative risk can be determined in cases where two or more routes are being compared or where a specific alternative routing is being compared with existing hazardous materials travel patterns. This Guide uses a relative risk approach, in which the risk associated with one route is compared to the risk associated with one or more alternate routings.

The objective of the route selection method suggested here is to identify routes that significantly reduce risk which is the primary consideration in the routing designation process.

Once the risk posed by alternative routes has been estimated, the "through routing" criteria can be used as a third tier of decision-making to eliminate additional routes from the analysis. These criteria address continuity of shipments to avoid unnecessary delay, while enhancing public safety.

Consideration of other factors that reflect community priorities and values (and that usually are not easily quantifiable) represent a fourth decision level. For example, the community may want the routing selection to be sensitive to the location of non-ambulatory hospital populations. In the methodology suggested, these factors are not explicitly included in the risk calculations, although semi-quantitative treatments of several of these factors are discussed. The existence or absence of such facilities as hospitals, schools, fire stations, water reservoirs, or wetlands may influence a decision among routes that otherwise present similar risk.

It is possible that neither the relative risk evaluation or consideration of other factors will indicate a preferable route. In this case, the current hazmat shipping route would probably be the preferred route.

Care should also be taken in assigning undue importance to relatively small differences in risk values among routes. In such cases, some consideration should be given to the statistical uncertainty of the underlying data, to the fact that the imposition of any routing restriction can be costly and potentially controversial, and to the possibility that the risk to a community from the transportation of hazardous materials may constitute a small fraction of the risk faced by a community from the storage and use of such materials at fixed facilities.

DEFINE OBJECTIVES AND RESPONSIBILITIES

Initial activities involve the designated State or Tribal routing agency structuring the routing analysis and building consensus. Thoughtful problem identification and planning in the early stages of the process will greatly assist in selecting the routes to be analyzed and the procedures to be used.

Participants

Decisions about routing requirements for hazardous materials will affect a broad spectrum of community members, including motor carriers, shippers, public safety officials (e.g., fire, police, civil defense), State/local government and Indian tribe officials, the general public, and industries served by motor carriers. The first step in the process is for the State routing agency to identify the possible routing alternatives and compile a list of potentially affected parties. Input may be solicited through these potentially affected parties by correspondence or by including them on the analysis team. Participation by these representatives early in the process has the dual benefit of introducing multiple perspectives on the issues and building consensus on the approach. The motor carrier industry, in particular, should be encouraged to identify its special needs. Involving the industry in the process is likely to foster the development of routing requirements that are reasonable and workable. In addition, representatives (e.g., highway officials) of Indian tribes and other jurisdictions potentially affected by routing designations should be contacted as soon as possible. Their participation at the end of the process is required by the regulation, and including them earlier may facilitate the finalization of routing designations.

During the initial phase, an individual from the designated State routing agency should assume lead responsibility for conducting the routing analysis. Centralization of authority and responsibility will help ensure timely completion of the route analysis and assist in the resolution of disputes.

Objectives

It is important, whether an individual or a team is charged with developing routing designations, to establish and document the State's goals and objectives in conducting a routing analysis. For example, some States may desire to minimize their exposure to hazardous materials shipments to the extent feasible, while other States, more dependent on hazardous materials shipments, may view routing as but one of several methods to improve roadway safety. Other considerations may include such things as State or regional politics, local traffic concerns, or loss of critical service routes (e.g., tunnels). Careful consideration of the State's goals, the potential costs of implementation, and possible non-routing strategies at the outset may help to identify safety measures that are more effective than routing.

Identifying routes that are safer than others can involve complicated, time-consuming, and expensive evaluations of each routing alternative. As a result, State planners may wish to focus their attention and resources on routing alternatives that are likely to provide the greatest safety. Focusing on a few reasonable routes would reduce the commitment of funds by eliminating options that have little chance of meeting the goal.

There are several types of common routing designations in existence, including:

- tunnels, and to some extent bridges, may be restricted. These routing designations are common to longer tunnels (with ventilation systems) and generally either prohibit the transportation of flammable, poisonous gases, and/or explosives through the tunnel, or restrict the time when these materials can be transported. These routing designations are relatively short, generally between the most appropriate exit or access points on either side of the tunnel that provides for alternative routing.

- bypass designations result in hazardous materials being routed around rather than through densely populated areas. Routing designations of this type typically are 5 to 15 miles in length and may either restrict or designate a specific highway over which all or certain hazardous materials can travel.

- origin/destination designations have common origination and/or destination points, at facilities like ports, terminals, and chemical/industrial plants. These designations vary in length, depending on the proximity of highway access to the hazardous material origin/destination point. Some have a terminus at a State boundary to provide continuity in routing through a State.

- through routing designations provide for routing a hazardous materials shipment through a city, county, Indian tribal land, or in some cases a State, where the shipment origin and destination are outside the community.

- miscellaneous routing designations are less common, developed for specific or unique situations.

Whether the routing analysis will apply to through or local deliveries/shipments should be established. Although the analysis of routes for through shipments may differ from the analysis of routes for local shipments, in neither case is there normally available a network of alternatives for hazardous materials shipments. The number of route alternatives for shipments of hazardous materials that pass through a State or locality is typically small. Through shipments of hazardous materials (i.e., shipments of hazardous materials that neither originate in or are destined to a State) often constitute a small percentage of the total risk faced by a State from the transportation and storage of hazardous materials.

Another issue that should be resolved early in the process is whether the routing analysis will address all hazardous materials, commonly transported hazardous materials (e.g., gasoline), or only unusually dangerous materials (e.g., poison gas). This determination will partially reflect State opinion on the tradeoff between public safety and the costs of achieving that safety. It will also reflect the extent to which those materials are used within the local economy.

Other objectives the State may wish to consider are route specific issues such as traffic problems and lane restrictions because these issues may reflect on the desirability of designating a route. For example, identification of traffic problems (e.g., stoplight timing) or the avoidance of such problems may be an important concern in the route designation analysis. Traffic and certain roadway features (e.g., curvature) may be associated with an increased probability of accidents and delays to commerce. Lane restrictions that require trucks to use the far right lane for routes on steep hills may need to be considered because they minimize the negative effects of large grade roads. Also, other lane restrictions for high occupancy vehicles may have impact on the number of individuals potentially at risk from a release of a hazardous material. Other routing issues, such as the presence of railroad crossings, can pose certain risks that the State routing agency may chose to consider in the route designation process. Consideration of such issues is important in characterizing the attributes of each route.

The discussion and formulation of goals and objectives should be clearly documented in minutes of meetings and memoranda. Written policy statements will provide a reference for future actions and serve as important resources as the analysis proceeds to the selection and application of other factors that may be more difficult to quantify or define explicitly.

Jurisdiction

Several agencies and groups are likely to have overlapping responsibilities in the area of hazardous materials transportation management within a State. State police and departments of transportation also have certain responsibilities and powers, as do local governments; fire and local police departments; and bridge, tunnel, and turnpike authorities, that can affect and will be affected by routing decisions. However, one designated agency within the State will have primary responsibility for establishing route designations, and all activities regarding route designation must be coordinated through this agency.

Inherent in such a system is the potential for jurisdictional conflict. A basic first step for resolving conflicts is to ensure that all affected jurisdictions are consulted with and brought into the process at the earliest stages.

Becoming familiar with regional responsibilities in the area will also help structure the overall strategy for planning, implementing, and operating hazardous materials transportation management policies. A review of existing statutory and institutional arrangements may indicate a need to reorganize these activities, authorize new responsibilities, or augment existing authority so that the responsible agencies can execute their functions more effectively.

DEFINE ALTERNATIVE ROUTINGS FOR ANALYSIS

By this point in the analysis, the State routing agency should be well acquainted with the agencies and individuals involved with hazardous materials movements and the overall purpose of the routing analysis. After establishing the routing objectives which may be proposed for a specific highway routing designation, a first cut should be made at identifying those routes that (1) appear to satisfy jurisdictional objectives, (2) are reasonably compatible with existing hazardous materials trucking patterns and allows access to terminals and other facilities, (3) are devoid of obvious physical and legal considerations that seriously constrain or prohibit their use, and (4) are consistent with adjoining routes in adjacent jurisdictions.

Physical Routing Considerations

Consideration of the physical factors that characterize a route is the first step in defining the viability of a routing alternative. Weight limitations on bridges and height restrictions on overpasses are the most common physical restrictions that will preclude the use of a route by large trucks. Other physical constraints might include inadequate shoulders for breakdowns, steep gradients, extensive construction activities, or inadequate turning radii.

Legal Routing Considerations

Ordinances that limit the transportation of hazardous materials on specific roadways or structures (e.g., bridges, tunnels) must be investigated for each of the potential alternatives. Whether or not an existing restriction will change the focus of a route analysis is at the discretion of the State routing agency. For example, tunnel authorities have frequently limited or prohibited the transport of hazardous materials; however, this Guide discusses considerations for estimating the risk of transport along routes including tunnels. The planner may wish to calculate the risk along a route that includes a tunnel and if the route proves to be substantially safer for hazardous materials shipments, the State routing agency may consider changing the route designation. Caution must be exercised to assure that existing routing designations are considered. While some may be subject to change, arbitrary limits on otherwise acceptable routes may become targets for legal challenge during later stages of the routing designation process.

Local and State traffic engineers are the best source for information about existing legal constraints. Bridge, tunnel, and turnpike authorities also should be contacted to identify any hazardous materials restrictions currently in place on these infrastructures.

The initial selection of routes should reflect a knowledge of local demography, roadways, and traffic conditions. As a general rule Interstate routes that avoid populated areas should be used as much as possible because of their better safety records. The State routing agency should be wary of arbitrarily excluding potential alternative routings, but must make some judgments at this point to reduce the number of options. It is useful to look at total length of each possible route and calculate route circuity, the ratio of an alternative's length to the minimum path serving the same origin/destination pair. Public input, especially from motor carriers, can be helpful at this point in determining if alternative routes with a high circuity would be economically viable or would burden commerce.

METHOD FOR DETERMINING RISK (OVERVIEW OF SECTION III)

The risk associated with hazardous materials shipments on a highway may be calculated for nearby populations. (Note that population risk must be performed in conducting route analyses; property risk is an optional consideration that can be included at the discretion of the routing designation agency.) As defined above, risk is the probability of a truck accident multiplied by a measure of the population potentially exposed to the accident. The basic formula is:

Risk = Probability x Consequences

where the probability term represents a hazardous materials truck accident rate, in units of accidents per vehicle-mile, that characterizes a route or route segment; and the consequences term is a measure of the population potentially exposed to a hazardous materials truck accident along a route or route segment.

Because this Guide uses a relative risk model rather than absolute risk model, calculations can be simplified by substituting representative values for the probability and consequences terms in the formula. For example, actual consequence measures, which are difficult to predict accurately, should be represented by population density figures, eliminating the need to exhaustively define a hypothetical accident and calculate the consequences (e.g., fatalities and injuries) associated with the release of a hazardous material. Use of population density figures, in effect, assumes that the actual consequences are proportional to the population exposed to a major release. As such, it is a greatly simplified and conservative measure of the consequences that would be expected, on average, to occur.

The primary criterion for a routing designation is that the designated route significantly reduce risk. This may not necessarily be the highway with the smallest adjacent population or the lowest accident rate. A route with a high population density may have a low total risk if the associated accident rate is very low and vice versa. This important concept is key to applying this methodology.

The risk values calculated by this method are not meaningful as absolute numbers; it is the relative difference in the risk among routes that is used to differentiate routes. If sufficient differences exist in the risk values for alternative routes, this can be used to designate the preferred hazardous materials route. However, some thought should be given at the outset of the analysis to the question of how large the differences among routes should be to justify a routing decision. This question is closely related to the accuracy of the data and the nature of the simplifying assumptions used in the analysis. Implementation of any routing decision will incur costs for signs, driver notification, enforcement, community acceptance, and related matters. Small differences in risk among routes are unlikely to result in benefits sufficiently large to justify these costs.

Accident Probability

To determine the probability of a hazardous materials truck accident, highway and route accident and traffic volume data must be collected for all routes and route segments under review. However, truck accident and traffic volume data are often limited or not available; therefore, data can be approximated by more readily available total vehicle accident data (i.e., data that do not differentiate between trucks and automobiles). The same type of data must be used on all routes; comparing truck data on one route with all vehicle data on an alternative route will lead to erroneous results. The types of data used in this analysis must be consistent.

The usual way to determine highway accident rates is to contact State or local traffic engineers and use data that have already been collected. In some instances, appropriate accident rates will be readily available. Other departments may be able to provide accident frequencies and traffic volumes that can be easily transformed into accident rates. In the event that neither reliable accident rates nor frequencies are available, the State routing agency may estimate accident rates using rates from a similar or nearby State, or from national data.

Accident Consequences

Accident consequences are represented by the population within the impact area (the people who would be potentially exposed to the consequences of a hazardous materials release).

The potential impact area for a hazardous materials release will depend upon the type of material under consideration. Some hazardous materials will have larger probable impact areas than other hazardous materials, and the affected population within their potential impact area will be greater. The choice of which materials to analyze may be based on consideration of the factors affecting the safety of highway routing.

To measure the population within the potential impact area, the area is scaled off on census tract maps. Residential population is available for each tract. Employment data may be available from State or local sources. The routing methodology is flexible enough to permit modifications in the consequence measurement techniques without distorting the fundamental risk equation, so long as the choices made are documented and consistently applied to all of the alternatives under consideration.

Risk Calculation

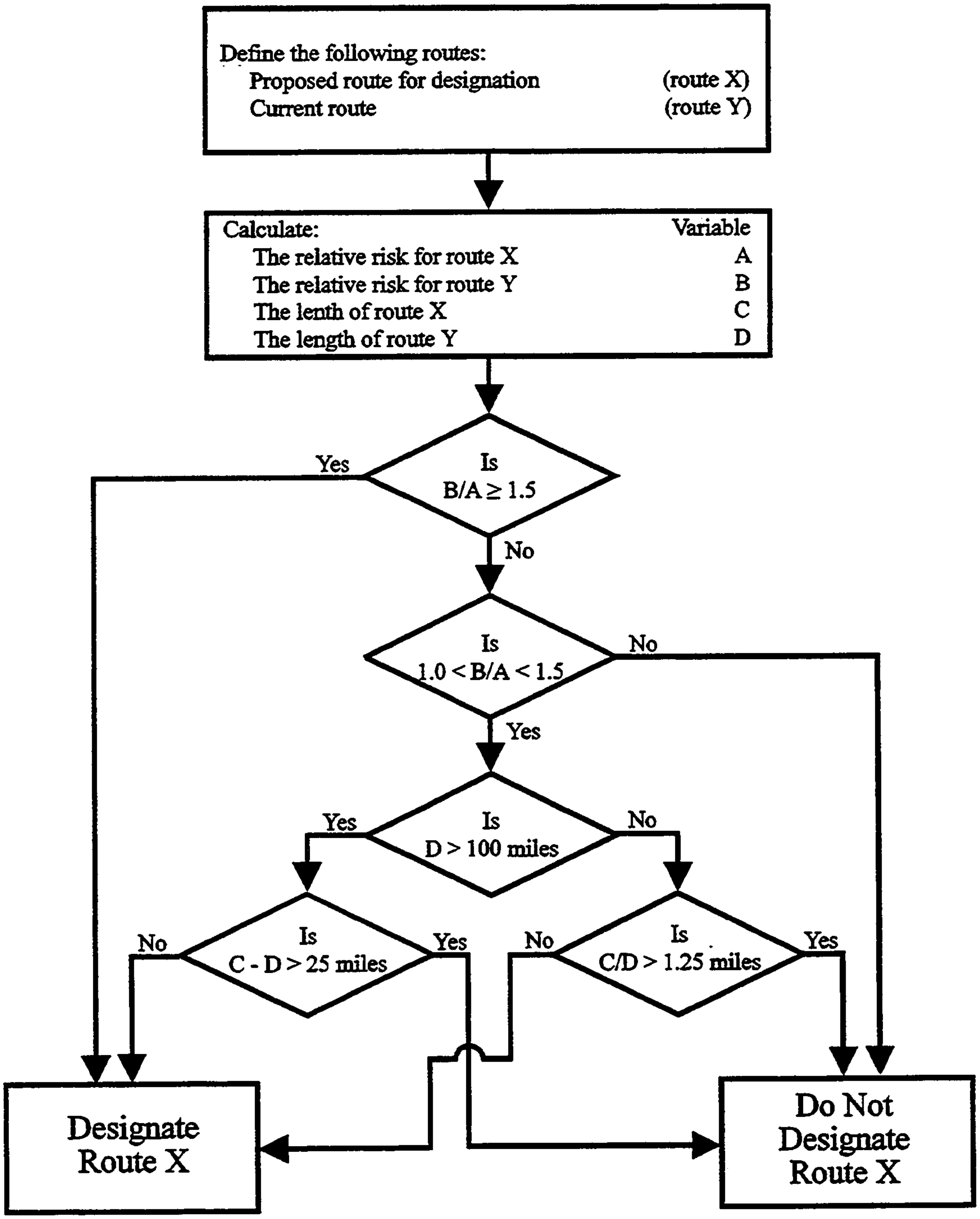
The alternative routes to be analyzed usually are subdivided into route segments by noting significant differences in population densities and accident rates. The potential consequences and accident probability for each segment are multiplied to calculate the segment risk. Summing all the individual segment risks of an alternate route produces the total risk for that route.

APPLY THROUGH ROUTING CRITERIA

One of the criteria that has to be considered is "through highway routing," which addresses continuity of movement of NRHM transportation so that it is not impeded or unnecessarily delayed by routing designations. The primary goal of a routing designation is to enhance public safety while not unduly burdening commerce. The through routing criteria provide quantitative measures of these two goals.

The flowchart presented in Exhibit 2 provides a simplified method for applying these criteria, and the routing analysis worksheet contains a section for answering the questions posed. To apply the through routing criteria, the State routing agency must first determine the relative population risk for the current routing and the proposed alternative(s). If the ratio of the relative risk of the current routing to that of the proposed alternative is greater than 1.5 i.e., "the current routing presents at least 50

Exhibit 2
Through Routing Analysis Process



percent more risk to the public"), then the proposed alternative can be designated without further analysis. If the ratio is between 1.0 and 1.5, then the length of the deviation is examined.

In the rule, two tests are provided for determining acceptable deviations:

- If the current routing is greater than 100 miles, a deviation of 25 miles is acceptable for a route.

- If the current routing is less than 100 miles, a 25 percent increase in route length is not considered unduly burdensome on commerce.

As clearly stated in the rule, no routing with a population risk higher than that of the current routing can be designated.

ADDITIONAL ANALYSES (OVERVIEW OF SECTION IV)

Although all factors discussed in the preface must be considered in the routing designation process, the manner and extent to which they are applied in the routing process is at the discretion of the State routing agency. This Guide provides some additional ways to consider or use factors which are not explicitly used as input to the risk determination effectively in a routing designation. The weighting of these factors is largely judgmental and the importance they play in the overall analysis of the routes should reflect their relative value or expected influence. The manner in which the routing agency applies various factors in the routing designation analysis will depend in part on the outcome of the risk calculations and how conclusive the findings are. Consideration of various factors may be useful for tie-breaking decisions where no one alternative is clearly superior to the others based solely on population risk.

Consideration of factors should reflect community priorities and values, and should be arrived at through community discussion and consensus. Factors of interest to the community may include:

- exposure and other risk factors (i.e., special populations, sensitive environments)
- emergency response capabilities
- burden on commerce
- congestion/transportation delays
- property risk

One community might elect to evaluate the locations of emergency response teams and their ability to respond to hazardous materials releases, the locations of semi-ambulatory or pre-school populations that may be difficult to evacuate, and the proximity of sensitive ecological areas of critical importance (e.g., watersheds and reservoirs). Another community might limit the other factor analysis to property risk calculation. Property risk, which is similar to the population risk described above, is relatively easy to quantify; however, consideration of property risk is not discussed in the Routing Rule and is provided in the Guide as an optional consideration.

The State routing agency has discretion not only in selecting the level of analysis for each factor but also in deciding how to apply the results of the analysis. For example, the location of one hospital along a route may be difficult to justify as the final decision-making factor. On the other hand, the locations of several medical and primary education facilities as well as emergency response stations may be decisive in differentiating routes that have similar risks.

IDENTIFY ROUTES

After conducting the analysis, the next step in the process is to compare the alternatives according to their lengths, travel times, potential population risk and any other factors that were assessed. The decision sequence for ranking the routes is as follows:

- eliminate routes with physical constraints;

- consider the legal and political implications of trying to change mandatory legal limitations and exclude routes or reserve judgment accordingly;

- select route(s) with significantly smaller relative risk values that meet the through routing criteria; and

- consider and apply factors, as appropriate, maintain current routing patterns if unable to differentiate on risk, or designate route.

Selection of the preferred route (or routes) should reflect the community's consensus on which criteria are most important and should include input from other affected jurisdictions. The route selection decision should be thoroughly documented for the public record. Correspondence, memos, and all worksheets should be dated, signed, and filed. In particular, any assumptions or other factors that are assessed should be thoroughly explained and recorded.

Once the preferred route is selected, the regulation requires that the route be made available for public comment and, when determined appropriate, that a public hearing be held to receive comments. If the analysis has included input from interested parties throughout the process, the public comments received should be minimal. On the other hand, after reviewing proposed route selections, it is possible that new data may be made available and portions of the routing analysis might need to be revised. After initial notification to the public of their opportunity to comment, routes must be finalized within 18 months. Therefore, efficiency in resolving comments is important at this final stage of the route designation.

SEEK PUBLIC INPUT

Public involvement allows members of the community who are interested in or otherwise affected by routing designations an opportunity to add meaningful input into the process. They are often a key source of local information that could affect routing decisions. While the level of interest within a community may vary, the State routing agency should be prepared to consider and respond appropriately to significant information received, and particularly to hold public hearings following a sufficient expression of interest. Thorough documentation of the on-going selection process, corresponding analyses, and consultations with potentially affected parties (e.g., neighboring States) will become extremely useful at this point, as it may be necessary to justify decisions (e.g., eliminations of potential routes) made previously.

The State routing agency has certain responsibilities under the Routing Rule to involve the public and other affected parties in the route selection process. As shown in Exhibit 1, it is important to get input from affected parties early on, and there are specified time frames for making proposed route designations available for review and comment prior to final selection to allow reasonable time to reach agreement between States or Tribes. There are two primary groups that must have an opportunity to comment on the designated route(s):

- *Indian tribes and/or officials in other affected States, who are responsible for highway routing*: These groups should be given notice, in writing, of the proposed designation with a request for written approval at least 60 days prior to a final route selection. If no response is received within 60 days, it can be assumed that the routing designation is approved. The mechanisms for consulting with others and resolving any issues raised is left to the discretion of the State routing agency.

- *The public*: The public must be provided with notice of any proposed routing designation and 30 days in which to comment. The decision to hold public hearings is at the discretion of the State routing agency. If hearings are being held, the public must be given at least 30 days notice. Notice of the comment period and any hearings is given by publicizing announcements in at least two newspapers of general circulation.

Specific procedures and additional detail are found in §§ 397.71(b)(2) and (b)(3) of the Rule. Appendix A provides additional guidance on the public comment process.

