HAVE WASTE, WILL TRAVEL: AN EXAMINATION OF THE IMPLICATIONS OF HIGH-LEVEL NUCLEAR WASTE TRANSPORTATION

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Overview and Conclusion by
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SUMMARY

This paper is a critical look at the transportation problems posed by the establishment of a national nuclear waste repository in the western United States, and as such, outlines the major technical, logistical, organizational, and policy questions that have not been addressed regarding the movement of spent nuclear fuel across the nation. Included are a brief history of the policies and legislation that have promoted nuclear energy production in the U.S., a critical review of the legal and political issues currently surrounding nuclear energy transportation, and a history and critique of the siting process that resulted in three final candidate sites for the western repository--Yucca Mountain, Nevada; Hanford, Washington; and Deaf Smith County, Texas. This material is followed by an analysis of the routing problems involved with nuclear waste transportation, an overview of the emergency preparedness measures needed to complement such transportation, and a thorough survey of how all these various issues specifically apply to the state of Colorado.

Emerging from this study is one clear problem concerning nuclear waste transportation. The issue is subject to a fundamental tension that makes resolution of conflict unlikely: the federal government has essentially imposed routes and regulations upon state and local governments, but has not provided means or support for abiding by those mandates. Lower levels of government bear the responsibility for safe transportation but have little say in how it should be managed.

FOREWORD

The research for this project was undertaken by Ann FitzSimmons, with the assistance of Tim Brown, Gerald Jacob, and Kathy Kindquist. Some of the research was undertaken as part of a graduate class taught by Andrew Kirby in 1985, and the participants in that class are also thanked. The project was funded by the Natural Hazards Research and Applications Information Center, and the continued support of Susan K. Tubbesing and Bill Riebsame, plus the editorial assistance of David Butler, is also noted with thanks.

PREFACE

This paper is one in a series on research in progress in the field of human adjustments to natural hazards. It is intended that these papers be used as working documents by those directly involved in hazard research, and as information papers by the larger circle of interested persons. The series was started with funds from the National Science Foundation to the University of Colorado and Clark University, but it is now on a self-supporting basis. Authorship of the papers is not necessarily confined to those working at these institutions.

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OVERVIEW

Introduction

The disposal of spent nuclear fuels receives less attention than the issues of reactor siting and emergency evacuation. However, for several reasons it is this part of the nuclear fuel cycle which is central to any evaluation of nuclear energy. First, the active life of nuclear fuels is in reality a very brief portion of their overall longevity. Disposal strategies must involve projections over very long time frames, and in consequence, the successful management of active nuclear fuels is, when measured over time, of almost insignificant importance compared to the management of spent nuclides. Second, the disposal process is usually concentrated in a small number of locations in order to minimize the social and environmental impacts of storage. As a result, there is typically a transitional period between fuel use and spent fuel storage which involves some high-level waste transportation from reactor sites to a small number of storage sites. In this paper, it is argued that this transitional period represents a weak link in terms of nuclear safety. As a result, the transportation issue is of crucial importance in evaluating the overall safety of nuclear industries and in understanding political opposition to nuclear power. As the latter increases in step with the demonstration of the fallability of the nuclear industry, it becomes more possible to place this part of the nuclear process within the realm of policy debate.

An analysis of the situation existing within the United States demonstrates the technical, political, and constitutional issues that surround high-level nuclear waste (HLNW) transportation. Implicit in the choice of the U.S. as an example is the recognition that this issue is under a good deal of scrutiny at federal, state, and local levels, and thus represents a fairly clear struggle between technical and political positions. In this paper a brief history of policy evolution is followed by an indication of some of the organizational problems pertaining to waste transport, and an interpretation of the political and constitutional implications of this issue. The remainder of the paper then builds on these insights, and explores some of the detailed issues facing those managing waste transport. Much of the material in the following chapters is then applied to Colorado specifically; there, the inherent problems of moving hazardous or radioactive substances are revealed quite clearly, although we believe that our analysis is of general applicability throughout most, if not all, of the United States.

The United States: A Brief History of Nuclear Disposal

At the outset, it must be argued that the technical context of disposal and storage of HLNW is not greatly different from other waste issues, with the exception of the longevity of the problem. Certainly in terms of quantity, the problem is less pressing; there exist only 40,000 cubic metres of HLNW, in contrast to the far larger annual production of both toxic materials and low-level nuclear wastes in the U.S.. Nor should the potency of the latter material be underestimated; many toxics have a demonstrated ability to kill and to cause genetic damage. There are, however, a number of other factors which conspire to place HLNW in a unique category. These include: the nature of nuclear materials, perceptions of nuclear threats, and the implications of the disposal problem for political conflict. These factors are discussed in turn below.

Although civilian nuclear waste exists primarily as a result of the generation of nuclear power, the history of the latter is inextricably linked to other nuclear technologies, and in particular, to nuclear weapons. (There is within the U.S., for instance, much more military than civilian waste.) In consequence, in many advanced societies nuclear power is controlled by para-statal organizations, which operate with varying degrees of secrecy. Certainly in Europe and the United States, nuclear power is typically regulated by powerful bureaucratic organizations. In the U.S., this control extends back to the era of the Atomic Energy Commission, created in 1946. The threats of terrorism and nuclear proliferation are frequently given as the primary reasons for this state control. Regardless of specific reasons, any analysis of nuclear materials is thus inevitably placed firmly in the context of the state, rather than squarely within the market.

The singularity of the HLNW disposal process itself is to be found in the nature of the substances to be disposed of. Nuclear wastes are interlinked in the popular imagination with the ever-present threat of nuclear war, and as noted, there is both civilian and defense waste in the U.S.. Spent nuclear materials pose measurable threats to human life, but are perceived to be much riskier than any other substance. Research undertaken after the TMI emergency, for instance, showed that residents there widely overemphasised the potential risks. In addition, the time frame over which such a threat exists is greater than anything yet known, a factor which has at times threatened to place the storage issue somewhere beyond the margins of science and out into the realms of metaphysics.

Under the terms of the 1982 Nuclear Waste Policy Act, the federal government is committed to the safe storage of the nation's HLNW in a small number of nationally designated sites. The Department of Energy (DOE) has been given this responsibility, and the task is being pursued with greater vigor than can be detected in the case of toxic wastes. Utility companies who are in need of waste disposal are already being taxed to fund the construction of a repository, and the DOE is in the middle of a site selection process for the first of what may turn out to be a number of secure disposal sites. Concern for the geologic integrity of storage sites and the urge to constrain storage to as small a number of locations as possible dictates this solution.

For all the reasons cited above--relating to both policy and perception--the search for a long-term and secure disposal solution has been accelerated. There is little real question that the siting problems can ultimately be dealt with in a dispassionate, technological way, although this does not imply that the potential for conflict does not exist. It is far less clear, however, that the problems of transporting spent fuels from reactor sites to a repository can be dealt with in the same manner. This difficulty relates to the general image of nuclear materials already noted, the sheer logistic problems of transportation, and the numbers of residents who will regard themselves to be at risk. We will examine these issues in turn below.

The Transportation Problem

The Routing Problem

There are two basic geographical questions that are embedded within the repository solution. The first of these is: Where should the first site be located? A remote western site is a likely result from the first round of choices. The second is: How should the HLNW then be transported? The choice of transportation routes is rather circumscribed. New England, the Midwest, and California represent the three largest concentrations of reactors, and a remote western repository--in Yucca Mountain, Nevada, for instance--would thus involve the movement of the bulk of the wastes across the country. In addition, the federal requirement placed upon the movement of HLNW to follow designated routes--typically Interstate highways--further concentrates the flows.

When we consider the technical implications of a single repository, and then factor in public attitudes towards nuclear materials, we find the basics of a major policy problem. In the first instance, some of the routes which would be utilized by a remote western repository are simply not up to the standards required for safe transportation. Second, many of the safety standards dictated by the Department of Transportation are below those which would realistically deal with public concern. Third, the complex issue of liability and insurance is indeterminate, despite claims to the contrary. And fourth, it is likely that the federal government will encounter extensive political opposition across the country; this opposition is highly predictable, given that large numbers of people will regard themselves as being under threat from the transport of HLNW, without there being any obvious benefits for them or their locality.

Political Attitudes Toward HLNW Transport

There are currently in excess of 180 million hazardous waste shipments per annum in the United States. Typical annual accident data indicate in excess of 15,000 incidents, involving several hundred injuries, over a dozen fatalities, and in excess of $10 million worth of property damage. Less than 3% of these accidents have in the past involved radioactive materials, although the proportion of shipments which involved radioactive materials of some description has also been small. Although these accidents represent a relatively small proportion of total shipments, the figures do give us a legitimate reason to evaluate the likely implications of accidents occurring during the shipment of HLNW. We have attempted to calculate the numbers of individuals who are at risk from such shipments in order to evaluate the magnitude of the problem. As will be seen, we have used a simple strategy which sums the numbers of residents who live in some proximity to scheduled transportation routes.

It is important that we stress that this approach does not depend upon the usual calculation of risk probabilities and radiation leakage. We have eschewed attempts to define populations who might suffer radiation effects from day to day exposure to HLNW. Rather, we start from the initial assumption that an accident might occur at any point on the overall transport network. We then ask: What would the results of such an accident be in terms of individual household responses? Studies in other nuclear contexts (notably around power stations, which are analogous, at least in the public mind), show that individuals define safety margins in a very different way than do professional emergency management personnel. For instance, even though the evacuation advisory at Three Mile Island pertained only to a limited segment of the population within five miles of the reactor, self-evacuation involved a majority of the households in the ten-mile zone, and continued up to at least 25 miles from the plant. The 25-mile band has also been used by the Nuclear Regulatory Commission as a realistic risk threshold. From this observation, we can make three inferences. First, a HLNW road or rail accident is likely to result in widespread self-evacuation, producing disruption and further traffic accidents. Second, as such threats become more widely discussed in the public realm, political opposition of the NIMBY (not-in-my-back-yard) variety will arise. And in the longer term, residents whose property is close to a transport route will face equity loss and will seek compensation.

The issues outlined here are no different from those extant in any locational decision. What is potentially different is the number of people who may see themselves as threatened by HLNW transportation. Our calculations are necessarily simple, but are consistent and reasonable measures of the involved population. We have assumed that residents of any county through which a HLNW transport route passes will view themselves as being at risk from a putative accident. Given that perceptions of risk can include locations up to 25 miles from an accident source, this seems a fair inference. There will be some instances, particularly in the western states, where very large counties will extend in excess of this distance threshold; conversely, such jurisdictions will typically have very low populations, and will thus not systematically add greatly to any bias within our calculations.

This form of analysis reveals that approximately 80 million people--nearly one-third of the population of the U.S.--would regard themselves as being at risk from HLNW transportation accidents. To reiterate, this total is not an estimate of the population possibly affected by a single incident; rather, it represents a proportion of the population likely to be concerned about the general issue of transportation. It also indicates the proportion of the U.S. population that must be prepared to deal with the consequences of a HLNW accident.

There is a massive gap between objective measurements of risks and public perceptions. The NRC estimates that a serious radiation release from a nuclear waste transportion accident would occur only once every 25 billion years. Public safety films showing Hollywood-type images of spent fuel transportation casks being rammed by trains and dropped onto metal spikes have been used to solicit public acceptance that HLNW can be transported safely, despite the fact that these tests have been criticized as unrepresentative of actual accident conditions. Individuals are likely to remain skeptical, but not because they have a technical appreciation of nuclear engineering. Rather, federal agencies have been reluctant to take the steps necessary to reassure the public. The veil of secrecy which covers many federal nuclear operations has kept nuclear technology on a high shelf, making it appear even more mysterious and dangerous. Because the scientific and political communities are dealing with complex and potentially dangerous substances, they face a sort of Catch-22 dilemma: admit the possibility of a serious accident and need for extensive preventive actions and perhaps validate the public's worst fears about HLNW transportation, or continue to defend the current engineering solutions, deny that worst case scenarios are realistic, and continue an uphill battle to gain public acceptance.

In their current form, programs emanating from the 1982 Nuclear Waste Policy Act will compound these problems. The choice of a repository site--and thus of transportation routes--is being accomplished within a federal and bureaucratic context, to the exclusion of broad participation. Opposition from state and municipal governments along likely transportion corridors is evident but has yet to disrupt the existing DOE program. The limited involvement of these jurisdictions in the HLNW issue is unfortunate, as local knowledge is extremely important for managing a safe transportion system. According to present plans, while the burden of policing and inspecting vehicles carrying nuclear waste will fall upon local jurisdictions, routing will remain outside their control. However, some local control over routing appears to be necessary if dangerous conditions and accidents en route are to be avoided.

These issues are discussed further in the chapters that follow. There, our concern is to explore in some greater depth the general assertions that have been made in this first statement. The chapters examine a number of specifics, including the routing procedures, the equipment involved, the measurement of highway standards, and the implications of HLNW transport for emergency preparedness.

BACKGROUND

Transportation and the Nuclear Waste Policy Act

The Nuclear Waste Policy Act of 1982 (NWPA) governs the disposal of the nation's nuclear wastes. The act authorizes two key activities: the development and operation of a repository for the disposal of spent nuclear fuel (fuel rods removed from reactor cores) and other high-level radioactive waste (mainly from defense nuclear activities), and a transportation system to move the waste to the repository. The intent of the act is to find locations for at least two repositories (DOE, 1985a), with Congressional action needed to authorize construction of the second repository. It has been decided that the preferred mode of storage is permanent underground storage in stable geologic formations. The U.S. Department of Energy (DOE) will site, license, construct, and operate the repositories and "will provide a reasonable assurance that the public and the environment will be adequately protected" (DOE, 1985a). The President will select the first repository site in 1991; the governor of the chosen host state can then veto the President's choice, but both houses of Congress can override the governor's veto.

Current plans for fulfilling the requirements of the act call for DOE to have full responsibility for the management of transportation activities. DOE will rely on private industry to perform this function so long as costs are reasonable and needed services are provided. DOE will develop both truck and rail transport systems and will, to the extent possible, try to minimize the number of waste shipments.

Originally, the complete transportation system was to be ready by 1998 for the routine shipment of spent fuel and other high-level waste. However, this date was changed during 1986 when the first repository was rescheduled to open in 2003. Transporting waste safely and economically "is critical to the implementation of the Act [and] . . . is contingent on the availability of the necessary equipment and a stable, supportive institutional environment" (DOE, 1985a, p.97). Although this date may seem remote, any regulatory inconsistencies and impediments to effective transportation need to be worked out as soon as possible, and DOE will have to work with concerned jurisdictions to resolve institutional issues that could impede waste transportation.

The NWPA created the Office of Civilian Radioactive Waste Management (OCRWM) to carry out the program functions and responsibilities assigned to DOE and to establish procedures "uniquely applicable" to NWPA shipments (DOE, 1985b). Creating new procedures would involve synthesizing the policies and procedures of DOE, the Department of Transportation (DOT), and the Nuclear Regulatory Commission (NRC)--policies which were in effect prior to the passage of the act.

Because it will be helping to fulfill DOE's mandate to establish national system to manage and dispose of spent fuel and other high-level radioactive waste, the OCRWM will be guided by four transportation goals:

1) meet DOT and NRC transportation safety requirements;
2) assure transportation risks are reduced to "an acceptable level" and are not disproportionate to other societal risks;
3) establish ways to promptly identify and resolve transport issues; and
4) meet fiscal requirements established for the Nuclear Waste Fund. (DOE, 1985c)

Achieving these goals will be accomplished through the provision of information and the initiation of appropriate programs concerning regulations governing shipments, responsibility for the various phases of transport, cask development, and risk analysis. OCRWM will also begin a dialogue with the wide range of parties interested in nuclear waste transport "to develop a climate conducive to issue identification and resolution" (DOE, 1985c, p.3).

It is OCRWM's intent that interested parties will include all corridor states--states through which nuclear waste will pass--although the NWPA does not address DOE interacting with those states. Within corridor states OCRWM will work--via designated state liaisons--with those local fire, police, and emergency services personnel who have primary responsibility for responding to transportation accidents (DOE, 1985c, p.12).

All state and local requirements governing nuclear waste transport will be respected, provided they are consistent with the Hazardous Materials Transportation Act (HMTA) and associated federal transportation regulations. Thus the federal government has the ability to preempt local and state regulations, a perogative that is critically important to establishing the transport system. DOE will oppose laws and regulations that are not based on valid state responsibilities and that do not recognize the role and responsibilities of the federal government. Obviously, inconsistent local/state regulations as well as questions about safety must be addressed and resolved before shipments can occur in an efficient manner. Equally obviously, the requirement that state and local regulations be consistent with federal laws could seriously curtail the ability of local jurisdictions to control nuclear waste shipments within their borders.

Safety questions concerning the transportation of nuclear waste cover a range of issues and are complicated by waste transport accidents being low probability, high consequence events for which no historical accident data exist. The main issues include: routing; the process of designating alternative routes; time of travel; prenotification; escorts; emergency response capabilities and preparedness; liability; sabotage, theft, or other methods of shipment diversion; accident consequences (e.g., release mode, radiation pathways); cask vulnerability; and inspections. The provision of financial assistance to states to study transport issues is itself an issue.

Nuclear Waste Transport

Overview

A 1981 study by the National Academy of Sciences concluded that the federal regulatory framework for dealing with nuclear waste transport is "primitive" (Millar, 1984a). As a consequence, the system will result in problems and impasses with state officials, and the probability of serious accidents will increase. Rail transport is unacceptable because its high cost would dictate that rail cars be "assembled" (i.e., marshalled at a rail yard), and the rail yard where assembly occurred would become a de facto short-term repository. Further, the study concluded that having a single repository in the West (as opposed to several regional repositories) would make transport costly, enlarge inequities among regions, and result in a transport system potentially vulnerable to operational bottlenecks. Corridor states would also bear significant risks, costs, and other institutional burdens.

The Critical Mass Energy Project (Cluett et al., 1980) has made recommendations for the safe transport of nuclear waste which attempt to answer the three main concerns with such transport: routing, emergency response capabilities, and accidents. They suggest that states and cities should be able to restrict transport routes to avoid highly populated areas, industrial centers, and roadways with hazardous terrain. States should have the ability to levy tolls on highway shippers with the money going into a fund for dealing with a radiation spill. Federal guidelines should be developed detailing emergency responsibilities and procedures, and drivers should receive training to insure that they can cope with an emergency. The group's emphasis is on road transport because the limited/nonexistent rail accessibility to reactors and the problems mentioned above mean that spent fuel will be shipped mainly by road. Thus, the discussion of transport focuses on the use of the nation's roadways.

Regulations. The federal government relies on the secure packaging of nuclear waste shipments to insure the safety of those shipments and to permit their traveling in general commerce. Thus, one key to safe transport of nuclear waste is effective package design (discussed in greater detail below) --that is, the development of a cask that provides all of the protection needed to assure public safety. By relying on package design, the problems of having specially trained handling personnel, and special drivers, vehicles, and highways are eliminated. Federal regulations require that "the carrier . . . exercise control over radioactive material packages" (Foster and Jordan, 1984, p.108) by loading and storing them away from people and limiting the aggregation of packages so that possible cumulative radiation exposure is limited. If an accident occurs, the carrier must notify the shipper and DOT, isolate the spilled material from people, wait for qualified personnel to arrive, give disposal instructions, and then evacuate and clean the affected areas.

The shipper has most of the responsibility for the safe transport of wastes. Only a few federal regulations, beyond those required for carriers of "regular" hazardous cargo, are added for carriers of radioactive materials. Separate federal/state regulations do contain requirements regarding safe vehicle conditions.

While nuclear wastes are in transit, federal regulations apply that are designed to protect the hauler, workers, the general public, and the environment from radiation. Three basic methods of protection are employed: time, distance, and shielding. In simplest terms, as the amount of time the shipment is in transit goes down, safety goes up, and as the distance between the shipment and those who could be affected by it goes up, safety also goes up.

Not surprisingly, for the DOT the key to safe shipment of spent fuel and other nuclear wastes is enforcement of regulations. The agency desires uniform nationwide enforcement of its standards which necessitates that states adopt federal hazardous materials regulations. Due on the federal government's past experience with hazardous materials regulation, DOT feels that state adoption and enforcement of federal regulations would make transport easier for shippers and carriers because they would only have to deal with one set of regulations, regardless of location. Based on the accident record to date, DOT does not see a need for special regulatory treatment by individual states.

A study by the state of Illinois (Foster and Jordan, 1984) identified the most common regulation violations as:

1) improper shipping papers;
2) improperly prepared or missing shipping labels;
3) improper placarding of the vehicle; and
4) lack of shipping papers.

During the course of normal transport these violations do not pose problems, but in an emergency they "could be a critical factor in instituting the proper emergency response procedure" (Foster and Jordan, 1984, p.55).

Packaging

As mentioned, spent fuel is shipped in specially designed casks. Spent fuel is not explosive, and because of the way waste is spaced within the shipping cask, there is no risk of a self-sustaining nuclear reaction occurring inside the container. The federal government has tested shipping casks and has estimated that their testing conditions are more severe than those that would be encountered in approximately 99.9% of all transport accidents (DOE, 1985a).

Currently, the types and quantities of shipping casks are limited. For the first shipments to a national repository, they will probably be used on an "as available" basis. Still, present casks may not be cost-effective; new casks could be designed to carry more waste and reduce the number of total shipments. However, it takes time to design, construct, test, and license a new cask--the recent development of a new rail cask took five years. The lack of a need for new casks has hindered their development, and it may be necessary to offer incentives, or have some other kind of federal involvement, to push private industry to develop new vessels.