REVISE (IF NEEDED) AND PUBLICIZE ROUTE SELECTION

After all comments and results of consultation with other participants have been received, the State routing agency should review any new information and, if necessary, update the analysis. If it is decided that new information warrants a change in the route selection, the change and the reasons for the change should be documented and included in the records of the process. A second round of public input is not required if the route selection is revised at this point. One important requirement to keep in mind at this stage is that of timeliness in terms of responsibility for local compliance: once notice is given to the public or highway officials in other States (whichever occurs first), the length of time for establishing a final routing designation may not exceed 18 months. Reporting requirements for new route designations are outlined in Appendix B.

SECTION III

METHOD FOR DETERMINING RISK

Section III discusses the following Standards and Factors:

Standards	**Factors**
enhancement of safety	✓population density
public participation	✓type of highway
consultation with others	✓types and quantities of NRHM
through highway routing	emergency response capabilities
burden on commerce	✓results of consultation
reasonable routes to terminals and other facilities	exposure and other risk factors
reasonable time to reach agreement between affected States or Indian tribes	✓terrain considerations
timely responsibility for local compliance	✓continuity of routes
	✓effects on commerce
	✓alternative routes
	delays in transportation
	climatic conditions
	congestion and accident history

The risk associated with hazardous materials movements over each alternative is the primary criterion for routing designation. Risk is defined as the probability of a hazardous materials accident multiplied by a measure of the population potentially exposed to an accident along each alternative routing. In the following discussions, an introduction is given to route characteristics and segmentation, and then the two components of risk are discussed and methods for estimating each component are illustrated.

<u>It is recommended that you read this section of the Guide thoroughly before starting any of the data collection or analysis activities</u>. Some of the analytical techniques are applicable only in certain situations and the availability and formatting of data will influence the choice of methods for estimating the hazardous materials accident probabilities and consequences.

Because the same simplifying assumptions and estimations are applied to feasible alternative routes, risk values are considered a measure of relative risk rather than absolute risk. The relative risk value for a single alternative routing does not provide any guidance for routing designation. The risk values are important **<u>only</u>** when compared to similarly derived risk values for other alternative routings. Further, these relative risk values cannot be used to measure absolute risk because the simplifying assumptions may greatly overstate the risk. For example, the methodology overstates the risk by assuming that **<u>all</u>** hazardous materials vehicle accidents will result in a release and/or spill of the entire quantity of material involved. This assumption, however, has no bearing on relative risk if consistently applied.

ROUTE CHARACTERISTICS

Risk is not uniform over the length of a route. For example, a high degree curvature in a route may be responsible for a higher accident probability and therefore higher risk than a straight segment along the same route. Also, variations in population along a route will influence the potential consequences from a hazardous material release. To develop better risk values and to assist in the data collection, the route can be divided into discrete units, referred to as segments. The overall risk is calculated for each segment of a route and then summed to produce the risk value for the entire routing alternative. Thus, the definition of segments along a route is critical in reflecting differences in roadway types, accident rates, average daily traffic (ADT), population density, or land-use characteristics along the length of the route. Also, tunnels are likely to require their own segments. Routes that are essentially uniform with respect to those factors do not require segmentation.

One of the important considerations in determining route segments is roadway functional type:

- interstate;
- urban arterials; and
- rural highways.

Another important issue is changes in population density along a route, often delineated by tract boundaries based on census data. In addition, traffic volume and accident rate data, should be considered. Routes may be segmented by roadway functional type evaluating changes in ADT or accident rates, changes in population density, or when county or city boundaries are crossed.

ACCIDENT PROBABILITY

As discussed in Section II, the probability of an accident is the likelihood or chance that a vehicle carrying hazardous materials will be involved in a roadway accident. The likelihood of a hazardous materials shipment being involved in an accident will vary with the distance travelled. Accident probability, or the expected number of accidents along a route segment, can be expressed as:

$$P_a = A \times L_s$$

where: P_a = Probability of an accident along a route segment
A = Accident rate or number of accidents per vehicle-mile along a route segment
L_s = Length of route segment in miles

Accident rate (A) is normally expressed as the number of accidents per 100 million vehicle-miles. The ideal measure would include accidents that:

- involved only vehicles carrying hazardous materials,
- occurred along particular routes or route segments, and
- resulted in releases of hazardous materials.

Unfortunately, this information is generally not available because of the infrequent occurrence of hazardous materials accidents.

Therefore, it is necessary to use accident rate data that are the best possible surrogates. When accident information on hazardous materials truck shipments is not available or is insufficient, accident rates for all trucks or even all vehicles may be substituted. Generally, truck accident rates should be used, if available, as long as the sample size is sufficiently large. At least three years of accident data are preferable to determine accident rates.

Accident rates on major roadways are usually available from the State or local highway department. Exhibit 3 shows other possible sources for State commodity flow, incident, and accident data. There are documents that provide thorough descriptions of how to develop accident rate information, and includes numerical examples of how a State highway agency might use its own data.[3] If specific State data are not available, the use of accident rates for similar roadway types for a similar or nearby State is next recommended. For example, California, Illinois, and Michigan have extensively developed accident rates that can be used by States that are nearby or are similar in terms of highways and traffic. Exhibit 4 lists these accident rates for each major roadway type.

Exhibit 3
Possible Sources for State Incident and Accident Data

State Traffic Accident Records Systems. Each of the 50 states maintains an automated traffic accident records system containing data from police accident reports. A 1990 study indicated that 15 states (AL, CA, FL, IL, KS, LA, ME MN, MO, NH, NY, OH, PA, SC, WY) identify whether hazardous material-carrying vehicles were involved, three states (LA, MO and WY) identify whether a release of hazardous materials occurred.

State spill reporting systems. The environmental or transportation agencies in some states operate reporting systems and may have databases containing this information.

When neither State-specific data nor a comparable State's data are available, then national data by highway type can be substituted. Several national databases exist that contain summary findings and information on highway vehicle and truck accidents (Exhibit 5). National accident rates for trucks and passenger vehicles through tunnels are also available.[4]

It is unusual to find route-specific data concerning the probability that an accident will result in a release or relating the probability of a release with roadway type. However, the recent study of accident data mentioned above for California, Illinois, and Michigan, has estimated the probability of a hazardous materials release for truck accidents as a function of roadway type.[5] These release probability data could be used as default values to further refine the probability term in the risk analysis. Whatever the source of accident rates, it is extremely important that the same type of data be used for all alternative routes examined. That is, if only all-vehicle accident rates are available for some route segments, then all-vehicle accident rates should be used even for those segments for which truck accident rates are also available. Serious biases can result when dissimilar data are used.

ACCIDENT CONSEQUENCES

The consequences of hazardous materials accidents are largely dependent on the type and quantity of material released. Therefore, to determine the potential consequences of a release, it is important for the State planner to know the types of materials and the individual quantities of hazardous shipments that travel along a route. There are many methods to determine what hazardous materials are being transported on a route. One way is to conduct a hazardous materials commodity flow study to assess the types and volumes of materials. Guidance for conducting such a study is provided by EPA, DOT, and State agencies (e.g., Arizona, New Jersey, Oregon, Colorado).[6]

Understanding the flow of hazardous materials along a route will assist the State planner in determining the hazards classes and specific chemicals to focus on whether a worst-case scenario should be developed based on varied shipments of hazardous materials.

In this Guide, the consequences of a hazardous materials release are assumed to be proportional to the number of persons within a release impact area along a route. Thus, the impact area or zone and the population exposed need to be defined. In special situations, such as tunnels and bridges, the impact to the travelling

Exhibit 4
Representative Truck Accident Rates by Area and Roadway Type

Highway Class		Truck Accident Rate (accidents per million vehicle-miles)			
Area Type	Roadway Type	California	Illinois	Michigan	Weighted Average[a]
Rural	Two-lane	1.73	3.13	2.22	2.19
Rural	Multilane undivided	5.44	2.13	9.50	4.49
Rural	Multilane divided	1.23	4.80	5.66	2.15
Rural	Freeway	0.53	0.46	1.18	0.64
Urban	Two-lane	4.23	11.10	10.93	8.66
Urban	Multilane undivided	13.02	17.05	10.37	13.92
Urban	Multilane divided	3.50	14.80	10.60	12.47
Urban	One-way street	6.60	26.36	8.08	9.70
Urban	Freeway	1.59	5.82	2.80	2.18

[a]Weighted by the number of vehicle-miles travelled

public that might become trapped in a release must also be considered.

Impact Area

The impact **distance** is specified by the distance from the transportation accident to a potential effect threshold (e.g., health, environmental contamination, and property damage) caused by a hazardous materials release. The impact **area** is the potential route corridor bounded by the impact distance on each side of the route and by the route segment origin and destination points. The factors identified in the preface must be considered in developing any routing analysis. The following factors are directly related to defining the impact area of a hazardous material release: types of non-radioactive hazardous materials (NRHM), quantity of NRHM released, climatic conditions, and terrain/topography considerations. **Types of materials** differ in their physical, chemical, and toxicological properties. These properties along with the storage/release conditions of temperature and pressure, largely determine the potential for the material to explode, to catch fire, to form a pool or a cloud of vapor, and to disperse as a neutrally buoyant or dense gas. The **quantity released** controls the energy released (i.e., overpressure) from an explosion, the heat generated from a fire involving a flammable pool or vapor cloud, or the toxic concentration contained in a vapor cloud. **Climatic conditions** such as wind speed and direction, atmospheric stability, temperature, and humidity are important components of accident consequence analysis when dealing with hazardous materials that can be dispersed in the air either by being released directly or result from a fire (i.e., toxic combustion products). Generally, low wind speed and stable atmospheric conditions will slow dispersion. Atmospheric stability is a measure of the turbulence and mixing in the atmosphere near the ground and is characterized in a commonly-used scale with A stability as most turbulent and F as least turbulent. Dispersion models or simplified methods incorporate climatic conditions into a calculation of the impact area. **Terrain/topography** can influence the pool size formation and dispersion of hazardous liquids or

Exhibit 5
Sample National Databases

Office of Motor Carrier Safety "Form 50-T" (OMC)--Federal Highway Administration (FWHA). Accident data filed by truck operators and only those carriers who operated interstate from 1973 through March 1993. Database includes data on the frequency and distribution of truck accidents that resulted in a hazardous materials releases, but it cannot be used to obtain reliable estimates of vehicle-miles or ton-miles. OMC can be contacted at (202)366-2971. This reporting system will be replaced by the SAFETYNET system described below.

Hazardous Materials Information System (HMIS)--DOT's Research and Special Programs Division (RSPA)/OHMT. Every hazardous material release during transportation, except those from bulk water transporters and those motor carrier firms doing solely intrastate business, must report to RSPA in writing. To conduct search on HMIS, contact Evelyn Gainey at (202) 366-4555.

Truck Inventory and Use Survey (TIUS)--Bureau of the Census, U.S. Department of Commerce. TIUS is part of the Census of Transportation conducted once every 5 years. A random survey of truck owners indicates the percentage of time that a particular truck is used to carry hazardous materials. The TIUS data can be used to estimate vehicle-miles of travel and ton-miles of hazardous materials shipped and for specific types of trucks.

Commodity Transportation Survey (CTS)--Bureau of the Census, U.S. Department of Commerce. CTS is a survey of transportation modes used by a sample of approximately 16,000 companies to ship specific commodities including hazardous materials. CTS is limited to particular commodities and cannot provide vehicle-miles of travel or ton-miles of cargo shipped.

Highway Statistics--Federal Highway Administration.

SAFETYNET--Bureau of Motor Carrier Safety (BMCS). An integrated Federal-State Data Network system containing uploaded police reports on accidents involving trucks and buses from 20 states. The network should contain driver-vehicle inspection data, carrier census data, safety management audit summary data, and accident report summary data and should be able to generate system reports.

National Accident Sampling System (NASS)--National Highway Traffic Safety Administration (NHTSA), National Center for Statistics and Analysis. The system provides accident data on police-reported accidents, including non-fatal injury and/or property damage. It is a probability sample of all police-reported accidents in the U.S., collected by each State under contractual agreement with NHTSA. Contact NCSA for information on NASS at (202) 266-1603.

Fatal Accident Reporting System (FARS)--National Highway Traffic Safety Administration (NHTSA). FARS contains data on every police-reported traffic accident in the U.S. that results in a fatality. Only about 120 to 150 of these accidents involve vehicles carrying hazardous materials.

General Estimates System (GES)--National Highway Traffic Safety Administration (NHTSA). This system, which has a truck subset, is a probability sample of the nation's police-reported accidents, and is designed for making national accident estimates, not estimates for individual states.

Trucks Involved in Fatal Accidents (TIFA)--Center for National Truck Statistics, University of Michigan's Transportation Research Institute. TIFA is a survey of 12 years of accidents using data elements from the Office of Motor Carriers MCS 50-T form. Beginning with the 1991 accident year, TIFA has added new data elements that provide even greater detail on truck configurations, cargo bodies, and cargoes. For publications, contact Lee Ferris at (313)764-0248.

gases. Usually used in modeling releases, terrain is assigned a numerical surface roughness, which is a measure of the irregularity of terrain over which a cloud passes. Irregularities include mountains, trees, buildings and other structures. Terrain can also affect the severity of accident consequences, e.g., emergency responders cannot reach the accident site to contain and mitigate the spill.

An explosion is expected to cause a similar impact in all directions. In contrast, a toxic vapor cloud will travel in the direction of the wind and be dispersed based largely on the wind speed, atmospheric stability, and topography. Consequently, the impact distance for toxic chemicals may not be equal in all directions from the release point. However, because the wind direction cannot be predicted, the impact area is assumed to extend to an impact distance on either side of the route.

The methods for determining impact distances and areas discussed below, do not apply to route segments that contain a tunnel. A tunnel is a special case. It is a confined space that also confines the results of the hazardous materials release (e.g., fire, explosion or toxic gas dispersion). Appendix C briefly summarizes an approach for determining risk (e.g., accident probability and accident consequences) posed by a tunnel segment.

The following methods can be used to determine impact areas for releases of NRHM.

METHOD 1. A simple but extremely conservative option, is to use a large fixed potential impact distance (e.g., five miles on either side of the route). This option is applicable to routes on which poisonous gas, etc., are being shipped. Explosive, flammable, and most reactive chemicals are not expected to result in such large impact distances.

METHOD 2. A somewhat more detailed treatment of impact area is to assume that the size of the impact area varies based on the type of material released or its hazardous materials class. Hazardous materials classes, as specified by DOT, are groups of specific materials with similar physical or chemical properties. The complexities and costs of performing routing analyses for thousands of individual chemicals and materials, as a practical matter, usually requires some level of generalization about categories of hazardous materials. DOT revised its Hazardous Materials Regulation (49 CFR Par 173, December 21, 1990) changing several hazard classes to ensure consistency with the United Nations Recommendations on the Transport of Dangerous Goods. Consequently, the impact distances in this Guide reflect the new hazardous materials classes. The impact distances (Exhibit 6) are taken directly from the DOT Emergency Response Guidebook (December 1990). The Guidebook specifies evacuation distances for large quantities of explosives and specifies isolation and protective action distances for large spills of other primarily toxic/poisonous chemicals. The isolation and protective action distances are based on modeling large spills of toxic chemicals assuming one set of topography conditions and quantities released (e.g., from one ton cylinder, tank truck, railcar). The distances for various hazmat classes in the 1990 Guidebook vary from 0.2 to 5 miles. The data in Exhibit 6 are from the 1990 DOT ERG because the 1993 ERG was not yet published when this document was being developed. In the 1993 Guidebook, distances were refined and updated for daytime and nighttime releases. The 1993 Guidebook does not include a generic table with distances by hazmat class, but the distances given for specific chemicals range from 0.1 to 7 miles. The 1993 DOT Emergency Response Guidebook should be used when chemical-specific commodity flow information is available on toxic chemicals. If the user knows that toxic chemicals are of greatest concern but does not know the specific toxic chemical with the largest shipment quantity, a default of 5 miles is suggested.

To obtain commodity flow information, the State routing agency may survey fire and police officials and manufacturing and trucking representatives to make judgments about the types and frequencies of hazardous materials

Exhibit 6
Potential Impact Area by Hazardous Materials Placard Class

H.M. Class		Impact Area
Explosives	(EXP)	1.0 mi. (1.6 km) all directions
Flammable Gas	(FL)	0.5 mi. (0.8 km) all directions
Poison Gas*	(PG)	5.0 mi. (8.0 km) all directions
Flammable/Combustible Liquid*	(FCL)	0.5 mi. (0.8 km) all directions
Flammable Solid; Spontaneously Combustible; Dangerous when Wet*	(FS)	0.5 mi. (0.8 km) all directions
Oxidizer/Organic Peroxide*	(OXI)	0.5 mi. (0.8 km) all directions
Poisonous, not gas	(POI)	5.0 mi. (8.0 km) all directions
Corrosive Material*	(COR)	0.5 mi. (0.8 km) all directions

* Consult U.S. DOT 1993 Emergency Response Guidebook (RSPA P 5800.6) for specific chemical impact area or use default value in table. For information about obtaining copies of the Guidebook, call the Hazardous Materials Information Exchange (HMIX) at 1-800-PLANFOR or 1-800-367-9592 in Illinois.

shipments. Information also may be available from a local Emergency Planning Committee (LEPC) or a State Emergency Response Commission (SERC), established under the Emergency Planning and Community Right-to-Know Act as Title III of the Superfund Amendments and Reauthorization Act (SARA).

Another approach to determining what hazardous materials are shipped in the area is to examine accident data compiled by DOT. This approach assumes that all hazardous materials shipments have similar likelihoods of being involved in accidents; therefore, accident frequencies are an acceptable surrogate for the level of exposure or frequency of commodity movements. The distribution of hazardous materials accidents by class may be compiled at the city or State level by consulting the RSPA hazardous materials incident database.[7]

The choice of hazardous materials class to be analyzed may be based on a determination of which commodities are most commonly transported in the area. Another approach might be to chose a somewhat less frequently transported material that has a potentially larger impact area. The overall route risk could be greater for these less frequent, but higher impact hazardous materials (e.g., poison gas). Another approach might be to select hazardous materials for analysis that reflect the community's concerns about emergency planning.

METHOD 3. For a more site-specific or refined determination of impact areas, computer models can effectively incorporate site-specific climatic conditions, release quantities, hazardous materials types, and topography into modeling the release, explosion, or dispersion of hazardous materials. Chemical and site-specific computer modeling can help differentiate the impact areas for chemicals in the same hazard class, by accounting for the range of chemical properties/storage conditions, by accounting for hazardous materials that behave as a dense gases versus neutrally buoyant gases, and by accounting for various levels of toxicity for chemicals in the same hazardous materials class. Computer modeling requires data or assumptions about the hazardous material, the release conditions, and a working knowledge of the appropriate model to use. Many models are publicly available and relatively easy to use. The models and tools identified in Exhibit 7 and further guidance in Exhibit 8 can assist in conducting part or all of a consequence analysis.

Population Exposed

Exposed population is a key factor in determining the consequences of a release of a hazardous material, in estimating risk, and in designating routes for hazardous materials transport. Also, the rule specifies that the exposed population should be estimated. Therefore, special efforts should be taken to develop reliable and well-constructed population estimates. The population potentially exposed to a hazardous materials release may be estimated from the density of residents, employees, motorists, or a combination of these three variables. Population data from the U.S. Department of Commerce, Bureau of Census should be used to determine resident populations. Census data and tract maps show tract boundaries in Standard Metropolitan Statistical Areas (SMSA) and are available in most States through State census offices or through the U.S. Bureau of Census. Census data should be provided in a convenient form (e.g., maps, disks) to conduct an analysis of exposed population.

The four steps to determine residential population consequences are:

Step 1. Compile Census Tract Maps, Identify Routes, and Mark Off Impact Zone.

As only the boundaries of the census tracts are shown on these maps, it may be necessary to draw in portions of the alternative hazardous materials routes. After each alternative route is identified, the zone of potential impact is delineated on the tract maps by scaling the impact radius to the census tract map scale and drawing two parallel lines on each side of the roadway at this scaled distance. The area within the parallel lines can then be segmented according to the route segmentation.

Step 2: Measure Share of Census Tract Which Falls Within Impact Zone.

With the exception of census tracks lying wholly within the impact zone, it is necessary to measure or estimate the amount (or percentage) of each tract that falls within the impact zone boundaries. The amount of the tract within the zone is then multiplied by the total tract population to estimate the number of people in each tract that live within the potential impact area. This approach assumes that the population within each census tract is evenly distributed – an assumption that can be refined with local knowledge.

There are two methods to determine what percentage of a tract lies within the impact zone boundaries: estimation and measurement. The level of precision desired for the alternatives analysis will indicate which technique is appropriate. Measurements may be made with a planimeter, a small drafting instrument that measures area maps, or by overlaying a grid of small squares and counting those that lie within and outside of the impact area.

Step 3. Look Up Tract Populations and Determine Total Population Within Impact Zone.

The population from each tract can be obtained from the U.S. Census Bureau data or from State census bureaus. The product of the tract population and the percent of tract in an impact area equals the population in the impact area in that tract. Summing all of the different tract populations in the impact area gives the total population in the impact area.

Exhibit 7
Sample Models/Tools for Consequence Analysis

Model/Tool	Description/Capability
WHAZAN	Determines impact area from modeling of release and dispersion of toxic chemicals and the explosion and fire from flammable chemicals; accounts for weather conditions, topography, release quantity, the specific chemical released, the fraction flashed and explosive yield, and the exposure dose. Model is commercially available from the World Bank or Technica International.
ALOHA/CAMEO	Determines impact area from modeling of release and dispersion of toxic chemicals; accounts for weather conditions, topography, release quantity, the specific chemical released, buoyant and dense gas algorithms, and exposure dose; produce plume maps. ALOHA is distributed by the National Safety Council, Washington D.C. at (202)293-2270.
SLAB	Determines impact area from modeling of release and dispersion of toxic chemicals; accounts for weather conditions, topography, release quantity, the specific chemical released, and exposure dose. Computer code and users' manual can be obtained upon request from Donald Ermak, L-216, Atmospheric and Geophysical Sciences Division, Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94550.
HGSYSTEM	Determines impact area from modeling of release and dispersion of toxic chemicals; accounts for weather conditions, topography, release quantity, the specific chemical released, and exposure dose; specialized in complex release characteristics of hydrogen fluoride. Model requires extensive experience and is commercially available from the Industrial Cooperative HF Mitigation/Assessment Program.
ARCHIE	Determines impact area from modeling of release and dispersion of toxic chemicals and the explosion and fire from flammable chemicals; accounts for weather conditions, topography, release quantity, the specific chemical released, and exposure dose; over 12 different algorithms that model different release type scenarios (e.g., pressurized liquid, pressurized gas from pipeline, non-pressurized spherical tank of liquid); assumes neutrally buoyant plumes. The model is publicly available from ARCHIE Support (DHM-51/Room 8104), Office of Hazardous Materials Transportation, Research and Special Programs Administration, U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590.
Du Pont Safer	Determines impact area from modeling of release and dispersion of toxic chemicals; accounts for weather conditions, topography, release quantity, the specific chemical released, and probit equations to determine probable fatalities. Model is commercially available from Du Pont.

Exhibit 8
Additional Guidance for Consequence Analysis

Guidance on the Application of Refined Dispersion Models for Air Toxics Releases, U.S. Environmental Protection Agency, March 1991, Document Number: EPA-450/4-91-007. Provides guidance on input considerations and describes applications to dense gas models (e.g., DEGADIS, SLAB, and HEGADAS) and non-dense gas models (e.g., AFTOX). Available through NTIS as Doc # EPA-450/4-91-007.

A Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants, U.S. Environmental Protection Agency, September 1988, Document Number: EPA-450/4-88-009. Provides a logical approach to the selection of appropriate screening techniques for estimating ambient concentrations due to various toxic/hazardous pollutant releases. Available through NTIS as Document Number: EPA-450/4-88-009.

Technical Guidance for Hazards Analysis, U.S. EPA, FEMA, and U.S. DOT, December 1987, Document Number 519-501/63067, describes a methodology and provides equations and tables for screening possible airborne releases of extremely hazardous substances based on accident scenarios developed by local planners. Contact EPCRA Hotline at (800)535-0202 to obtain free copy. Available through NTIS as Document Number: 519-501/63067.

Guidelines for Chemical Process Quantitative Risk Analysis, American Institute of Chemical Engineers.

Guidelines for Use of Vapor Cloud Dispersion Models, American Institute of Chemical Engineers.

Handbook of Chemical Hazards Analysis Procedures, FEMA, EPA, and DOT, 1988. Addresses hazards analysis and introduces ARCHIE computer software; more specifically, chapters 10 and 11 offer extensive information to aid you in assessing rail, highway, water, and pipeline transportation. You can obtain free copy by writing the FEMA Publications Office, 500 C St. SW, Washington, DC 20472, or by contacting the EPCRA Hotline at (800)535-0202.

Step 4. Calculate Population Per Mile Within the Impact Area for Each Route Segment.

The population density per mile within the impact area is determined by dividing the total impact area population for each segment by the segment length.

This method approximates the impact area and, therefore, the population exposed to the hazardous materials release. This method, however, has several limitations. It assumes that the population within each impact zone is homogeneous throughout. In fact, at any point along the road segment, the immediate area around a release or the impact area itself (assumed to be a circle) may contain a population center which may not be contained in an immediate exposure area only a short distance away. However, proper segmentation, considering a number of factors including significant population differences along the route, will help minimize this limitation. Because the segmentation of the impact area is drawn with a straight line, the method does not account for the circular curvature of the impact area near the end of a segmentation area. In addition, because of this straight line segmentation, the method may under- and over-count population for routes that have large curvature at the segmentation points. These limitations have been addressed through new approaches and methodologies.[8]

The Routing Rule also specifies that the population estimate should consider the amount of time during which an area will experience a heavy population density, any employees, motorists, and other persons in the area, and any special populations. The above estimate of exposed residential population does not consider changes in population by time of day or in terms of the movement of commuters from home to workplace. The planner has the option of refining the consequence analysis using local data to incorporate daytime/nighttime population shifts. A hazardous materials routing study in Cleveland approximated daytime household population as the sum of the population over age 65, plus twice the population under age six. The population under age six was multiplied by two based on the assumption that there was at least one caretaker for each child. Other techniques, including rush-hour traffic flow patterns, are possible.[9] To better determine the number of people who may be in an impact area because of work, a State park and planning commission, a local fire department, the area chamber of commerce, or the Census of Manufacturers might be able to provide office/commercial occupancy numbers. Also, the number of motorists in an impact area will not be accounted for with residential census data and therefore motorist exposure should be considered in situations where it is likely to be most critical: congested highways, depressed highways, bridges, and elevated structures. A State department of transportation or police department should have the information on the peak and off-peak number of vehicles on the roads in impact areas. Special populations such as schools, hospitals, prisons, and senior citizen homes should also be considered in some manner when determining the potential risk to the populations along a highway routing. Further guidance on considering special populations is presented in Section IV.

If census data are unavailable, the planner can use alternate data sources. Relative population risk could be calculated by multiplying the probability of an accident by a less accurate measure of population density (e.g., county or city population density data).

RISK CALCULATION

Risk for each route alternative is determined by summing the risk over each route segment. It is important to use the same type of data and calculations consistently throughout the risk estimation process. The risk for each route segment is determined by multiplying the probability of an accident times the population density along that segment exposed to the hazards created by the release. Remember that the risk calculated using the methods in this Guide provides the relative risk among routes. The estimation is not an absolute measure of risk, nor does it have any mathematical value.

However, relative risk can be used as the basis for selecting among alternative routes if the differences in risk are significant. If the difference in risk is not significant, other factors should be used to select one route versus another.

The question of significance is a complex matter. Uncertainties or biases in the data can be propagated in the calculation of risk. For example, the Toronto Area Rail Task Force contended that some of their estimates of risk were most likely high by a factor of 3 due to biasing assumptions to the worst case.[10]

Determining confidence in the risk values involves the use of statistical methods to assess the uncertainty of the data used and to determine the sensitivity of the input variables on the risk value.[11,12] Unless these statistical methods are used and a clearly better route alternative is identified, other factors should be considered. Before assessing the other factors discussed in Section IV, it is useful to apply the through routing criteria (Section II, Exhibit 2) and determine which routes do not require further analysis.

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SECTION IV

ADDITIONAL ANALYSES

Section IV discusses the following Standards and Factors:

Standards	Factors
✓enhancement of safety	✓population density
public participation	type of highway
consultation with others	✓types and quantities of NRHM
through highway routing	✓emergency response capabilities
✓burden on commerce	results of consultation
reasonable routes to terminals and other facilities	✓exposure and other risk factors
reasonable time to reach agreement between affected states or Indian tribes	✓terrain considerations
timely responsibility for local compliance	continuity of routes
	✓effects on commerce
	✓alternative routes
	✓delays in transportation
	✓climatic conditions
	✓congestion and accident history

Even when the relative risk values using the above methods yield an obviously "safer" route based on risk, the planner should also consider additional analyses, both quantitative and qualitative, considering several other factors to further assist in the routing designation. These analyses include exposure and other risk factors (i.e., special populations and sensitive environments), emergency response capabilities, burden on commerce, congestion/traffic delays, and property along a route (optional). Where possible and appropriate, these additional analyses have been quantified for consistency of application; otherwise this Guide discusses ways for a planner to consider these factors and apply them in designating routes. For routes with tunnels, consideration of some of these factors is discussed in Appendix C.

EXPOSURE AND OTHER RISK FACTORS - SPECIAL POPULATIONS

Special populations are groups that may be particularly sensitive to hazardous materials releases, may be difficult to evacuate, are highly concentrated, or are outdoors. Examples of special populations include schools, hospitals, and senior citizens homes, shopping centers, sports stadia, parks, outdoor theaters, and golf courses. Depending on the hazardous materials of interest to the community, the planner may choose to focus on the potential exposure of outdoor populations to a hazardous materials release.

METHOD 1. Special populations may be dealt with in a subjective, non-quantitative way. The planner may develop map overlays of special populations (e.g., schools, nursing homes, shopping malls) for each alternative, as a way to visually compare the potential consequences of a release. A Dallas-Ft. Worth study used this method to ensure consistent application of secondary factors. [13]

METHOD 2. Using USGS, State, or county level planning maps, count the number of special populations along the route (e.g., one hospital counts as one "point"). Then sum the numbers for each alternative route and compare.

METHOD 3. School enrollment figures, stadia capacity, or parking lot spaces in shopping malls, could be used to estimate population concentration shifts. The total population change could be added or subtracted to the population factor in the accident consequence analysis. Another possible way to incorporate population concentration shifts is to consider estimates of special population shifts along a route as a separate, secondary population count, which would be compared to the shifts in special population along the other routing alternatives.

EXPOSURE AND OTHER RISK FACTORS - SENSITIVE ENVIRONMENTS

A list of sensitive environments that the State routing agency may want to consider is given in Exhibit 9. This list has been compiled from the Transport Canada document and the EPA Hazard Ranking System final rule. The types of sensitive environments found along a route segment can be determined from a variety of sources, and the level of effort applied to locating sensitive environments is an area where the State routing agency can exercise discretion. More information on the types of sources to use for locating sensitive environments is provided in Step 2, below. In the methodology presented, equal weighting is given to all environments that are identified. However, the State routing agency may decide to give added consideration to certain types of environments on a case-by-case basis (e.g., areas that are known to be used by a threatened or endangered species that has a very limited range).

The impact of a hazardous materials accident on a particular sensitive environment will vary with the type of hazard and the topography of the area. In addition to the type of hazard and the presence of sensitive environments of concern, the State planner will also need to consider the likelihood of exposure and subsequent adverse effects. The methodology below accounts for the distance over which the threat of a given hazard is likely to occur by selection of an appropriate impact area. Other terrain or route characteristics (e.g., presence of drainage ditches) could be factored into the calculations at the discretion of the State routing agency.

Step 1. Determine the potential impact area.

Refer to Section III for the methodology used to determine the impact area. Generally, the distance used should be the same as that used in the calculation of "population exposed."

Step 2. Identify sensitive environments within the impact area.

Using the distance selected for the impact area, compare a road map showing the route segments with specialized maps or aerial photographs that can be used to establish the presence of sensitive environments. USGS quad maps are usually excellent starting places because many types of sensitive environments are clearly delineated. Specialized maps such as wetland maps and habitat maps (that specify habitats of threatened and endangered species) can also be useful. Specialized maps or other documents can often be obtained from State agencies such as departments of natural resources, State fish and wildlife offices, or State offices of geology. A more detailed approach could include consultation with, or even visual inspection by, someone with professional expertise (e.g. local or State wildlife agency, environmental group, ecologist). The State routing agency can elect to identify all of the types of environments listed in Exhibit 9 or only a subset of those environments. It is important, however, that the same information be collected for all routes under consideration. If, for example, a local wildlife club provides detailed information about endangered species along one route, efforts must be made to obtain information containing the same level of detail for all other routes.

Step 3. Measure the area of each type of sensitive environment within the impact area and sum to determine the total area.

Several different methods could be employed to measure area. For example, a planimeter could be used to trace the area of each environment type along the route segment. Area could also be estimated by overlaying a grid (drawn to the same scale as the map and copied onto a transparency) on the map and counting and summing the "squares" of each environment type. If all environments included in the inspection are to be considered equally, the total area for each type can simply be summed. If certain environments are to be given extra consideration, additional calculations (e.g., use of a multiplier) may be necessary prior to determining the total. The decision to weight certain environments is at the discretion of the State routing agency and may involve qualitative reasoning in addition to quantitative.

In general, it is only necessary to consider the environments that are inside the impact area. However, the presence of a river or other vector that a hazardous material could enter (and be carried away to a greater distance than that established by the impact area) in the vicinity of the route may provide a justification for either extending the impact area and including additional acreage or for multiplying the acreage within the impact area by a multiplier, thus, increasing its relative contribution.

Exhibit 9
Sample Sensitive Environments

Water Sources	Natural Areas
Lakes	Wetlands
Tidal flats & estuaries	Sensitive and/or unique vegetation
Marine deep water	Special or unique habitat
Rivers/major tributaries	Wildlife breeding, nesting, or denning areas
Sloughs	Critical habitat for threatened or endangered species
Tributaries (streams, creeks)	Federal wilderness area
Aquifers (groundwater)	Marine sanctuaries
Coastal zone management area	National/state wildlife refuge
	National/state management area
	National/state park
	National preserve
	Public lands
	Migratory pathway (water)
	Spawning areas
	Barrier islands
	Recreation areas (lakeshore, river, seashore)

Step 4. Multiply the total sensitive environment area within each route segment by the appropriate accident rate, and sum to determine relative route sensitive environment risk.

This step will result in an estimation of the relative risk to sensitive environments potentially vulnerable after a hazardous materials accident for each route alternative. As in the calculation for population exposed, the estimation is not an absolute measure of risk and has no mathematical value, however, it provides a relative risk measure among the route alternatives.

The relative risk to sensitive environments can be used in part as the basis for selection of a preferred route. If the difference in relative risk between the routes under consideration is large and/or the State routing agency has determined that consideration of sensitive environments is a high priority for the area in question, then the sensitive environment evaluation will carry additional weight in the final decision-making for preferred route selection.

EMERGENCY RESPONSE CAPABILITIES

Emergency response capabilities can be a critical consideration in evaluating the consequences of a highway accident involving the release of hazardous materials. The major elements to be considered in assessing response capabilities include the availability of equipment, materials, and adequately trained personnel, their proximity to potentially affected impact areas along a highway route, and the availability of accurate and complete information on the materials at the scene of an accident. Additional information on emergency response capabilities can be found in Appendix D.

Consideration of Emergency Response Capabilities in Routing Analyses

At this time FHWA has decided to recommend that States determine the number of properly trained and equipped firefighting units within a 10-minute response window from any point along a highway route under analysis to include consideration of the effects of emergency response capabilities on mitigating the consequences of hazardous materials incidents. Care should be given to identifying some minimum training requirements in hazardous materials management for members of a unit (e.g., 8 hours of training at the Emmittsburg, MD National Fire Academy) as well as equipment and materials available to respond to hazardous materials incidents (e.g., personal protective equipment (PPE), communications, environmental monitoring, firefighting, sorbents, construction equipment, chemical agents, containment devices, first-aid equipment). It may also be important to assess the level of planning and preparedness at the local level as an important indicator of the vulnerability of a community to the consequences of a hazardous materials incident.

These considerations may be assigned numerical values and/or weights to use in the routing risk analysis, especially in those cases where the risk values do not indicate one clear choice of route over another solely on the basis of risk. For example, response capability may be expressed as:

$$\textit{Response Capability} = \frac{\textit{Response Units Within 10 Minutes}}{\textit{Route Length}}$$

The resulting Response Capability value may be made smaller or larger by considering such things as whether or not a firefighting unit has personnel who have had at least 8 hours of hazardous materials fire training, or has sufficient self-contained breathing apparatus for each unit member facing potentially hazardous atmospheres, or has appropriate foam application equipment for fires involving flammable materials. In other words, the consideration should include some measure of whether the available response capability along the route has the requisite level of hazardous materials training, the range of equipment and materials on-hand, and the level of planning and preparedness within communities along the route to mitigate the consequences of a highway incident.

Rather than incorporating response capability as a quantitative mitigation factor into the risk analysis equation at this point, FHWA recommends that States use this factor as a qualitative consideration in assessing the relative risk of two highway route alternatives when no clearly superior route is identified on the basis of the population risk analysis. The additional considerations identified above can be used to further refine the consideration of response capability as an additional factor.

BURDEN ON COMMERCE

Understanding and evaluating the likelihood of burden on commerce is an intrinsic part of the selection process, but not one that requires any additional steps or actions. If steps in the Guide are followed, burden on commerce should not become an issue. At the same time, the legal ramifications necessitate some awareness of this aspect as each route is considered. In the event that the selected route is perceived to create an unreasonable burden on commerce (e.g., by an affected party such as a hazardous materials shipper), a petition may be filed with DOT, who has the authority to issue a waiver of preemption. This Guide will provide some background information on the requirement; a general understanding of burden on commerce and its legal/regulatory basis should assist in considering impacts when designating routes.

Sections 397.71(b)(5) and (9)(x) of the Rule State that any routing designation selected by an agency may not create an "unreasonable burden on commerce." This term is not defined in the Rule and is therefore subject to interpretation on a case-by-case basis. DOT preemption determinations and related court decisions provide some guidance on interpreting "unreasonable burden"; future cases may further clarify this issue. In evaluating a petition for a waiver of preemption there are four factors that DOT must examine:

- increased costs and impairment of efficiency,
- whether there is a "rational" basis for the ordinance,
- whether the ordinance achieves its goals, and
- the need for uniformity in implementing HM-164.

These factors are listed in 49 CFR 107.221, and are derived from the Commerce Clause cases. The Commerce Clause of the U.S. Constitution prohibits States from erecting barriers to the free flow of interstate commerce. Three cases involving constitutional challenges to State laws that restricted the operation of transport vehicles within a State established the basis for the factors. In general, the courts have used qualitative rather than quantitative reasoning as a basis for decisions.

It is likely that a State routing agency will have to consider State and local prohibitions on hazardous materials (e.g., for roadways, tunnels) that are already in place for each route alternative. The basis for any restrictions may need to be researched and potentially re-evaluated because they too may become the subject of legal challenge on an otherwise acceptable route.

If representatives of shipping industries are involved during the route selection process, "unreasonably burdensome" routes may be eliminated early on. During the public comment period, the selection committee should specifically request comments on whether selected routes are perceived to pose an unreasonable burden on commerce. These comments should be reviewed carefully and addressed with the guidance of legal counsel.

CONGESTION/TRANSPORTATION DELAYS

Highway congestion is typically associated with level of service (LOS) C through E, where LOS is a qualitative measure that incorporates the collective factors of speed, travel time, traffic interruptions, freedom to maneuver, safety, driving comfort, and convenience, and operating costs provided by a highway facility under a particular traffic volume. Congestion has a strong influence on accident rates because of the increase in multi-vehicle conflicts due to stop-and-go operations and extensive lane change operations at short headways. Based on data from California, Illinois, and Michigan, the highest probability of releasing accidents, other than collisions with trains, were non-collision, single vehicle types. Single vehicle accidents typically result from one of two scenarios:

- There is relatively little congestion and driver speeds are primarily determined by the individual driver and not by surrounding vehicles. An accident occurs when an individual driver travels too fast for the design speed of the roadway and/or the environmental conditions present.
- There is congestion. Drivers trying to avoid a multiple-vehicle collision take actions to avoid hitting other vehicles and end up leaving the roadway.

Because single vehicle accidents frequently result in releasing accidents (i.e., hazardous materials escape from the vehicle and applicable packaging), traffic congestion appears to be an important factor in determining not only accident frequency but also accident severity.

Congestion also can affect the consequences of a release. If the arrival time increases and access of emergency responders to a location following a releasing hazardous material accident is limited, the consequences may be more severe than in the absence of congestion. In addition, with more congestion the exposure to motorists increases in the vicinity of an accident, parallel to and approaching the accident location in opposite lanes and on nearby roads outside the highway's right-of-way.

Delays in transportation are an important consideration in evaluating routing alternatives because the longer an NRHM shipment is in the traffic flow, the greater are its chances of being involved in an accident that may result in a release. Delays can be caused by congestion on certain route segments at certain times of day or night; they may be a function of the maximum safe posted speed for a route. Delays may be avoided by imposing time of day restrictions for certain routes or segments, selecting Interstate travel whenever possible to maximize safe driving speeds, selecting minimum time in transit routes, and considering single transport modes, as appropriate. In considering alternate routing it is important to maximize safety while minimizing delays to the extent that routes are technically and economically feasible.

When an incident occurs on a highway, the roadway's remaining capacity may be reduced below the demand volume. Under these conditions, measure of congestion is average delay per incident in vehicle-hours. This delay can be estimated using one of the following methods.

METHOD 1. A simple but conservative option makes use of such knowledge about a route's interchange spacing on freeway type facilities or major crossroad spacings on non-freeway main roads. It involves the following three steps:

Step 1. <u>Identify maximum queue length for each route segment</u>.

It is assumed that the maximum delay along a route segment will occur between adjacent access points which are farthest apart. If traffic queues back to an interchange or major crossroad (which it will over a very short time period when all lanes are closed regardless of traffic demand), it is speculated that **all** drivers beyond this point will exit the route to find another route to their destination. Therefore, in this method, users are encouraged to select the longest interchange or major crossroad spacing to calculate segment delay. This procedure assumes that the number of lanes within the segment never changes. If they do, users should then select the longest interchange or major crossroad spacing within the segment where the maximum number of single-direction lanes occur.

The spacings determined above are the maximum queue lengths for each route segment regardless of where a hazmat accident occurs within a segment. This is true because of two assumptions: 1) all vehicles downstream of the accident clear the roadway, and 2) traffic in both directions is impacted by the hazmat release.

Step 2. Determine incident duration.

This time interval includes two elements: the time it takes the emergency response personnel to get to the hazmat accident scene, and the time it takes them to clean up the area such that traffic can again use the roadway.

The first time element is assumed to be 10 minutes. The second time element should be based on the hazardous materials selected for analysis in determining the consequences of an accident. Local emergency response teams should be asked to provide their best estimate of the time it typically takes them to remove the hazardous material once they have arrive on scene. The sum of these two times is the incident duration time.

Step 3. Determine vehicle length.

Vehicle length is needed to determine how many vehicles would be in the maximum queue length identified in Step 1. A user has two options: assume all vehicles are passenger cars which maximizes the number of vehicles delayed, or use the traffic composition travelling each route. The first option is easier because the user can use an estimated length of 30 feet per vehicle; 19 feet for the normal mean length of passenger car plus 11 feet headway to the vehicle ahead. Assuming all vehicles are passenger cars increases the estimated number of delayed vehicles against a typically greater value of time assigned to trucks than to passenger cars.

The second option requires determining the traffic composition along each alternative route and selecting a representative length or assuming a standard composition and selecting a representative length for each vehicle type. Although highway agencies usually have a roadway's traffic volume and composition, users may wish to simplify matters by using the following typical composition and vehicle length:

Vehicle Type	Percentage[14]	Length (ft)[15]
cars	76	30
single unit	9	45
combination	15	85
Weighted composite	100	40

The lengths for the two truck types are composite figures; single unit trucks and busses typically 30 and 40 feet in length, respectively, and combination trucks ranging from 50 to 118 feet in length. The longer lengths are for trucks with more than a single trailer.

Step 4. Calculate delay.

Delay, in vehicle-hours, is the product of distance in feet (Step 1), time in hours (Step 2), and the number of single-direction lanes divided by the vehicle length (Step 3) in feet per vehicle. This calculated delay assumes the probability of a hazmat accident is 100% Since this is not the case, the delay must be multiplied by the accident probability.

METHOD 2. A second method for estimating delay uses a PC-based model developed by Juan Morales. This model, called DELAY (*Version 1.0*), is available from McTrans at the University of Florida Transportation Research Center

[(904) 392-0378]. The model employs an interactive spreadsheet for use with LOTUS 1-2-3 on an IBM-compatible microcomputer with at least 128k of memory.

The model should only be used where at least one of the route segment's lanes will still be open to traffic. If there is not at least some traffic discharge downstream, the model would provide unreasonable answers. Under light freeway traffic demand conditions exhibited by LOS A, which is less than 13 vehicles per lane per mile, it would take only approximately 13.5 minutes to back up traffic one mile. Because most hazmat accidents take hours to clean up, the model could easily predict queue lengths extending tens of miles long. In these distances, drivers are likely to exit the roadway and find a different route.

The Morales model calculates delay as a function of three variables: remaining capacity, traffic demand, and incident duration. Although this model is directed at freeways, it can also be used for other rural multi-lane arterials and 2-lane highways if one assumes there are no nearby, parallel routes for traffic diversion. Since urban areas typically offer more possible route diversions to get around a hazmat accident, the model is not recommended for use on non-freeway urban streets and arterials.

There are five steps to determine delay on freeways and other rural roadways using the Morales model. The first four must be performed for each segment within a route. The five steps are:

Step 1. Determine the segment's capacity, S_1, and bottleneck, S_3, flow rates in vehicles per hour.

Average volumes based on historic data can be used. Exhibit 10 presents typical capacity and bottleneck flow rates for both in-lane and shoulder incidents for freeways with two, three, and four lanes in one direction. In this case, where the user must assume some lane or lanes will remain open, the user must determine the number of lanes to be assumed left open. This will depend on the hazardous material in the analysis. If all lanes will be closed, the user must employ **METHOD 1** or 3.