Once the first repository is operational, the backlog of spent fuel is projected to require the receipt of one shipment every ninety minutes, twenty-four hours a day, every day for twenty years (KCTS-TV, 1986), depending on the mode of transport and the volume of the casks used to transport the spent fuel. The present "conservative" cask design limits capacity (and therefore weight); indeed, the government claims that existing casks are "overdesigned" because the fuel rods they will have to carry will have been out of the reactor for five years and that radiation-exposure levels will consequently be much lower than what regulations allow.

Highway load restrictions also limit the capacities of truck casks by limiting their weight. The government contends that "slightly larger truck casks can increase payload capacity [and] . . . significantly reduce the number of shipments" (DOE, 1986a, p.A-17). Reducing the overall number of shipments would aid in meeting the safety objective of minimizing the total number of shipments. However, increased road damage would be the key disadvantage of this approach. In this instance, the states play an influential role because they have the authority to issue permits for overweight equipment.

Despite the federal government's assurances that shipping casks are reliable, critics contend that the casks have serious safety problems (Millar, 1984a). Several casks, examined after being used to transport wastes have been found to be defective. The cask most often used by railroads has also been found defective, and the railroads claim that these casks are not designed to withstand real crashes. Crash tests conducted by the Sandia National Laboratory (funded by DOE) have also been questioned. None of the casks currently in use have been physically tested in actual accident conditions.

Accidents

Overview. The federal government asserts that because there have never been any life threatening radiation transport accidents, the danger of getting cancer ten to 20 years following a radioactive release due to such an accident is theoretical. Therefore, in the majority of accidents, they maintain, traumatic injuries and deaths resulting from the accident or subsequent fire would far outweigh any radiological consequences.

A different scenario for a severe rail accident is offered by Resnikoff (1984). People downwind from the accident would inhale significant radioactivity and also be exposed to "cloudshine" (gamma rays from the radioactive cloud) and whole-body radiation. Inhalation would result in the greatest exposure, while whole-body radiation, resulting from exposure to settled radiation, would also be significant. Further downwind, particles would settle and create long-term exposure to "groundshine" (radioactive particles settled on the ground). The exact path the radiation cloud would take would depend on site-specific climatological conditions such as prevailing winds and the presence or absence of precipitation. The impacts of groundshine can be eliminated by evacuating affected areas and then cleaning them. In urban areas affected by groundshine large amounts of interior space would also have to be cleaned.

The federal government recognizes that health effects, radiological or nonradiological, would not be the only consequences of a nuclear waste transport accident. In fact, the most significant potential outcome from an accident might be changes in attitudes and beliefs on the part of the previously uncommitted general public (Cluett et al., 1980). Given the public's lack of knowledge concerning decontamination technologies and their effectiveness, the DOE could have trouble convincing the public, following government clean-up of radiation, that any long-term dangers posed by radioactivity were under control. In addition, social organization could also be significantly disrupted, and business in the affected area could suffer temporary, or even long-term, economic effects. One can envision a community rapidly organizing on a grass-roots level to deal with problems caused by such an accident.

If an accident were to occur, the nuclear industry's response would probably include efforts to make transport safer; however, to date, the transport of nuclear waste has met the industry's expectations. Industry representatives assert that the public does not understand nuclear safety and the probabilities and consequences of an accident. They believe a broader spectrum of data on the relationships between accident severity and cask integrity will show that transport is safe and thus hasten the acceptance of nuclear waste transport by both carriers and the general public (Cluett et al., 1980). Despite industry assurances, railroads have shown some reluctance to carry shipments unless special trains equipped with guards and traveling at reduced speeds are used. However, the nuclear industry is afraid that the imposition of stringent safety requirements "could make the cost of transporting nuclear materials unnecessarily expensive" (Cluett et al., 1980, p.58).

Incidents. Incidents are accidents, non-road or vehicle related or caused, which result in the release of radiation. They fall into two categories: human errors and malevolent acts. The majority of reported incidents have been the result of human error, have generally been relatively benign, and have rarely resulted in the release of radiation. However, should such incidents become more numerous and be extensively reported by the media, human error might appear to the public to be a problem that the federal government has not adequately addressed. Incidents--most often caused by deviation from specified quality assurance and safety practices--would probably have greater impacts in urban rather than nonurban areas.

Malevolent acts, primarily sabotage, are probably felt by the public to pose the greatest threat to the safe tránsport of radioactive materials, and a serious sabotage attempt would involve an evacuation effort resulting in serious social disruption. Extensive public concern would, no doubt, be generated, and activist groups would increase their demands for transport security.

Urban Studies. Beginning with a 1978 study (DuCharme et al., 1978), a series of urban studies have been undertaken for the federal government to examine the consequences of a successful malevolent act occurring in downtown New York City during a weekday mid-afternoon, with the release of "X" amount of radioactivity. The original study indicated very severe consequences; several hundred latent cancer fatalities (LCFs) would result. As a result, in 1979 the NRC instituted regulations requiring physical protection measures for spent fuel shipments in urban areas. A second study (Finley et al., 1980) reduced the release quantity by a factor of 14, with latent cancer fatalities falling to approximately 100. This new data caused the federal government to reduce the stringency of the transport regulations; still, the government sees the regulations as "serious restrictions on the shipment of spent fuel [that] have resulted in increased shipping costs" (Sandoval et al., 1983, p.5).

The objectives of a third urban study (Sandoval et al., 1983), were to evaluate the effectiveness of "selected" high energy devices (HEDs--i.e., explosives) in breaching "full size" casks, to quantify and characterize the "relevant" aerosol properties of released fuel, and to evaluate the health consequences of such releases. This study was undertaken because the two previous studies did not have a base of experimental data available, and therefore their estimates contained a high degree of uncertainty, particularly with respect to the character of the radioactivity that would be released. With respect to release parameters, the 1983 study can be compared to the 1980 study--they postulated use of the same HED--but not the 1978 study which relied on a range of HEDs. However, the health consequences of all three can be compared (Sandoval et al., 1983). The effects found by the 1983 study were minimal compared to the other studies.

Truck Safety

In April of 1985, the Knight-Ridder News Service published a series of investigative articles on truck safety (Cannon, 1985; Moore, 1985a; 1985b; Moore and Cannon, 1985). The information provided in the series brings into question the ability of the nation's haulers to safely transport spent fuel and other high-level nuclear wastes to a national repository. The main conclusion was that interstate trucks are the nation's most deadly form of commercial transport. They often operate with defective brakes and worn tires, and their drivers are often exhausted. Compared to automobiles, trucks are involved in twice as many fatal accidents per mile. The most recent complete data (for 1982) listed 3,790 truck-related fatalities (Moore, 1985a). This amounts to three times as many fatalities as experienced that year by the nation's airlines, passenger ships, trains, and interstate buses combined.

The federal agency responsible for truck safety, the Bureau of Motor

Carrier Safety (BMCS), is underfunded, understaffed, and usually unwilling (or unable) to deal with unsafe trucks (Moore, 1985a). The agency has 130 inspectors with a budget of $14 million to police at least 210,000 trucking companies operating over one million trucks. In Colorado the agency has two part-time inspectors and a trainee to audit and inspect the 2600 motor carriers based in that state (Rep. Tim Wirth Reports, 1985). The majority of truckers have never had a federal safety inspection. To adequately do their job, the BMCS probably needs at least 1,000 inspectors, yet their staff was reduced 8% from 1981 to 1985 due to cuts in the federal budget (Moore, 1985b). For decades the federal government has given low priority to truck safety. In comparison, the Federal Aviation Administration (FAA) devotes about half of its budget to monitoring less than 100 airline companies, operating 2,600 aircraft; in so doing it uses $2 billion and 22,000 employees.

The latest data on roadside inspections, covering 1983, show that the BMCS performed 24,721 inspections. These inspections were confined to two brief periods during the year, with one announced in advance. Of the trucks inspected, 74% had safety defects, 32% were ordered out of service, 25% had defective brakes, and 9% had badly worn tires (Moore and Cannon,1985). (Unfortunately it is often cheaper for safety violators to pay the fines levied against them for such defects than to fix the actual problems.) In addition, one driver in five was found to be violating rules designed to prevent drivers from operating vehicles when exhausted or insufficiently alert. (Fatigue is often a significant factor in accidents attributed to driver error, and driver error has been determined to be the cause of up to two-thirds of truck accidents.)

When safety violations are found, companies are "almost never punished--as a matter of policy" (Moore, 1985a); the law and BMCS policy dictate lenienty for violators having financial trouble. During the years 1981-1984, only one in five of the companies the BMCS checked (including some of the largest trucking firms in the nation) were found to be free of serious violations. Over half of those checked (55%) failed to receive a "satisfactory" safety rating. Moreover, 76% of the nation's trucking companies have never been subjected to the bureau's basic safety management audit (Moore, 1985a).

The Reagan administration has dealt with the problem of truck safety by attempting to turn responsibility over to the states. Problems will no doubt arise from this approach because the industry is fundamentally an interstate endeavor. Three of four reported accidents on interstate highways (totalling 31,957) involved trucks operated from outside the state where the accident occurred. Nevertheless, the administration continues plans for a Motor Carrier Safety Assistance Program (MCSAP) which will give money to the states to deal with truck safety. Besides its not focusing on the interstate nature of trucking, the MCSAP has been criticized because it does not address two other critical safety issues: the national licensing/registration of drivers and the development of a required safety training program for drivers prior to licensing.

The MCSAP proposed to give out $14 million nationwide for 1985. In contrast, California alone spent $24 million on truck safety enforcement during 1984 but was to receive only $1.25 million from the federal government for 1985 (Cannon, 1985). California's safety program included the state highway patrol operating an inspection station on I-80 where it performed 100 inspections a day. The patrol checked trucks that looked or sounded bad and failed 90% of the trucks they inspected. A full 90 to 95% of those trucks failing inspection did so due to brake problems. The inspections also found that 35% of the trucks checked were from out of state, again suggesting the need for a strong federal role in truck safety.

Careful monitoring of trucking seems even more essential when one considers that those companies with records of serious safety violations have had three times more accidents per mile and twice as many fatal accidents per mile as companies with good safety records (Moore, 1985a). The trucking industry claims that the vast majority of truckers adhere strictly to safety standards, but they can present no hard evidence to support their assertion. Drivers are required to take a test on BMCS safety rules, but the test is open book, and drivers do not have to pass the test to operate a vehicle. Only a few repeat violators have these BMCS safety rules enforced against them, often in the form of a small fine. Thus, by all accounts, safety will be a weak link in the nuclear waste transportation system.

LEGAL AND POLITICAL ASPECTS OF THE PROBLEM

Overview

The public is more concerned with the transport of nuclear materials than with the movement of any other type of hazardous substance, despite the relatively minimal consequences of such transportation to date. The transport of nuclear waste will undoubtedly generate political activity beyond that spurred by the transport of other hazardous wastes even though nuclear waste is subject to a more complex system of regulation by more agencies (Cluett et al., 1980).

The public is generally more concerned with the possible consequences of an accident involving nuclear wastes than with the probability of such an accident actually occurring. This attitude differs from that of trained technicians and researchers who examine both the consequences and probability of an accident (Cluett et al., 1980). Federal transportation policy must take into account this public concern for potential accident consequences in order to avoid a likely increase in public resistance to nuclear waste transport. Conversely, the imposition of state and local restrictions on nuclear waste transport could be an additional strategy that opponents of nuclear power could use to restrict the growth of the nuclear industry.

Social impacts of transport would be greatest in the country's urban areas. There, in contrast to the situation in rural areas, more governing bodies can regulate transportation, and more agencies would be involved in the emergency response to an accident. In such areas, the issue of nuclear waste transport will be heavily politicized because of the involvement of these many jurisdictions, and because of extensive media coverage and the presence of active interest groups. Clearly, many negative consequences of an accident could be reduced if wastes were not transported through urban areas. However, this option creates additional problems because nonurban areas are likely to have poorer roads and to lack adequate communication facilities. Regardless of the area through which nuclear wastes are transported, some people will still be opposed to nuclear waste transport and will not be willing to accept the risk to which they will be involuntarily exposed.

Indeed, barring the occurrence of a major transport accident, the political and legal dimensions of the transport debate will probably continue to be more significant than the social impacts of actual transportation.

To date, the political and legal issues of transport have paralleled those associated with fixed nuclear facilities, and they have received more emphasis than have social or psychological issues. Future debate will probably also center more on these political and legal concerns than on purely technical concerns (Cluett et al., 1980).

Legal Issues

Routing

The Department of Transportation is authorized by the Hazardous Materials Transportation Act (HMTA) to govern highway routing of radioactive materials. The HMTA establishes policies and procedures for shipping spent fuel, DOT regulations implement the HMTA, and DOE shipments (including NWPA spent fuel shipments) comply with DOT requirements. The DOT final rule (HM-164) governing the highway routing of radioactive materials was published January 19, 1981 (DOE, 1986a). DOT controls routing, as the HMTA allows DOT to preempt any state or local requirements if they are inconsistent with federal statutes. Regulations which require haulers of nuclear wastes to pay fees to fund emergency response activities or equipment will be prohibited, yet localities will most likely be responsible for maintaining the proper emergency equipment to cope with an accident as well as for maintaining adequate roads (Kirby and Jacob, 1985).

It is possible for the DOT to grant exemptions to the HMTA's "blanket preemption provision" and allow inconsistent state or local requirements to stand--one criteria being that those requirements do not "unreasonably burden commerce" (DOE, 1986a, p.A-86). However, the agency has concluded that the risk to the public from truck transport of radioactive materials is "too low to justify the unilateral imposition by local governments of bans and other severe restrictions on the highway mode of transportation" (DOE, 1986a, p.A-86). The federal government believes requirements to be inconsistent if they:

- ban transport between any two points without providing an alternate route;
- conflict with NRC or DOT "physical-security requirements";
- require more or different entries on shipping papers, placards, or hazard warning devices;
- call for route plans or documents to have shipment specific information;
- ask for prenotification;
- require accident or incident reporting beyond what is immediately needed for emergency assistance;
- unnecessarily delay transport. (DOE, 1986a, A-87).

The preemptive effects of HM-164 have not yet been completely determined because many state and local laws have yet to be reviewed by DOT. Each determination of inconsistency will have to be made separately, and delays related to litigation (the courts can allow inconsistent requirements to stand) may mean that the scheduled deadlines required by the NWPA will not be met.

Litigation. To date the key case involving routing deals with New York City's right to ban shipments of nuclear wastes from passing through the city. DOT established a route to move spent nuclear fuel from the Brookhaven

National Laboratory on Long Island, through New York City, to Idaho for disposal. The City proposed an alternative route which DOT rejected in September, 1985. New York City then took the DOT to court arguing that the DOT route was not safe because it passed through densely populated areas (Fein, 1986).

In the case's initial hearing (before the U.S. District Court, Southern District of New York), DOT asserted that transport had no significant effect on the environment. DOT believed the public's concern with a transport accident to be genuine but misplaced, and felt that they did not have to consider an accident's environmental consequences. The court disagreed (in a temporary ruling on February 19, 1982) and found DOT to have underestimated the risk of an accident and its possible or probable physical and social consequences, and to have violated its obligations under the National Environmental Policy Act (NEPA).

The temporary ruling sided with New York City and found that HM-164 did not apply to "shipments of radioactive materials through densely populated areas, specifically limited to New York City" (Foster and Jordan, 1984, p.41). The final district court judgement continued to uphold the ban, but again applied only to New York City. In order for other urban areas to receive the same ruling, they would have to show, for their specific case, that DOT's analysis of the consequences of an accident had not been broad enough, and that alternative routes for waste transport were available.

The District Court ruling was subsequently reversed by the U.S. District Court of Appeals for the Second Circuit and the ruling appealed to the U.S. Supreme Court. The Supreme Court refused to hear the case, finding that New York City had not exhausted the administrative process (Fein, 1986). On December 23, 1986, DOT reaffirmed its earlier decision thus rejecting New York

City's final attempt to use administrative measures to stop the shipment of spent nuclear fuel through its boundaries.

Liability

Obviously, a good deal of the concern states and localities have with routing relates to the possibility of a transportation accident and its aftermath. Emergency response and clean-up activities will place a significant financial burden on those governments responding to an accident. Individuals whose property or person are affected by radiation released during an accident will suffer financially as well, and the question of who is liable for these costs and damages does not have a definitive answer.

The Atomic Energy Act of 1954 addresses liability in relation to nuclear energy matters in the section known as the Price-Anderson Act. Price-Anderson establishes a system for paying for damages by directing the "NRC to require its licensees to be able to pay damages for 'public liability' in the event of an accident" (Jacobsen, 1985, p.20). The limit on liability, with funds coming from a combination of private insurance and NRC indemnification, is $560 million. Once damages exceed the amount of coverage called for in the act, the responsible parties are relieved of further liability. Congress is then required to investigate and take appropriate action.

In general, state law is used to determine liability and extent of damages. However, Price-Anderson restricts the use of state law--waiving certain defenses--in the event of an "extraordinary nuclear occurrence." The federal government is responsible for determining if there has been such an occurrence--i.e., one that involves "substantial offsite releases of radiation and is likely to result in substantial offsite damages to persons and property" (DOE, 1986a, p.A-89).

Price-Anderson is due for renewal in 1987 and will expire unless reauthorized by Congress. Suggested changes to the act would remove the limit on liability or increase it to $1 billion. Even this increase might not be sufficient; the NRC estimates that short-and long-term clean-up costs for an urban area contaminated by radiation could surpass $2 billion (Jacobsen, 1985). The DOE supports a reauthorized Price-Anderson Act which places a limit on liability with the coverage under DOE's indemnity agreements to be the same as those required of large commercial utilities. They also support extension of Price-Anderson's "extraordinary nuclear occurrence" provisions to waste-management activities.

Under the law, people or property irradiated because of a nuclear waste transport accident could seek relief by filing a tort suit. The law assumes that the person who "did the damage" had a duty not to do so and breached that duty due to negligence. The federal government can be sued for tort liability if there was negligence, an employee of the government was involved, and this employee was acting within the duties of their employment. It is likely that "only a transportation accident involving negligence could trigger federal government liability" (Jacobsen, 1985, p.6). The federal government would, in all likelihood, also not be held liable if a truck hauling nuclear waste was in an accident while the driver was traveling off of a designated route for personal reasons and therefore acting outside of the scope of his or her employment. It is also not clear if a truck driver--an employee of a federal contractor--would be considered a federal employee.

Price-Anderson does authorize DOE "to enter into indemnity agreements with its contractors for activities, under contract and conducted for the benefit of the United States, that involve 'the risk of public liability for a substantial nuclear incident'" (DOE, 1986a, p.A-90). DOE can indemnify contractors up to a $500 million statutory limit. DOE has indicated that "contracts for the operation of any DOE facility associated with the waste-management program" will include indemnity agreements per Price-Anderson, and such contracts cover transportation activities to and from a waste-management facility. DOE supports a reauthorized Price-Anderson Act which includes specific language addressing these types of NWPA activities.

Federal government liability could be limited by the "discretionary function exception" found in the Federal Tort Claims Act. This exception exists to prevent the government from being the subject of a tort suit "if the act from which the tort claim arose was one committed as part of high-level policy making--if it was a 'discretionary function,' or one requiring judgement" (Jacobsen, 1985, p.13). In short, the federal government did not want its policies tested through tort actions in the courts.

The Nuclear Waste Policy Act does not help to clarify the liability issue. It "does not create liability on the part of DOE in the event of an accident" (Jacobsen, 1985, p.23), and a court would have to determine if DOE were liable. However, it is reasonable to assume that the Nuclear Waste Fund, set up by the NWPA, would be used to pay injured parties, and DOE supports amending Price-Anderson so that liability coverage for NWPA waste-management activities comes from this fund. In any event, it is highly unlikely that the federal government would not end up paying for damages caused by a waste transport accident.

State and Local Actions

Addressing Nuclear Waste Transport

Most commonly, states have responded to issues of nuclear waste transport by passing legislation. Similarly, some local governments have adopted ordinances banning or restricting transport. As noted earlier, such laws are still subject to federal preemption as authorized by the HMTA. Due to this federal right, states and localities could be interpreted as aiming to protect the welfare of their citizens by filling a federal "regulatory gap."

State statutory requirements have generally included two key points: first, state regulatory agencies are asked to develop rules for transport within the state including the designation of travel routes; second, haulers are required to obtain permits to transport certain quantities and types of radioactive materials within state boundaries.

Local ordinances which restrict urban transport can do so in any of several ways: banning shipments of spent fuel/nuclear wastes, prohibiting transport on downtown highways, banning nonmedical/nonindustrial shipments from state highways, or severely restricting commercial shipments. Local jurisdictions could also require advance notice and/or permits for the shipment of specific materials within local boundaries and could designate specific allowable routes.

Because of the federal right of preemption, state and local requirements that restrict routing or prohibit the passage of certain shipments, that call for personnel qualifications and/or escorts, or that deal with packaging will probably not be allowed to stand. Other requirements--governing such things as labeling, storage, loading, and handling; certain other personnel qualifications; driver records and manifests; insurance and bonding; registration, fees, permits, and licenses--could also be preempted, but again only if they conflict with the HMTA or seriously burden nuclear power development.

There are some state and local requirements that will probably not be preempted: requests for generic advance notification (e.g., notice that shipments will be passing through a jurisdiction the following week), accident notification, and delineation of accident emergency response procedures.

The NLC Proposal. The National League of Cities (NLC), at its December, 1986 annual convention, voted to amend NLC policy on hazardous materials transportation after a resolution to do so was brought forward by the city of Boulder, Colorado. The NLC, in essence, expanded its definition of hazardous materials to cover DOE and Department of Defense (DOD) shipments of nuclear materials and wastes (Olson, 1987).

The NLC policy addresses what should be done to insure that local governments can effectively deal with emergencies arising from nuclear waste transport (Boulder City Council, 1986). The routing, local notification, emergency response, enforcement, financing, and insurance elements of the hazardous materials policy were extended to cover nuclear shipments. States and localities, the policy says, should have concurrent jurisdiction with the federal government over routing. Further, because there may be special circumstances requiring local regulations that are inconsistent with federal standards, nonfederal jurisdictions should be able to adopt and enforce requirements including time-of-day restrictions, escorts, and local bans. Additionally, shippers should be required to give general, not shipment by shipment, notification to cities if they are hauling "Type B" shipments (casks containing spent fuel rods). An accident involving these nuclear shipments may require an evacuation or other "anticipatory emergency response preparations." The federal government should set minimum standards for insurance requirements for all Type B shipments in order to assure that shippers would be able to cover the costs of emergency response and clean-up activities. Federal, state, and local governments should develop a centralized emergency response authority for each of their jurisdictions.

The policy also states that the appropriate federal response authority should provide to states and localities timely notification of shipments, that the federal government should set minimum training and education standards so that shippers and responders will have a common understanding of accident prevention and mitigation, and that the federal government should also provide emergency planning and response guidelines as well as technical information during an emergency. Additionally, states and localities should have jurisdiction concurrently with the federal government over vehicle operating requirements and standards, including the power to levy fines or civil penalties. The federal government should levy registration fees, with monies put into a national trust fund to be used for state and local hazardous materials-related needs. The money would be distributed based on the number of shipments traveling through an area and should be proportional to the amount of risk associated with the shipments. To be eligible for trust fund money, a state would have to demonstrate a certain level of commitment to planning and response activities, and, if it chose to accept money from the federal government, would not be allowed to levy its own fees.

A DOT Response to Transport Restrictions

An example of how DOT has dealt with state and local requirements restricting the transport of nuclear waste comes from a 1985 DOT ruling (Maseng, 1985). The ruling was prompted because restrictions placed on transport forced a Canadian carrier to halt shipments of spent fuel from Chalk River, Ontario to Savannah River, South Carolina. DOT found that seven state and local regulations enacted in New York, Vermont, and Michigan restricting the transportation of spent fuel were inconsistent with federal law and therefore preempted. The regulations were found to be inconsistent because, collectively, they required transportation permits tied to prenotification (seven regulations), higher levels of insurance (five regulations), additional personnel and/or equipment to go along with the shipments (six regulations), and the inspection of shipments to assure compliance with state and federal rules. DOT said these restrictions had "the effect of rerouting shipments in a chaotic, unpredictable manner that is damaging [to] overall public safety" (Maseng, 1986). DOT concluded that the localities were attempting to export their safety problems to neighboring jurisdictions which the agency states they may not do.

Signs of Future Conflict

In May 1985, the governor of Nevada stated that he planned to temporarily withhold authorization allowing shipments of low-level radioactive waste produced in New Jersey to a dump site at Beatty, Nevada (Wall Street Journal, 1985). The state felt that the 1980 federal Low-level Radioactive Waste Policy Act, addressing regional disposal, was not being enforced. Nevada officials wanted other states to be forced to set-up their own regional waste disposal compacts and phase out the use of the Beatty site. While low-level waste transport is governed by a different set of regulations and institutions than is transport of high-level waste, this reaction of Nevada officials indicates an increasing level of state concern, involvement, and regulatory aggressiveness. The governor saw this dispute as a preview of what would happen if Yucca Mountain were chosen to be the site of the first national high-level waste repository.

A second example of state-level concern and resulting conflict comes from Nebraska. High-level radioactive wastes from the accident at the Three Mile Island (TMI) nuclear power plant are being shipped across the country, by rail, from Pennsylvania to eastern Idaho. The route follows tracks from Kansas, through bits of Nebraska and Colorado, into Wyoming.

The first such shipment reached the Kansas-Nebraska border on July 23, 1986. There, Nebraska state troopers, acting on Governor Kerrey's orders, halted the train for three and one-half hours until the state could determine exactly what was happening; neither Governor Kerrey nor the state patrol had been notified that the train would pass through Nebraska. Colorado's Governor Lamm had been notified of the shipment one week earlier, but apparently Kerrey was not notified due to an oversight--an excuse that did not placate Kerrey (KCNC-TV, 1986). The Nebraska governor had negotiated with the federal government to insure that the state would have a role in the TMI shipments, and he called the lack of prenotification "a serious breach of faith on the part of the federal government" (Boulder Daily Camera, 1986c).

Prenotification has become a significant issue because state and local officials want to be forewarned of any possible transport accident and necessary response. On the other hand, federal officials fear that prenotification will increase the likelihood of transport vehicles being targets of antinuclear demonstrations, civil disobedience, and possibly even terrorism.

THE SITING PROCESS

Overview

The federal government's involvement in the problem of nuclear waste disposal, particularly disposal of spent fuel, did not begin with the Nuclear Waste Policy Act. Following various federal storage schemes, "by 1980, active site work was limited to Louisiana, Mississippi, Texas, Utah, Nevada, and Washington" (Salisbury, 1985a, p.6). The passage of the NWPA in 1982 provided an opportunity to broaden the scope of this work. The act made geological considerations the primary site selection criteria, and, by so doing, essentially directed the federal government to begin anew their site selection and development process.

By mid-1985, only DOE and the nuclear industry were happy with the program devised to meet provisions of the NWPA. Critics claimed that the accelerated schedule Congress had incorporated into the act "ensured that [DOE] would pick from among current [i.e. 1980 site] candidates." They felt that the 1998 target date for opening the first repository in effect instructed DOE to use the existing candidate sites (Salisbury, 1985a). In fact, DOE does see the Nuclear Waste Policy Act as ratifying their pre-NWPA selections. The selection of a repository site is further confused because the NWPA in effect promises the utility industry a site by a given date.

Critics feel that site selection has been based upon political, rather than technical, parameters. For example, Washington state's Nuclear Waste Board criticized DOE for not granting the state's request for a thirty-day extension of the period the board had to review the Hanford Draft Environmental Assessment (DEA). The state had been given only 90 days to study this 1500 page technical report. Even within this limited period, a Washington state senator had time to conclude that DOE's ranking methods were "so obscure that they could not be reproduced" (Williams, 1985).

Draft Environmental Assessments were prepared for each of the nine proposed repository sites and issued in December of 1984. In these DEAs, the sites were ranked on a variety of factors and final rankings assigned. Following a comment/response period, which included public meetings in the affected states, final Environmental Assessments (EAs) were released in May, 1986. The top three sites designated for further study were Yucca Mountain, Nevada; Hanford, Washington; and Deaf Smith County, Texas.

Prior to the completion of the EAs in early September, 1985, the Reagan administration asked the Nuclear Regulatory Commission to let it declare Yucca Mountain, Hanford, and Deaf Smith County suitable locations for the first national nuclear waste repository. The NRC has demanded that "site characterizations" be conducted prior to declaring a site a suitable location for a repository. Site characterization involves buying (or acquiring) land in the site area and conducting extensive technical studies that include the drilling and excavating of exploratory shafts and tunnels. However, the administration contended that the NRC's demand posed the unacceptable risk that the mandated 1998 deadline for an operational repository would not be met. Work on site characterization will continue with the deadline moved forward, as already mentioned, to 2003.

Transport and Siting

Each Environmental Assessment contains an analysis of the transport of wastes to the repository site using two systems: the "authorized" system and an "improved performance" system. The transportation analyses are broken down further by transport mode: either 100% truck or 100% rail. Although the final system will be a combination of both modes, DOE felt that analyses based on the maximum use of either mode would produce the most conservative results. The "authorized" system of transport involves truck and rail transport directly to the repository. The "improved performance" system employs monitored retrieval storage (MRS--i.e., temporary intermediate storage where materials would be repackaged) as part of the waste transport system. The facility for such storage is planned for one of three sites in Tennessee. However, Tennessee has filed suit against the DOE contesting the agency's choices (DOE, 1986b). DOE will most likely win the case since the NWPA does not require that the agency consult with a state before recommending it to Congress for the site of a MRS facility.

Two types of MRS could occur at the facility: all spent fuel could go to the MRS facility for repackaging, or only waste from eastern U.S. reactors could go to the site. Following repackaging, the nuclear waste would move by rail to the repository via ten-car dedicated trains carrying 100-ton casks. Dedicated trains are ones having special equipment specifically designed to transport "a particular commodity between fixed origin and destination points" (DOE, 1986a, p.A-89).

At the Environmental Assessment stage of the siting process, the intent was to choose sites for characterization. Each EA transportation analysis emphasizes the repository site--with regional transport analyses focusing on effects near the repository sites--as the NWPA siting guidelines dictate. Route-specific analyses that include the impacts of waste transport are scheduled to be conducted in the future and will be included in the Environmental Impact Statements (EISs) prepared for the "finalist" sites. It can be assumed that issues which commentors found had received inadequate or no attention in the DEAs--responsibilities in an emergency, impacts of using overweight trucks, inspection and enforcement, liability, safe havens, and advance notification--will be addressed in the EISs. The DOE response to these issues is that "most . . . while of concern in the overall context of the transportation program, have little bearing on the site-selection process" (DOE, 1986a, pp.C2-C49).

Yucca Mountain, Nevada

The proposed Yucca Mountain repository would be located 100 miles northwest of Las Vegas on federal land adjacent to the Nevada Test Site (Figure 1). Access to the site would be available via U.S. Highway 95. The bulk of the nuclear waste shipments, traveling by truck, would cross Colorado and two-thirds of Utah on I-70 then head south on I-15 to its juncture with U.S. 95. Each waste truck, while traveling along U.S. 95, would have an escort vehicle. It is estimated that during the early years of the repository's 28-year "emplacement period," truck transport would move 30 to 50% of the repository waste to be stored. In later years at most 30% would move via roads. The DOE's analysis of truck transport places the number of trucks carrying waste to Yucca Mountain at between 2.5 and four per hour.

Transportation of Nuclear Waste

Regional Shipment and Routing. Defining "regional" as within Nevada, the DOE used two scenarios for the Yucca Mountain regional routing analysis. The first involved six truck and two rail routes; the second involved the same two rail routes and the first three truck routes (Table 1). These principal candidate routes were determined following an examination of the "locations of waste origination and information regarding the current network of regional and interstate highways and mainline rail systems" (DOE, 1986a, pp.5-79). The percent of the total number of waste shipments (assuming 100% truck transport) that would fall on each route has been projected for both the authorized and MRS systems.

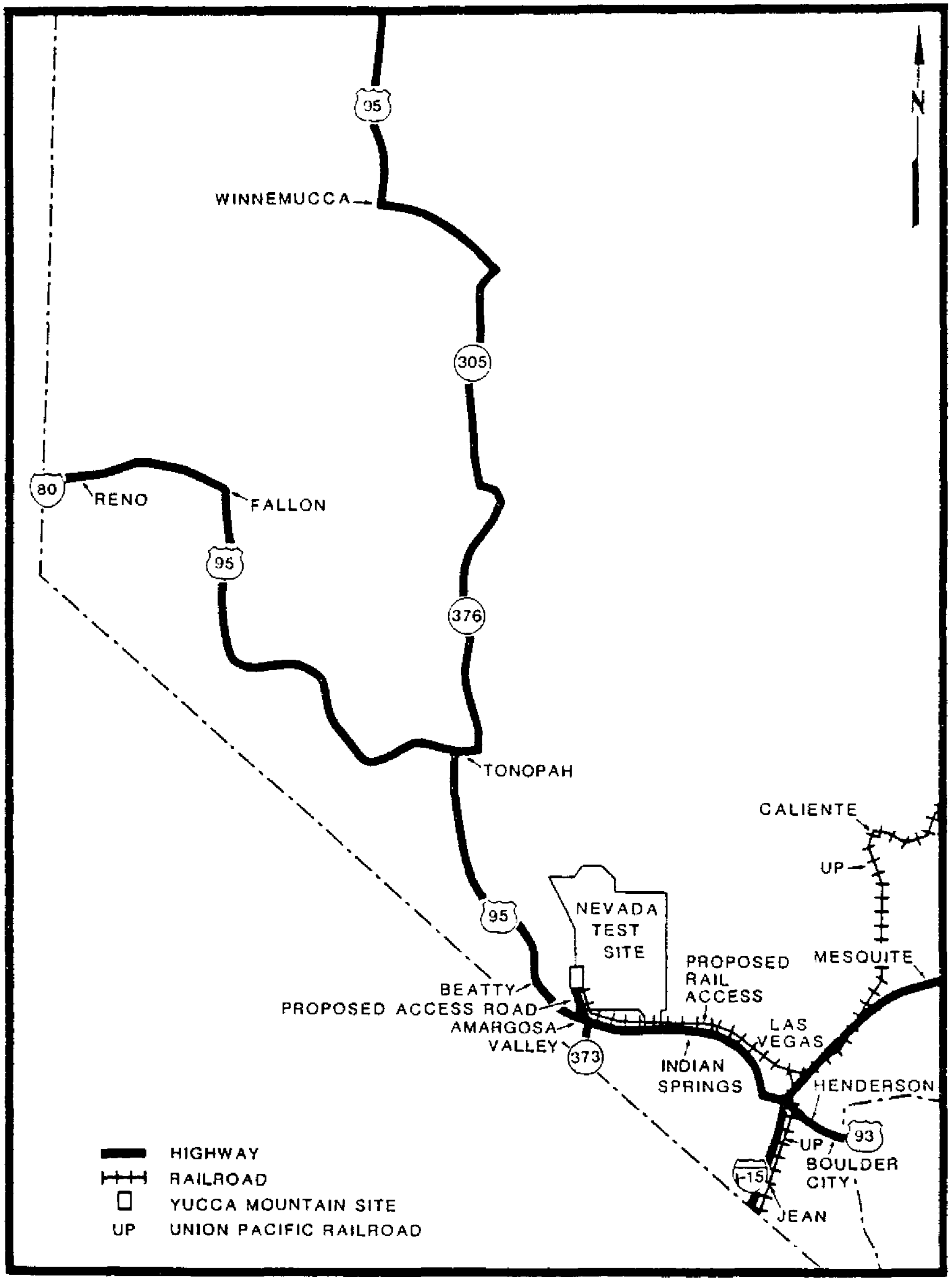

FIGURE 1

THE YUCCA MOUNTAIN SITE AND ACCESS ROUTES

TABLE 1

ROUTING SCENARIOS USED IN YUCCA MOUNTAIN REGIONAL ROUTING ANALYSIS

Scenario I

Truck Routes
- I-15S (southbound from I-70)
- I-15N (northbound from southern California)
- U.S. 93N (northbound from I-40--Arizona and the Southeast)
- I-80E (eastbound from northern California)
- U.S. 95S (southbound from Idaho, Oregon, Washington)
- Nevada 373N (northbound from southern California, avoiding Las Vegas)

Rail Routes
- UPW (Union Pacific westbound)
- UPE (Union Pacific eastbound)

Scenario II

Truck Routes
- I-15S (southbound from I-70)
- I-15N (northbound from southern California)
- US 93N (northbound from I-40--Arizona and the Southeast)

Rail Routes
- UPW (Union Pacific westbound)
- UPE (Union Pacific eastbound)

Impact of a Second Repository. The NWPA transportation siting guidelines require that "the second repository be considered in the cost and risk analyses" for the first repository (DOE, 1986a, p.A-73). If there were only one repository, the age of the fuel and the amount of storage space remaining at each reactor would determine the shipment of spent fuel to the repository. By adding a second repository to the waste disposal system, distance also becomes a factor, as the "logic and the mandate of the Act appear to dictate that fuel closest to the repository should be shipped to it, with the remainder being shipped to the second repository" (DOE, 1986a, p.A-75).

Unfortunately, the geographic location and distribution of spent fuel were not fully considered in the analyses of the two disposal systems (with/without MRS) that assumed there would be one repository. However, geographic location was considered in the analyses of the impact of a second repository on the waste transport system. Again, two analyses were performed: without and with MRS. Two cases were considered within these analyses. In the first case, the first repository receives spent fuel from reactors closest to it; in the second case, the repository receives spent fuel from reactors located farthest away. Figure 2 indicates the areas of the country where those reactors closest to and farthest from Yucca Mountain are located.

The results of the impact of a second repository on transport to the three potential repository sites are shown in Table 2. Cask-miles were chosen as the comparative measure because DOE finds them to be a good surrogate measure for the costs and risks of transport. The indicated decreases were large enough for DOE to conclude "that the introduction of a second repository can produce a significant effect on the results for a single repository analysis" (DOE, 1986a, p.A-76).

TABLE 2

PERCENT CHANGE IN CASK-MILES WITH A SECOND REPOSITORY ADDED TO THE TRANSPORT SYSTEM

	WITHOUT MRS		WITH MRS	
	close	far	close	far
Yucca Mountain	-29%	+21%	-27%	+30%
Hanford	-25%	+19%	-33%	+37%
Deaf Smith	-30%	+23%	-38%	+34%

Source: DOE, 1986a, p.A-78

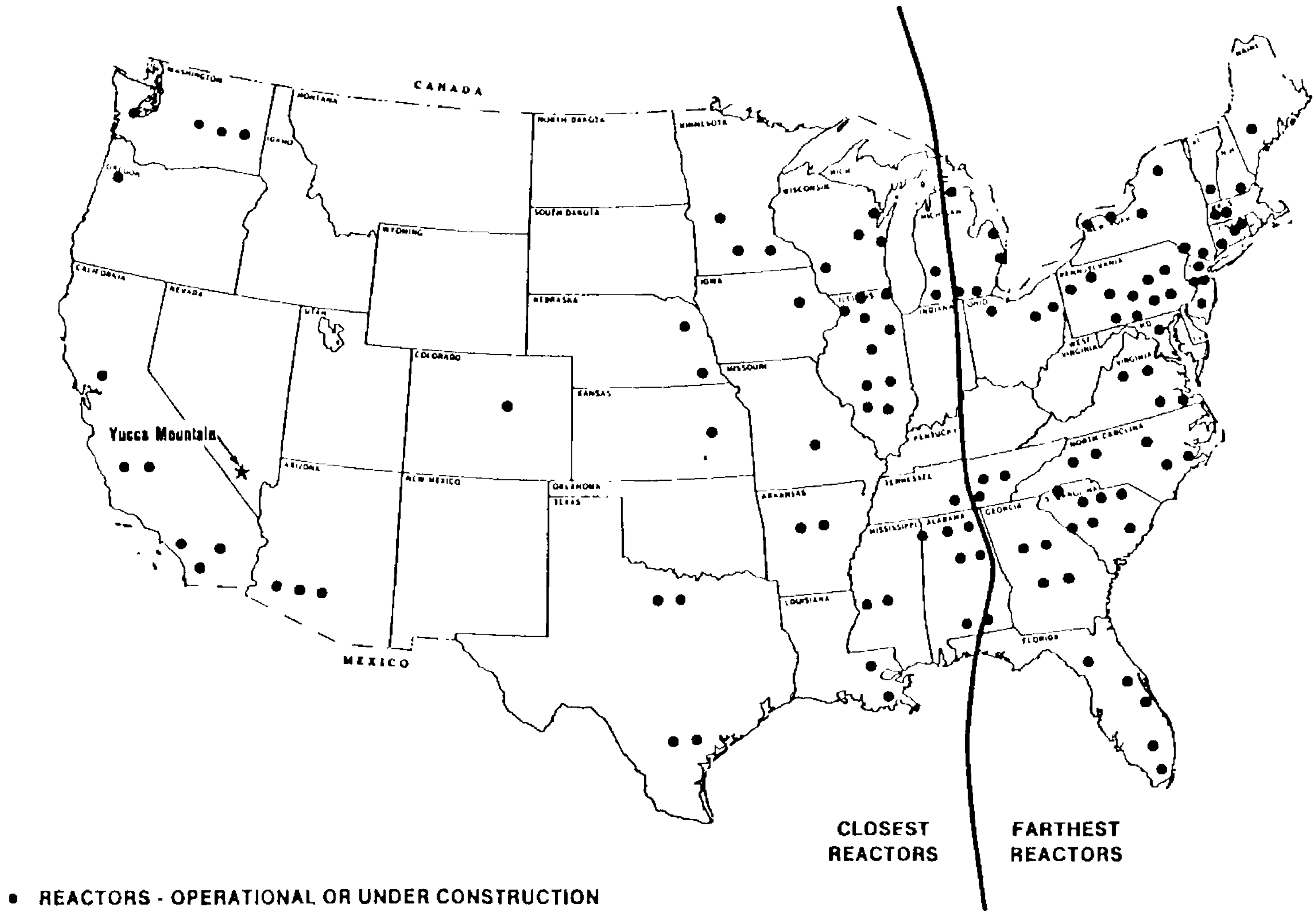

FIGURE 2

CLOSEST AND FARTHEST REACTORS TO YUCCA MOUNTAIN

Risk Assessment

As part of the Yucca Mountain Environmental Assessment, the risk to the public--both nationally and regionally--due to the transportation of spent nuclear fuel was calculated by summing the radiological and nonradiological consequences of transport. Total risk is a function of the number of shipments. The analysis assumed that the waste shipments would travel by truck or rail in general commerce, and the results are intended to be used only to compare potential sites. Nationally, six shipment scenarios were posited: without MRS: A=100% truck, B=100% rail; with MRS: C=100% truck (from all reactors), C_1=100% truck (western reactors only to repository), D=100% rail (from all reactors), D_1=100% rail (western reactors only to repository). Regional shipment parameters varied because with MRS all western reactors were assumed to ship their waste directly to Yucca Mountain (the case chosen by DOE for the analysis). Therefore, only scenarios A, B, C_1, and D_1 apply to the regional analysis.

Radiological Impacts. The impacts of accident-free (normal) transport combined with the impacts due to the release of radioactivity following an accident comprise the radiological impacts of nuclear waste transport. Even in accident-free transport, a small fraction of radiation penetrates the shipping cask, and people in the vicinity of the cask are therefore exposed to low levels of radiation.