Step 2. Determine a segment's demand flow rate, S_2, in vehicles per hour.

Since population density considerations must include the amount of time an area will experience a heavy population density, a high traffic condition should also be evaluated. Specifically, the 30th highest hourly traffic volume in a year (typically selected as a roadway's design hourly volume) be used as the demand flow rate. This is normally 15 percent of the ADT on main rural highways and 11 percent for urban facilities.[16] ADT values on any given route are usually available from local and State highway agencies.

Step 3. Determine incident duration, T_1, in minutes.

Perform as in Step 2. for **METHOD 1.**

Step 4. Calculate segment delay.

A segment's delay can now be calculated using values for S_1, S_2, S_3, and T_1 as input to Morales computer model. The model calculates the average delay per incident in vehicle-hours. Although the model also allows for use of revised demand, adjusted bottleneck flow rates, and incident durations under the adjusted flow, they are not required here as we are assuming simple blockage (with at least one lane open), no changes in demand, and no changes in bottleneck discharge rates (i.e., no additional lanes are opened until the incident is entirely cleared). As for **METHOD 1**, the delay values must be multiplied by the accident probability.

Step 5. Calculate alternative route delay.

Steps 1-4 are repeated for each route segment within an alternative route. Once these are computed, they must be summed to obtain the total route delay.

METHOD 3. Both the preceding methods have limitations, For example, neither method assumes any traffic diversion from the alternate route and considers no delay to off-route traffic. In urban areas, there will be nearby roads and streets. Traffic may have to be restricted on such routes for up to five miles distance from the alternate route.

If funds and staffing permit, traffic delays can be analyzed in more depth using FHWA's TRAF integrated simulated system. TRAF's operating system generates a simulation program tailored to user needs. Five models are incorporated into TRAF; two (microscopic and macroscopic) for urban networks (NETSIM and NETFLOW) and freeways (FRESIM and FREFLOW), and a single microscopic one for two-lane roads (ROADSIM). All of these models quantitatively predict traffic effects as a function of new geometry, traffic control techniques, and incidents. Contact FHWA's Intelligent Vehicle/Highway Systems Research Division [(703) 285-2031] to obtain additional information.

One component of the determination of burden on commerce is increased costs due to delay. The calculation of the cost of delay would be fairly straightforward: 1) Determine the length of each route, 2) determine the number of expected hazmat vehicles on that route, 3) obtain mileage operating costs for large trucks, 4) multiply items 1), 2), and 3) to obtain total operational cost for each route, 5) calculate expected travel time on each route using speed data available by route type, 6) calculate driver labor costs for each route by multiplying items 2) and 5) and typical driver hourly rates, and 7) sum items 4) and 6) to obtain total cost by route for comparison.

PROPERTY RISK CALCULATION (OPTIONAL)

Property exposed following a hazardous materials accident may include private property (e.g., houses) and commercial developments, as well as roadway structures (e.g., bridges, overpasses). Evaluating property at risk as part of the routing selection process is not required by the Routing Rule, and it is the judgment of the State planner (or the community) whether to include this as a criterion for route selection. However, it may be a useful tool for differentiating routes that have similar population risks. The decision to use potentially exposed property in the routing analysis and its weight as a criterion are likely to be influenced by the extent of available resources. To that end, this Guide presents several options for determining specific inputs into the overall analysis.

Two different property types can be included in the property inventory: structures on the roadway (e.g., bridges, tunnels, and overpasses) and lineal frontage of buildings adjacent to the roadway. The State planner can decide to include only one or both types of property in the analysis. Unlike the population inventory, in which impacts are estimated for an area, the study confines estimates of potential property damage to the right-of-way and its immediate environs. This approach was adopted largely because of a lack of historical data for developing impact radii for potential hazardous materials property damage. Also, for many classes of NRHM (e.g., explosives) much of the property damage will be concentrated on buildings adjacent to a roadway, which in turn, act as buffers for the ones behind them. Scarcity of data also precludes differentiating potential impacts among the hazardous materials classes in any more than a cursory fashion.

Exhibit 10
Typical Capacity and Bottleneck Flow Rates

Number of Lanes in One Direction	Freeway Capacity (S_1)	Bottleneck Capacity (S_3) One Lane Blocked (S_3)	Shoulder Blocked (S_3)
2	3,700	1,300	3,000
3	5,550	2,700	4,600
4	7,400	4,300	6,300

Source: "Analytical Procedures for Estimating Freeway Traffic Congestion," Morales, Juan M., *Public Roads*, Vol. 50, No. 2, September, 1986.

The overall estimation of the value of potentially exposed property includes five steps detailed below. Steps 1-3 are used if the land-use value adjacent to the roadway is being analyzed; step 4 is used if roadway structure's values are being included; step 5 is used for both analyses. Within several of the steps, alternate methods are described which depend on differing levels of data that may be available.

Step 1. Select an Appropriate Multiplier or Estimate the Dollar Value Per Lineal Foot of Frontage.

OPTION 1. Exhibit 11 presents multipliers based on the building replacement costs for different land-use types.

OPTION 2. A more detailed analysis would use State-wide data, assuming that they are available or can be obtained without too much difficulty. This method incorporates dollar/foot estimates of State-specific average land-use values in place of the multipliers. Because the results will be in dollars, they may have more meaning than relative weights. When determining the State land-use values, the available land-use type categories may differ from those in the table above. For example, it may not be possible to differentiate between institutional and commercial values, or a State may organize its residential values into fewer (or more) categories. It is important to define the land-use categories that data are available for before continuing with Step 2.

OPTION 3. The third option uses the same approach as the second, however, local land-use data (e.g., county data obtained from tax assessors) for property along the route are used in place of State-wide average data. This would reflect the most accurate land-use values, but would require the greatest level of effort to complete.

Step 2. Measure Lineal Frontage for Each Land-use Type Along the Route.

This can be done in two ways: (1) obtain land-use maps (from city, county, or regional planning agencies) and use a planimeter to trace each route segment to estimate the amount of each land-use type or (2) actually drive along the route and use an odometer to measure the amounts of each land-use type in each route segment that fronts the road (this option would obviously require more resources in terms of time and necessary staff). Exhibit 11 contains a number of land-use types and because State-specific data may be grouped according to slightly different definitions, it may be necessary to consider compatibility of the categories. In most cases, not all land-use types given in the chart will be found along each route.

Step 3. Multiply Lineal Frontage of Each Land-use Type by the Associated Weighted Factor or Value Per Lineal Foot and Add Together the Property Values for Each Land-use Type.

After total linear footage for each land-use type is measured, multiply the totals by the associated value for each land-use type and sum. This represents a weighted factor or total cost for the property along the route segment.

Step 4. Estimate the Value of Roadway Structures.

The existence and location of roadway structures (e.g., bridges, tunnels, underpasses, and overpasses) can be determined using maps, but speaking to officials in communities along the routes or actually driving along the routes would ensure greater accuracy. Special properties such as communication and power utilities directly adjacent to the roadway could also be considered in this step, and their values can be ascertained by contacting the facilities directly.

OPTION 1. This option makes use of the regional cost per square foot data shown in Exhibit 12. The methodology requires driving each alternative route and recording each structure type and its square footage (width times length). This is for **common** type structures. **Non-common** structures would be high-cost facilities such as tunnels and long suspension bridges. Costs for these non-common structures should be handled as described in **OPTION 2.**

For common structures, determine their length and width either by direct measurement of by estimating these dimensions. A structure's length may be estimated by using a vehicle's odometer readings at the beginning and end of the structure. The width may be estimated by multiplying the number of lanes times 12 and adding 24 feet to accommodate shoulder widths and lateral clearances to accommodate bridgerails and guardrails.

These width and length dimensions should always be obtained by driving on the structure. Where the alternative route is an underpass, the recorder would have to exit the alternative route and obtain the needed measurements by driving over the crossroad structure (upper part of the overpass).

Summation of each structures cross-sectional area multiplied by the cost value in Exhibit 12 then yields the value of a route's common structures. The cost of non-common structures, obtained using **OPTION 2**, must then be added to obtain a route's total structure cost.

OPTION 2. This method makes use of a State's bridge inventory. States typically have this type of inventory that lists each bridge, the route where it is located, and what crosses over or under (e.g., creek, lake, route), the year it was built, its length (often by span), and type of structure (e.g., steel beam, concrete box girder, brick arch, stone arch, prestressed concrete).

Average costs for building the most recent 1-3 bridges of each type should be sought from local authorities responsible for planning, designing, and building the structures. Such costs are typically available from the design element in any highway department. These average costs should be pegged to an average year in which the structures were built; i.e., if the latest three prestressed concrete bridges were built in 1988, 1990, and 1992, assume their composite average cost is for the year 1990. The dollar value of each structure can then be obtained by using the average cost for a similar structure and adjusting it using to present prices using the highway cost index data, available from FHWA, or an assumed annual inflation rate.

The property damage value associated with tunnels could be determined by contacting municipal and State authorities that manage or maintain insurance records. Once the cost is determined for each structure along a route, they can be totalled and used as input to Step 5.

Step 5. Add the Land-use Property Values (if Determined) and Roadway Structure Values (if Determined) to Find the Total Segment Property Value. Determine the Linear Property Value Per Mile of the Route Segment.

The final step involves summing the total property value for the land-use values from step 3 and the total value for roadway structures from step 4, and dividing by the segment length. If both values were determined, but their units are different (e.g., relative weightings were used for property value and actual replacement costs in dollars were used for roadway structures), it is not possible to sum the two values. In this circumstance, each value should be separately divided by the segment length, and two property values included in the analysis.

To determine the overall property risk for a route, each segment's property value is multiplied by its accident rate and the segments that comprise the route are summed, as detailed above for population risk.

Exhibit 11
Sample Weights for Exposed Property Calculations

Land-use Type	Basis for Building Replacement Cost	Multiplier*
High-Density Residential	10-story apartment building	2.0
Medium-Density Residential	duplex	0.7
Low-Density Residential	single family home	0.1
Commercial	10-story office building	4.0
Industrial	warehouse	1.0
Agricultural	farm buildings (e.g. barn, silo)	0.1
Institutional	4-story public building (e.g., library, hospital, government)	2.0

* The relative weighting factors are based on property values from Canada's "Transport Dangerous Goods Directorate." In the directorate, figures are given in Canadian $/linear meter. These figures have been normalized to the relative weightings listed above.

Exhibit 12
Regional Square Foot Unit Costs for Exposed Highway Structure Calculations

Region	Replacement Cost ($/sq ft)*	Rehabilitation Cost ($/sq ft)*
Northern New England (ME, NH, VT)	94	64
Southern New England (CN, MA, NY, RI)	123	84
Middle Atlantic (DE, MD, NJ, PA, VA, WV)	82	56
Southeast (AL, AK, FL, GA, KY, LA, MS, NC, SC, TN)	42	29
Midwest (IL, ON, MI, MN, OH, WI)	58	39
Plains (IA, KS, MO, NE, ND, SD)	45	30
Southwest (AZ, NM, OK, TX)	42	28
Rocky Mountain (CO, ID, MT, NV, UT, WY)	49	34
Pacific Coast (CA, OR, WA)	60	41
Alaska	111	76
Hawaii	143	97

* Source: Federal Highway Administration, Bridge Division, Tables for 1992 Construction Unit Cost for FY 1994 Apportionment. Costs are three year averages (1990-1992) for structures on the Federal-Aid System and for States in the same part of the U.S. with similar unit costs. Data were supplied to FHWA by each State. Since data were based on a small number of structures within a single State, costs were averaged across a region. These data are updated approximately every 2-3 years.

ROUTING ANALYSIS WORKSHEET

The Hazardous Materials Routing Analysis Worksheet (RAW) presented in Exhibit 13 provides a comprehensive format for summarizing each stage of the analysis for each route. It is recommended that the RAW be completed for each alternative in the order presented on the worksheet. This order corresponds to the sequence of activities described earlier. The first part on the RAW records basic information about the route. Parts 2, 3, and 4 correspond to the three activity boxes identified as "Analyze Risk," "Apply Through Routing Criteria," and "Additional Analyses" in Exhibit 1.

The RAW is provided to help ensure consistent application and documentation of the criteria used to evaluate alternative hazardous materials routes.

Section V illustrates the use of the RAW for one of two alternative routings in a hypothetical community. Each entry on the RAW is explained along with supporting materials and references for further information. The routing analysis and worksheets for the second alternative can be found in Appendix E. Reproducible blank worksheets can be found in Appendix F.

Exhibit 13
Hazardous Materials Routing Analysis Worksheet

1. ROUTE CHARACTERISTICS

Alternative No.__①__ Origin ______②______ Destination__________③______________ Via ____________④________________

Length_____⑤______Miles Travel Time____⑥____minutes Circuity_________⑦__________

Description___⑧____

2. PHYSICAL AND LEGAL CONSIDERATIONS

Are there any physical constraints? ☐ Yes ☐ No
Explain________________________________⑨____________________________

Are there any legal constraints? ☐ Yes ☐ No
Explain________________________________(10)____________________________

3. RISK DETERMINATION

Select hazardous materials class for study. ☐ EXP ☐ FL ☐ PG ☐ FCL ☐ FS ☐ OXI ☐ POI ☐ COR **OR**

Specific hazardous material_______(13)___________________ Impact Area_________(14)___________________

Risk Calculation

Segment No.	Accident Probability (10^{-6})		Potential Population Exposed Per Mile in Impact Area		Relative Risk (10^{-6})
___(11)___	______(12)______	X	______(15)______	=	_____(16)______
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
				TOTAL	

4. THROUGH ROUTING

Relative Risk: Alternative __ = A = ________
Current Route = B = ________

Route Lengths: Alternative __ = C = ________
Current Route = D = ________

B/A = _____ C-D = _____ C/D = _____

B/A > 1.5 ? ☐ Yes ☐ No C-D > 25? ☐ Yes ☐ No C/D > 1.25? ☐ Yes ☐ No

Through routing criteria met? ☐ Yes ☐ No If no, do not complete the rest of this worksheet.

Exhibit 13 (continued)
Hazardous Materials Routing Analysis Worksheet

5. ADDITIONAL ANALYSES

Special Populations ☐ Analyzed ☐ Not analyzed Factor_____(18)____ OR Population Factor______________

Sensitive Environments ☐ Considered ☐ Not considered Comments________________(19)________________

Segment No.	Sensitive Environment Area (acres, or other area units)		Accident Probability (10^{-6})		Relative Sensitive Environment Risk (10^{-6})
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
			TOTAL		______

Emergency Response Capabilities

Response Capabilities = (Total # Trained, Equipped Units Within 10 minutes) / (Route Length (miles)) = ______ = ___(20)_

Burden on Commerce ☐ Considered ☐ Not considered Comments________________(21)________________

Congestion/Delay Calculation

Queue Distance (ft)		Total Time (hrs)		No. of lanes		Vehicle Length (ft)		Delay (Vehicle-hrs)		Accid. Prob. (10^{-6})		Delay Risk
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
										Total =		___(22)___

Property Exposed Calculations (Optional)

Segment No.	Accident Probability (10^{-6})		Potential Property Value Exposed Per Mile in Impact Area		Relative Property Risk (10^{-6})
______	______	X	_____(23)______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
				TOTAL	______(24)____

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SECTION V

EXAMPLE

INTRODUCTION

This section illustrates the application of the hazardous materials routing methodology to a hypothetical city named Plainfield. It describes the routing procedures in a step-by-step fashion and applies the methods explained in the previous sections using representative data and making reasonable assumptions.

The explanation of the routing methodology is structured around the Routing Analysis Worksheet (RAW). A circled number (e.g., ①) is used to refer each line item on the RAW to an explanation of that item and the calculations or process used to develop the entry. Each line item includes a brief definition, and an example entry, i.e., the specific value for the Plainfield example and the process used to derive it. For further explanation of the terms used in the line item, the method for analyzing it, and how to assemble the necessary information, refer to **Section III or Section IV**. The sub-section of **Section III or** IV corresponding to the entry is noted, where appropriate. As seen in these sections, differing methods with varying levels of detail are provided for several factors involved in the routing analysis. For this hypothetical worked example, the "worked" level of detail will be that which **is considered the most thorough, given the data available to the planner.**

The following discussion describes Plainfield's characteristics, the alternative routes to be analyzed and the methods used to complete the RAW for Alternative 1.

HYPOTHETICAL CITY

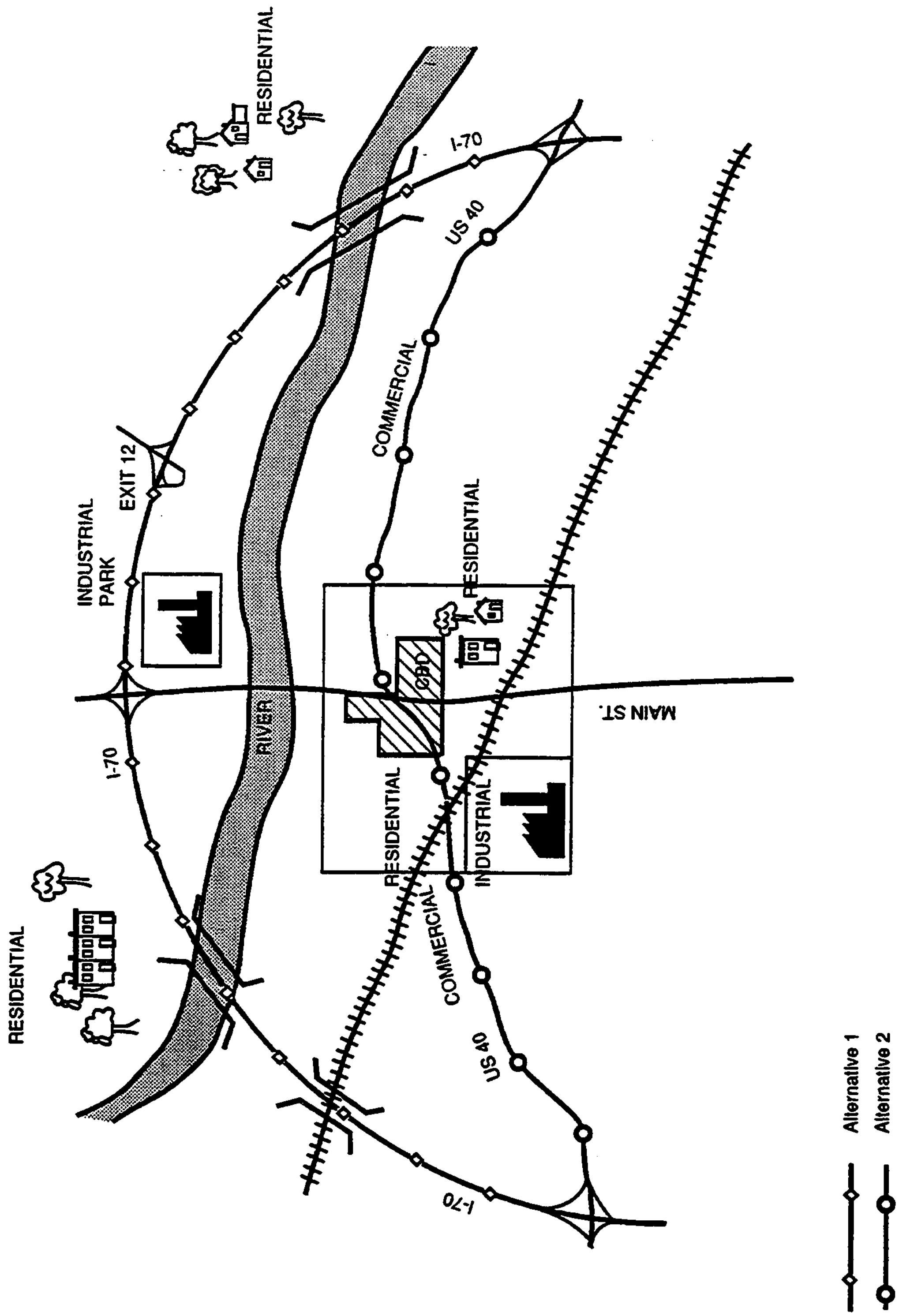
Characteristics

Exhibit 14 presents several features of Plainfield that may influence the hazardous materials routing decision (i.e., bridges, interchanges, residential and commercial property, a river). Plainfield is served by two major highways running east to west: I-70 (an interstate highway), and U.S. 40 (an urban arterial). Currently, U.S. 40 is the route chosen by most hazardous materials carriers. The current route must be analyzed as an alternative. The interstate highway and U.S. 40 are the alternatives.

Plainfield's distribution of land-use activities reflects the city's historical role as a regional trade and service center. More recent settlement patterns are illustrated by the suburban residential and workplace locations. Commercial activity is located principally along U.S. 40 and consists mainly of sales and service-related establishments. Industry originally was located near the railroad and a few older plants remain to the southwest of the central business district (CBD); however, the new industrial park is located on I-70.

The older, downtown sections of Plainfield are characterized by high population densities due to the prevalence of multi-family units and smaller lot sizes. New residential development has occurred in subdivisions along I-70. These areas have low population densities and are almost exclusively single-family houses on large lots. Population of the city and its environs is 75,000.

Exhibit 14
Hypothetical City Alternatives



Preliminary Alternatives Selection

After examining the major roadways in the Plainfield region, two potential alternatives were selected for through-routing of hazardous materials shipments travelling from east to west. (The process for selecting alternatives to be analyzed is discussed in detail in Section II, Process for Hazardous Materials Routing Analysis, Section III, Method for Determining Risk, and Section IV, Additional Analyses). The following two routes were selected because they appear to be the most direct and have no obvious problems that preclude hazardous materials movements:

- I-70 (Alternative 1); and
- U.S. 40 (Alternative 2)

USE OF THE ROUTING ANALYSIS WORKSHEET

The following discussion presents a completed RAW for Alternative 1 (see Exhibit 15). Each entry on the RAW is first explained in general terms and then illustrated with specific data for Alternative 1. Computational worksheets that may be used to develop information for the RAW are also presented and explained. Appendix E presents the complete worksheets for Alternative 2. Appendix F provides reproducible blank worksheets.

Part 1. Route Characteristics

Part 1 of the RAW records basic information about the alternative and its travel characteristics. This section is also used to record information about current usage of the route by hazardous materials shippers/carriers and to identify the hazardous material class (or classes) that the routing analysis will address.

① *ALTERNATIVE NUMBER*

Definition: Each alternative is arbitrarily assigned a number for easy identification of the route throughout the analysis.

Example Entry: Alternative Number 1.

② *ORIGIN*

Definition: The origin is the starting point of the route under analysis. City or county boundaries may be used or the analyst may select an intersection or an otherwise recognizable starting point. To assure consistency, all alternatives to be analyzed must have common origins and destinations. Comparisons will be invalid if routes serving different starting points are evaluated.

Example Entry: The origin for Alternative 1 is the intersection of I-70 and U.S. 40, 4 miles (6.4 km) west of the Plainfield CBD.

Exhibit 15
Hazardous Materials Routing Analysis Worksheet for Alternative 1

1. ROUTE CHARACTERISTICS

Alternative No._1_ Origin _intersection of I-70 and U.S. 40, 4 mi. W of city Destination_intersection of I-70 and U.S. 40 6 mi. E of city Via _I-70__

Length___15_____Miles Travel Time__18____Minutes Circuity____1.25_______

Description__Some peak-hour congestion at the Main St. interchange. Terrain exhibits no unusual characteristics. No areas of extreme weather conditions.

2. PHYSICAL AND LEGAL CONSIDERATIONS

Are there any physical constraints? ☐ Yes ☒ No Explain___no construction planned

Are there any legal constraints? ☐ Yes ☒ No
Explain

3. RISK DETERMINATION

Select hazardous materials class for study. ☐ EXP ☐ FL ☐ PG ☐ FCL ☐ FS ☐ OXI ☐ POI ☐ COR **OR**

Specific hazardous material_______Ammonia Impact Area____________1 mile

Segment No.	Accident Probability (10^{-6})		Potential Population Exposed Per Mile in Impact Area		Relative Population Risk (10^{-6})
1-A	15.5	X	240	=	3720
1-B	21.9	X	204	=	4470
1-C	7.08	X	207	=	1470
		X		=	
				TOTAL	9660

4. THROUGH ROUTING

Relative Risk: (Population Risk)
- Alternative _1_ = A = __9,660__
- Current Route = B = _100,100__

Route Lengths:
- Alternative __ = C = ___15____
- Current Route = D = ___12____

B/A = _10.4_ C-D = __3__ C/D = __1.25_

$B/A \geq 1.5$? ☒ Yes ☐ No C-D > 25? ☐ Yes ☐ No C/D > 1.25? ☐ Yes ☐ No

Through routing criteria met? ☒ Yes ☐ No If no, do not complete the rest of this worksheet.

Exhibit 15 (continued)
Hazardous Materials Routing Analysis Worksheet for Alternative 1

5. **ADDITIONAL FACTORS**

Special Populations ☒ Considered ☐ Not considered Factor 2 **OR** Population Factor ______

Sensitive Environments ☒ Considered ☐ Not considered Comments river and its banks

Segment No.	Sensitive Environment Area (acres, or other area units)		Accident Probability (10^{-6})		Relative Sensitive Environment Risk (10^{-6})
1-A	9.1 (acres)	X	15.5	=	140
1-B	3.6	X	21.9	=	79
1-C	22	X	7.08	=	160
		X		=	
		X		=	
		X		=	
			TOTAL		376

Emergency Response Capabilities

Response Capabilities = Total # Trained, Equipped Units Within 10 minutes / Route Length = 2 / 15 mi. = 0.13

Burden on Commerce ☐ Yes x No Explain no burden

Congestion/Delay

Queue Distance (ft)		Total Time (hrs)		No. of lanes		Vehicle Length (ft)		Delay (Vehicle-hrs)		Accid. Prob. (10^{-6})		Delay Risk
36,960	X	1.17	X	2	/	40	=	2,200	X	15.5	=	34,000
10,560	X	1.17	X	2	/	40	=	620	X	21.9	=	14,000
31,680	X	1.17	X	2	/	40	=	1,900	X	7.08	=	13,000
	X		X		/		=		X		=	
	X		X		/		=		X		=	
											Total=	61,000

Property Exposed Calculations (optional)

Segment No.	Accident Probability (10^{-6})		Potential Property Value Exposed Per Mile in Impact Area ($ million)		Relative Property Risk (10^{-6})
1-A	15.5	X	0.87	=	13.0
1-B	21.9	X	2.93	=	64.0
1-C	7.08	X	0.36	=	2.6
		X		=	
		X		=	
				TOTAL	80

③ *DESTINATION*

Definition: The destination is the end point of the route under analysis. Like the designation of an origin, the destination may be an intersection or other landmark. All alternative routes must have a common destination.

Example Entry: The destination for Alternative 1 is the intersection of I-70 and U.S. 40, 6 miles (9.6 km) east of the Plainfield CBD.

④ *VIA*

Definition: The term "via" is used to identify the route that the alternative follows. In some instances, an alternative may include several roadways and require turns. This entry traces the course of the route.

Example Entry: Alternative 1 uses I-70 exclusively and is therefore via I-70.

⑤ *LENGTH*

Definition: Length is the roadway distance of the alternative (to the nearest mile or kilometer).

Example Entry: Alternative 1 is 15 miles long (24 km).

⑥ *TRAVEL TIME*

Definition: Travel time is the elapsed time between the alternative's origin and destination for a vehicle travelling the route under normal circumstances (to the nearest minute). This value may be measured by performing travel time runs or may be calculated by dividing the distance by the average travel speed.

Example Entry: The travel time of 18 minutes was calculated by dividing the route length of 15 miles (24 km) by an estimated average highway speed (AHS) of 50 miles per hour (80 kph).

$$\frac{\text{15 miles (24 km)}}{\text{50 miles (8 km) per hour}} \times \text{60 minutes} = \text{18 minutes}$$

Further Information: Consult reference for information on conducting travel time runs.[17]

⑦ *CIRCUITY*

Definition: Circuity is the ratio of an alternative's length compared to the minimum path serving the same origin and destination pair. Circuity is a generalized measure of the added travel costs associated with routes that are not the most direct.

Example Entry: Alternative 1 circuity is 1.25. The current route between the origin and destination is 12 miles (19 km) using U.S. 40 (Alternative 2).

$$\frac{\text{15 miles (24 km)}}{\text{12 miles (16 km)}} = 1.25$$

⑧ *DESCRIPTION*

Definition: The route description should include any roadway or climatic conditions that might affect hazardous materials shipments. The new regulations require that type of highway, climatic conditions, terrain considerations, congestion and accident history be considered when analyzing routes.

Example Entry: The route experiences some peak-hour congestion at the Main Street interchange. The terrain exhibits no unusual characteristics, and there are no areas of extreme, severe weather conditions such as snow, high winds, ice or fog.

Part 2. Physical and Legal Considerations

Part 2 of the RAW is used to record any mandatory physical or legal factors that may preclude or constrain the use of a roadway for some or all of the hazardous materials classes. It may be necessary to eliminate alternatives from further analysis if the minimum physical requirements cannot be met.

⑨ *PHYSICAL CONSTRAINTS*

Definition: Mandatory physical constraints are physical factors that preclude the use of an alternative for hazardous materials shipments.

Bridge weight restrictions and overpass or tunnel clearance limitations are examples of physical constraints. Highway type characteristics such as insufficient turning radii or weight limits may also preclude the use of certain routes.

Example Entry: A drive-by inspection and conversation with the Plainfield traffic engineer revealed no physical constraints. No construction is planned.

(10) LEGAL CONSTRAINTS

Definition: Mandatory legal constraints are laws, agreements, ordinances or other legal instruments that may preclude the use of a route (or structure on that route) for some or all of the hazardous materials classes. For further definition of applicable legal constraints, refer to **Section II, Define Alternative Routes for Analysis.** This information may be obtained from the city attorney; police and fire departments; or bridge, tunnel, and turnpike authorities.

Example Entry: Contacts with the Plainfield city attorney, city police department, and State highway police revealed no legal constraints.

Part 3. Risk Determination

The risk to population associated with hazardous materials movements over each of the alternatives is the major criterion for route selection. As defined above, risk is the probability of a hazardous materials accident multiplied by a measure of the population and/or property potentially exposed to an accident along each alternative route. Analysis of property risk (Entry 23), is optional and cannot substitute for a thorough risk analysis based on population. The components of Risk Determination are Accident Probability, Part 3A below, which consists of Entry 12, and Accident Consequence, Part 3B below, which consists of Entries 13-16 (hazardous materials for study, impact radius, and population).

The planner is strongly encouraged to read Section III, Method for Determining Risk, before starting any of the data collection or analysis activities.

---

(11) SEGMENTATION

Definition: The route can be segmented (or divided into discrete units) to assist in the data collection and risk calculations for each alternative. Refer to **Section III, Route Characteristics** for a discussion of segmentation. Keep in mind that the same segments boundaries defined here are to be used in calculations for accident probability (Entry 12 below), potential population exposed (Entry 15 below), and property exposed (Entry 23). Also note that the number of segments need not be limited to the number of lines on the worksheet--attach additional pages if necessary.

Example Entry: Alternative 1 is divided into 3 segments (labelled 1-A, 1-B, and 1-C) on the basis of both roadway type and census tract boundaries (see Exhibit 16). Roadway type is used as a criterion in dividing Alternative 1 into segments because of the method that is later employed to estimate vehicle accident rates in Plainfield; these accident rates are based on roadway type (see Entry 12). Exhibit 16 illustrates how the boundaries between segments are established. For example, Segment 1-A is a rural, 2-lane road, with one-fifth the accident rate of Segment 1-B, which is an urban, 2-lane road. The change in roadway type also occurs near the boundary between census tracts 72.01 and 74.01 (see Exhibit 19). Segment 1-C is designated because the road becomes a rural freeway as one gets further away from the industrial park and the Main Street interchange.

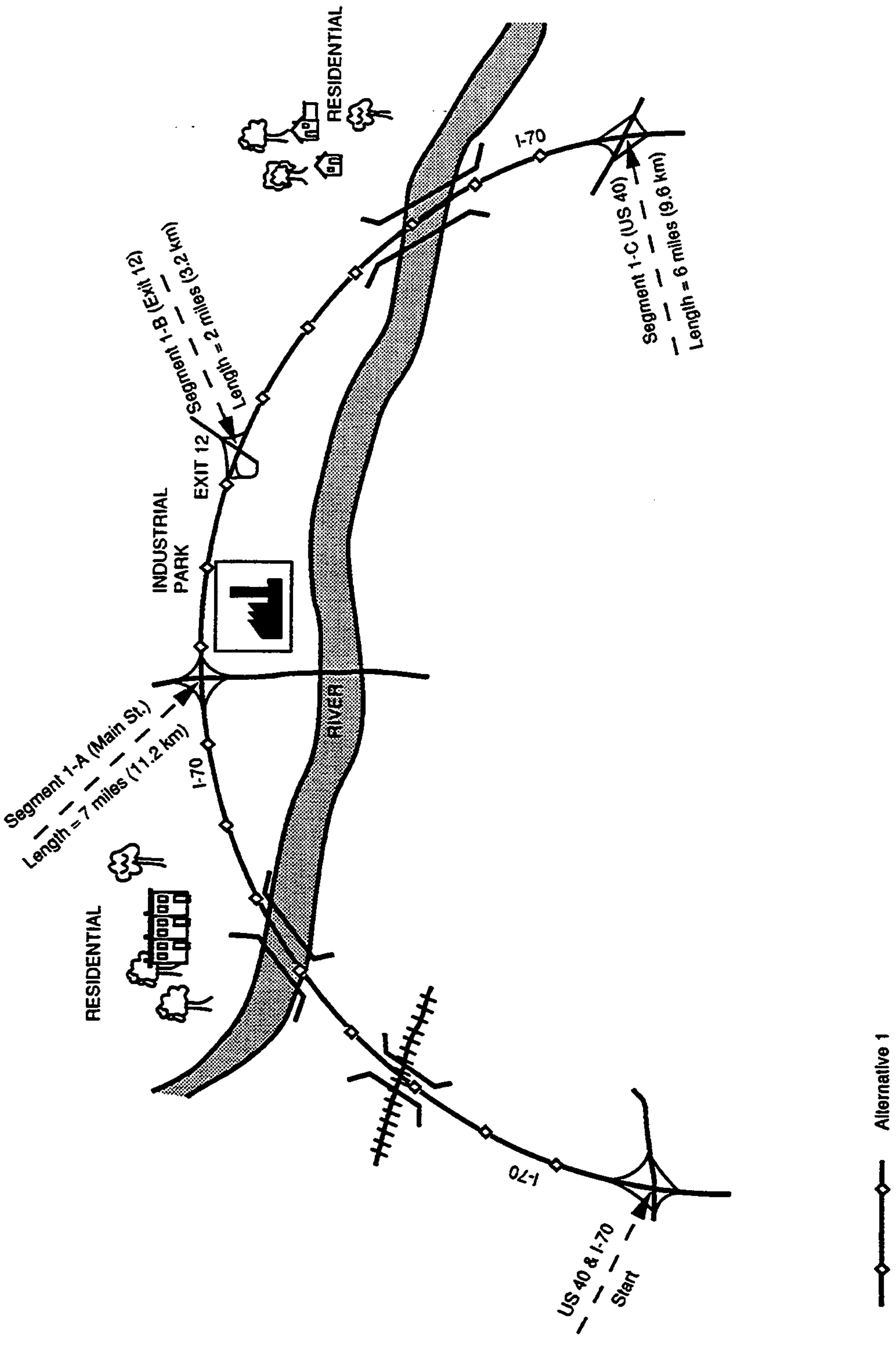
Part 3A. Accident Probability

(12) ACCIDENT PROBABILITY

Definition: The probability of an accident is the likelihood or chance that a vehicle carrying hazardous materials will be involved in a roadway accident. Accident rates in themselves are not probabilities until they are adjusted to reflect the amount of exposure a vehicle experiences. The likelihood of a hazardous materials carrier having an accident will vary with the number of miles (km) travelled.

Since the actual probability of an accident is quite low, accident rates are normally expressed in terms of accidents per million vehicle-miles in order to avoid manipulating extremely small numbers. For example, an all-vehicle accident rate of one accident for every one million miles

Exhibit 16
Segments in Alternative 1



driven is usually expressed as 1.0 x 10^{-6}, which is equivalent to 0.000001. For purposes of the relative risk computation of this methodology, the factor of 10^{-6} will be eliminated. Because of this and other simplifying assumptions, such as the use of vehicle accidents as a surrogate measure for actual releases of hazardous materials, the results obtained cannot be used as measures of absolute risk.

Exhibit 17 illustrates the Roadway Inventory Worksheet that is used to record roadway and traffic data about each alternative. Space is also provided on this worksheet for the accident probability calculations. Columns 1 through 5 should be completed for each segment. The last two columns are provided for the probability calculations. In this example, the total accident rate for all vehicles (trucks and automobiles) is used.

The sequence of steps to determine the probability that a hazardous materials vehicle will have an accident while traversing a route segment is:

1. Determine the accident rate for all vehicles on a particular roadway type; and

2. Calculate the probability of an accident for any vehicle based on vehicle exposure.

The general form of the probability equation for each segment is:

Probability = (Accidents per vehicle mile) x (segment length in miles)

The levels of detail for accident rate calculation are described in **Section III, Accident Probability.**

Example Entry: The planners of Plainfield found that their State highway department had accident rate data by a variety of road types. Therefore, they used METHOD 1. The data were collected over a three year period, and thus provide a sufficiently representative sample.

Roadway Type		Accidents per million vehicle-miles (mvm)
Rural	Two-lane	2.22
Rural	Freeway	1.18
Urban	Two-lane	10.93

The roadway types shown above correspond to the roads in Segments 1-A, 1-B, and 1-C respectively (refer to Exhibit 4 in Section III). These values are entered in Column 4 of Worksheet 1 (Exhibit 17) and on the appropriate lines in the RAW (Figure 8). Columns 4 and 3 are multiplied to obtain probability, which is recorded in column 5.

Probability = 7 x 2.2 = 15.4

Part 3B. Accident Consequence

(13) HAZARD MATERIALS FOR STUDY

Definition: The State planner must determine the types of materials and the individual quantities and shipments that travel along the route being analyzed. This may be a hazard class, or a particular hazardous material of great importance or significance to the community. Refer to the

Alternative: _____1_____
Date: __12_/__1__/__93_
Page ___1_ of __1__

Exhibit 17
WORKSHEET 1: Roadway Inventory for Alternative 1

1		2	3	4	5
Segment		Road Type	Length (miles)	Accident Rate (accidents/ mvm)	Probability of Any Vehicle Accident (10^{-6})
#	O/D				
1-A	Intersection of U.S. 40 and I-70 W of city to Main St.	Rural 2-lane	7.0	2.22	15.5
1-B	Main St. to interchange	Urban 2-lane	2.0	10.93	21.9
1-C	Interchange to intersection of U.S. 40 and I-70 E of city	Rural Freeway	6.0	1.18	7.08

Preface (Type and Quantity of NHRM Factor) and **Section III, Accident Consequences** for a more detailed discussion.

Example Entry: Poison gas is the hazardous material class of interest in Plainfield. This class was chosen because there are several chemical plants in the area, and most of the hazardous materials incidents reported for this region to DOT involve poisonous gases. Ammonia is singled out as the particular hazardous material of interest, since the community is concerned with the transport and presence of this chemical.

Further Information: Consult reference for more information on hazardous materials classes.[18]

---

(14) IMPACT RADIUS

Definition: The impact area is the potential range of effects in the event of a hazardous materials release. Impact area may be determined using any one of the three methods discussed in **Section III, Accident Consequences.**

Example Entry: Because poison gas, particularly ammonia, is of interest to the planners of Plainfield, Method 2, an impact area analysis based on hazard class, is appropriate. Refer to Section III for a discussion of impact area based on hazard class. The isolation distances in the DOT Emergency Response Guidebook can be used to find the specific impact area for ammonia. The 1990 Guidebook lists a distance of 0.2 miles for small quantities, and 1 mile for large quantities. To be conservative, and to account for the worst-case scenario, the distance for large quantities is used.

Further Information: Consult reference for more information on potential impact distances.[19]

---

(15) POPULATION EXPOSED

Definition: The population potentially exposed to a hazardous materials release may be estimated from the density of residents, employees, motorists, or a combination of these three variables. The proposed technique does not consider changes in population by time of day or in terms of the movement of commuters from home to workplace. The analyst can represent these conditions in the consequence measurements by making some assumptions and modifying the methodology accordingly. Refer to Section III, **Accident Consequences**, for information on resources for population data, and possible methods for estimating population changes due to time of day and traffic.

The four steps to determine population consequences are:

1. Compile census tract maps, identify routes, mark off impact zones;

2. Measure share of census tract that falls within impact zone;

3. Record census tract populations and determine total number of people within the impact zone; and

4. Determine the per mile population density within the impact area of the route segment. This number is calculated by dividing the total segment impact zone population by the segment length.

Example Entry: The procedures for estimating population within the potential impact zone for Segment 1-A are described below. The values for Entry 15 are calculated using Worksheet 2: Population Inventory (Exhibit 18) and then recorded on the RAW.

Step 1. Compile Census Tract Maps, Identify Routes, and Mark Off Impact Zone

As only the boundaries of the census tracts are shown on these maps, it may be necessary to draw in portions of the alternative hazardous materials routes. After each alternative route is identified, delineate the zone of potential impact on the tract maps by scaling the impact area to the census tract map scale and drawing two parallel lines on each side of the roadway at this scaled distance. (Selection of an impact area is discussed in Entry 14.)

The potential impact area of 1 mile is marked off for Alternative 1 in Exhibit 19. The three census tracts lying partially or wholly within the potential impact zone on Segment 1-A are identified and recorded in Column 3 of Worksheet 2 (see Exhibit 18).

Step 2. Measure Share of Census Tract Which Falls Within Impact Zone

With the exception of census tracks lying wholly within the impact zone, it is necessary to measure or estimate the share (or fraction) of each tract that falls within the impact zone boundaries. The share of the tract within the zone is then multiplied by the total tract population to estimate the number of people in each tract that live within the potential impact area. This approach assumes that the population within each census tract is evenly distributed -- an assumption that can be refined with local knowledge.

There are two methods to determine what fraction of a tract lies within the impact zone boundaries: (1) estimate and (2) measure. The level of precision desired for the alternatives analysis will indicate which technique is appropriate. Measurements may be made with a planimeter, a small drafting instrument that measures area maps, or by overlaying a grid of small squares and counting those that lie within and without the impact area.

The share of census tracts 71.02, 72.02, and 72.01 that falls within the potential impact zone for Segment 1-A was determined by visual inspection and estimation. The estimated shares for these tracts are 40 percent, 90 percent, and 25 percent, respectively. These values are recorded in Column 5 of Worksheet 2 (see Exhibit 18).

Step 3. Look Up Tract Populations and Determine Total Population Within Impact Zone

Population from each tract is obtained from the U.S. Census Bureau data and recorded on Worksheet 2 in Column 4. The product of Columns 4 and 5 gives the impact area population for each tract (Column 6). Sum the tract populations within a segment to calculate the total population in the potential impact area of that segment.

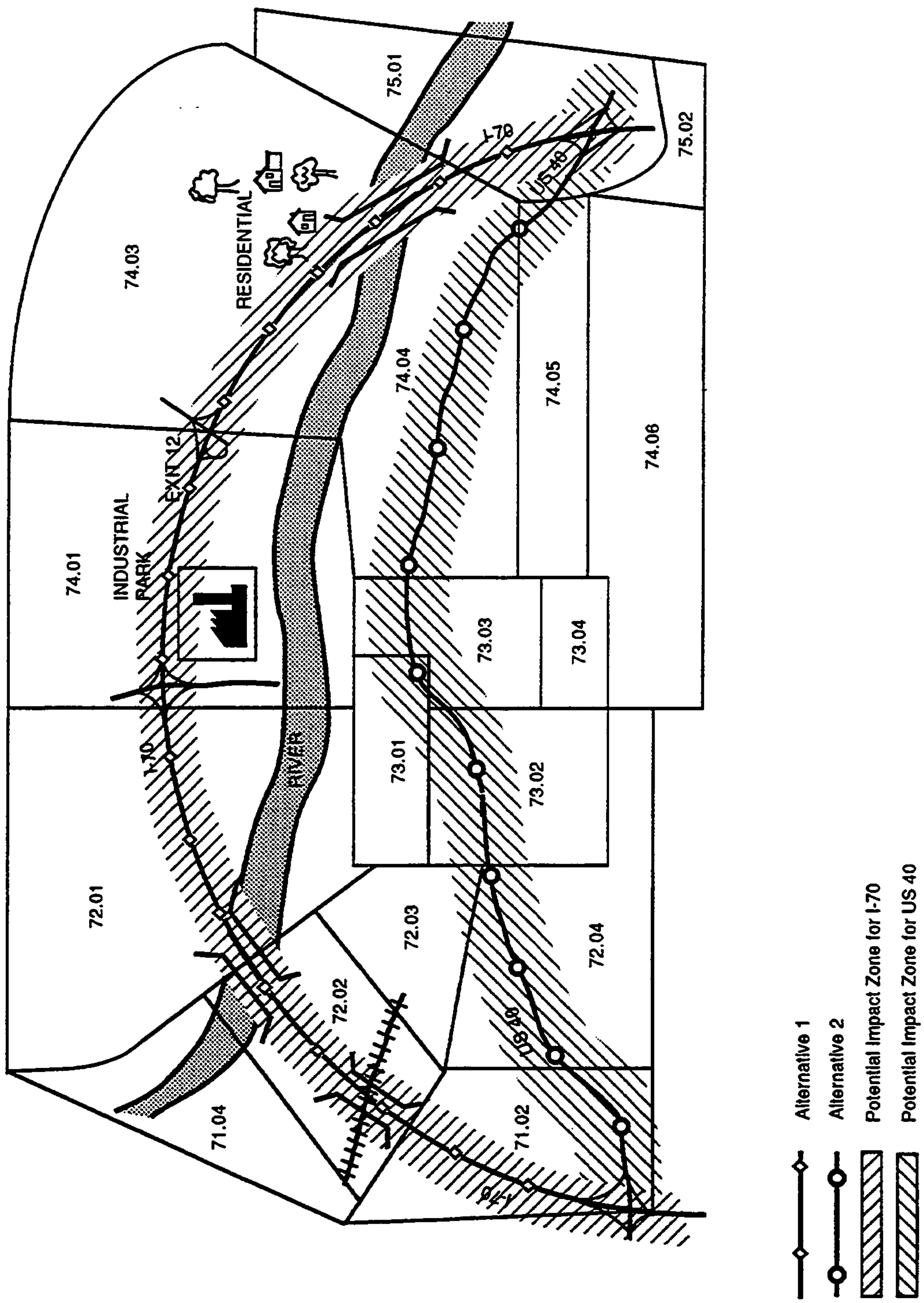
Alternative: _____1______
Date: __12_/___1_/__93_
Page __1__ of __1__

H.M. Class:_______________
or Chemical:___Ammonia______
Impact Radius:____1.0________

Exhibit 18
WORKSHEET 2: Population Inventory

1	2	3	4	5	6	7
Segment		Census Tracts				
#	Length (Miles)	Number	Population	Fraction of Tract in Impact Area	Population in Impact Area	Population/Mile in Impact Area
		71.02	1540	0.4	616	
		72.02	850	0.9	765	
1-A		72.01	1200	0.25	300	
Total	7.0				1681	240
1-B		74.01	1630	0.25	408	
Total	2.0				408	204
1-C		74.03	2480	0.3	744	
		75.01	1420	0.35	497	
Total	6.0				1241	207

Exhibit 19
Census Tract Boundaries and Potential Impact Zones



Step 4. <u>Calculate Population Per Mile Within the Impact Area for Each Route Segment</u>

The population density per mile within the impact area is determined by dividing the total population in impact area for each segment (Column 6) by the segment length (Column 2). This number is recorded in Column 7.