Following an accident, radiation will affect transportation workers, the general population along the route, workers responding to the accident, and other "maximally exposed individuals." The latter are those persons who, because of their occupation or place of residence would receive maximum amounts of radiation.

The analysis of radiological impacts used a general model, RADTRAN-II, to determine the risk of transporting nuclear waste through a given population zone (DOE, 1986a). Risk is calculated as the product of a unit risk factor, the number of shipments, and kilometers per shipment. Unit risk factors vary depending on transportation mode, population zone (urban, suburban, rural), and waste type. They are calculated for both normal transport and accident conditions, and for the general public and transport workers.

The results of the assessment of the radiological impacts of transport within Nevada indicate that the risk from truck transport is greater than that from rail shipment. However, these regional radiological risks are very low, and the risk due to accidents is quite small. It should be noted that the RADTRAN-II model "may understate accident conditions in Nevada" for truck transport (DOE, 1986a, pp.5-95). During 1983, based on overall death rates, accident rates in Nevada were 40% above the national average. The accident rates that will actually be used in the model will be determined during site characterization.

Nationally, the radiological risk attributable to spent fuel transport is also greater for truck transport than for rail shipments. Over the 28-year emplacement period for the repository, deaths from truck transport would range from 11.3 without MRS (scenario A) down to 5.7 (scenario C) and 5.3 (scenario C_1) with MRS. Rail transport would account for less than one death (scenarios B, D, D_1) regardless of the use of MRS (DOE, 1986a, pp.5-89). However, the repackaging of spent fuel at a MRS facility would produce a very slight increase in the total national radiological impacts.

Nonradiological Impacts. Nonradiological impacts, with unit risk factors taken from actual records, are the sum of cancers attributable to nonradioactive pollutants and deaths or injuries due to vehicle accidents in which no radioactivity is released. Overall, DOE finds that nonradiological fatalities and injuries "far exceed those due to the radiological nature of the cargo" (DOE, 1986a, pp.5-97). Still, the Yucca Mountain regional analysis found the total nonradiological risk to be low; the largest risk came from scenario C_1 and the lowest from scenario B--making 100% rail transport directly to Yucca Mountain the safest means of transport (DOE, 1986a, pp.5-100). Again, the risks due to truck transport were shown to be greater than shipment by rail.

Analysis of national nonradiological impacts also showed truck transport to pose a greater risk than shipment by rail. Accidents would be the "dominant cause" of these impacts. Over the emplacement period, nonradiological deaths from truck transport would range from 36.4 without MRS (scenario A) up to 42 (scenario C) and 39 (scenario C_1) with MRS. Rail transport would account for three deaths without MRS (scenario B) increasing to 27 (scenario D) and 25 (scenario D_1) with MRS (DOE, 1986a, pp.5-96).

Preclosure Transportation Technical Guideline

The method used to determine the suitability of a site for the first national repository relies on comparing information about the site against a set of predetermined guidelines. The guidelines, detailed in the Yucca Mountain Environmental Assessment under the heading "Preclosure Transportation Technical Guideline," cover nine favorable conditions, four potentially adverse conditions, and a qualifying condition. The objective of the preclosure guideline is "to insure that proper consideration is given to the transportation of waste to a repository site, as it could affect the health and safety of the public, the environment, and the cost of waste disposal" (DOE, 1986a, pp.6-95).

Application of the preclosure guideline to the Yucca Mountain site showed the location to be suitable for a spent fuel repository. However, the total projected life-cycle cost and risks due to transportation for Yucca Mountain are not significantly lower than those for comparable siting options; the site is a long distance from the East, where the majority of spent fuel is located. In addition, the proposed rail spur to the site could possibly increase the risks to the public (compared to other sites) because it would be close to an Air Force bombing range. Detailed study of this condition during site characterization will evaluate that potential risk.

The meteorological history for the region shows that routine or seasonal severe weather conditions will not significantly disrupt transportation activities. A significant weather disruption is defined as one "that could cause the repository not to meet its annual [emphasis added] receipt rate" (DOE, 1986a, pp.6-108). During 1984, I-15 was closed three times due to flooding, while there were no weather-related closures of I-80. During 1985, U.S. 95, between I-15 and I-80, was also closed three times because of weather.

The DEA for Yucca Mountain cited several legal impediments to waste transportation in or through Nevada and adjoining states. A legal impediment is defined as a state/local/tribal law which makes compliance with federal regulations impossible "without being found to be preempted by the Federal judicial system" (DOE, 1986a, pp.6-105). However, the EA changed this assessment, finding no legal impediments to compliance with federal regulations. While state and local regulations exist that DOE considered impediments to waste transport--California's "time-of-day requirements," Humboldt and Marin County's (California) bans on radioactive waste transport, Las Vegas' ordinance restricting transport--DOE also considers them preempted by federal regulations. However, it is possible--but highly improbable--that the courts or DOT (by its authority) would allow these state and local regulations to stand.

Critiques of the Siting Process

> Citizen opposition, primarily at the grass-roots level, to siting plans has been extremely strong, regardless of geography.
> (Rheem, 1986)

Key Issues

Screening criteria for DOE's siting decisions for the first repository have emphasized distance from population centers, the availability of federal land, the lack of previous exploratory drilling, and the existence of specific geologic formations. Thus, implicitly the criteria seem to favor sites in the western U.S.--sites far from the generators of spent fuel in the East and Midwest. Finding an acceptable site has therefore gone beyond being a technical problem to being a political one (Jacob and Kirby, 1986). The DOE has not considered any transportation issues beyond the need to link the repository site with the nearest highway and rail systems. Because of the narrow scope of this analysis, there appear to be five key issues fueling opposition to the siting program (Jacob and Kirby, 1986).

Three of the issues deal specifically with corridor states. First, the involvement of corridor jurisdictions in the site selection process is ambiguous. DOE has refused funding to the corridor states to monitor and critique the repository program; states must use their own funds for these studies.

The second issue involves the lack of legal recognition by DOE of the interests of corridor states and of the public living and working along the possible transport routes. These jurisdictions and citizens are a potentially powerful constituency that could influence Congress, but for the present, they are using the courts in an effort to have their interests recognized in the siting process. Because of the antagonism fostered by DOE's actions (or lack thereof), DOE may find it difficult to achieve the workable system of cooperation and consultation with local governments called for in the Mission Plan

(Jacob and Kirby, 1986).

The third issue concerns DOE's failure to recognize (much less to provide mitigation for) the potential problems that repository siting will impose upon corridor states. Since funds for mitigation will be provided for communities near repository sites, similar compensation may become an issue for corridor states. As previously mentioned, DOE expects local jurisdictions to provide emergency response capabilities, but most programs that exist are designed to deal only with problems at permanent nuclear facilities. In fact, most local emergency responders currently lack the equipment and training to deal with a transport accident involving high-level nuclear waste. For example, 80% of the country's fire departments are composed of volunteers, and most of those departments do not have members trained to handle radiological emergencies.

In addition to not addressing the problem of local emergency response, DOE appears to have not adequately addressed other elements of the risk posed by transport. For example, the relative risks associated with different potential routes were not considered (e.g., moving waste to Yucca Mountain over mountainous I-70 versus routing it to a regional repository closer to the source(s) of the waste). Yet, specific transport routes need to be evaluated when selecting a repository site, particularly since it has been found that the accident estimates in DOE's generic models may underestimate true accident rates by a factor of forty or more (Jacob and Kirby, 1986).

Local jurisdictions along proposed transport routes have other concerns as well---concerns regarding health, public safety, and the maintenance of property values. In a more fundamental sense, they are wary of the possible erosion of their authority to impose regulations to protect such local concerns.

The remaining two issues apply to both corridor states and states that have potential repository sites. First, for the transport program to be effective, a high level of coordination is needed--particularly with respect to emergency response--between local, state, and federal agencies. Yet future cooperation and coordination between the federal government and local jurisdictions is threatened by conflicts over the rights of local jurisdictions to regulate waste shipments. This conflict and mistrust is reinforced by the federal prerogative to preempt local requirements if they will impede transport. This right of preemption makes it difficult for states to get DOE to recognize their interests.

The final issue involves the need for a large increase in government agency resources and personnel to oversee the shipment of waste by private carriers. For government and industry, relative responsibility will have to be determined concerning driver training, shipment scheduling, specific route selection, leakage monitoring, and general reporting. DOE estimates the cost of such a radioactive waste management program to be $21 to $35 billion, whereas the General Accounting Office estimates the costs could run to $114 billion.

The major responsibility for monitoring shipments will fall to the states, because transport problems will most likely be discovered at state ports of entry and weigh stations (Jacob and Kirby, 1986). Transport schedules will be monitored and, if needed, shipments will be stopped and rerouted at such state inspection facilities. States will thus need more personnel trained to deal with radioactive cargo, and residents living along transport routes may demand that radiation levels be monitored as well. The question remains: Who will pay for this increased local activity?

Top Candidates for the First Site

Deaf Smith County Texas is wheat and cattle country--the most productive agricultural county in Texas, and the third most productive in the nation. Not surprisingly, the strongest criticism of the choice of Deaf Smith County for a repository has come from its farming community. Local merchants have been somewhat more uncertain, but large businesses have not. Frito Lay and Holly Sugar have said they might leave the county if it is the chosen site, and Arrowhead Mills, a health food company, says its operation is incompatible with a high-level nuclear waste repository (Salisbury, 1985b). A survey has shown that 73% of the people residing in the region are opposed to locating the repository in Deaf Smith County. Less is known about the geology of this site than the Yucca Mountain and Hanford sites. What is known is the location of the Ogallala aquifer--the nation's largest aquifer. It supplies water to the nation's eight most productive agricultural states and is critical to the farm economy of northern Texas. The repository shaft would pass right through it. The state is investigating the repository shaft technology because it believes problems of leakage exist which could, over time, introduce radioactivity into the aquifer (KCTS-TV, 1986).

The area around Hanford, Washington--a dry, remote, "unpopulated" region --is generally pro-nuclear country. Hanford is a federal reservation (owned by DOE), created as part of the Manhattan Project, that has "played a key role in the early history of nuclear power" (Salisbury, 1985c, p.3). Its workforce is trained to handle and protect radioactive materials. The nearby Tri-Cities --Richland, Kennewick, and Pasco--have been characterized as seeking the repository, but this is not entirely the case. Rather, according to Richland's city manager, the local people want to be sure that repository technology is proven safe before they give the site their support. Once safety has been proven, then "you will see us boosting it [the Hanford site],and boosting it heavily" (Salisbury, 1985c, p.6). This local guarded support notwithstanding, citizen opposition to the Hanford site does exist throughout the rest of the state. A proposition on the November, 1986 ballot calling for the endorsement of the state of Washington's challenge to DOE's plans to locate the first repository at Hanford was overwhelmingly endorsed by the state's voters (Boulder Daily Camera, 1986d).

A geologist for the state government has investigated the problem of groundwater contamination from the repository causing contamination of surface water after long periods of time (hundreds of years). The Columbia River--a major recreation resource, transportation corridor, and water source for the large eastern Oregon wheat crop--is within four miles of the Hanford site. Even the public perception of contamination could make the wheat unsaleable, curtail recreation, and have serious impacts on the Pacific Northwest (KCTS-TV, 1986).

The Yucca Mountain, Nevada site is located on federal land adjacent to the Nevada Test Site, home of the nation's underground nuclear weapons testing program, near Las Vegas. Nevada's governor, Richard Bryan, and other state Democrats oppose locating the repository in Nevada. State Republican leaders are neither for nor against the site, claiming that taking a stand is premature (Salisbury, 1985d). Public concern about the location of the repository in southern Nevada and transportation to the site, appears to be growing. There was a low turn-out at the February, 1985 public hearings on the site, with the principal critics being those persons already in opposition to the test site and the nation's nuclear weapons program. However, within the next year, the Las Vegas Sun (Nevada's largest newspaper) ran coupons for readers to send to local government officials protesting the location of the repository in Nevada. Following the receipt of 30,000 coupons, the Clark County commissioners became unified in their opposition to siting the repository in adjacent Nye county. One hundred miles away from the site, Las Vegas is dependent upon tourism for its survival, and nuclear waste and tourism are felt by many local citizens to be incompatible. An accident, with or without injuries, would certainly make national headlines and harm the local tourist industry (Salisbury, 1985d). Thus, Las Vegas has adopted a resolution opposing the location of a repository in southern Nevada and transport of waste through the city and Clark County. Reno, also heavily dependent upon tourism, has adopted a similar resolution concerning transport through Reno and Washoe County (Knox ert al., 1986).

The Yucca Mountain site is attractive, according to the EA, because of its geology and arid climate. Perhaps the key attribute necessary for a national high-level nuclear waste repository is its location in a stable geologic formation, where, theoretically, the waste can only escape from the repository via groundwater. Since the repository must be able to contain waste for 10,000 years, the amount of time it will take water to "pass through" the repository to the water table must be greater than 10,000 years. DOE estimates the Yucca Mountain site's annual rainfall to be six inches, with evaporation and plants using up most of this water. The water table, at 500 feet, is extremely deep, and DOE claims that water in the area moves downward at only a few inches per year through rock pores. However, consultants to the Nevada Nuclear Waste Project Office believe that the water moves through fractures in the rocks at a much faster speed. If this faster movement existed, it would probably disqualify the Yucca Mountain site from consideration (Salisbury, 1985d).

An additional serious drawback of the site is the area's susceptibility to earthquakes. The USGS has determined that significant earthquakes affect the area about every 90 years. Analysis indicates that an earthquake would damage the repository's surface structures but not the tunnels, and might alter the water table (Salisbury, 1985d). The evidence shows that Yucca Mountain, with faults that appear to be 4000-6000 years old, does not meet the siting guidelines which generally require a site to be disqualified if earthquake activity has occurred more recently than 10,000 years.

Nevada, Washington, and Texas have all objected to DOE's site plans, the site selection criteria, and virtually every aspect of the siting process. Washington, via its Nuclear Waste Board, joined Nevada in a suit against DOE claiming DOE "must provide federal funds to affected states so that they can independently study proposals for waste dumps within their borders" (Baker, 1985). The U.S. Ninth Circuit Court of Appeals (in a December 3, 1985 ruling) granted $2.1 million to Nevada from DOE for underground hydrologic and geologic testing. The court found that states can conduct their own studies of the repository sites with the federal government bearing the costs (Los Angeles Times, 1985). Currently, all three states are conducting their own site assessment programs.

Nevada has also challenged whether DOE actually used its own guidelines in the site selection process, while Texas has filed suit against DOE, claiming that the agency selected the final sites based on political rather than geological criteria. Part of Texas' case rests on the fact that DOE published the site selection guidelines five months after choosing the Deaf Smith site (Salisbury, 1985b).

The Nevada governor (who was re-elected in November, 1986) has stated he will veto the Yucca Mountain site if it is chosen as the location for the first repository (Not Man Apart, 1985). As mentioned earlier, the NWPA allows the governor of the state chosen for the repository the right to veto DOE's decision, but Congress can override the governor's veto. The governor of

Texas (who was defeated in the 1986 election) stated in 1985 that he too would use this veto power. The governor of Washington has not stated his position (Salisbury, 1985c); however, the governors have joined to take their case to Congress. They want the repository siting process immediately halted and the site selection process restructured, so that a significant decision making role for independent technical groups is included (KCTS-TV, 1986).

By 1986, a group of Deaf Smith County landowners had formed a Nuclear Waste Task Force and filed suit to prevent further site studies in their area. The suit is based on the facts that there are extensive food processing and agricultural activities near the proposed site and that possible contamination of the water table could occur if there were an accident during site characterization. Additionally, Utah (location of one of the top five sites) has considered joining the various law suits brought by the first site states. Utah's intent would be to prevent reconsideration of its Davis Canyon site should any of the sites in Washington, Nevada, or Texas be dropped from consideration.

Selecting a Second Site

Altering the Process. When DOE formally announced that the first national high-level nuclear waste repository would be located in either Nevada, Washington, or Texas, the announcement was accompanied by the unexpected news that the process of selecting the site for the second repository was being postponed indefinitely because of questions concerning cost and need, though the commitment to a two repository system was upheld (Rheem, 1986, p.3). DOE had determined that the amount of nuclear waste requiring underground storage was growing at a slower rate than had been assumed. Initial projections showed that by 2020, storage would be needed for 140,000 metric tons of waste; current projections indicated 110,000 metric tons. In the words of the Secretary of Energy, "It is clear that to go ahead and spend millions of dollars on site identification now would be both premature and unsound fiscal management" (Rheem, 1986, p.4). Yet, the first repository would be limited to storing 70,000 metric tons of waste--an amount that would be reached by 2025.

The second repository is to be located east of the Mississippi River and in an area geologically different from that of the first repository. The seven eastern states containing twelve possible secondary sites (first announced on January 16, 1986) were Wisconsin, Minnesota, Maine, New Hampshire, North Carolina, Virginia, and Georgia. DOE held community briefings in the areas with potential second repository sites following the announcement, but many citizens were not able to get the information they wanted from DOE at those meetings. For example, DOE could not answer questions concerning "how communities would be protected from transportation accidents, leaking containers, shifting earth, and other potential dangers" (Christian Science Monitor, 1986, p.23). In Maine, the federal government showed an apparent ignorance of local geology when they overlooked a known fault (Christian Science Monitor, 1986), and opposition in all the states to hosting a repository was "tremendous" (Rheem, 1986). Critics subsequently charged that the federal government postponed the second siting decision fearing that "citizen outrage" in the East would threaten the whole program and that the first repository would be scrapped along with the second (Rheem, 1986).

Critics also charge that the decision to postpone the quest for a second site was a political move by the Reagan administration in light of the upcoming 1986 and 1988 elections. The dropping of consideration of a second repository eliminated siting as an election issue in two key Republican races (Gottlieb and Wiley, 1986). North Carolina's Representative Broyhill, a Republican, had been "beaten-up" in the 1986 primary election by an opponent who charged that he had lobbied for the site's location in North Carolina (Rheem, 1986). Similarly, the 1988 presidential primaries begin in New Hampshire, and Vice President Bush would have a difficult time in this important primary if the voters were enraged by the inclusion of their state on the second repository site list.

The West Responds. The Department of Energy's decision to suspend plans for a second repository has left western politicians believing that their region has been shortchanged since the national repository will be located in a western state. In the words of Nevada's governor, "Nevada doesn't generate any high level waste. Why should we be the dumping ground for other people's garbage?" (Gottlieb and Wiley, 1986, p.4). This view coincides with the perception many Westerners have that the region "is often seen by the rest of the country, and particularly by officials in Washington, D.C., as a vast open space where deadly government-sponsored activities can be accommodated" (Gottlieb and Wiley, 1986, p.4).

The original congressional compromise which led to the passage of the Nuclear Waste Policy Act was based in part on the regional, political solution that DOE "shall have a second site" (Gottlieb and Wiley, 1986, p.4). Washington's Representative Swift, a Democrat who worked on the regional compromise, feels it has been violated and may initiate legislation to put a moratorium on site selection and reassess the whole question of nuclear waste disposal.

Western legislators, at an October, 1986 meeting, sent a resolution to Congress urging that work on the siting and development of the first repository be suspended until such time as work begins on siting the second repository. The legislators fear that unless forced to do so, the federal government will never locate a repository in the eastern U.S.. With 85% of the country's spent fuel, destined for long-term storage, coming from east of the

Mississippi River, they fear the West will have to carry "more than its share of the nation's nuclear waste burden" (High Country News, 1986, p.3).

ROUTING

Federal Regulations

The goal of the federal government's routing regulations for high-level nuclear wastes is to reduce risk "by reducing the amount of time the radioactive material is in transit" (DOE, 1986a, pp.5-77). Because interstate highways provide the quickest means for crossing the country (and usually have lower accident rates than other routes), they are the federal government's routing choice.

There are three basic concepts, detailed in HM-164 (the DOT final rule governing highway routing of radioactive materials), used to devise a highway routing system. First, uniform and consistent route selection rules, which are also practical and add to safety, must be used. In addition, route selection should be based on a valid measure of reduced public risk; the overall risk of a route is dependent upon various factors including: accident rates, duration of travel, traffic patterns, population density, road conditions, driver training, and time of travel. Thirdly, routing decisions should carefully consider local views "because routing is a site-specific activity unlike other transportation controls, such as marking and packing" (DOE, 1986a, p.A-85). However, routing regulations and final route selection should balance local and national interests. For rail transit, there are no federal routing regulations--fewer alternative routes exist, track conditions limit the number of acceptable routes, and rail lines generally are privately owned and maintained (KCTS-TV, 1986).

DOT rules

As previously mentioned, the Hazardous Materials Transportation Act gives the federal government the power to preempt state requirements which are inconsistent with the HMTA. For a state requirement to be preeminent, it must afford greater protection to the public and not place an unreasonable burden on commerce.

Nevertheless, the federal government recognizes that nuclear waste shipment routing is a key concern of state, local, and tribal officials, and, to address this concern, states can designate alternate highway routes for spent fuel shipments. For a route to become an acceptable alternate, the state must demonstrate that the alternate is as safe as the routes specified by the federal government. Thus, HMTA preferred routes encompass interstate highways (including beltways around major cities) and/or state designated alternate routes. Carriers can leave these preferred routes to pick-up, deliver, or transfer a "large-quantity package of radioactive materials" (DOE, 1986a, p.A-86); to obtain necessary rest, fuel, and vehicle repairs; or to avoid emergency conditions that might make travel on a designated route unsafe.

HM-164 further clarifies routing requirements, stating that trucks generally are to follow the most direct interstate route and are to avoid large cities when an interstate bypass or beltway is available. State governors must also receive timely notification before spent fuel is transported into their state.

Motor Carrier Safety Act

Another federal regulation, the Motor Carrier Safety Act, also deals with the transport of hazardous materials. It states that trucks with hazardous cargoes should not go through cities and that they also must "'not go through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets, or alleys,' unless there are no 'practicable alternatives' from a safety standpoint" (Millar, 1984b). Convenience of operation cannot be the basis for making the determination of whether it is practicable "to avoid places of high risk where a serious accident could have catastrophic results" (Millar, 1984b, pp.8-9). State and local governments can thus use the act (by enforcing its provisions) to impose routing regulations and curfews governing hazardous material shipments. The courts have upheld such safety rules.

Selecting Alternative Routes

The DOT strongly encourages states to examine their highway networks and designate preferred routes for spent fuel transport either to supplement or provide alternatives to the interstate system; permitting the designation of alternative routes is one method of allowing local input into routing decisions (DOE, 1986a). States are directed to select routes with the lowest risk to the public--i.e., a route or set of routes which minimizes possible radiological impacts from shipments. Selection is made either in accordance with DOT guidelines or by using "an equivalent routing analysis that adequately considers overall risk to the public" (DOE, 1986a, pp.5-78). Substantive consultation with affected localities and states must be included in the analyses so all potential impacts are considered. Because transportation costs are a "tiny proportion" of the cost of nuclear-generated electricity, the use of alternative routes should be feasible (Surrey, 1984).

However, should the federal government accept a state's alternative route or routes, it will be setting a precedent which the residents and landowners along the newly designated route(s) could then apply in order to have those new routes changed again. This situation would create "a virtual veto on the movement of irradiated fuel on all routes" (Surrey, 1984, p.4). In order to avoid this scenario, the federal government has attempted to allay fears by stressing cask safety and the low risk of an accident occurring.

Selection Methodology

Guidelines have been prepared by DOT for states to use to select their preferred highway routes for nuclear waste shipments. These federal guidelines are not the only route analysis method available, as federal regulations allow states "considerable flexibility in carrying out the routing function" (DOT, 1984a, p.ii). However, the method of analysis a state chooses needs to be equivalent to the federal guidelines in that it "adequately considers overall risk to the public" (DOT, 1984a, p.ii). States must also meet the requirement that they "solicit and consider input from other jurisdictions which are likely to be impacted by a routing decision" (DOT, 1984a, p.iii). Consulting with affected local governments and adjoining states is intended to ensure that all the impacts of an alternate route and the route's continuity are considered; obviously, alternate routes designated by one state must meet those designated by another state at state boundaries. The method of public participation is up to each state, but states are encouraged to provide the public with notice of the proposed alternate routes, hold hearings if they are needed, and provide a period of time for comments.

There are six general steps a state must follow to select an alternative route. First, routes potentially available for shipping wastes between the points being considered in the analysis must be determined. A list of route comparison factors, including primary and secondary factors, must then be developed. The third step involves the evaluation of the route comparison factors for each potential route. This evaluation must include an analysis involving each primary comparison factor and, if deemed necessary, further analysis based on the secondary factors. Next, the route which best minimizes the impacts of waste transport, based on data from the evaluation, is then selected as the preferred route. The whole route selection process must be documented, and finally, the state must obtain public comment and the appropriate reviews or approvals of other agencies and affected local jurisdictions.

A state has several options it can pursue in its evaluation. It may analyze all of the federal preferred interstate routes so that those routes can be compared with available noninterstate routes. It then may want to remove the preferred status from a part of a federally designated interstate route or designate additional preferred routes to supplement those chosen by the federal government. These alternate routes could include noninterstate by-passes around urban areas where interstate by-passes do not exist. Regardless of the course a state chooses, it assumes the burden of proof and must perform a comparative analysis that shows that the alternate route results in lower overall impacts than does the designated route.

Routes must be compared based on what occurs both during normal transport and after an accident. Comparisons of radiological and nonradiological risks must be provided for normal transport, and, under the accident scenario, routes must be compared with respect to the effectiveness of emergency response, evacuation capabilities, and the route's avoidance of certain special facilities. Appendix A contains a more complete listing of the specific data needs for the various route comparison factors.

Primary route comparison factors. Primary route comparison factors are used to choose a route which minimizes radiological risk. Three factors are specifically examined to develop the data needed to analyze this risk: first, radiation exposure due to normal transport along available routes (which could vary significantly); next, the risk to public health from the accidental release of radioactive materials (which could vary because of differences in the frequency of severe transport accidents and in the number of people who would be affected by emitted radioactivity); and finally, economic risk due to an accidental release (which could vary because decontamination costs can change considerably depending on the property involved). Obviously, accident frequency needs to be considered when determining these costs.

Primary comparison factors can either be averaged along the entire route, or the route can be broken down into segments and then analyzed. Segmenting the route provides a more valid and detailed analysis when accident rates or population densities differ greatly for different parts of the route. The specific data needed for a primary comparison include accident frequencies (accidents per vehicle mile), traffic counts, average vehicle speed, population distribution, and land use information.

Secondary route comparison factors. Secondary route comparison factors are used only after a careful primary analysis shows that the alternate routes have virtually the same level of risk or "if unusual conditions exist in the State that increase the importance of one or more of the secondary factors" (DOT, 1984a, p.7). These factors are inherently subjective and therefore more difficult to quantify and estimate than primary factors. Secondary factors fall under four headings related to accidents: emergency response effectiveness, evacuation capabilities, the location of special facilities, and traffic fatality and injury data. States may also identify other important secondary factors, or they can delete some of those listed.

Measuring emergency response effectiveness involves assessing how well the planned response mitigates the potential consequences of an accident. This is dependent in large part on the amount of time needed to reach an accident site, and such response times could vary significantly among available routes. To understand this factor, data would have to be gathered on the location and capabilities of agencies or groups who would be involved in emergency response or evacuation along the various routes. Similarly, the time and effort required for an evacuation; an evacuation's economic impacts; the location, type, and number of special facilities would also need to be assessed as they can vary between routes. Special facilities are those which contain either large populations (such as stadiums), persons sensitive to radiation (such as schools), or people who are hard to evacuate (such as hospitals and nursing homes). The fourth secondary factor includes traffic data concerning fatalities and injuries due solely to the hazards of transportation and independent of the radioactive nature of the waste being transported. States are to use the data to choose routes that minimize accidents. As mentioned earlier, the federal government is well aware that any accident could result in bad publicity or even precautionary evacuations when radiation is not in fact released, and thus could cause the public to take a negative view of nuclear waste transport (DOT, 1984a).

Sample Case. The federal guidelines include an example demonstrating how to take two routes and apply the route comparison factors using "fill-in-the-blank" prepared worksheets. Copies of the worksheets are found in Appendix B. In the example, the evaluation of primary components shows Route B to be clearly preferable to Route A.

When the choice between routes is not as clear-cut, the values for each primary factor can be normalized and then summed for each route. Normalizing the factors in the example involves summing each factor (A + B) and then dividing A and then B by their sum. The total of these normalized values for each route determines a figure of merit that is used for the comparison of the routes (see Appendix B, Worksheet H).

Conclusion

Route comparison implies that each primary factor will be of equal importance in reducing the impacts of exposure to radiation. For this reason the factors are weighted equally. But normal exposure to radiation (from cask penetration during transit and, particularly, when the vehicle is stopped) "often contributes a greater share of the health risks from transportation of radioactive materials than accidents resulting in public health impacts" (DOT, 1984a, p.38). This route assessment method, therefore, cannot be used to determine the actual risks associated with transport, nor can it be used to develop comparative risk figures to assess routing alternatives. More specific information is needed to develop such "true" risk assessments.

EMERGENCY PREPAREDNESS

Background

Although transportation accidents involving high-level nuclear waste are low probability events, the magnitude of the hazard dictates that jurisdictions should be prepared to respond to such an emergency. An emergency response plan should be activated once an accident occurs "if only to verify that there is no hazards [sic] from the accident" (FEMA, 1983, p.8). Emergency response occurs more often because radiation has leaked during normal transport than because containers have been breached during an accident (Mitter et al., 1980). Containers that leak during transit do so because of improper packaging by the shipper. Thus, more work is clearly needed to insure that containers are properly packed and sealed.

As a hazard, radiation has two unique qualities; it is odorless and invisible. Hence, use of proper detection equipment is essential. Such detection requires knowledge of both the form of radiation being looked for and possession of the proper instruments to detect this radiation. Such instruments must be properly calibrated, responders must know how to use them, and those same persons must be protected by proper clothing from possible radiation. If a significant release has occurred, the spread of radioactive material due to wind must be considered, and the responsible agencies must plan for possible decontamination of responders and the public.

The consequences of a transportation accident will depend upon its severity and location, the amount and type of material being moved, packaging, the fraction of material released, meteorological conditions at the site, response time of emergency personnel, and the presence or possibility of a fire. All of these variables will affect the dispersal of the radioactive material and its interaction with other nearby substances.

Obviously, the actual emergency response effort will also strongly affect the consequences of the accident. Emergency response operations are typically plagued by certain recurring problems, the more persistent being:

1) lack of coordination among responding agencies;
2) lack of a predesignated, local on-scene coordinator;
3) lack of involvement by state transportation organizations in local emergency response planning and preparedness programs;
4) poor communication between on-site responders and response agency representatives;
5) public overreaction to an accident.

This final problem can often be attributed to the failure of response organizations to develop timely and accurate communications with the media, and, conversely, to the failure of the media to accurately report the situation.

Accident Response

Overview

State and local government officials have primary responsibility for immediate emergency response to a nuclear waste transport accident. On the federal level, FEMA coordinates the response of federal agencies with support provided by the Department of Energy. This support by DOE includes on-scene radiological monitoring and assessment.

Following an accident, local and state governments are also responsible for the broader protection of public health and safety. States must decide who will be notified in the event of an accident and what services each responding group will handle. Clear delineation is important; the driver of a truck involved in an accident, local police, fire personnel, and other local officials must all know what to do and who to call no matter where an accident occurs along a route.

Police officers should have a minimal level of field training in radioactive hazard response, and fire and ambulance personnel should have training in the identification of radioactive materials, site control, and notification of specialized response teams. A high level of training and expertise among initial responders is more desirable than a rigid hazards analysis procedure (Gunderloy et al., 1984). Similarly, state response systems that rely on informal contacts between state and local agencies appear to work as well as centralized, highly documented response systems (Gunderloy et al., 1984).

An alternative approach to emergency response is offered by Mitter et al. (1980). The authors feel that the Nuclear Regulatory Commission (NRC) should recommend that only specialized response teams be responsible for determining if a hazard to the public really exists. Too often, they say, first responders do not know how to properly use radiation detection equipment, or the equipment has not been properly maintained and calibrated. The actions of first responders could result in an incorrect reading of radioactivity, leading to local panic. For these reasons, they feel that such specialized equipment should only be used by designated radiological emergency response teams.

FEMA Guidelines

FEMA (1983) has spelled out guidelines for an effective response to a high-level waste transportation accident. (Again, it is important to remember that packaging and transport are the responsibility of the shipper and carrier, while response falls to state or local governments.)

Shippers should know and comply with all pertinent regulations and maintain a twenty-four hour phone contact for spent fuel shipments. Carriers have the same responsibilities and should also be able to assist in the management of an accident site. They should see that the accident is cleaned up but are not required to perform the clean-up themselves. This notwithstanding, carriers will have to reimburse emergency responders according to applicable laws and court decisions.

States should have a radiological emergency response plan, an emergency radiological response team, a coordinated communications system, and response agreements with contiguous states. In turn, local jurisdictions should have local plans that are compatible with the state plan. Local law enforcement and/or fire service personnel will most likely be the first responders to an accident and will need to be able to deal with injured persons, determine if radioactive materials are present, and obtain information on the materials involved. They will have to notify the appropriate authorities and determine what steps must be taken to save lives and property. For its part, the federal government will support these leading roles taken by state and local government.

Model Plan

The NRC Division of Risk Analysis has prepared and ideal model detailing the critical elements of a state emergency response system for dealing with radiological materials transportation incidents (Gunderloy et al., 1984). Because there are no constraints in the model on the availability of personnel or funding, as well as no other "real world" restrictions, state and local governments can use it as a standard against which they can check their own response systems.

The critical elements of the model system include a carefully constructed response plan, a well-structured state organization, on-scene coordinators, well-equipped mobile command centers, backup support vehicles and equipment, and a dedicated communication system.

On-scene coordinators are predesignated, well trained, and the focus and information source for all responders. They are responsible for training first-on-scene personnel and conducting advance coordination activities. The response plan to be followed includes a well thought out initial tactical approach. (However, as alluded to earlier, there are numerous problems that can hamper any response plan and render it less effective. Problems in government organization and structure, the actions of the on-scene coordinator, deficiencies in responder training, lack of advance planning, failure to develop a tactical approach, insufficient resources, and failure to establish the plan's basis in law constitute areas where difficulties often arise.)

In the ideal system, emergency responders plan their emergency response and then take part in operational training to acquire and maintain the necessary response skills. This operational training is required of all first responders--police, fire, emergency rescue, emergency medical personnel--and of state response team members. A specific course of basic training (Appendix C) is designed to give responders a reasonable level of expertise in assessing the radiological effects of an accident.

Conclusion/General Comments

As the volume of radiological materials in transit increases, detailed planning for emergency response will increasingly be necessary to insure that first responders know how to control an accident scene and which expert response teams to call in an emergency. In this light, the NRC should develop and distribute a standard list of questions and decision rules to be used by dispatchers and other communication personnel when dealing with a transport accident (Mitter et al., 1980). Ideally, any guidelines for emergency response should address performance--i.e., the ability to identify specific problems, effect a quick response, control and contain the scene until dangerous materials are removed.

THE COLORADO CASE

The purpose of this research has been to gain an understanding of the transportation of nuclear waste in relation to a national program to dispose of this waste in underground repositories. A cursory look at the issues involved with siting the first national repository has shown that western corridor states will bear the costs, while receiving few if any benefits, of nuclear waste transport.

Colorado is one such corridor state. This final chapter will present the case of Colorado in relation to spent fuel transport, with special attention paid to the stretch of Interstate 70 from the edge of the Denver metro area, westward through the mountains, to Rifle. Focusing on this transportation corridor, referred to as the the I-70 route or study area, provides examples of what states and local jurisdictions could be up against when and if nuclear waste passes their way.

Nuclear Waste Transport

Colorado is one of the states through which wastes will pass on a daily basis once a national repository is finally designated (maps of Colorado and Denver are included in Figures 3 and 4). In particular, Interstate 70 (I-70), which bisects the state, would be the primary east-west route used by trucks if the Nevada site were selected. This highway passes through the Denver metropolitan area, and many sections through east Denver are elevated. These sections pass over business and residential neighborhoods and in bad weather often become dangerously icy. Moreover, they are routinely clogged with commuters during morning and evening rush hours.

To the west of Denver, I-70 "winds through some of the most dramatic and difficult-to-navigate mountains in the Nation" (U.S. Senate, 1985). The route includes steep grades, sharp turns, and is subject to unpredictable mountain weather that can reduce visibility to zero. During 1984, weather closed I-70 for more than 300 hours--the equivalent of more than twelve days. Also during 1984, I-70's four runaway truck ramps (located on grades between Denver and Silverthorne--three for eastbound traffic, one for westbound) were used 34 times, including one time when two trucks had to use the same ramp. It can take up to two hours to get a truck off one of these ramps.

A portion of I-70 goes under the Continental Divide via the 1.7-mile long Eisenhower Tunnel. Because hazardous cargo is banned from the tunnel, trucks hauling nuclear waste must use Loveland Pass--"a very narrow, twisting, two-lane State [sic] highway which rises in elevation to nearly 12,000 feet" (U.S. Senate, 1985). U.S. 6 over Loveland Pass was closed 16 times during the winter of 1984-85, once for nine days.

Further west, Vail Pass receives large amounts of snow during the winter and is the site of many tractor-trailer accidents. Traffic in the area is heavy to extremely heavy during the winter ski season. Dowd Junction, a narrow canyon west of Vail, is another site of many accidents "due to peculiar combinations of weather, road/bridge configuration and river confluence" (U.S. House, 1986a, p.47).

State Highways

Colorado roads have been characterized as underfunded, underbuilt, overused, crumbling, and dangerous (Udevitz, 1986a). The sprawling system will need $11 billion worth of repairs and maintenance over the next 15 years. Critics argue that a good portion of this money would be available if truckers paid their fair share of the costs attributable to their use of the roads and developers paid for the added burden their construction places on the existing road network. State studies show that trucks cause around 32% of the damage

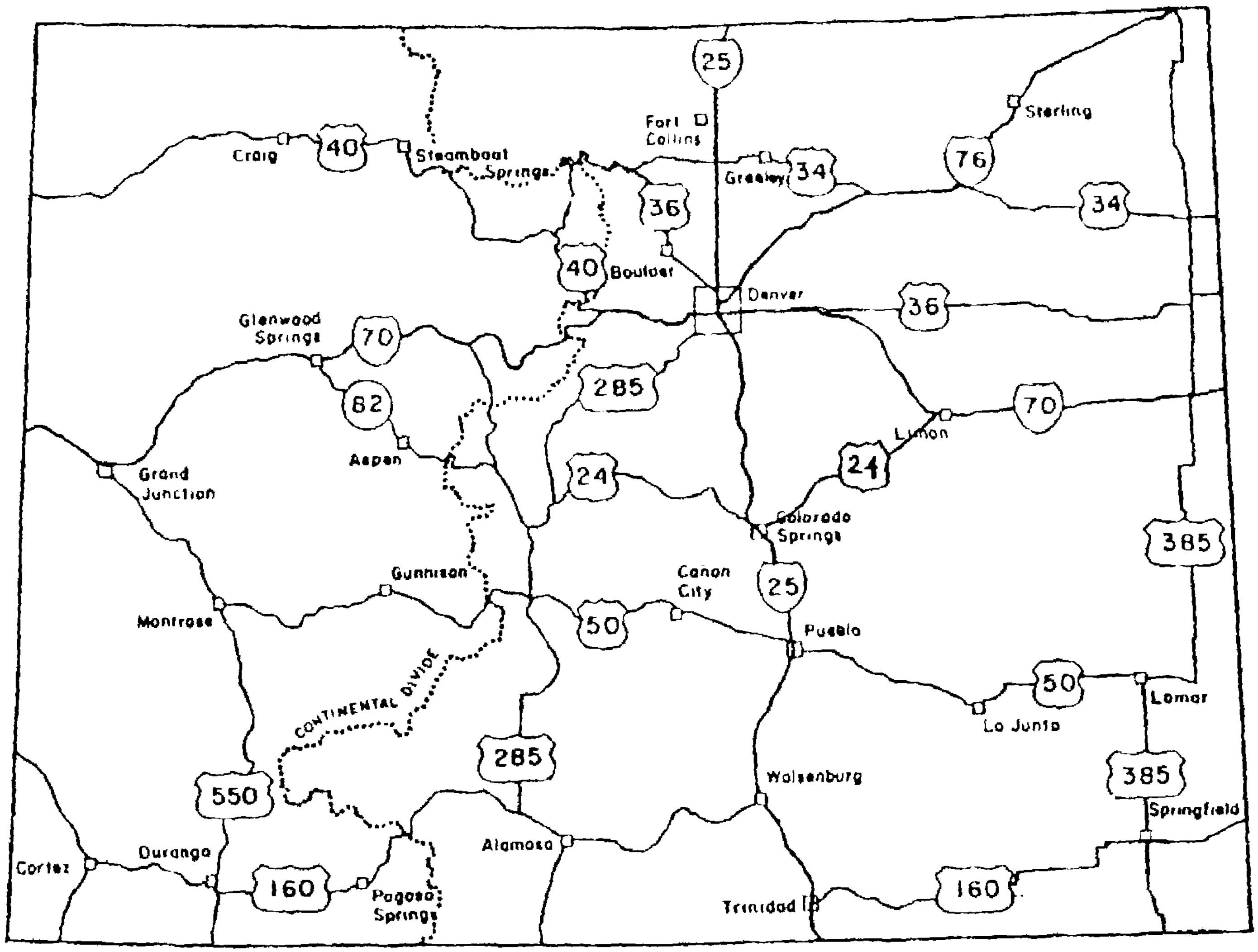

FIGURE 3

PRINCIPAL HIGHWAYS OF COLORADO

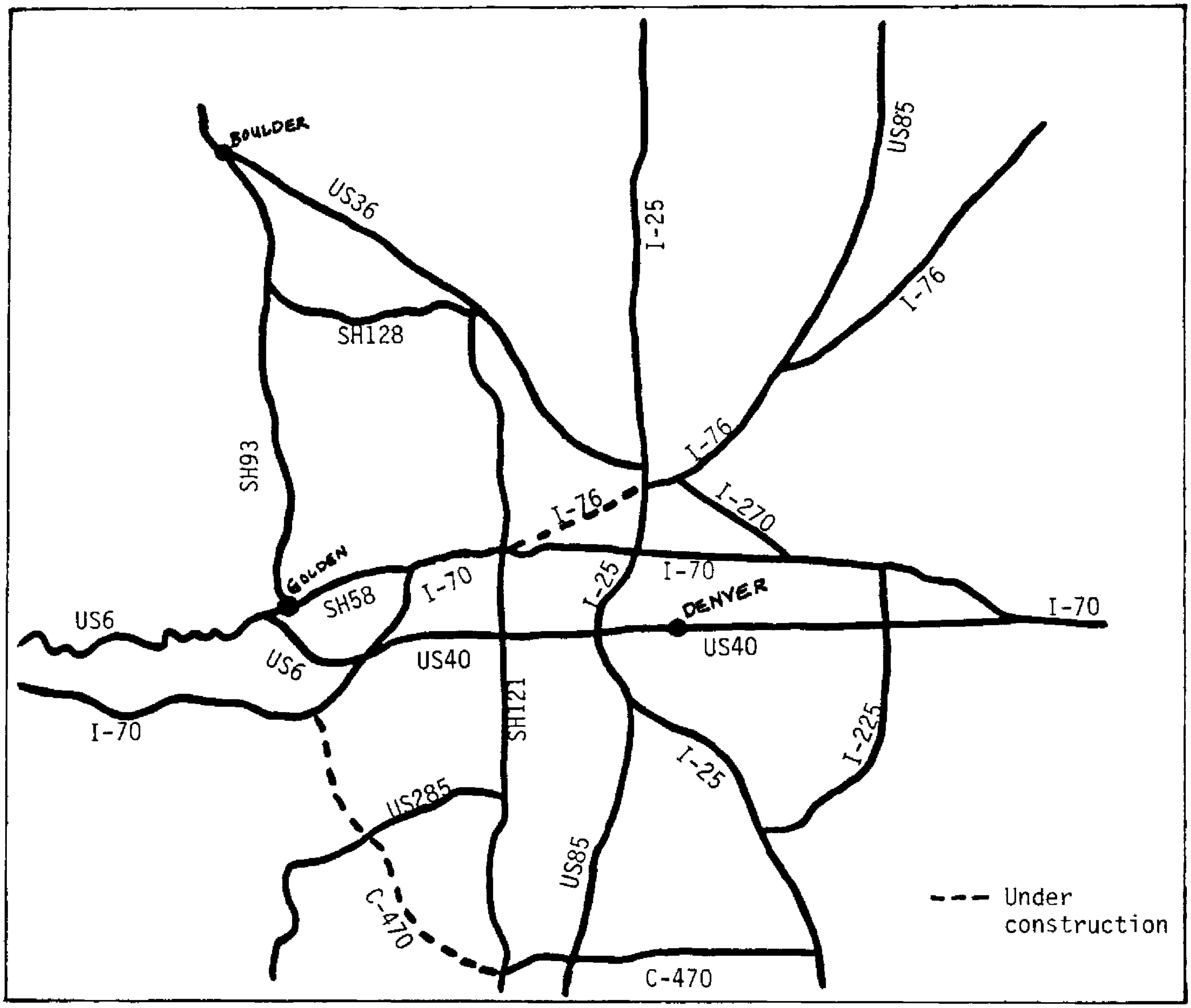

FIGURE 4

PRINCIPAL HIGHWAYS IN THE DENVER METROPOLITAN AREA

Colorado's highways sustain, while the trucking industry contributes only 21% of the cost of highway repairs. Compounding this problem, the legislature has been reluctant to fund new roads and road repairs.