(16) *RELATIVE POPULATION RISK*

Definition: The relative population risk is calculated by multiplying the probability of an accident (Entry 12) by the potential number of people exposed to the accident if it does occur (Entry 15).

Example Entry: The probability of a vehicle accident on Segment 1-A is 15.5 and there are 240 potentially affected people within the one-mile impact zone along this segment. The product of these two numbers is 3720. The sum of the risk values for all segments on Alternative 1 is 9,653, which is obtained as follows:

[15.5 x 240] + [21.9 x 204] + [7.08 x 207] = 3720 + 4467 + 1466 = 9,660

The risk value 9,660 is placed in the RAW (Exhibit 15) under Risk Determination.

(17) *THROUGH ROUTING*

Definition: Through routing ensures continuity of movement so that the transportation of non-radioactive hazardous materials is not impeded or unnecessarily delayed. The Rule States that proposed designated routes can go into effect only if the following through routing criteria are met; 1) the current routing must present at least 50 percent more risk to the public than the deviation under the proposed designation; 2) the current routing presents less than 50 percent more risk, but does not force a deviation from the current route of the lesser of (a) 25 miles or (b) 25 percent of that part of a trip affected by a deviation.

Example Entry: The procedure for applying through routing criteria is presented in a flowchart in Section III Exhibit 2. To use the flowchart, you will need relative population risk and length of route for the current route *and* the proposed route.

US40 (current route):	rel. pop. risk = 100,100
	length = 12 miles
Alternative 1:	rel. pop. risk = 9,660
	length = 15 miles

Compare the risk of the current route to the risk of Alternative 1:

$$\frac{100{,}100}{9{,}660} = 11$$

This ratio is greater than the cutoff of 1.5. Therefore, the first condition box on the flow chart is answered affirmatively, and the route defined in Alternative 1 meets the through routing criteria.

Part 4. Additional Analyses

The persons performing the routing analysis may decide whether any secondary factors should be applied, and which factors to select. The primary purpose of the secondary factors is to modify or "fine tune" the risk determination.

The planner is strongly encouraged to read Section IV, Other Factors for Consideration, before starting any of the data collection or analysis activities.

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(18) SPECIAL POPULATIONS

Definition: Special populations may be groups that are particularly sensitive to hazardous materials releases, may be difficult to evacuate, are highly concentrated, or are outdoors. Refer to **Section IV, Special Populations,** for a discussion of methods for dealing with special populations.

Example Entry: To utilize METHOD 2, USGS maps were obtained for the Plainfield area along I-70 and U.S. 40. There are two elementary schools in the Alternative 1 potential impact zones, as illustrated in Exhibit 20. The number "2" is entered in the RAW under "Subjective Factor" for entry 18.

---

(19) SENSITIVE ENVIRONMENTS

Definition: The planner may determine to what degree sensitive environments will be considered. The Rule requires that the route designation take into account distance to sensitive areas, water sources (e.g., streams, lakes), and natural areas (e.g., parks, wetlands, wildlife reserves. A method for identifying sensitive environments is described in **Section IV, Sensitive Environments,** and is outlined in the example below.

Example Entry:

Step 1. Determine the potential impact area.

The impact area (entry 14) is one mile.

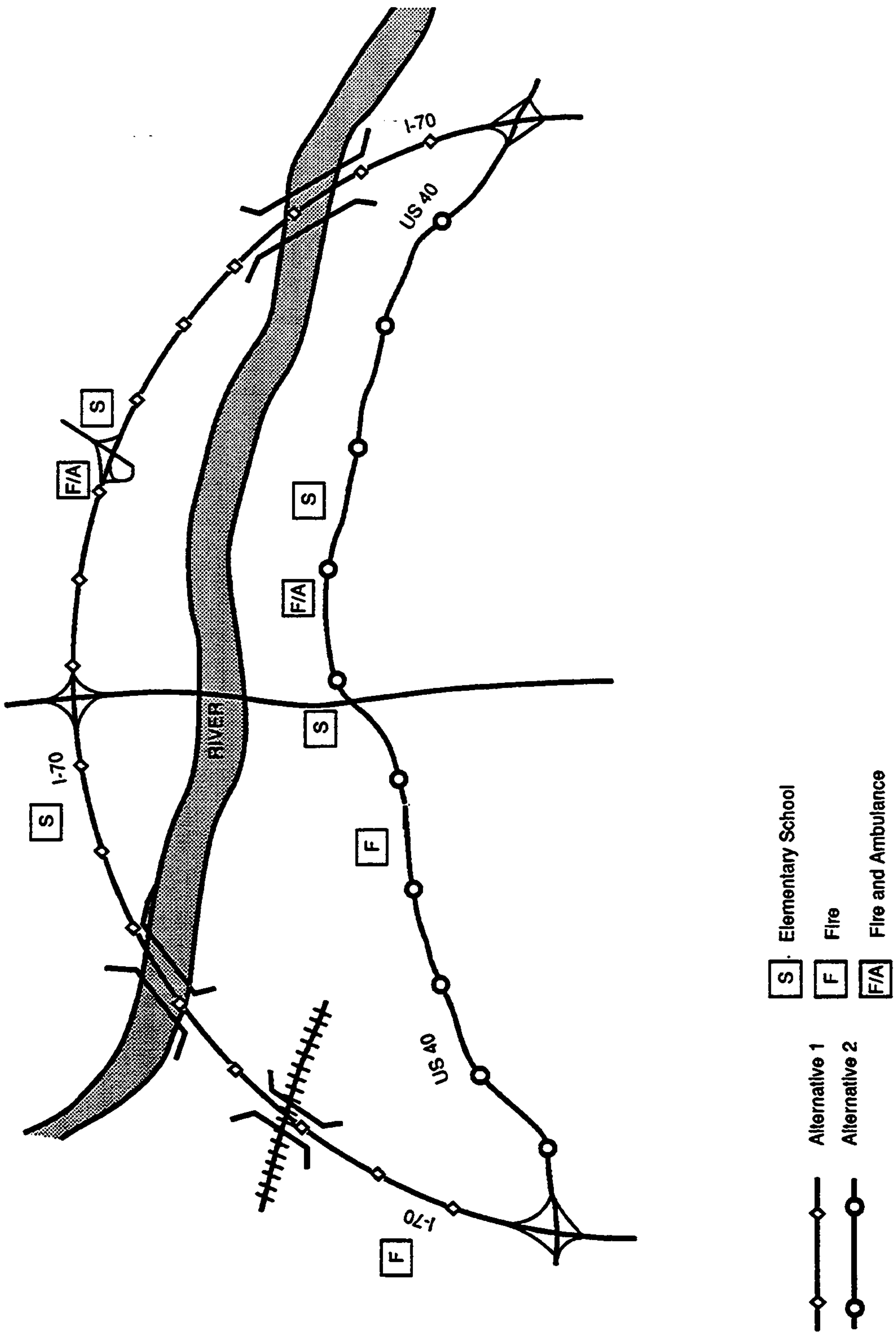
Step 2. Identify sensitive environments within the impact area.

Specialized maps of parks were obtained from the local park service. These maps of recreational areas covered the extent of both alternatives, and were overlaid with the route maps (see Exhibit 20). To identify natural habitats, an ecologist with the Park Service was asked to review the overlaid maps and identify any particular wildlife habitats within the impact zone. The ecologist informed the planners that no protected species would be impacted, however, a hazardous materials spill that reached the river would harm the birds, fish, beavers and other animals that frequent the river and its banks.

Step 3. Measure the area of each type of sensitive environment within the impact area and sum.

Using a planimeter, the State planners measured the river area that runs along I-70.

Exhibit 20
Locations of Elementary Schools and Emergency Response Units in Hypothetical City



Segment No.	Sensitive Environment Area
1-A	9.1 acres
1-B	3.6 acres
1-C	22 acres

These values are entered on the RAW at entry 20.

Step 4. (Optional) Factor in any other special characteristics or criteria.

No special terrain or geographic considerations were apparent.

Step 5. Multiply the total sensitive environment area within each route segment by the appropriate accident rate.

For each segment, the acreage obtained in step 3 is multiplied by the corresponding accident probabilities to obtain the sensitive environment risk. The risks for each segment are then summed.

$$(15.5 \times 9.1) + (21.9 \times 3.6) + (7.08 \times 22) = 376$$

This sum is the sensitive environment risk factor that may be used to compare alternative routes' potential risk.

(20) *EMERGENCY RESPONSE*

Definition: The analysis of emergency response capabilities with respect to each alternative should be based on the proximity of the emergency response facilities and their capability to contain and suppress a hazardous material release. To make the proximity determination, it is sufficient to identify and discuss with fire personnel the proximity of all fire stations to each of the alternative routes. To make the capability determination, it is necessary to assess each fire station's ability to respond to incidents involving the types of hazardous materials carried in the area.

The diverse chemical properties of hazardous materials often require that sophisticated suppression techniques be used in an emergency. The capability assessment should compare the level of training and equipment of the emergency response units to determine which are better prepared to react to a release of hazardous materials. For example, fully trained fire fighters are more likely to recognize placards and use the proper suppression agent to extinguish a chemical fire; whereas poorly trained personnel simply may flood a chemical fire with water, which may make certain chemical fires worse.

The planner should consult with fire personnel to determine how they would respond to fires involving chemicals that require suppression agents other than water. Those fire stations that have had better training should be noted along each route, as should those with less training. The implication is that better trained fire personnel are more likely to handle a spill properly and thereby make the route safer. Consideration can be given during the analysis to training and/or redeploying units as part of the routing process.

Example Entry: The locations of the emergency response units on the alternative routes are plotted on Exhibit 20. The two fire departments located along I-70 are within a 10- minute response window and are trained and equipped for dealing with hazardous materials accidents.

Therefore, the response capability for this alternative is 2 units per 15 miles or 0.13. This value can be compared with those for the other alternative routes. The one with the highest value has the "best" response capabilities and the greatest potential for reducing the consequences of a hazardous materials release.

Further Information: Consult **Section IV, Emergency Response Capabilities**, and reference for more information on emergency response.[20]

(21) BURDEN ON COMMERCE

Definition: A burden on commerce is an effect that creates additional shipment costs arising from such things as routing restrictions that create circuitous routes that in turn may create shipment delays. Any routing designation made in accordance with Subpart C of Part 397 shall not create an unreasonable burden upon interstate or intrastate commerce. [§ 397.71(b)(9)(x)]

Example Entry: No burdens would be placed on commerce if Alternative 1 were designated.

(22) CONGESTION/TRAFFIC DELAY

Definition: When an incident occurs on a highway, the capacity of the roadway to handle the volume of traffic demanded is reduced. Congestion and delay can be quantified as average delay per incident in vehicle-hours. In this example, METHOD 1 is used, as the planner does not have access to the METHOD 2 DELAY model or the METHOD 3 TRAF simulation system (refer to **Section IV, Congestion/Transportation Delays**). The steps below will lead to a number for delay on I-70 that can be compared to the delay number for Alternative 2.

Example Entry: The procedures described in **Section IV, Congestion/Transportation Delays** are applied here to each segment in Alternative 1.

Step 1. Identify maximum queue length for each segment.

Each segment boundary occurs at an interchange (see Exhibit 16). Therefore, segment length is equivalent to queue length.

Segment 1-A queue = 36,960 ft
Segment 1-B queue = 10,560 ft
Segment 1-C queue = 31,680 ft

Step 2. Determine incident duration.

Two time periods are needed to determine incident duration: time to respond to an incident, and time to clean up an incident and clear the roadway. The time to respond is assumed to be 10 minutes. Discussions with the local emergency response team revealed that about one hour is needed to clean up a hazardous materials release. The sum of the following time periods is entered on the RAW.

Time to respond = 0.17 hours (10 minutes)
Time to clean up = 1 hour

Step 3. Determine vehicle length.

The Plainfield planners determined that their highway traffic volume and composition were similar to that outlined in **Section IV, Congestion/Transportation Delays**. Thus, the weighted composite length of 40 feet/vehicle was used.

Step 4. Calculate delay.

Delay is the product of queue distance (ft) from Step 1, incident duration (hours) from Step 2, and number of single-direction lanes, divided by vehicle length (ft/vehicle). These factors are entered in the RAW.

Number of single-direction lanes = 2

Multiply the delay value for each segment by the accident probability for that segment. The sum of these products is the "delay risk" to use for comparison with Alternative 2.

(23) PROPERTY EXPOSED (OPTIONAL)

Definition: Property potentially exposed to a hazardous materials accident may include roadway structures such as bridges and overpasses as well as private property such as houses and commercial developments. To provide the planner with options for analyzing property exposed, the steps are presented with varying levels of detail (options). For a complete description of these levels, and more detail on performing the steps, refer to **Section IV, Property Risk Calculation (optional)**. This example focuses on Option 2, as this method provides optimum detail without requiring extensive time and research efforts.

Example Entry: The procedures described above are applied to property located along Segment 1-A. The values for Entry 22 are calculated using Worksheet 3: Property Value (Exhibit 21) and then recorded on the RAW.

Step 1. Estimate Dollar Value Per Lineal Foot of Frontage

The land use values were obtained by the state housing department. This method is preferred over Option 1 because the property types in the Option 1 tables, and their associated values are not representative of this particular state.

In the case of this state, assessed value per lineal mile of frontage was available for various land use types; in the table below, these values have been converted to dollars per lineal foot. Segment 1-A consists of rural residential property, which corresponds to the land use type Rural residential in the above table. Segment 1-B consists of industrial property, which corresponds to the land use type Industrial. Segment 1-C consists of sparsely populated, mainly agricultural property, which corresponds to the land use type Agricultural/vacant. The dollar per foot values of these land types are recorded in column 3 of Worksheet 3 (Exhibit 21).

Alternative: ___1_______
Date: __12_/__1__/_93__
Page __1__ of __1__

H.M. Class: ______________
or Chemical: _____Ammonia_____

Exhibit 21: Property Value for Alternative 1

WORKSHEET 3: Property Value

1	2	3	4	5	6			7	8	9
Segment	Option 1 Land Use Type and Multiplier				Value of Roadway Structures ($ millions)			Segment Total ($ millions)	Segment Length (miles)	Value/Mile ($ millions)
#		Value (Factor)	Length (ft)	Value	Structure	Value	Total			
	High-Density Residential	2.0								
	Medium-Density Residential	0.7								
	Low-Density Residential	0.1								
	Commercial	4.0								
	Industrial	1.0								
	Agricultural	0.1								
	Institutional	2.0								
Segment	Option 2 Land Use Value--State or Local									
#	Land Use Type	Value ($ /ft)	Length (ft)	Value ($ millions)						
1-A	Rural residential	28	36960	1.03	RR bridge	1.56		6.06	7	0.87
					River bridge	2.07				
					Interchange	1.4	5.03			
1-B	Industrial	555	10560	5.86	none			5.86	2	2.93
1-C	Agricultural/vacant	2	31680	0.06	River bridge	2.07		2.13	6	0.36

Step 2. Measure Lineal Frontage for Each Land-Use Type

There is one type of land use along Segment 1-A: Rural residential. The lineal frontage of this land use is equal to the length of the segment: 7.0 miles (36,960 feet). This value is recorded in column 4 of Worksheet 3. The same logic follows for each segment and is shown in Exhibit 21.

Representative State-Wide Land Use Values[21]

Land Use Type	$ per foot
Urban residential	$1,193
Rural residential	$28
Commercial	$1,527
Industrial	$555
Agricultural/vacant	$2

Step 3. Multiply Lineal Frontage for Each Land Use by Value Per Lineal Foot

The estimated property value per lineal foot is multiplied by the distance recorded for that land use and the resultant value is entered on Worksheet 3 in column 5.

On Segment 1-A, there are 7.0 miles (36,960 feet) of Rural residential property fronting the roadway. Multiplying by the value per lineal foot (of Rural residential property), the land-use type has a property value:

Rural residential: $28/foot x 36,960 feet = $1.03 million

Step 4. Estimate Value of Roadway Structures and Add to Land Use Property Values

There are three roadway structures on Segment 1-A: a railroad bridge, a bridge over the river, and the interchange at Main Street. The values of these three structures were estimated by the State Highway Department. Replacement cost for the railroad bridge was estimated at $1,560,000; each river bridge at $2,070,000; and the interchange at $1,400,000. These values are recorded in column 6 of Worksheet 3. Combining the value of land use and roadway structures on Segment 1-A produces a total value of $6.15 million. The totals for structures and property values are entered in Column 7 of Worksheet 3 (Exhibit 21).

Step 5. Determine the Property Value Per Mile of the Route Segment

The linear property value density, for each segment, is calculated by dividing its total segment property value (Column 7) by the segment length (Column 8):

Segment 1-A value per mile: $\frac{\$ 6.06 \text{ million}}{7 \text{ miles}} = \$0.87$ million/mile

---

(24) *RELATIVE PROPERTY RISK*

Definition: The relative property risk is calculated on the RAW by multiplying the probability of an accident (Entry 12) by the property value per mile exposed to an accident (Entry 18).

Property risk values are calculated for each segment of a route and then summed to produce the risk value for the routing alternative.

Example Entry: The probability of a vehicle accident on Segment 1-A is 15.5 and the value of the potentially affected property is $0.87 million/mile. The product of the two numbers is $13.49. The sum of the property risk values for all segments on Alternative 1 is 80.36, determined as follows:

[15.5 x $0.87 million] + [21.93 x $2.9 million] + [7.08 x $0.36 million]
= $13.49 + $64.17 + $2.55 = $80.36 million

DESIGNATE ROUTE

The final step in the process is to compare the alternatives and select the preferred route according to the criteria described previously. Exhibit 22, Alternatives Comparison, is the final worksheet for the route selection process. It summarizes the characteristics and calculations for the alternatives in Plainfield.

In Plainfield, none of the routes were eliminated on the basis of mandatory physical or legal factors. Alternative 1 has the lowest risk.

Exhibit 22 compares the factors considered in the routing analysis. The risk on Alternative 1 is 9,660, and the risk of Alternative 2 is 100,100 (i.e., Alternative 1 has 0.1 of the risk associated with the current route). Alternative 1's lower population risk is due to the low accident rates on interstates and the lower-density settlement that has occurred along I-70. Alternative 2, on the other hand, has both higher accident rates and a greater population density, since this urban arterial passes through downtown Plainfield.

Because Alternative 2 poses more than 50% greater risk than Alternative 1, Alternative 1 may become the designated hazardous materials route regardless of its length and circuity relative to the other alternatives. If there were no substantial differences in the risks of the two alternatives, the other factors would need to be considered. These other factors – exposure and other risk factors (i.e., special populations and sensitive environments), emergency response capabilities, burden on commerce, congestion, and possibly property exposed – are analyzed in the worked example for each alternative, in order to demonstrate how they may be considered.

Exhibit 22: Alternatives Comparison

Alternative			Physical and Legal Considerations		Risk Determination		Additional Factors						
Number	Length	Travel Time (minutes)	Physical	Legal	Risk	Fraction of Current Risk	Special Populations	Sensitive Environments	Emergency Response	Burden on Commerce	Congestion/ Delay	Property Risk (optional)	Rank
1	15	18	No	No	9,660	0.10	2	376	0.13	No	61,000	80	1
2	12	16	No	No	100,100	1	3	2,230	0.17	No	820,000	836	2

Additional analyses also indicate that Alternative 2 presents more relative risk. Alternative 2 has more special populations, more sensitive environments, greater congestion, as well as higher property risks. Congestion along Alternative 2 is much higher than along Alternative 1. Property risk is also higher, mainly due to the higher land use value associated with commercial property. Alternative 1 has a slightly longer travel time than Alternative 2 (just 13 percent). Alternative 1 also has a lower emergency response value, indicating that response would be faster on Alternative 2.

Again, risk is the primary factor for designating a route. In this hypothetical example Alternative 1 clearly presents less risk to the public, and, on the basis of the analysis presented here, should be designated as the hazardous materials route through Plainfield.

GLOSSARY

GLOSSARY

Accident consequence: The results of incidents involving releases from hazardous materials-carrying vehicles. Accident consequence may be measured in terms of population exposure, property damage, deaths, injuries, environmental damage, costs, and can be quantified by determining an appropriate impact radius and identifying potential receptors and expected damage levels.

Alternative routes: Routes with the same origin-destination pair that are under consideration as designated routes for hazardous materials routing. Alternative routes would include the route presently used by hazardous materials carriers and at least one other route. [§ 397.71(b)(9)(ix)]

Agreement of affected States or Indian tribes: States or Indian tribes affected by any NRHM routing designation must be given 60 days in which to review and approve the proposed routing designation. [§ 397.71(b)(5)(ii)]

Burden on commerce: A burden on commerce is an effect that creates additional shipment costs arising from such things as routing restrictions that create circuitous routes that in turn may create shipment delays. Any routing designation made in accordance with Subpart C of Part 397 shall not create an unreasonable burden upon interstate or intrastate commerce. [§ 397.71(b)(9)(x)]

Census tract: Data on population density are broken down into geographic areas. Census tracts are the boundaries between areas of different population.

Circuity: The ratio of an alternative route's length compared to the minimum path connecting the same origin and destination. Circuity is a generalized measure of the added travel costs associated with routes that are not the most direct.

Climatic conditions: Weather conditions along a highway route that could affect transport safety, the dispersion of the hazardous material upon release, or increase the difficulty of controlling and cleaning up as hazmat release. Such climatic conditions include snow, wind, ice and fog. [§ 397.71(b)(9)(xii)]

Consultation: Prior to the establishment of any routing designation, the State or Indian tribe shall provide notice and consult with officials of affected political subdivisions, States and Indian tribes, and any other affected parties. [§ 397.71(b)(3)]

Designated routes: A route or portion of a route that **must** be used when transporting non-radioactive hazardous materials (NRHM) over highways. When applicable specifically to NRHM-carrying motor vehicles, a route designation includes any regulations, restrictions, curfews, time of travel restrictions, lane restrictions, routing bans, port-of-entry designations, or route weight restrictions. [§ 397.65]

Dispute resolution: States, political subdivisions of different States, or Indian tribes may disagree over a proposed or established highway route designation, limitation, or requirement, or over matters relating to through highway routing. To resolve such disagreements (disputes), the parties in disagreement may petition the Secretary of Transportation to provide the greatest level of highway safety without unreasonably burdening commerce and to ensure compliance with Federal standards. If a dispute arises between or among political subdivisions of the same State, the State routing agency is responsible for resolving the dispute. [§ 397.75]

Emergency response capabilities: The resources available for responding to hazmat incidents to protect public safety and health and the environment. The analysis of emergency response capabilities is to be based upon the proximity of the emergency response facilities and their capabilities to contain and suppress hazardous materials releases within the impact zone. [§ 397.71(b)(9)(iv)]

Enhancement of public safety: The State or Indian tribe shall make a finding that any routing designation enhances public safety in the areas subject to its jurisdiction and directly affected by such designation. The finding shall be supported by documentation of any public hearings or consultation with affected States or Indian tribes. [§ 397.71(b)(1)]

Exposure and risk factors: States and Indian tribes shall define the exposure and risk factors, including distance to sensitive areas, associated with any hazardous materials routing designations. Sensitive areas include, but are not limited to, homes and commercial buildings, hospitals, schools, handicapped facilities, prisons, stadia, water sources, natural areas such as parks, wetlands, and wildlife reserves. [§ 397.71(b)(9)(vi)]

Factors: The rule lists 13 factors at § 397.71 (b)(9) that must be considered in establishing any non-radioactive hazardous materials designation. These factors are: population density, type of highway, type and quantity of NRHM, emergency response capabilities, results of consultation with affected persons, exposure and other risk factors, terrain considerations, continuity of routes, alternative routes, effects on commerce, delays in transportation, climatic conditions, and congestion and accident history.

Impact radius: The maximum range, from the point of an accidental release of NRHM, over which the material released poses a risk to public safety and health. The impact radius is used to determine the impact zone.

Jurisdiction: The territory over which a State, local government or Indian tribe has the power or authority to interpret and apply Federal regulations.

Origin-destination pair: The two locations that identify the beginning and termination of a route. When comparing alternative routes, all routes must have the same origin and destination pair.

Placarded shipments of NRHM: Certain types and quantities of NRHM require placarding when they are transported by motor vehicles. These types and quantities are identified in Tables 1 and 2 of 49 CFR 172.504. [§ 397.65 and § 397.71(b)(9)(iii)]

Population density: A measure of population along a route used in the relative risk determination. Population may consist of residents, employees, motorists, and other persons in the area. Population density is the population along a segment of an alternative route divided by the segment area. [§ 397.71(b)(9)(i)]

Preemption: If a State or Indian tribe establishes, maintains, or enforces highway route designations, limitations, and requirements that were not made in accordance with procedures and requirements set forth in the Federal regulations, these routing designations are invalid. Additionally, if compliance with, enforcement, or application of a routing designation is inconsistent with any requirement or regulation issued under the Hazardous Materials Transportation Act, the route designation is invalid. To determine whether a designation is preempted, any individual, business, organization, State, political subdivision of a State, or Indian tribe affected by a routing designation can request review by the Administrator.

Public participation: A State or Indian tribe shall provide 1) notice to the public of any proposed routing designation, 2) a period in which to comment, and 3) a public hearing, if deemed necessary by the State or Indian tribe. [§ 397.71 (b)(2)]

Reasonable access (terminal and facilities): Any routing designation must provide reasonable access for motor vehicles transporting NRHM to reach terminals, points of loading, unloading, pickup and delivery, and facilities for food, fuel, repairs, rest, and safe havens. [§ 397.71(b)(7)(i)-(iii)]

Reasonable routes: The shortest practicable route based on consideration of 13 factors listed in paragraph (b)(9) of §397.71. The routes established by a State or Indian tribe must provide reasonable access to terminals, points of loading, unloading, pickup and delivery, and facilities for food, fuel, repairs, rest, and safe havens. [§ 397.71(b)(7)]

Relative risk: A measure of the risk associated with one alternative as it relates to other alternatives being considered. A risk value calculated using the hazardous materials routing methodology (probability times consequence) has no meaning unless it is compared to other relative risk values calculated using the same methodology.

Responsibility for local compliance: The States are responsible for ensuring that all of their political subdivisions comply with the provisions of Subpart C of Part 397. The State is responsible for resolving all disputes between subdivisions. A routing agency for the State or Indian tribe, designated by the Governor or Indian tribe, respectively, shall ensure compliance with the Federal standards. [§ 397.71(b)(8)]

Restricted routes: Highway routes along which non-radioactive hazardous materials (NRHM) **may not** be transported. Restrictions covered under this regulation must apply specifically to NRHM-carrying motor vehicles, and could include forbidding travel on specific routes or route segments, or constraining travel by time of day, lane, or type of NRHM.

Routing agency: An agency that supervises, coordinates, and approves the non-radioactive hazardous materials routing designation. For a State, this agency could be the State highway agency, or other State agency designated by the Governor; for an Indian tribe, this would be an agency designated by that Indian tribe. [§ 397.65]

Route continuity: The State or Indian tribe must consult with adjacent jurisdictions to ensure routing continuity for hazardous materials across common borders. [§397.71(b)(9)(vii)]

Sensitive environments: Ecological and wildlife areas that could be seriously harmed by a hazardous materials spill. Sensitive environments include wetlands, water sources, habitats of threatened or endangered species, nesting or breeding ground.

Special populations: Groups of people that have a greater potential to be impacted by a hazardous materials release than the general public. Such populations could be difficult to evacuate, outdoors, or highly concentrated. Examples of special populations include schools, hospitals, senior citizens homes, shopping centers, sports stadia, parks, outdoor theaters, and golf courses. [§ 397.71(b)(9)(i)]

Standards: Federal standards are the basis for a State or Indian tribe's establishment of a routing designation. The standards are set forth at § 397.71 (b)(1)-(9). They are: enhancement of public safety, public participation, consultation with others, through routing, agreement of other States (burden on commerce), timeliness, reasonable routes to terminals and other facilities, responsibility for local compliance, and factors to consider.

Terrain: The topography along and adjacent to the proposed non-radioactive hazardous material (NRHM) routing designation, including height of vegetation, shoulder surface, natural and man-made surface features, that may affect the potential severity of an accident, dispersion of the NRHM, and control or clean up of the release. [§ 397.71(b)(9)(vii)]

Through routing: The routing designation must ensure continuity of movement so as not to impede or unnecessarily delay the transportation of NRHM. Criteria set forth in the rule to enhance public safety require that, for a proposed designation to go into effect, 1) the current route must present at least 50 percent more risk to the public than the deviation under the proposed designation; 2) the current route presents less than 50 percent more risk, but the proposed designation does not force a deviation from the current route of the lesser of (a) 25 miles or (b) 25 percent of that part of a trip affected by the deviation. A proposed designation cannot go into effect if the current route presents the same or less risk. [§ 397.71(b)(4)]

Timeliness: A State or Indian tribe must establish a NRHM routing designation within 18 months of proposing it by public notice or notice and consultation with affected political subdivisions, States and Indian tribes, and any other affected parties. [§ 397.71(b)(6)]

Traffic congestion: Congestion is related to the potential for traffic flow to be disrupted by an accident involving a hazardous materials-carrying vehicle. Traffic congestion can affect the potential for a release, the ability of emergency responders to reach the scene, the exposure to motorists, or the temporary closing of a highway for cleaning up any release. [§ 397.71(b)(9)(xiii)]

Transportation delays: Transportation delays or traffic backups may be caused by congestion on certain route segments and certain times of day or night. Delays may be a function of the maximum safe posted speed for a route. Delays may be avoided by imposing time of day restrictions for certain routes or segments, maximizing use of Interstates, selecting minimum time in transit routes, and considering single transport modes.

Type of highway: Characteristics of a highway, including vehicle weight and size limits, underpass and bridge clearances, roadway geometrics, number of lanes, degree of access control, and median and shoulder structures. The types of each alternative highway are compared when establishing a routing designation. [§ 397.71(b)(9)(i)]

Waiver of preemption: If a route designation, limitation, or requirement established by a State or Indian tribe is subject to preemption by Federal standards, a State, political subdivision, or Indian tribe may apply to the Secretary of Transportation for a waiver allowing the State or Indian tribe to maintain their route designation, limitation, or requirement. The waiver may be granted if the Secretary determines that the State or Indian tribes' designation, limitation, or requirement is at least as or more protective of the public, and does not unreasonably burden commerce. [§ 397.213]

APPENDIX A

PUBLIC INVOLVEMENT INFORMATION

PUBLIC INVOLVEMENT INFORMATION

Public participation is an important part of the routing selection process, and is required by §§397.71(b)(2) and (9)(v). The public is often a key source of local information that could affect routing decisions. This section of the guidelines provides an overview of the public involvement process. It is designed to serve as an introduction for State and Tribal planners to assist them in these types of activities.

The following list contains activities that should be considered when involving the public; each will
be discussed in more detail below.

- Notification process and maintaining communications
- Conducting informal public meetings
- Rule requirements
- Developing informational materials
- Holding formal hearings

At the beginning of the routing designation process, the State routing agency should establish an overall schedule for public participation, including a length of time for the public comment process. The time required for publicity and organization will depend on what format will be used for public input. Agencies may wish to consider developing a public involvement plan that establishes goals and objectives for the overall process and specific components (e.g., meetings). In cases where there is known public interest or potential controversy, early contact and involvement with the public should be established and maintained throughout the process to minimize or even avoid potentially controversial public meetings or hearings.

NOTIFYING THE PUBLIC/MAINTAINING COMMUNICATIONS

Contact person. The first step is to designate a contact person (preferably from the State routing agency) to handle questions and collect any written comments. Because the person will be handling questions from affected parties and potentially the media, he or she should be reasonably knowledgeable of the route selection process and the basis for a determination, including how the standards and factors may be applied. It may be helpful to have more than one contact person when the proposed route designations cover a broad geographic area; local contact people throughout the area may improve public access to information and improve communication.

Mailing Lists. Mailing lists are a primary means of distributing information to the public. Building a mailing list can be a labor-intensive activity, but if the State route agency begins during the initial stages of the analysis, it will ensure that affected parties are identified early on, or at a minimum during the public comment stage. Members of communities potentially affected by a routing decision and any others likely to have an interest in hazardous materials transportation should be included on the master mailing list. Obviously the list should include hazardous materials facilities and shippers known to transport over the route that may be affected; in addition, representatives of response agencies, officials from neighboring states, media contacts, appropriate government personnel, city/county officials, organization representatives, and interested members of the public should be included. It may be useful to organize the list by category. If, for example, the State routing agency wanted to provide a quick update regarding access to terminals, perhaps shippers of hazardous materials would be contacted on a priority basis.

The mailing list should include names, addresses, and when possible, telephone/fax numbers. Sources for developing the list include telephone directories (e.g., business, public, government), interest groups, lists of public meeting attendees, people who contact agencies to get transportation-related information, association lists, and lists developed for other projects, such as highway construction in the area.

Use of Media. Newspapers are the primary mechanism for developing public awareness. Therefore, the contact person, or whomever is responsible for publicity, will need to work effectively with them to maximize public awareness. For example, by finding out the newspaper's deadlines to determine when press releases should be sent. Radio is another useful means of alerting the public to impending route decisions.

The size and circulation of a paper will make a difference in how they can provide publicity. A large newspaper may be able to assign a reporter or have an editor responsible for the story. Conversely, a small paper may simply accept and publish a well-written news release. It is in the best interests of the agency to try and work with newspapers early on, particularly in cases of contentious route selection. If a newspaper goes ahead on a story without involvement of the agency, the agency may find itself having to respond to criticisms or concerns that are raised, but not addressed, in an article.

Access to technical materials. It is likely that the public will request more detailed or technical information used in the selection process. Technical support documents should be available for review in locations that are convenient to the public (e.g., libraries or government offices) and near to the proposed routes, prior to any hearings. Even when no public hearing is scheduled, these materials should be made available to persons preparing written comments.

PUBLIC MEETINGS

Public meetings, although not required by the rule, may facilitate the route selection process. As a general rule, public meetings and hearings serve different purposes. Meetings are usually more informal and interactive, and are primarily for information dissemination, gathering information, and resolving questions and concerns. By contrast, a hearing is an opportunity for people to formally comment on an issue; question-and-answer sessions or other interactions with representatives are not usually included. A meeting format is usually more appropriate early in the routing designation process.

Although meetings are the less formal option for soliciting public input, it is still important to determine the objective, and adequately consider what agenda, format, and presentation will best help in attaining that objective. Although many different alternatives for conducting meetings exist, the major goal is to encourage communication with the largest cross-section of agency personnel and community members as possible. At an early point in the process, an introductory information meeting, using a traditional presentation/question-and-answer/discussion format designed to acquaint the public with the overall scope of the proposed work, is usually the best option. More specific, but still informational-oriented meetings (e.g., addressing possible environmental impacts or right-of-way and relocation issues), might be better suited to small group meetings or workshops.

Determining when and where to hold meetings (and later, public hearings) will depend largely on who the target audience is. Generally, convenient to the public means primarily the evening, but consider the communities involved with respect to typical work schedules and lifestyles. The meeting location should be somewhere that is relatively well-known, centrally located, and within reasonable proximity to the affected area. Other considerations might include availability of parking and accessibility by public transportation.

RULE REQUIREMENTS

The rule requires the public be given a 30-day period to comment on a formal proposal of a routing designation. However, if the proposed routing designations are complex or controversial, more time may be appropriate.

Notice of the comment period (and public hearings, if they are held) must be given in at least two newspapers of general circulation in the affected area of the State. These announcements should include a complete description of the proposed routing(s) and where possible, a map or representation of the route. If the announcement includes, or is for a public hearing, then the date, time, and location of the hearing(s) must also be given.

During the comment period or after reviewing the comments, the State may decide to hold a public hearing. Hearings can be a useful forum for airing concerns and getting additional information that may influence the route selection. Organizing public hearings, however, can be a resource-intensive task. Therefore, the rule allows the State routing agency to exercise discretion in determining whether sufficient interest has been expressed to justify the effort. According to the rule, the public must have 30 days notice of any scheduled hearings. The rule also requires that the transcript of hearings be made available to any member of the public who wishes to purchase a copy, and specifies that the transcript must include any exhibits and documents presented during the hearing.

INFORMATIONAL MATERIALS

Basic information should include the route selection choice (or alternatives), background detail on the need for route designation(s), and the basis for the determination(s). Optional information could include advantages/disadvantages for each route if alternatives are being offered (particularly if the routes are fairly equal in risk); legal or statutory background information on the regulation; greater detail on the determinations; and maps or diagrams. Several common formats for information include fact sheets, pamphlets, and brochures. They can be short (2-4 pages) documents designed to provide a basic overview of a given topic, or can be much longer with more complex detail and information. The level of technical detail can vary with the target audience and the complexity of the subject; if resources allow, more than one type of fact sheet or pamphlet could be developed for specific audiences. For distribution to a general audience, informational materials should be relatively short, simple to read (i.e., avoid acronyms, technical language, and bureaucratic terms), and concise. They should always include a contact for more information. If they are also being used to advertise meetings or hearings, then that information (time, place, contact person) should be included.

PUBLIC HEARINGS

After the proposed route selections have been publicized, the State or local jurisdiction (as a representative of the State), may determine that a formal public hearing is necessary.

Planning considerations for holding hearings include selection of appropriate location(s), date(s) and time(s); use of a court reporter; development of a format for proceedings and procedures for speakers; and appropriate publicity. Dates and times should generally be convenient to the public (i.e., in the evening), but it is also appropriate to consider your target audience. If the primary groups expressing interest in the process are industry, trade groups, or officials, a daytime hearing may be more appropriate. There are a number of different formats for hearings, ranging from an informal open house conducted by agency staff to a formal hearing led by a public hearing officer. Generally, a less formal format will be more effective with the public, however, if time and space allow, different formats could be combined into one evening. Regardless of the format used, procedures for how the meeting will be run (e.g., determining who should lead/facilitate, length of time for speakers) should be established and guidelines made available to the public beforehand.

Announcements for hearings could appear in the legal notices section or as a display ad (depending on cost). A well-designed display ad among the commercial advertisements may get more notice. In addition, it may be desirable to publicize the hearing beyond the rule minimum requirements (advertisements in two newspapers). Sending a brief notice to the entire mailing list, or a series of media contacts (to generate free publicity) may be important. Notices of hearings could also be included in any informational materials.

Responding to Comments. After all written comments are received and meetings or hearings held, the selection committee should review any new information provided by commenters that may influence the route selection, and if necessary update the analyses. It can be a good practice to summarize the comments and make them available to the public -- along with any responses, particularly if the route selection process has been contentious. If the committee decides that new information warrants a change in route selection, it may be helpful to document it and make that information available to the public as well. If a major change is made in the proposed routing designations prior to finalizing the route selection, it may be useful to seek additional public input on the revised routings. However, the rule does not require a new round of public comments.

Additional Resources. A number of publications have been developed by U.S. DOT on how to plan and conduct meetings and hearings. These documents include: "Improving the Effectiveness of Public Meetings and Hearings" and "Innovations in Public Involvement for Transportation Planning."

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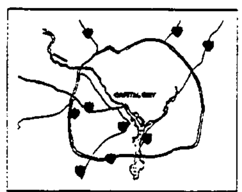
APPENDIX B

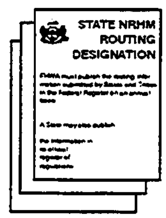
PUBLIC INFORMATION AND REPORTING REQUIREMENTS

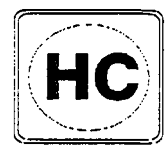
PUBLIC INFORMATION AND PUBLICATION REQUIREMENTS: 49 CFR 397.73

Public Information

States and Indian tribes must make information on NRHM routing designations available to the public in the form of:





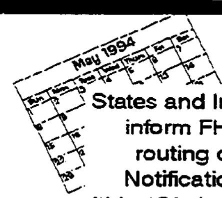


Maps or Lists or Road signs.*

* Road signs must comply with the provisions of the *Manual on Uniform Traffic Control Devices*. See 49 CFR Part 7, Appendix D and 23 CFR 655, subpart F.

Reporting and Publishing Requirements

1

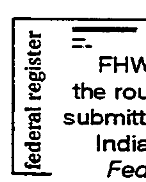


States and Indian tribes must inform FHWA of NRHM routing desingations. Notification must occur within 150 days of publication of the final rule. Any subsequent changes or additions to the list of designated routes must be submitted to FHWA within 60 days.

2

States must submit to FHWA a *description* of the routing designations, and the *date* they were established.

3



FHWA will publish the routing information submitted by States and Indian tribes in the *Federal Register* on an annual basis.

(A State may also publish the information in its official register of regulations)

APPENDIX C

CONSIDERATION OF RISK AND OTHER FACTORS FOR TUNNELS

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CONSIDERATIONS OF RISK AND OTHER FACTORS FOR TUNNELS

According to 49 CFR 177.810, State and local regulations and ordinances regarding the transport of hazardous materials (except radioactive materials) through urban tunnels used for mass transportation will not be superseded by the Federal hazardous materials regulations (parts 170 to 189). However, the new regulations regarding the highway routing of non-radioactive hazardous materials establish that routing designations for tunnels are now subject to the same Federal standards and procedures as other highway routing designations. Thus, a State routing agency is required to evaluate tunnels against route designation criteria to decide if hazmat shipments should be transported through tunnels or on alternative routes.

Tunnels have certain features such as large grades, high degrees of confinement, and limited access for traffic, that make them unique. As a result, it should be assumed that tunnels and other non-common roadway structures such as bridges comprise one segment of the route for the purposes of simplifying the risk analysis. Tunnels may also require a special approach or data to perform a routing risk analysis. This appendix briefly examines possible approaches to address tunnels with regard to the following routing criteria most applicable to tunnels: risk, including accident probability and accident consequences; and other factors such as emergency response capabilities, burden on commerce, congestion/delays, and property risk.

ACCIDENT PROBABILITY

For tunnels and bridges, a State routing agency could develop accident rates based either on actual accident data for the tunnel, on the rate for the nearest roadway segment, or on information available from national data or studies. For example, one study of tunnels revealed that accident rates for light and heavy trucks were four times greater than that for the average passenger car.[22] This information could be incorporated into the development of accident rates for hazardous materials transport in tunnels. Accident probability for the tunnel segment can be determined (as in Section III) by multiplying the number of accidents per mile for the tunnel segment by the length of the tunnel (in miles).

ACCIDENT CONSEQUENCES

Tunnels are confined structures; thus, the consequences of a fire, explosion, or toxic cloud from the release of a hazardous material in a tunnel may also be largely confined. Large grades may concentrate releases of dense flammable vapors (e.g., LPG) in the center of the tunnel and may create drafts to fan a fire. After a release, it is likely that traffic in the tunnel will become trapped as additional traffic continues into the tunnel in both directions. The persons exposed to the release will likely be those persons in vehicles trapped in the tunnel. However, because of the uncertainty in the nature of the accident and the type of tunnel, it is unclear whether the entire tunnel, some fraction of the tunnel, or an area beyond the tunnel would be affected by the immediate consequences of a release.

Many approaches of varying sophistication could be used to determine the consequences of a hazardous material release in a tunnel. A simple approach would be to assume that the number of fatalities would be the maximum number of persons expected to be trapped in the tunnel. To determine the total population in the tunnel, the State routing agency can calculate the total capacity of trapped vehicles in the tunnel and then assume an average number of persons per vehicle. A method to calculate the number of vehicles can be determined by adapting the method 1 used in Section IV for calculating congestion/ transportation delays. The maximum queue length (step 1 of Method 1) can be set to the length of the tunnel. The vehicle length (for cars and trucks) can be determined by following step 3 of Method 1. Tunnel population is then determined by the following equation:

$$P = TL/VL \times PV \times L$$

where:

P = Tunnel Population
TL = Tunnel Length
VL = Vehicle Length
PV = Average Number of Persons/Vehicle
L = Total Number of Lanes (both directions)

For toxic chemicals, a more complex approach would consider that the toxic cloud could potentially drift out of the tunnel and cause fatalities. In this approach, the tunnel population calculated above would be added to the number of persons in two circular impact areas that are centered at the ends of the tunnel. The size of the impact area could be determined either by Method 2 or 3 for calculating accident consequences in Section III. Overall risk of the tunnel segment can then be determined, as in risk calculation in section III, by multiplying potentially impacted population by the accident probability of the tunnel segment.

EMERGENCY RESPONSE

Tunnels are largely inaccessible in terms of responding to an accident within the tunnel structure. Consequently, the emergency response capability calculations in Section IV may be more applicable for routes without tunnels than for those with tunnels. Emergency response to accidents in a tunnel will depend on:

- the type and design of the tunnel,
- traffic congestion created inside the tunnel,
- access to the tunnel,
- the state of preparedness for an event (e.g., simulation, exercise),
- the response capability available, and
- the speed at which the tunnel area can be secured.

These parameters may be difficult to evaluate. However, if other routing criteria favor a route containing a tunnel, the acceptability of the route with a tunnel might depend on whether or not these parameters indicate that the emergency response capability is adequate given the physical imitations posed by a tunnel.