In early 1986, the Colorado State Highway Department released a report on the state's roadways that included information on the condition of state highways--interstates and U.S. highways--and found around 50% to be either in very bad shape, hopelessly congested, or very dangerous. In part, the problem is that roads and bridges built years ago were not designed to handle "the scores of 30-ton trucks that rumble over them daily" (Udevitz, 1986a) and are rapidly wearing out. The state interstate system, although not yet finished is already beginning to crumble. "By the turn of the century, 62 percent of the state's roads won't be safe, and the rest will be in gridlock" (Udevitz, 1986a, p.14A).

A map of road conditions included in the highway department report shows that the condition of I-70 varies from Denver to Rifle (Udevitz, 1986a). West from Denver, I-70 is in good or fair condition. U.S. 6, the route taken over Loveland Pass to avoid the Eisenhower Tunnel, is in generally poor condition. Because several ski areas exist on its west side, just off U.S. 6, Loveland Pass is the only road in Colorado for which the volume of winter traffic exceeds that of the summer.

Truck Safety

Presently, DOT has two inspectors in Colorado who devote less than 15% of their time to inspecting hazardous materials shipments within the state (Lindsay, 1984). During 1984, they found 44,600 safety violations on 27,875 trucks that were carrying hazardous materials through the state. Only 2,509 of these trucks were found to be completely safe; 3,624 were taken out of service immediately because they were in such bad repair. Colorado punishes violators by imposing fines of $25 to $1000, sentencing offenders to one year in jail, or both (O'Brien, 1986b). State inspection data for the twelve months ending July 1, 1985 show that 4,000 trucks hauling hazardous cargo in Colorado were checked. These trucks were found to be in violation of federal regulations 5,000 times; more than 1,000 violations were serious enough to warrant issuance of a citation (Abas, 1986).

Nuclear Shipments

Trucks carrying nuclear warheads frequently pass through Denver. They often travel through an interchange called "the mousetrap"--the intersection of Interstates 70 and 25 just north of downtown Denver--and also use Loveland Pass to cross the Continental Divide (Lindsay, 1984). Denver officials, as discussed in greater detail below, feel that the routes used for the shipment of nuclear waste should be chosen based on the criteria used to determine transportation routes for other hazardous materials, i.e., populated areas should be avoided and local officials should be notified of impending shipments ahead of time. Additionally, they feel that emergency response capabilities should be upgraded.

Part of Denver's, and Colorado's, concern with nuclear shipments results from an August 1, 1984 accident at the mousetrap in which a truck load of torpedoes spilled onto the roadway just prior to the morning rush hour. The emergency response to the incident was generally considered inadequate--particularly on the federal level. The private carrier hauling the torpedoes did not have the authority to direct an emergency response, and local officials had great difficulty contacting anyone with knowledge of the shipment. They could determine neither how hazardous the materials were, nor what actions were appropriate to take.

Another occurrence in Colorado provides an example of current, and possible future, conflict stemming from nuclear waste transportation. In August, 1986, Governor Lamm asked DOT to determine if a trucking company had been illegally transporting radioactive materials through Colorado using highways other than the federally designated interstates. The company, Tri-State Motor Transit of Joplin, Missouri, was a DOE carrier that hauled plutonium, uranium, and cobalt. Colorado found that during 1984 and 1985 Tri-State had transported waste along U.S. Highway 285 south of Denver, U.S. 287 north of Denver, and U.S. 666 in southwest Colorado. The DOE office in Hanford, Washington acknowledged there had been shipments made which were off the designated routes; however, "DOE's Idaho office concluded that none of the shipments violated routing regulations" (Denver Post, 1986, p.B4).

Overweight Trucks

The current truck load limit in Colorado is 80,000 pounds; Utah allows 129,000 and Wyoming, 117,000. The state trucking industry claims that Colorado's relatively low limit in relation to its neighboring states puts Colorado shippers at a great disadvantage (Dubroff, 1986). However, state officials are wary of increasing load limits because, as already mentioned, interstates through Colorado are deteriorating. Officials blame tractor trailers for much of this current road damage. If Colorado were to increase truck weight limits, allowing "supertrucks" to travel in the state, it would find itself in need of billions of dollars to maintain the integrity of its roads. In addition officials are particularly concerned that increasing the permissible loads would create additional safety problems with the hauling of hazardous and, later, nuclear wastes.

Legal and Political Aspects of the Problem

Activities of Colorado's Federal Legislators

In May of 1986, Colorado Senator Gary Hart introduced into Congress Senate Bill 1162 to amend the Nuclear Waste Policy Act. Unfortunately, due to a full calendar, the bill was not accepted by committee; no hearings were held, witnesses heard from, nor any further action taken.

As outlined in the bill's introduction, the transportation of nuclear wastes poses the greatest risks in the repository process because of the likelihood of an accidental spill or other release of radioactivity. Hart estimated that by the year 2000, there would be 120 shipments of radioactive waste per day traveling to a national repository. The bill would have required DOE to incorporate transportation impacts on corridor states into any assessment of repository siting.

Hart's bill also would have required that DOE address the full scope of transportation impacts by assessing the public health and environmental impacts of waste transport through the region surrounding all proposed sites, identifying the most likely routes and modes of transport, evaluating the conditions and terrain along these routes, analyzing and characterizing the mileage traveled on these routes by type of vehicle, describing the significant human activities and population densities within ten miles of these routes, and estimating the cost of upgrading and maintaining these routes in order to minimize risks to public health and the environment. Finally, federal funds would have been made available to the affected states to upgrade and maintain these waste shipment routes.

In August of 1985, the House Subcommittee on Telecommunications, Consumer Protection and Finance, chaired by Colorado's Congressman Tim Wirth, called for federal, state, and local efforts to ensure safer transport of hazardous materials. All levels of government were called on to develop legislation addressing the problem of transporting such dangerous cargoes.

Wirth appointed a ten-member, bipartisan Colorado task force to formulate legislation and "tighten up" federal laws dealing with hazardous waste transport, to strengthen federal truck safety laws, and to protect citizens from transport accidents. More specifically, the legislation would ensure that states could designate truck routes, upgrade truck driver qualifications, increase funds for training response crews, and require the government "to analyze the risk of hauling nuclear waste to a national disposal site" (Kelly, 1985).

In addition, issues concerning routing were to be clarified. For example, the Motor Carrier Safety Act requires trucks hauling hazardous materials to go around populated areas, yet DOT has never clearly defined a "populated area." Therefore, this key regulation has never been enforced.

The Colorado Task Force developed legislation to provide grants to states and local jurisdictions to consult with community officials and the transport industry and select the safest routes around populated areas. The legislation also required DOT to grant states and localities money (acquired from annual registration fees charged to manufacturers, shippers, and haulers of hazardous wastes) to train emergency responders. The qualifications for drivers of vehicles carrying hazardous materials would be upgraded; 150 additional safety inspectors would be added (for a new total of 300); and the National Highway Traffic Safety Administration would assume sole authority for the regulation of hazardous materials transportation. Most important to this discussion, the Secretary of the DOT would be required to study the risks associated with transporting high-level radioactive wastes. The funding required to implement the legislation was estimated at $100 million per year for the additional enforcement. That money would come from the federal Highway Trust Fund, which, at the time the legislation was introduced, had a $9 billion surplus.

The legislation, H.R. 4612, was introduced April 17, 1986 by Wirth and numerous co-sponsors. The bill was forwarded to the House Committee on Energy and Commerce and three of its subcommittees began hearings July 17, 1986. However, the hearings did not result in any further action on H.B. 4612, thus effectively killing the bill.

However, legislation similar to portions of H.R. 4612--H.R. 5568, the "Commercial Motor Vehicle Safety Act of 1986"--was passed into law October 27, 1986. (H.R. 5568 and companion bill S. 1903 are part of Public Law 99-570, the "Anti-Drug Abuse Act of 1986"). H.R. 5568 "requires increased testing and qualifications for drivers of commercial motor vehicles, including those that carry hazardous materials, and requires that brakes on large trucks are connected and working" (U.S. House, 1986b, p.H8748). Minimum federal standards will be required for written and driving tests taken by all heavy truck drivers. Those drivers hauling hazardous cargo will have to meet qualifications above these requirements.

State Government Actions

Not only Colorado's representatives in Washington, but also its state-level officials are concerned about shipments of nuclear waste via I-70 and the continued inadequate assessment and planning being done by the federal government. The state, in March of 1985, joined a lawsuit brought by the Environmental Defense Fund (EDF) challenging the DOE's site selection process. The DOE guidelines used to select sites failed to adequately address the possible transport of nuclear waste through Colorado.

A sharply worded statement from Colorado's Governor Richard Lamm described the DOE work as "fatally flawed, totally unrealistic and wholly inadequate" (Schmitz, 1985, p.A8). The agency, Lamm said, failed to consider "snowstorms and associated rock, mud and snowslides" which occur along Interstate 70 (Boulder Daily Camera, 1985). DOE itself has determined that the greatest risk to the public due to radiation occurs when shipments are stopped in transit "such as by weather-related road closures on I-70" (Schmitz, 1985, p.A8). Appendix D contains a list of major I-70 road closures for the one-year period from February, 1984 through February, 1985. The state's chief concern was the assumption by DOE that all interstate highways offer similar levels of safety. Countering this assumption, Colorado officials point to the runaway truck ramps on I-70, which have been used by more than 400 out-of-control trucks since they were first built in 1978.

State Senator Glass (a Democrat from Frisco) in early 1984 requested that DOT withdraw a portion of I-70 (through the mountains west of Denver) as a federally designated nuclear waste transport route. DOT in essence refused, stating that "the influence of terrain and physical features . . . [are] reflected in the documented accident rates of the . . . roadways" with the rates also reflecting "chronic weather conditions (e.g., winter snowfall)" (DOT, 1984b, p.1). Short-term weather conditions, such as closure of Loveland Pass, cannot be anticipated and considering them would be speculative. DOT's "long-held position on the validity of its reliance on the safety of the Interstate System of highways" (DOT, 1984b, p.2) was the agency's basis for denying Senator Glass' request.

Legislative Activity

Late in the 1985 legislative session, Governor Lamm established the Interagency Hazardous Materials Transportation Working Group. Lamm believed the state needed a permit system for transporters of nuclear wastes, in part to insure that drivers were experienced and qualified to deal with Colorado's "unusual terrain" and winter driving conditions (Walker, 1985). The Working Group, along with a bipartisan group of legislators, developed House Bill 1377 and Senate Bill 194.

The purpose of H.B. 1337 was specifically the prevention of hazardous materials transportation incidents. Transport of nuclear materials would be strictly controlled, regulation and enforcement of safety requirements would be increased, and emergency preparedness improved. S.B. 194 would have gone further by adding stricter controls on nuclear material transport. The state would require prenotification, inspection of all nuclear shipments, permits for all transporters, and a specific set of qualifications for drivers. Shippers and carriers would have to maintain clean-up plans and carry liability insurance of at least $160 million.

Both pieces of legislation were rejected by the 1985 legislature.

On January 8, the opening day of the 1986 legislative session, another bill was submitted to "designate state roads for the transportation of nuclear material and assess minimal penalties on haulers who fail to obtain proper state transport approval" (O'Brien, 1986a). Senate Bill 19, "Transport of Nuclear Materials," was sponsored by Senator Donley (a Republican from Greeley) to put into state law what he argued was already in federal regulations.

Under this legislation, the director of the Colorado State Highway Department would be given the authority to designate <u>mandatory</u> routes for nuclear waste shipments (O'Brien, 1986c, p.4A). Haulers would have to give the state at least four days notice before truck or rail shipments could enter Colorado, and trucks transporting nuclear wastes would have to pass a safety inspection upon entering the state or be fined $100 to $1000. Drivers would have to meet driver training requirements, and shippers would be required to carry $160 million in liability insurance to cover costs if a radioactive spill occurred.

Legislative confusion regarding Colorado's legal authority to police nuclear waste shipments caused the postponement of action on S.B. 19; the Senate Transportation Committee was reluctant to overstep federal laws by establishing a state-wide inspection and permit system for haulers. The lobbyist for the Colorado Railroad Association had suggested that the federal government would nullify S.B. 19 because most of the major sections of the bill were inconsistent with federal law. S.B. 19 was passed on second reading by the Senate Appropriations Committee on February 26. For lack of a third and final reading, it did not leave this committee and received no further legislative action. The Colorado legislature did approve a hazardous materials bill, S.B. 58, during the 1986 session, but Governor Lamm vetoed the bill, claiming it was "so weak it was worse than no law at all" (Abas, 1986, p.10).

Following the 1986 session a group met informally to try to reach some sort of compromise and to draft a bill for consideration during the August special session of the legislature. Compromise legislation was needed since different interest groups had expressed significantly different wants and needs. Colorado's cities want stringent state and local controls on hazardous materials transport, while the trucking industry opposes local controls and wants state power to be sharply limited. The group gathered to formulate compromise legislation was composed of a representative of the Colorado Municipal League, the lobbyists for the Colorado Motor Carriers Association and Colorado Petroleum Marketers Association, and Governor Lamm's legislative lobbyist.

The group agreed that the state would have the authority to designate transport routes and that cities with more than 100,000 residents could limit the hours trucks could use those routes. Localities would submit their own regulations to the state, and the state would hold regional hearings to review local regulations for compatibility with state regulations. The trucking industry would be able to comment on the local regulations at that time. Only law enforcement officers who had received training familiarizing them with hazardous materials transportation regulations would have authority to stop trucks hauling hazardous materials. The group also agreed upon fines for violators.

Unfortunately, on July 21 Senate President Ted Strickland (a Republican from Westminster) set a July 28 deadline for the drafting of the compromise bill, and, despite all their work, the negotiators were not able to meet the deadline and the compromise bill fell by the wayside.

Local Actions

The cities of Denver, Aurora, and Boulder have adopted ordinances designating routes and imposing other restrictions on the transport of hazardous materials through their jurisdictions (Abas, 1986). The Denver ordinance has received the most attention. Beginning on September 1, 1986, a unit of four Denver police officers began looking for trucks that were in violation of the city's hazardous cargo ordinance. Trucks carrying radioactive materials are prohibited at all times from using the elevated portion of I-70--a segment in north Denver between Colorado Boulevard and Washington Street--and all trucks carrying hazardous cargo are prohibited from Denver's central business district during the peak commuting hours of 6:30-8:30 a.m. and 4:00-6:00 p.m. (Schrader, 1985).

Denver's hazardous cargo ordinance requires trucking firms to submit a permit application annually, and truckers must report the frequency of shipment and the nature of the cargoes they ship through Denver. Additionally, all trucks which DOT requires to display placards must also obtain a city license--a process that involves review and approval by the Denver Fire Department. The fees for permits--which pay for the administration of the ordinanace--range from $50 for companies with one or two trucks up to $600 for companies with 500 or more trucks.

The Colorado mountain and western slope localities of Aspen, Avon, Breckenridge, Crested Butte, Dillon, Eagle County, Garfield County, Grand Junction, Crested Butte, Silverthorne, Steamboat Springs, Summit County, Telluride, and Vail have all passed resolutions opposing the transportation of nuclear wastes through their jurisdictions (Knox et al., 1986). In general, they fear that an accident involving high-level wastes could effectively kill their tourism industry. (Avon, Eagle County, Garfield County, Silverthorne, Vail, and Grand Junction are along the I-70 route; Dillon is on the U.S. 6 route that bypasses Eisenhower Tunnel; and Summit County contains the I-70 route (including part of the Eisenhower Tunnel) and almost all of the U.S. 6 route.) The resolutions for Aspen, Avon, Eagle County, Garfield County, Steamboat Springs, and Vail were passed at the urging of the Common Sense Coalition in the hope that they would encourage lawmakers to impose higher standards and more stringent controls on transporters (McKhann, 1985). The resolutions were taken to Washington, D.C. in May, 1985 by coalition founder Paul Crawford of Glenwood Springs. Governor Lamm supported this effort, pushing for hearings on the use of I-70 to ship nuclear wastes to a national repository. Additionally, acting in consort, Aspen, Breckenridge, Crested Butte, Dillon, Eagle County, Garfield County, Vail, and the Colorado Association of Ski Towns have passed resolutions "urging state legislators to adopt regulations for transportation of hazardous materials" (Abas, 1986, p.10).

Routing

Interstate Routes

Currently Approved. At the present time, two of Colorado's interstate highways are federally approved for the shipment of nuclear waste. Within Colorado, waste is generated at the Fort St. Vrain nuclear power plant and at the Rocky Flats nuclear weapons plant. All of Interstate 25 and Interstate 70 from the Kansas border to Denver are approved routes (NRC, 1984).

Projections. In a study conducted by the Oak Ridge National Laboratory of the transport of spent fuel to potential repository sites at Yucca Mountain, Hanford, and in Utah adjacent to Canyonlands National Park, projections show that the major east-west truck route to Yucca Mountain would traverse Colorado (National Research Council, 1984) (see Figure 5). It would follow Interstate 70 from the Kansas border through Denver across the mountains to the border with Utah. Secondary access to I-70 is provided by I-76 from its origin off of I-80 at the Colorado-Nebraska border to its terminus at I-70 just north of downtown Denver. Trains hauling spent fuel would not cross Colorado but would follow rail lines that parallel I-80 across southern Wyoming.

The Yucca Mountain EA transport data (previously described in the section entitled "The Siting Process") provides additional information, based on its different shipping options, concerning the potential impacts of shipping nuclear waste on Colorado and the I-70 route (Table 3).

The increase in the number of shipments on I-15S, from Scenario I to Scenario II does not reflect an increase in the number of shipments traveling on I-70. The increase is due to the rerouting of waste from U.S. 95S east toward Salt Lake City and then south on I-15. However, one can assume that the waste traveling on I-15S in the first scenario could have only reached

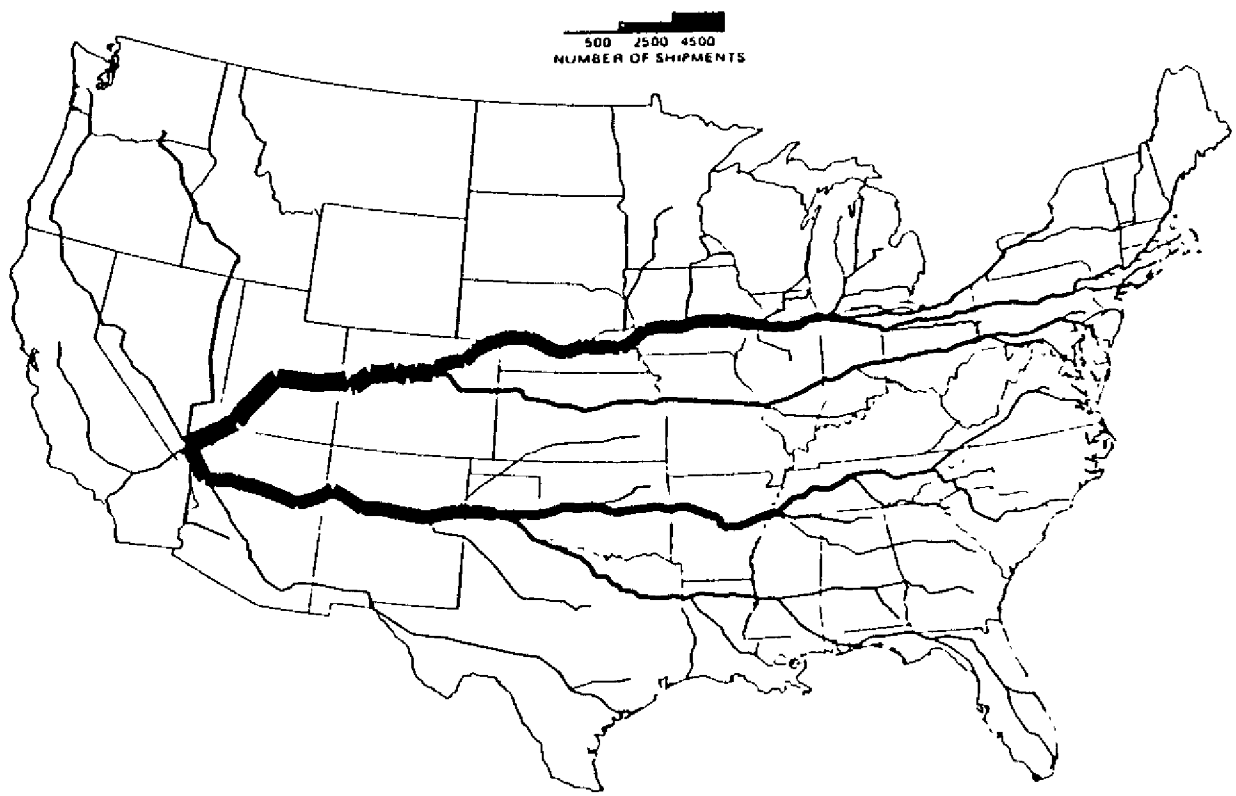

FIGURE 5

PROJECTED ANNUAL SPENT FUEL SHIPMENTS TO A WESTERN STORAGE SITE IN 2004
BASIS: TRUCK SHIPMENTS FROM ALL REACTORS

Source: National Research Council, 1984

TABLE 3

PERCENTAGE OF SHIPMENTS PROJECTED TO TRAVEL ON MAIN TRUCK ROUTES

	WITHOUT MRS	WITH MRS
Scenario I		
I-15S	49%	33%
I-15N	8%	5%
U.S. 93N	36%	40%
Scenario II		
I-15S	54%	48%
I-15N	10%	12%
U.S. 93N	36%	40%

this route after crossing Colorado on I-70. This means that virtually half of the total shipments, without MRS, or one-third, with MRS, will pass through Colorado.

Denver Metro Area. The Denver metro area is criss-crossed by five interstate highways: Interstates 70, 25, 76, 270, and 225 (Figure 4). I-70, an east-west route, passes two to three miles north of downtown Denver and travels under runways of Stapleton International Airport in northeast Denver. I-25 forms the western boundary of downtown Denver and intersects I-70 just north of the downtown area at the intersection known as the "mousetrap." I-76 joins I-25 about two miles north of the mousetrap, and an extension of I-76 from this point west to I-70, near Lakeside Amusement Park, has been proposed. The extension would make it possible to avoid the mousetrap when traveling south on I-25 and then west on I-70.

Interstate 270 already provides a means of getting from I-25 to I-70, or of getting from I-76 to I-70 without having to wind through the mousetrap.

The heart of Denver can be avoided when traveling from I-70 east of Stapleton to I-25 south of Denver by using the I-225 bypass.

State Routing Plan

Beginning in 1987, hundreds of shipments of nuclear waste will be moved from the Rocky Flats nuclear weapons plant northwest of Denver to the Idaho National Engineering Laboratories at Idaho Falls. Additionally, 1988 will be the first year that more than 1,000 shipments per year of low-level nuclear waste--i.e. rags, contaminated clothing, etc.--will move through Colorado to the federal Waste Isolation Pilot Project (WIPP) site near Carlsbad, New Mexico (projected for completion in October, 1988). Shipments will continue for 25-30 years along DOE approved routes (Chapman, 1986).

The Colorado legislature, during May of 1986 and in anticipation of the WIPP shipments, ordered the highway department to devise a nuclear waste transportation plan for Colorado. The director of the Colorado State Highway Department was given sole authority to adopt a Colorado routing plan, and the highway department can revise the routing plan as new roads are built or others are found to be safer. The Colorado Public Utilities Commission (PUC) was also authorized to develop rules for the granting of permits to nuclear waste haulers. Work on these rules, in consort with the highway department, to govern such things as hours of operation, parking, and emergency routing, was to have begun in November of 1986 (Udevitz, 1986b, p.3B).

The highway department's preliminary routing plan identified all of Interstates 25, 70, 76, 225, and 270 as nuclear waste transportation routes. U.S. 36--the Boulder Turnpike--and sections of state highways 93 and 128 would be used as access to and from the Rocky Flats plant. The state considered banning shipments on I-70 west of Denver to avoid potential accidents on mountain roads, in mountain tunnels, and near water supplies, and the elimination of U.S. 666 through Cortez in the southwest corner of the state was also an option.

The highway department held eight public meetings--in Cortez, Dillon, Fort Collins, Fort Morgan, Denver, Limon, Colorado Springs, and Pueblo--during the week of October 6-10, 1986. At the Denver meeting, the cities of Denver and Aurora joined together to challenge the preliminary plan. They held that truckers were being given too many routing options in and around the metro area. While the two cities agreed with the designation of I-25 as the north-south route, they did not want to allow the use of I-70 under the Stapleton Airport runways or along its elevated portions in north Denver. The elevated section of I-70 does not have water available for fire fighting and was described as "certainly not an ideal emergency response situation" (Day, 1986, p.10). The cities' preferred route to I-25 from the east, was I-225. In addition, the cities were wary of the use of I-70 west from Denver, including through the Eisenhower Tunnel, and other questions arose concerning the highway department's failure to indicate whether they would consider permitting nuclear waste shipments along C-470 once that highway is completed (completion is projected for 1990) around the southern edge of the Denver metro area (Chapman, 1986).

Denver and Aurora officials also disagreed with the state's presumption that emergency response to an accident involving nuclear waste would be better handled in urban rather than rural areas. Denver's environmental officer Tony Massaro summed up the issue: "The fact of the matter is we do not have in Denver, Aurora, or anywhere else, the ability to deal with a nuclear accident. . . . We can arrive on the scene, say it's radioactive and that's it." (Day, 1986, p.6)

These communities felt that rural routing made more sense because evacuating "a few hundred people," as opposed to "all those in the metro area," would be an easier task in the event of an accident (Day, 1986).

Due to public comment received at the highway department's meetings, the preliminary nuclear waste transport plan was substantially revised. The elevated portion of I-70 and all of I-70 west of I-25 were removed from the routing plan. Trucks coming into Denver from the east en route to I-25 will now be required to leave I-70 at either I-225 to go south or I-270 to go north. The use of U.S. 666 through Cortez was also eliminated, and the highway department agreed to investigate the use of C-470 once it is completed as well as the use of eastern Colorado's rural highways instead of I-25. (The data does not presently exist to compare I-25 with potential rural routes further to the east.) Officials from Denver, Aurora, and the state also agreed to continue to study routing alternatives and to revise the "final" state plan as new roads are constructed or other existing roads are determined to be safer routes.

Despite revisions to the preliminary routing plan, it remained controversial. Interstate 25, the shortest north-south route across Colorado, passes through four major Front Range cities and includes "portions that cut through the heart of the Denver metro area, Pueblo and Colorado Springs" (Udevitz, 1986b, p.3B). The director of the Pueblo Transportation Department, Harold Bastien, is not convinced that the state and federal governments have sufficiently studied the safety of this route. Federal officials claim the route "is the 'safest,' [but] it isn't safe" because it was constructed before the present volume of traffic was anticipated (Boulder Daily Camera, 1986e, p.8D). Pueblo lawyer Kirk Brown, a member of the Colorado Highway Commission, also questions the safety of the I-25 route and has asked the Highway Department to study "its liability to the communities and citizens if a nuclear waste disaster occurs" (Boulder Daily Camera, 1986e, p.8D). He feels that the probability of the public being exposed to radiation in the event of an accident and the safety of the nuclear waste containers need to be known.

The final routing plan was released November 13, 1986 and approved on November 20. I-25 remains the only north-south route. Shipments will be prohibited from stretches of I-70--specifically, west of its intersection with Colorado Boulevard to avoid the elevated portion through north Denver. Shipments coming from the east will have to exit I-70 at either I-225 or I-270 and follow the routes previously mentioned. The plan has been characterized by state Highway Department director Joe Dolan as "at best a short-term solution to a long-term problem" (Udevitz, 1986c, p.4B).

There are several important exceptions to Colorado's routing plan. Nuclear materials destined for research or medical purposes will not be limited to travel along designated routes. Any truck hauling nuclear cargo will be able to leave a state-approved route to make deliveries or pickups and to refuel. Trucks hauling radioactive materials that are owned by the Department of Defense or DOE and driven by their employees will not have to adhere to Colorado's routing plan, because of the federal government's right to preempt state regulations restricting the movement of nuclear materials shipments. That the highway department allowed this exception is based on the necessities of national security and the need to keep the movement of such materials classified. Thus, some shipments connected to the Rocky Flats nuclear weapons plant could fall outside Colorado regulation.

Alternative Routes

Can Colorado route nuclear waste shipments so they avoid the heavily populated Denver metro area? It depends on the acceptability of alternate non-interstate routes, and an examination of a map of Colorado suggests the answer. (Of course, hauling nuclear waste shipments by rail provides an alternative, though one that not necessarily avoids Denver. There are constraints to rail transport, however, because between Denver or Pueblo and Utah, the Denver and Rio Grande Western railroad can carry 263,000 pounds (131.5 tons) gross per rail car (Martin and Brown, 1985). But a loaded rail cask weighs 168 tons per car. Thus, the viability of rail transport is questionable, making the consideration of alternate truck routes even more important.) To completely avoid the Denver metro area, a truck hauling high-level nuclear waste westward on I-70 would have to not use that interstate from Limon to beyond Vail--a distance of almost 200 miles. Furthermore, I-76 could not be used as an approach to I-70 from I-80; a truck traveling west on I-80 would have to follow U.S. 385 (that runs close to and roughly parallels Colorado's eastern border) due south to I-70 and then west to Limon.

There are two main alternatives to the Limon-Vail length of I-70 (Figure 6). The first follows U.S. 24, passing through the center of Colorado Springs and the towns of Woodland Park, Buena Vista, and Leadville, before joining I-70 west of Vail. The second initially follows U.S. 24 to its junction with I-25 in Colorado Springs, then follows I-25 south to Pueblo, goes west on U.S. 50 via Canon City to Salida, and finally again joins U.S. 24 and goes north through Buena Vista to the junction west of Vail. Another alternative avoids the entire mountain portion of the I-70 route. It follows the second alternate route as far as Salida but continues west on U.S. 50 to Grand Junction, passing through Gunnison, Montrose, and Delta.

It is possible that by the time a Nevada repository is ready to receive shipments, a 100-mile beltway--Colorado 470--will encircle Denver and provide a means of avoiding the more heavily populated, congested sections of the metro area as well as the mousetrap and the elevated portions of I-70. The

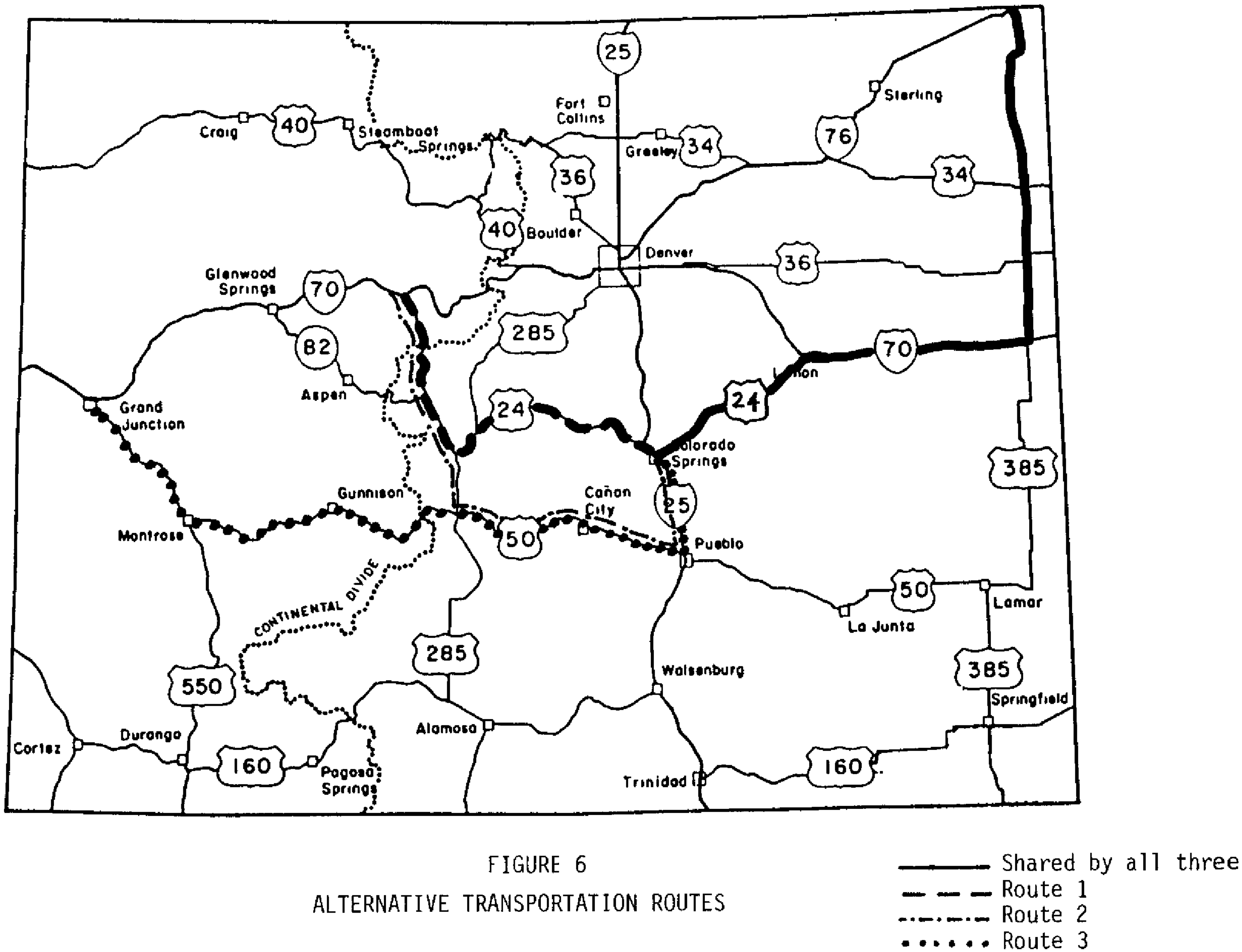

FIGURE 6

ALTERNATIVE TRANSPORTATION ROUTES

proposed Colorado 470 is a four-lane controlled access state highway broken down into three sections: C-470, E-470, and W-470 (Figure 7). These sections have different construction schedules and would be funded differently, and it is not known exactly when, or even if, all three will be constructed.

C-470, south of Denver, is currently under construction and projected to be completed by 1990. It is being funded in part with federal money because formerly it was part of Interstate 470. (Interstate 470 was effectively killed during the early years of the Lamm administration because of fears that it would stimulate growth in undeveloped portions of the metro area.) There will be no federal money available for construction of the other sections.

An "E-470 Authority"--a public agency created to finance and build the eastern section of the beltway--was formed in 1986. Arapahoe County, within which most of the road would lie, has plans to sell bonds to finance construction which would start around 1988 and finish by 1995 in time to serve a new larger Denver airport to be constructed north of Stapleton airport. The highway is controversial, however. Governor Lamm ordered the highway department not to acknowledge any plans for E-470--fearing that the possibility of its construction would fuel runaway growth--and state funds will probably not be available for construction. On the other hand, private development interests are aggressively pushing for construction of the highway.

The third section, W-470, is under study by the Denver Regional Council of Governments (DRCOG). In mid-1986 the DRCOG-sponsored "W-470 Task Force" overwhelmingly endorsed the W-470 beltway. The proposed route has been narrowed to two options, both passing through southeastern Boulder County, despite opposition from the county and the city of Boulder. It is proposed that work on W-470 begin in 1995 and finish by 2010.

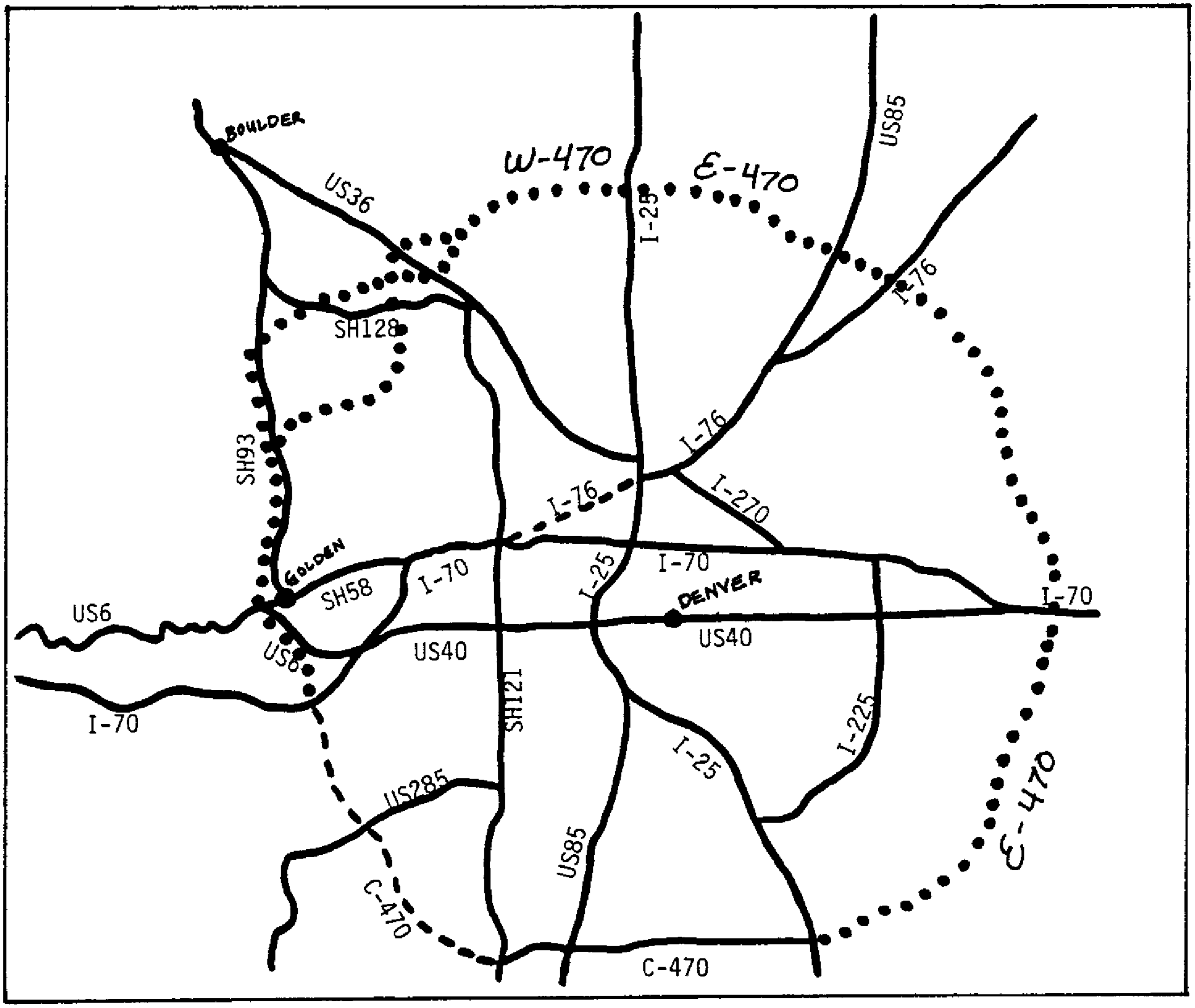

FIGURE 7

PROPOSED BELTWAY--COLORADO 470

Emergency Preparedness

The state of Colorado covers a vast area. If an accident involving high-level nuclear waste were to occur in a remote region, state agency officials in Denver could find it difficult and time-consuming to reach the scene. Even in good weather, it could take up to ten hours to reach an accident, and if the weather were bad and mountain roads had to be traversed, it could take up to twenty hours (Foster and Jordan, 1984).

In addition, in order for accident response to be effective, extremely expensive resources and expert human skills would probably be required; yet these resources and skills are often beyond the budgets and capabilities of local jurisdictions. Nonetheless Colorado statute assigns responsibility for emergency response to local government. Thus, providing accident response "is likely to constitute a significant problem for any local government" (DODES, 1984, p.1).

These difficulties notwithstanding, having a good response plan and doing a lot of work, including cooperating with other local governments, before an accident occurs could make it easier for a local jurisdiction to effectively allocate its resources. Although emergency response programs can be expensive, the cost is minor compared to the actual costs of accident management and clean-up. The cost of a state "Transportation Incident Branch" to handle emergency response to radiological materials transportation incidents, employing 100 people (modeled after an existing agency in Southern California) has been estimated at $5.6 million for one year (Gunderloy et al., 1981).