BURDEN ON COMMERCE

Local and State restrictions that once prevented the transport of hazardous materials in tunnels need to be evaluated in terms of burden on commerce according to the new regulations. The State routing agency should refer to Section IV on burden on commerce for guidance in considering this factor.

CONGESTION/TRAVEL DELAYS

Tunnels are a concentration point for traffic. In the event of a disruption of traffic as a result of an accident, especially one involving hazmat, there will be extensive delays. A State routing agency can use the same methods for estimating congestion and delay as discussed in Section IV. Additionally, whether other geometries such as bridges and viaducts are present, and the effects of an accident on traffic, should be considered as appropriate with the reduction in available escapes for the public on the highway when an accident occurs. The State routing agency should also consider that a hazmat incident may close a tunnel for weeks, months, or years rather than minutes or hours for a non-tunnel route.

PROPERTY RISK

Property risk for tunnels can be calculated as described in Section IV under the optional property risk calculation for non-common structures (Method 3, step 4). The property damage value for tunnels could be determined by contacting municipal and State authorities that operate or maintain insurance records on the tunnel.

COMPARISONS WITH NON-TUNNEL ROUTES

Consistent with other non-tunnel routes, the State routing agency should first evaluate tunnels in terms of physical and legal constraints, followed by analysis of relative risk to population. It may be difficult, however, to compare the tunnel route with an alternative route because comparisons of population risk will not tell the whole story. The high costs of other factors such as property damage and congestion/delays, and the difficulty of an emergency response are likely to carry considerable weight for an alternative to a tunnel. The challenge for the State routing agency is to consider these other factors in the context of the overall analysis and the enhancement of public safety.

In addressing this challenge, the State routing agency should evaluate all aspects of these factors including possible mitigating circumstances. For example, the capability to conduct hazmat emergency simulations on a tunnel can lessen the concern caused by the difficulty of conducting emergency response operations for such structures. Also, certain tunnel operating procedures could reduce accident probability and therefore reduce risk to public safety, property damage, and the likelihood of delays. For example, Colorado currently permits the use of a tunnel only if the alternative route is closed because of bad weather and only if the hazmat trucks travel through the tunnel together in an hourly caravan.

APPENDIX D

EMERGENCY RESPONSE CAPABILITIES

APPENDIX D

EMERGENCY RESPONSE CAPABILITIES

For the estimated 200 annual consequential incidents with problems arising from lack of proper information at the scene for responders as discussed in the TRB Special Report 239 *Hazardous Materials Shipment Information for Emergency Response*, the combined costs of property damage, evacuations, traffic delays, productivity losses, and response personnel and equipment amount to several hundred million dollars (excluding environmental and cleanup costs because of insufficient data). Further, these incidents are associated with approximately 400 reported acute injuries and illnesses. Clearly, timely and effective emergency response capabilities can provide reductions in the consequences of hazardous materials accidents.

Timely action by emergency responders can reduce the magnitude of the consequences associated with a hazardous material release, with proximity, resources, and planning providing the primary influences on effectiveness of a response. The time it takes to get emergency personnel to the accident site is important for establishing control of the immediate area and determining the nature of the hazard. The number of emergency response units or teams (e.g., fire, police, emergency medical) that are within a certain response window along segments of a route could be counted and rated on a scale. This could then be applied to reduce the consequence term in the risk calculation. However, the years of experience, quality, and extent of training of the team members, and the availability of appropriate equipment and materials (e.g., fire extinguishants and application equipment) are of equal, if not greater importance in assessing any real reduction in consequences that can be ascribed to emergency response capabilities considered only on the basis of proximity. Additional criteria (e.g., average number of years of experience of team members,numbers of hours and type of training, training on specific response equipment, response training on specific hazardous cargoes) are needed to assign a useful rating factor to emergency response capabilities, which could then be applied to the consequence term as an overall indicator of risk reduction.

Various methods which have been used to quantify this factor were identified which could serve as starting points for quantifying the emergency response capabilities factor in the routing designation process. DOT's *Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials* suggests the establishment of arbitrary scales for each emergency response parameter (e.g., time required for emergency response personnel to reach potential accident sites, availability of specialized equipment; amount of training of response personnel, and availability of trained response personnel) based upon land use types along a route. Land use types considered include rural, suburban, urban, and commercial/industrial. The scaling system is arbitrary and could be adjusted to describe local conditions in conducting a routing analysis.

Another possibility is found in the 1987 Transport Canada report entitled *Dangerous Goods Truck Route Screening Method for Canadian Municipalities*. The Canadian report includes a quantitative approach to consideration of emergency response capabilities by counting the number of trained and equipped fire squads, the number of police cars and the number of ambulances available within a 10-minute response period anywhere along a given route. This count is divided by the route length and is then translated into a rating on a scale from 1.0

(low) to 1.5 (high). The relative risk for each route can then be divided by the response capability factor, thereby reducing the overall risk score.

The Arizona Department of Transportation recently published a report entitled *Comparative Risks of Transporting Hazardous Materials on the State Highway System in Arizona*, FHWA-AZ93-285, which used a statewide GIS model to evaluate highway segments throughout the State in terms of hazardous materials transport risks. The location of emergency response units was integrated into the GIS model, which calculated emergency response time based on the response unit's proximity to each highway segment. The response units selected were fire departments as identified by the State Fire Marshall's Office and individual fire departments. The analysis assumed that the closest unit would respond whether or not it had actual jurisdictional authority. Further, the analysis assumed a homogeneity in response training and capability across all fire response units because consistent information on these important details was not available. Response time was used to determine vulnerability as a function of accident rate, shipment frequency, population affected and response time. While the specific model assumptions regarding calculation of time are fairly straightforward, the critical assumption regarding the capabilities of all fire units limits the usefulness of this technique.

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APPENDIX E

WORKSHEETS FOR ALTERNATIVE 2

APPENDIX E
WORKSHEETS FOR ALTERNATIVE 2

This appendix contains the RAW, Worksheets, segments and census tract boundaries for Alternative 2. Alternative 2 is U.S. 40, which is the current route used by most hazardous materials carriers. Where the entries on the worksheets are different than in Alternative 1, the example entry is also illustrated with explanatory text.

① *ALTERNATIVE NUMBER*

Example Entry: Alternative Number 2.

---

② *ORIGIN*

Example Entry: The origin for Alternative 2 is the intersection of I-70 and U.S. 40, 4 miles (6.4 km) west of the Plainfield CBD.

---

③ *DESTINATION*

Example Entry: The destination for Alternative 1 is the intersection of I-70 and U.S. 40, 6 miles (9.6 km) east of the Plainfield CBD.

---

④ *VIA*

Example Entry: Alternative 2 uses U.S. 40 exclusively and is therefore via I-70.

---

⑤ *LENGTH*

Example Entry: Alternative 2 is 12 miles long (19 km).

---

⑥ *TRAVEL TIME*

Example Entry: The travel time of 16 minutes was calculated by dividing the route length of 12 miles (19 km) by an estimated average highway speed (AHS) of 45 miles per hour (72 kph).

$$\frac{\text{12 miles (19 km)}}{\text{45 miles (72 km) per hour}} \times \text{60 minutes} = \text{16 minutes}$$

---

⑦ *CIRCUITY*

Example Entry: Alternative 2 circuity is 1, because U.S. 40 is the minimum path between the origin and destination.

$$\frac{\text{12 miles (19 km)}}{\text{12 miles (19 km)}} = 1$$

Exhibit 23

Hazardous Materials Routing Analysis Worksheet for Alternative 2

1. ROUTE CHARACTERISTICS

Alternative No._2_ Origin_intersection of I-70 and U.S. 40 4 mi. W of city Destination_intersection of I-70 and U.S. 40, 6 mi. E of city Via __U.S. 40_

Length___12_____Miles Travel Time__16____Minutes Circuity____1_______

Description__Some peak-hour congestion at the Main St. interchange. Terrain exhibits no unusual characteristics. No areas of extreme weather conditions

2. PHYSICAL AND LEGAL CONSIDERATIONS

Are there any physical constraints? ☐ Yes ☒ No Explain___no construction planned

Are there any legal constraints? ☐ Yes ☒ No Explain

3. RISK DETERMINATION

Select hazardous materials class for study. ☐ EXP ☐ FL ☐ PG ☐ FCL ☐ FS ☐ OXI ☐ POI ☐ COR OR

Specific hazardous material_______Ammonia Impact Area____________1 mile

Population Risk Calculation

Segment No.	Accident Probability (10^{-6})		Potential Population Exposed Per Mile in Impact Area		Relative Population Risk (10^{-6})
2-A	124	X	807	=	100,100
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	
				TOTAL	100,100

4. THROUGH ROUTING

Relative Risk: (Population Risk)
Alternative _2 = A = _100,100__
Current Route = B = _100,100__

Route Lengths:
Alternative _2 = C = ___12____
Current Route = D = ___12____

B/A = _1___ C-D = __0_ C/D = _1____

B/A > 1.5 ? ☐ Yes ☒ No C-D > 25? ☐ Yes ☒ No C/D > 1.25? ☐ Yes ☒ No

Through routing criteria met? ☐ Yes ☐ No If no, do not complete the rest of this worksheet.

Exhibit 23 (continued)

Hazardous Materials Routing Analysis Worksheet for Alternative 2

4. ADDITIONAL FACTORS

Special Populations ☒ Considered ☐ Not considered Subjective Factor 3 Population Factor ____

Sensitive Environments ☒ Considered ☐ Not considered Comments ____

Segment No.	Sensitive Environment Area (acres, or other area units)		Accident Probability (10^{-6})		Relative Sensitive Environment Risk (10^{-6})
2-A	18	X	124	=	2,232
		X		=	
		X		=	
		X		=	
		X		=	

TOTAL 2,230

Emergency Response Capabilities

Response Capabilities = Total # Trained, Equipped Units Within 10 minutes / Route Length = 2 / 12 mi. = 0.17

Burden on Commerce ☐ Yes ☒ No Explain no burden

Congestion/Delay Calculation

Queue Distance (ft)		Total Time (hrs)		No. of lanes		Vehicle Length (ft)		Delay (Vehicle-hrs)		Accid. Prob. (10^{-6})		Delay Risk
39,600	X	1.67	X	4	/	40	=	6,600	X	124	=	820,000
	X		X		/		=		X		=	
	X		X		/		=		X		=	
	X		X		/		=		X		=	
	X		X		/		=		X		=	
	X		X		/		=		X		=	

Total = 820,000

Property Exposed Calculations (optional)

Segment No.	Accident Probability (10^{-6})		Potential Property Value Exposed Per Mile in Impact Area ($ millions)		Relative Property Risk (10^{-6})
2-A	124	X	80.9	=	836
		X		=	
		X		=	
		X		=	
		X		=	
		X		=	

TOTAL 836

(11) SEGMENTATION

Example Entry: Alternative 2 is encompassed in one segment (labelled 2-A) because the roadway type (Urban, Multi-lane, Undivided) is the same along the entire route.

(12) ACCIDENT PROBABILITY

Example Entry: The planners of Plainfield found that their State highway department had accident rate data by a variety of road types. Therefore, they used METHOD 1. The data were collected over a three year period, and thus provide a sufficiently representative sample.

Roadway Type	Accidents per million vehicle-miles (mvm)
Urban Multi-lane, Undivided	10.37

The roadway type shown above corresponds to the road in Segments 2-A. These values are entered in Column 4 of Worksheet 1 (Exhibit 24). Columns 4 and 3 are multiplied to obtain probability, which is recorded in column 5 and on the appropriate lines in the RAW.

(15) POPULATION EXPOSED

Example Entry: The values for Entry 16 are calculated using Worksheet 2: Population Inventory (Exhibit 23) and recorded on the RAW.

The share or fraction of each census tracts that falls within the potential impact zone for Segment 2-A was determined by visual inspection and estimation. The census tracts for the surrounding area are shown in Exhibit 17. The estimated shares for these tracts are recorded in Column 5 of Worksheet 2 (see Exhibit 23).

(17) THROUGH ROUTING

U.S. 40 is the current route, therefore Through Routing is not applicable.

(18) SPECIAL POPULATIONS

Example Entry: METHOD 2 (USGS maps) is used. There is one elementary school, one shopping mall, and one nursing home in the Alternative 2 potential impact zones. Therefore, "3" is entered under "Subjective Factors" for entry 18.

(19) SENSITIVE ENVIRONMENTS

Example Entry:

Step 1. Determine the potential impact area.

The impact area (entry 14) is one mile.

Step 2. Identify sensitive environments within the impact area.

Exhibit 19 shows the Alternative 2 overlaid with specialized maps of parks, and the nearby river.

Step 3. Measure the area of each type of sensitive environment within the impact area and sum.

Using a planimeter, the State planners measured the river area that runs along U.S.40.

Segment No.	**Sensitive Environment Area**
2-A	18.2 acres

This value is entered on the RAW at Entry 19.

Step 4. (Optional) Factor in any other special characteristics or criteria.

No special terrain or geographic considerations were apparent.

Step 5. Multiply the total sensitive environment area within each route segment by the appropriate accident rate.

The acreage obtained in step 3 is multiplied by the accident probability to obtain the sensitive environment risk.

124 x 18.2 = 2,230

This product is the sensitive environment risk factor that may be used to compare alternative routes' potential risk.

(20) *EMERGENCY RESPONSE*

Example Entry: The locations of the emergency response units on the alternative routes are plotted on Exhibit 18. The two fire departments located along U.S. 40 are within a 10-minute response window and are trained and equipped for dealing with hazardous materials accidents. Therefore, the response capability for this alternative is 2 units per 12 miles or 0.17. This value can be compared with those for the other alternative routes. The one with the highest value has the "best" response capabilities and the greatest potential for reducing the consequences of a hazardous materials release.

(22) *CONGESTION/TRAFFIC DELAY*

Example Entry: The procedures described in **Section IV, Congestion/Transportation Delay** are applied here to Alternative 2.

Step 1. Identify maximum queue length for each segment.

The maximum queue length is the maximum distance between adjacent access points. For Alternative 2, this queue is from the intersection of I-70 and U.S.40 to the intersection of U.S.40 with main street, a distance of 7.5 miles.

Segment 2-A queue = 39,600 ft (7.5 mi)

Step 2. Determine incident duration.

The time to respond is assumed to be 10 minutes. The local emergency response team thought it would take somewhat longer to clean up U.S. 40 thoroughly because it is located along commercial land; they estimated 90 minutes. The following time periods are summed and entered on the RAW.

Time to respond = 0.17 hours (10 minutes)
+ Time to clean up = 1.5 hours (90 minutes)
1.67 hours

Step 3. Determine vehicle length.

Vehicle length is the same as for Alternative 1.

Step 4. Calculate Delay.

Delay is the product of queue distance (ft) from Step 1, incident duration (hours) from Step 2, and number of single-direction lanes, divided by vehicle length (ft/vehicle). These factors are entered in the RAW.

Number of single-direction lanes = 4.

(23) PROPERTY EXPOSED (OPTIONAL)

Example Entry:

Step 1. Estimate Dollar Value Per Lineal Foot of Frontage

The middle 2 miles of segment 2-A consist of rural residential property, which corresponds to the land use type Rural residential (see table in **Section V, Property Exposed (Optional)**). The first and the last 5 miles of Segment 2-A consist of commercial property, which corresponds to the land use type Commercial.

Step 2. Measure Lineal Frontage for Each Land-Use Type

The lineal frontage of Commercial property is 10 miles, Rural residential property covers 2 miles.

Step 3. Multiply Lineal Frontage for Each Land Use by Associated Value Per Lineal Foot

Rural residential: $28/foot x 10,560 feet = $0.296 million
Commercial: $1,527/foot x 52,800 feet = $80.6 million

Step 4. Estimate Value of Roadway Structures and Add to Land Use Property Values

There are no roadway structures on Segment 2-A.

Step 5. Determine the Property Value Per Mile of the Route Segment

$$\text{value per mile: } \frac{\$\ 80.9 \text{ million}}{12 \text{ miles}} = \$6.74 \text{ million/mile}$$

This value per mile is entered on the RAW (Exhibit 21) as the Potential Property Value Exposed Per Mile.

(24) RELATIVE PROPERTY RISK (OPTIONAL)

Example Entry: The probability of a vehicle accident on Segment 2-A is 124 (see Entry 12, Accident Probability).

124 x $6.74 million/mile = 836

This value is entered on the RAW in the Relative Risk column.

Alternative: _____2______
Date: ___5_/_____/__94_
Page ___1_ of __1__

Exhibit 24
WORKSHEET 1: Roadway Inventory for Alternative 2

1		2	3	4	5
Segment		Road Type	Length (miles)	METHOD 1 Historical Accident Rate (accidents/ mvm)	Probability of Any Vehicle Accident (10^{-6})
#	O/D				
2-A	Intersection of I-70 and U.S. 40 (W and E of city)	Urban, Multi-lane undivided	12.0	10.37	124.4

Alternative: ____2______
Date: __5_/____/__94_
Page __1__ of __1__

H.M. Class:____________
or Chemical:__Ammonia_____
Impact Radius:____1.0_______

Exhibit 25
WORKSHEET 2:- Population Inventory

1	2	3	4	5	6	7
Segment		Census Tracts				
#	Length (Miles)	Number	Population	Percent of Tract in Impact Area	Population in Impact Area	Population/Mile in Impact Area
2-A		71.02	1540	0.3	462	
		72.04	2300	0.3	690	
		72.03	1800	0.25	450	
		73.01	3050	0.4	1,220	
		73.02	4900	0.5	2,450	
		73.03	5100	0.45	2,295	
		74.04	2020	0.75	1,515	
		74.05	1140	0.3	342	
		75.01	870	0.3	261	
	12.0				9685	807

Alternative: ___2______
Date: __5_/____/_94__
Page __1__ of __1__

H.M. Class: ______________
or Chemical: _____Ammonia_____

Exhibit 26: Property Value for Alternative 2
WORKSHEET 3: Property Value

1	2	3	4	5	6			7	8	9
Segment	Option 1 Land Use Type and Multiplier				Value of Roadway Structures ($ millions)			Segment Total ($ millions)	Segment Length (miles)	Value/Mile ($ millions)
#		Value (Factor)	Length (ft)	Value	Structure	Value	Total			
	High-Density Residential	2.0								
	Medium-Density Residential	0.7								
	Low-Density Residential	0.1								
	Commercial	4.0								
	Industrial	1.0								
	Agricultural	0.1								
	Institutional	2.0								
Segment	Option 2 Land Use Value--State or Local									
#	Land Use Type	Value ($ /ft	Length (ft)	Value ($ millions)						
2-A	Commercial	1,527	52800	80.6	none	0	0			
	Rural residential	28	10560	0.296						
Total								80.9	12	6.74

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APPENDIX F

REPRODUCIBLE BLANK WORKSHEETS

Hazardous Materials Routing Analysis Worksheet

1. ROUTE CHARACTERISTICS

Alternative No._____ Origin _______________ Destination__________________________ Via ______________________________

Length____________Miles Travel Time__________minutes Circuity____________________

Description____

2. PHYSICAL AND LEGAL CONSIDERATIONS

Are there any physical constraints? ☐ Yes ☐ No Explain____

Are there any legal constraints? ☐ Yes ☐ No
Explain____

3. RISK DETERMINATION

Select hazardous materials class for study. ☐ EXP ☐ FL ☐ PG ☐ FCL ☐ FS ☐ OXI ☐ POI ☐ COR **OR**

Specific hazardous material____________________________ Impact Area______________________________

Population Risk Calculation

Segment No.	Accident Probability (10^{-6})		Potential Population Exposed Per Mile in Impact Area		Relative Population Risk (10^{-6})
________	____________	X	____________	=	____________
________	____________	X	____________	=	____________
________	____________	X	____________	=	____________
________	____________	X	____________	=	____________
________	____________	X	____________	=	____________
________	____________	X	____________	=	____________
				TOTAL	____________

4. THROUGH ROUTING

Relative Risk: (Population Risk)	Alternative __	= A = __________
	Current Route	= B = __________
Route Lengths:	Alternative __	= C = __________
	Current Route	= D = __________

B/A = _____ C-D = _____ C/D = _____

B/A > 1.5 ? ☐ Yes ☐ No C-D > 25? ☐Yes ☐ No C/D > 1.25? ☐ Yes ☐No

Through routing criteria met? ☐Yes ☐ No If no, do not complete the rest of this worksheet.

Hazardous Materials Routing Analysis Worksheet (continued)

5. **ADDITIONAL FACTORS**

Special Populations ☐ Considered ☐ Not considered Subjective Factor__________ **OR** Population Factor__________

Sensitive Environments ☐ Considered ☐ Not considered Comments____________________

Segment No.	Sensitive Environment Area (acres, or other area units)		Accident Probability (10^{-6})		Relative Sensitive Environment Risk (10^{-6})
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
			TOTAL		______

Emergency Response Capabilities

Response Capabilities = Total # Trained, Equipped Units Within 10 minutes / Route Length (miles) = ______ = ______

Burden on Commerce ☐ Yes ☐ No Explain____________________

Congestion/Delay Calculation

Queue Distance (ft)		Total Time (hrs)		No. of lanes		Vehicle Length (ft)		Delay (Vehicle-hrs)		Accid. Prob. (10^{-6})		Delay Risk
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
______	X	______	X	____	/	______	=	______	X	______	=	______
										Total	=	______

Property Exposed Calculations (Optional)

Segment No.	Accident Probability (10^{-6})		Potential Property Value Exposed Per Mile in Impact Area ($ millions)		Relative Property Risk (10^{-6})
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
______	______	X	______	=	______
				TOTAL	______

Alternative: ___________
Date: ____/____/____
Page ____ of ____

WORKSHEET 1: Roadway Inventory

1		2	3	4	5
Segment		Road Type	Length (miles)	Accident Rate (accidents/mvm)	Probability of Any Vehicle Accident (10^{-6})
#	O/D				

Alternative: ____________
Date: ____/____/____
Page ____ of ____

H.M. Class: ______________
or Chemical: ______________
Impact Radius: ______________

WORKSHEET 2: Population Inventory

1	2	3	4	5	6	7
Segment		Census Tracts				
#	Length (Miles)	Number	Population	Percent of Tract in Impact Area	Population in Impact Area	Population/Mile in Impact Area

Alternative: ____________
Date: _____/_____/_____
Page _____ of _____

H.M. Class: ______________
or Chemical: ______________

WORKSHEET 3: Property Value

1	2	3	4	5	6			7	8	9
Segment	Option 1 Land Use Type and Multiplier				Value of Roadway Structures ($ millions)			Segment Total ($ millions)	Segment Length (miles)	Value/Mile ($ millions)
#		Value (Factor)	Length (ft)	Value	Structure	Value	Total			
	High-Density Residential	2.0								
	Medium-Density Residential	0.7								
	Low-Density Residential	0.1								
	Commercial	4.0								
	Industrial	1.0								
	Agricultural	0.1								
	Institutional	2.0								
Segment	Option 2 Land Use Value--State or Local									
#	Land Use Type	Value ($ /ft	Length (ft)	Value ($ millions)						

Alternatives Comparison

Alternative			Physical and Legal Considerations		Risk Determination		Additional Factors							
Number	Length	Travel Time (minutes)	Physical	Legal	Risk	Fraction of Current Risk	Special Populations	Sensitive Environments	Emergency Response	Burden on Commerce	Congestion/ Delay	Property Risk (optional)	Rank

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REFERENCES

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