With a few exceptions, on both the state and local levels, Colorado does not have the resources necessary for adequate planning or response. For example, the Colorado State Health Department is not equipped to provide on-site technical assistance in the event of a major incident involving hazardous materials. A survey taken in 1984 found that only 25 of 170 local emergency response agencies had the minimum training and equipment necessary to effectively deal with such an incident (Walker, 1985). Denver's Mayor Federico Pena has stated that with the large number of nuclear waste shipments planned to come through the city, accidents will happen, and that Colorado's largest city, with a rather sophisticated hazardous materials response team, is "certainly not prepared to deal with radioactive spills of the magnitude and variety [we] are likely to see" (KCTS-TV, 1986). He also observed that Colorado's small towns and rural areas would find themselves "totally at the mercy" of a federal response team, who could take hours (or days) to arrive at the site and deal with a spill (KCTS-TV, 1986).

State Agencies

Division of Disaster Emergency Services (DODES). The Colorado Division of Disaster Emergency Services (DODES) deals with disaster mitigation, preparedness, response, and recovery and coordinates activities of other state agencies in these four areas. The specific responsibilities each agency assumes during an emergency are spelled out in the Colorado Natural Disaster Emergency Operations Plan.

The DODES is also responsible for overseeing local preparedness and emergency planning activities, reviewing local preparedness plans, and monitoring current preparedness and recovery research.

In the course of working on state preparedness, the DODES has studied county-level activities. Twenty of Colorado's 63 counties contain 90% of the state's population. For the 43 sparsely populated counties that contain the remaining 10%, the agency found that many "have effective life saving plans and organizations under a sheriff, police, or fire authority that will effectively save lives when extreme [natural hazard] events occur" (DODES, 1983, pp.8-9). Most, however, will need rapid, effective support from state agencies to assist with damage assessment and recovery operations. Therefore, to ensure quick response, "a strongly improved emergency communications capability is developing so that redundant systems can extend across the State" (DODES, 1983, p.31). Three-quarters--all the mountainous section--of the I-70 study area lies within some of these sparsely populated counties.

Colorado State Patrol. The state patrol's role during emergencies is primarily to deal with traffic. Local personnel in the field have the responsibility for determining if an emergency exists and then taking immediate, appropriate action.

Unique Attributes of I-70

In Colorado one of the unique features of Interstate 70 is the Eisenhower Memorial Tunnel. The tunnel is actually two tunnels: one for westbound and one for eastbound traffic. The tunnel is 1.7 miles long and handles around 5.5 million vehicles every year. This "volume of traffic alone raises questions about how safe the tunnels are, and if they need to be made safer" (Brimberg, 1986). Since 1977 there have been 90 accidents in the tunnel; twenty-four were injury accidents and two involved fatalities (Brimberg, 1986). (Although the first bore of the tunnel was opened in 1973, accident records were not kept until 1977.)

Tunnel officials believe the Eisenhower Tunnel is the safest part of the Colorado interstate system, but they are still taking steps to make it safer. The tunnel has a television monitoring system which enables emergency crews to spot and reach accidents in three to five minutes, depending on traffic.
The tunnel employs other safety measures as well: a twenty-four hour emergency crew of four (normally), a high-speed ventilation system, three fire trucks located at the east end of the tunnel, and back-up help available from the

Silverthorne Fire District. Officials are also now preparing a plan for mass evacuation of the tunnel. Such a plan has not been developed previously because shift work crews were not always large enough to carry out an evacuation.

Tunnel safety is also increased by the regulation of vehicles that can pass through the tunnel. Vehicles carrying 1,000 or more pounds of combustible liquids are not allowed to use the tunnel, and smaller loads of flammable liquids can be prohibited as well. Many other types of dangerous cargoes are also banned. As stated earlier, trucks hauling banned substances must take an alternate route--Loveland Pass--almost ten miles of winding road that passes the Keystone ski resort complex and the community of Dillon, rejoining I-70 at Silverthorne. When Loveland Pass (U.S. 6) is closed by bad weather, the banned trucks must wait near the Eisenhower Tunnel in the truck parking areas. Once the regular tunnel traffic has cleared, banned trucks move in a convoy, on the hour, through the tunnel.

Personnel are located at each end of the tunnel to monitor the vehicles passing through and to enforce the safety regulations. If caught, a hauler who has ignored the regulations can be fined up to $1000 and sentenced to one year in jail.

There is approximately 85% compliance with the hazardous materials regulations. Some of the trucks that do slip through do so because they are not carrying the required warning signs. To aid the enforcement personnel, officials are adding cameras at the tunnel approaches to monitor trucks carrying hazardous materials.

Natural Hazards

Natural hazards, with the exception of the effects of weather on the repository's long-term delivery schedule, have not been given much consideration with respect to spent nuclear fuel transport. This is troubling because natural hazards can increase the likelihood of a technological disaster. Numerous natural hazards are found along the I-70 route and deserve serious attention, particularly by those who would have to respond to a natural disaster involving a truck transporting nuclear materials. For example, an avalanche could render a mountain road impassable, cause vehicles to be stranded, or bury a truck under tons of snow.

Overview

Colorado is vulnerable to a variety of hazards: avalanches, dam failure flooding, flash flooding, riverine flooding, landslides, earthquakes, severe winter storms, tornadoes, and other severe weather. Of these hazards, the DODES has established dam failure flooding, flash flooding, riverine flooding, earthquakes, and tornadoes as Colorado's very high-risk hazards; all can have enormous impacts.

DODES has identified the areas under the greatest threat from very high-risk hazards and the populations which are threatened (DODES, 1983). Risks due to natural hazards are often interrelated and the occurrence of one can enhance the likelihood or compound the effects of another. For example, a flash flood could trigger the failure of a dam, thus compounding the overall flooding.

Not only is Colorado's resident population at risk from the state's natural hazards, visitors are also at risk. Tourism is the mainstay of many mountain areas of the state identified as being at risk from natural hazards, and tourists compound the problem because they are unfamiliar with these hazards or with the steps to take when a disaster (a flash flood comes immediately to mind) is imminent.

Avalanches

In 1974 Colorado enacted House Bill 1041, the "Land Use Act." It provided for identification, designation, and administration of areas and activities of state interest. One of the main purposes of the act was the regulation and management of natural hazard areas. These included flood plain hazards and geologic hazard areas--the latter areas being "where past, current, or foreseeable construction of land use would be affected by disturbances such as landslides, mudslides, earthquakes, or ground subsidence" (White and Petros,1977,1701).

The Colorado Land Use Commission provided model land use regulations and made funds available to counties so they could "identify and designate these matters of state interest" at county and municipal levels. The Colorado Geological Survey (CGS) provided technical assistance to identify geologic hazard areas and avalanche areas.

Avalanche hazards were mapped (Mears, 1979) for counties where the avalanche threat was the most urgent--i.e., locations where future development was likely in areas known to have such hazards. Two of the areas mapped--Silver Plume and Frisco--include avalanche paths which reach or cross Interstate 70. Avalanches also threaten the Vail area, yet none directly affect the route.

In the Silver Plume area, fifteen individual avalanche paths and three groups of small avalanches were identified. The small avalanches include a pair of paths that do not carry much snow and have no runout zone above I-70, but occasionally produce avalanches that reach the road. Of the avalanche paths, six south of I-70 and three north of the interstate can carry slides that reach or cross the road. Two of the south paths meet two from the north at I-70, and, in all instances, I-70 falls within hazard zones described as moderate. In the Frisco area four groups of avalanches and nineteen avalanche paths were identified and mapped. Nine of the paths south of the interstate can cross the road, with I-70 again falling within moderate hazard zones.

The potential for road-closing avalanches exists almost anywhere within the mountains of Colorado every winter. An interesting example occurred during the winter of 1985-86. On February 20, avalanches closed eastbound I-70 east of the Eisenhower Tunnel and U.S. 6 over Loveland Pass. Both avalanches were triggered by Colorado State Highway Department crews working to prevent the further dangerous build-up of heavy snows that threatened each route (Boulder Daily Camera, 1986a). The Interstate 70 slide, characterized as a "big one," was a controlled human-caused slide three miles east of the tunnel. It was fifty yards wide, twenty feet deep, and took road crews approximately three hours to clear. The snow threatening U.S. 6 had built up across from the Arapahoe Basin ski area. When triggered, the avalanche crossed U.S. 6 into the ski area, closing the road.

Dam Failure Flooding

The failure of a dam results in downstream flash flooding. Failure can be due to one of two causes: hydrologic or structural deficiencies. The latter (including such problems as seepage, cracking, general weakness) are most often caused by age, whereas hydrologic deficiency most often involves a spillway of inadequate capacity that causes overtopping when large amounts of water flow into the reservoir. There is also increasing information indicating that seismic risk must be taken into account when designing and building dams in Colorado, and that older dams that were not designed with this threat in mind pose a reasonably high risk to downstream areas.

The Office of the State Engineer has identified those Colorado dams (over ten feet high) which are hazardous to downstream land uses. Dams are listed by county (not by river) with the populations at risk identified "in very general terms" (DODES, 1983, p.27). This information is "not generally disseminated to local city and county officials [who are] responsible for public safety" (CWCB, 1985, p.138), and there is little public awareness of the damage which could occur due to a dam failure.

Hazardous dams are classified as being either a high, moderate, or low hazard, with a high hazard dam defined as one whose failure would cause one or more lives to be lost. Inundation zones for high hazard dams have been mapped, and communities potentially affected by the failure of a high hazard dam should obtain or develop worst case estimates of flooding and flood damage (CWCB, 1985). Without a current, tested response plan, the vulnerability of a community downstream from such a dam is very high.

The zones threatened by the failure of a moderate hazard dam can be estimated with sufficient accuracy to permit emergency planning. By definition, should a moderate hazard dam fail, no loss of life is expected, but the economic damage to agriculture, industry, and/or structures would be appreciable. In turn, the failure of a low hazard dam is not expected to result in loss of life, and economic loss would be minimal.

In the I-70 study area, there are two dams whose failure would cause the flooding of towns along the interstate. In Summit County, Dillon Reservoir dam threatens almost all of the downstream town of Silverthorne, and dam failure would result in severe inundation of the interstate through that town. Farther west, almost all of the town of Rifle would be threatened if the Rifle Gap Reservoir dam failed.

One of the largest known floods along the Colorado Front Range occurred on June 4, 1956 when the Georgetown Dam failed. The result was flooding along Clear Creek near Golden (also within the study area).

Flash Flooding

Flash flooding is one of the most pervasive natural hazards in Colorado, particularly in the mountains and Front Range flood plains. Obviously, these floods pose the greatest danger to "settlements located close to the major streams" (DODES, 1983, p.5); such settlements have been identified by DODES in the course of studying riverine flooding. In mountain regions and in southwestern Colorado, flash floods occur annually--usually during spring and summer--triggered by heavy rainfall which may be combined with snowmelt. (Thus, thunderstorm floods are synonymous with flash floods.) To compound the hazard, flash flooding can often be accompanied by landslides in canyons and along river headwaters.

Hazardous flash flood areas are those having a concentrated population, steep gradients, and large drainages capable of focusing considerable quantities of water. Of course, they are also areas subject to very heavy rainfall; but unfortunately, in Colorado the amount of rainfall from a storm and the time over which it falls are the "most difficult [parameters] to predict and prepare for" (DODES, 1983, p.4).

The Colorado Geological Survey assessed the extent of Colorado's flash flood hazard following the disastrous 1976 Big Thompson Canyon flood, identifying the most hazardous canyons--i.e., the ones where "the intensity and degree of potentially hazardous geological conditions and the intensity of current development coupled with projections of near-term and future development pressures" pose a significant threat to the population (DODES, 1983, p.A-1). The bulk of the hazardous canyons are found along the Front Range. Table 4 lists those communities along I-70 which are at risk.

TABLE 4

HAZARDOUS CANYONS IN COLORADO

DRAINAGE	COUNTY	COMMUNITY AFFECTED
Clear Creek-Tucker Gulch	Jefferson	Golden
Clear Creek	Clear Creek	Idaho Springs, Empire, Georgetown, Silver Plume
Lower Blue River	Summit	Silverthorne
Tenmile Creek	Summit	Frisco, Copper Mountain
Gore Creek	Eagle	Vail
Brush Creek-Eagle River	Eagle	Eagle
Roaring Fork River	Garfield	Glenwood Springs & suburbs
Colorado River-Elk Creek-Canyon Creek	Garfield	New Castle
Rifle Creek	Garfield	Rifle

The DODES, as well, prepared lists of those areas of Colorado where people are especially vulnerable to flash flooding. They first adapted the CGS hazardous canyons list, comparing susceptable areas to existing settlement patterns. The result, a publication entitled "Major Flash Flood Canyons of Colorado," identifies Clear Creek Canyon as the only major flash flood canyon along the I-70 route (DODES, 1983, p.18). Therefore, the communities of Idaho Springs, Empire, Georgetown, and Silver Plume are considered at risk due to flash flooding because they flank the headwaters of Clear Creek.

The DODES then ranked their list by order of the number of people at risk, and produced "High Risk Flood Areas in Colorado" (DODES, 1983, p.19). The people living in the drainages of the identified canyons are subject to the greatest flash flood risk in Colorado because they are in immediate danger due to the hazard's short time of onset. By these calculations, the canyon containing Clear Creek has the second highest number of people at risk due to floods in Colorado.

Communities in high-risk flood areas will need to be well prepared--i.e., have well thought-out and rehearsed warning plans, evacuation plans, and response plans--to protect their populations. Their problems are made more difficult because weather radar may not be able to pinpoint severe thunderstorms over the mountains east of the Continental Divide--particularly if the cells are part of massive weather systems. In addition, on any given summer day, the tourist population can double some mountain area's population and exacerbate warning and response problems.

Riverine Flooding

Large scale riverine flooding can occur throughout Colorado in the spring, summer, or fall. A flood greater than a 100-year flood has occured in every large Colorado stream basin. Springtime--particularly May and June--is the most dangerous time for riverine flooding due to the combination of peak smowmelt runoff and possible sustained or concentrated rainfall.

Compared to flash floods, riverine floods lack steep gradients, have a slower onset, afford greater warning time, and involve fewer fatalities. However, they often cause greater property damage because areas subject to riverine flooding typically contain valuable farmland, roads, bridges, and other infrastructure. Riverine flooding can be compounded by the occurrence of simultaneous flash flooding in headwater areas having steep gradients.

Flood design standards have been adopted for highways so that the effects of a flood are factored into road design to allow passability during less than severe flooding. The 100-year flood standard is used for interstate and U.S. highways in urban areas; interstate highways outside urban areas are subject to a 50-year flood standard; and U.S. highways in rural areas are subject to a 25-year flood standard (or less).

Colorado Water Conservation Board (CWCB) data shows that three floods affected the I-70 study area during 1983. Rifle Creek flooded June 11-12 at Rifle; Clear Creek flooded June 25-28 around Silver Plume and Georgetown, and the Colorado River flooded June 22-28 within Garfield County. The CWCB has indexed Colorado's flood plain mapping (which varies considerably in quality and detail) by county, city/town, stream, study director, report title, engineer, and completion date (CWCB, 1983).

Landslides

House Bill 1041 defined three types of landslide hazards--landslides, rockfalls, and mudflows (including debris flows). All slopes recognized as possible areas for landslides are considered "unstable or potentially unstable slopes" when the event is imminent--they are in a state of highly unstable equilibrium. Identifying and managing landslide hazards is difficult, making them a very serious hazard, because landslides are not continuous processes, are widespread, and are hard to recognize. The most serious threat is "probably from [the] accelerated movement of marginally stable old slides" (CWCB, 1985, p.19).

In addition, as alluded to earlier, catastrophic landslides can affect flooding. They can dam streams and produce downstream flooding when the landslide-formed dam is eroded and breached, or they can discharge into a reservoir and displace water over the dam, causing downstream flooding.

At least half of Colorado's mountain and foothill areas are or have been susceptible to landsliding, and the Colorado Geological Survey believes "some of the best known existing landslide areas . . . have catastrophic potential" (CWCB, 1985, p.127). The agency has listed twelve such areas, two of which are within the I-70 study area (Table 5). Mitigation measures have been undertaken to contain the slides at Dowds Junction because of the potential economic and social impacts of sliding in that area (Boulder Daily Camera, 1986b). CWCB has also documented two mudslides in the study area, both affecting I-70 near Minturn--one during May 23-29, 1983, the other June 7, 1983.

Mudflows occur in the spring and summer months. They are triggered by heavy runoff from either intense rainfall or a sudden heavy snowmelt. Snowmelt mudflows are usually more extensive, and their threat can continue over several weeks.

Debris flow hazards have been documented for "areas where development and . . . hazards coexist and continue to represent severe problems" (CWCB, 1985, p.123). Three of these twelve areas are along the Interstate 70 corridor (Table 6).

Seismicity

The potential for damaging earthquakes in Colorado has been underestimated in the past, and it appears that "many critical structures (dams, hospitals, schools) have not been adequately designed for larger size earthquakes that now appear possible in Colorado." (DODES, 1983, p.6). The Colorado Geologic Survey has mapped the state's earthquakes, from 1870 to 1979, and Colorado's potentially active faults (Kirkham and Rogers, 1981). In addition, the U.S. Geological Survey has delineated earthquake intensity zones for Colorado. The mapping is based on the Modified Mercalli Intensity Scale, and

TABLE 5

KNOWN OR SUSPECTED POTENTIALLY CATASTROPHIC LANDSLIDE AREAS

Name of Slide and Location	Type of Slide(s)	Facilities at Risk
Whiskey Creek and adjacent slides in Eagle County at Dowds Junction and extending approximately one mile each way along the Eagle River.	Large earthflows and slope failure complexes. Currently affecting highways at several locations.	Interstate 70, US Highway 6 and 24 mainline of D and RGW Railroad, valley development and facilities including Minturn and West Vail.
Wolcott slide, located along Interstate 70 from vicinity of Wolcott southwesterly about 1.5 miles southwesterly to Bellyache Ridge in Eagle County.	Very large earthflow and slope failure complex. Currently shows continuing movement.	Interstate 70, US Highway 6, D and RGW Railroad, community of Wolcott.

TABLE 6

AREAS WITH DEBRIS FLOW HAZARDS AND DEVELOPMENT

Community	Location	Facilities at Risk
Idaho Springs, Georgetown and numerous smaller communities along Clear Creek in Clear Creek Co.	Clear Creek County.	Residential and commercial properties, streets and other public facilities.
Vail and adjacent developing parts of Eagle County.	Development corridors along Gore Creek and Eagle River, Eagle Co.	Residences, commercial properties, muncipal facilities: water, power, sewer, streets.
Glenwood Springs and vicinity.	City and adjacent lands in Garfield Co. along Colorado and Roaring Fork rivers.	Residences, commercial properties, streets and other public facilities.

areas are, therefore, classified based on the effects an earthquake would have on persons, structures, and the environment. In the study area Interstate 70 passes through zones VII and VIII. An earthquake of intensity VII has the following characteristics:

> Difficult to stand. Noticed by drivers of motor cars. . . . Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets, and architectural ornaments. . . . Small slides and caving in along sand or gravel banks. (DODES, 1983, p.23)

The characteristics for an intensity VIII earthquake include:

> Steering of motor cars affected. Damage to masonry; partial collapse. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; . . . Branches broken from trees. . . . Cracks in wet ground and on steep slopes. (DODES, 1983, p.23)

Severe Winter Storms

The 1982 Christmas Eve blizzard in Denver illustrates an extreme in Colorado's winter weather. It is not uncommon for lesser blizzards to occur at any location across the state during the winter season. The Christmas Eve blizzard, however, was the fiercest twenty-four hour blizzard in Colorado's recorded weather history. The traditional mountain storm did not form; only ten inches of snow fell at Aspen and Vail. However, three-foot drifts formed on I-70 east of Denver, and the San Francisco Zephyr passenger train was stranded in Denver for 19 hours. The storm is particularly well remembered because the Denver city government chose to ignore its own snow emergency plan and did not mobilize equipment; officials did not believe the dire weather forecasts (Denver Post, 1983).

On December 24 at 8:00 a.m., Interstate 70 was closed east and west from Denver. A half hour later Interstate 25 was closed south from Denver, and at 12:30 p.m. Interstate 76 was shut down. The following day, I-25 reopened at 4:15 in the afternoon, and that evening at 7:00 p.m. I-70 was partially reopened. By midnight on Christmas day almost all major roads that had been closed were open. In all, I-70 was closed for about thirty-five hours.

As previously mentioned, the Eisenhower Tunnel is closed regularly in either or both directions each winter. Westbound traffic is stopped at Georgetown or Silver Plume while eastbound traffic is halted at Dillon. While the tunnel is closed, depending upon the severity of the weather, Loveland Pass may or may not be open and, if open, could have chain law restrictions in effect. Should a vehicle somehow get past the roadblocks halting traffic and reach the tunnel while it is closed, the vehicle would be turned around and sent back to the waiting point.

A typical closure of I-70, caused by a spring snowstorm, occurred in early April, 1985. Vail Pass was closed for more than three hours due to blizzard conditions; extreme whiteout and icing conditions resulted in jackknifed trucks and stuck vehicles along the pass. This same blizzard also closed Loveland Pass.

Weather can do more than close roads. In mid-March of 1985, I-70 from Vail to Eagle developed severe potholes almost literally overnight following a freeze-thaw cycle, creating a hazardous situation during heavy traffic when vehicles, trying to avoid the potholes, veered into other lanes (KCNC-TV, 1985).

Tornadoes

No tornado has been observed striking I-70 along the areas under study. However, tornadoes occur with considerable frequency along the eastern slope and plains of Colorado, making I-70 east of the mountains vulnerable. Colorado ranks seventh among the fifty states in tornado occurrence. Despite their frequent occurrence, Colorado's tornadoes are usually of relatively short duration and not as severe as those of the Midwest. According to the National

Weather Service (NWS) the greatest risk exists from May through July, and during this season "any Eastern Slope community must realistically expect and prepare for tornado impact" (DODES, 1983, p.25).

Weather

The National Oceanic and Atmospheric Administration (NOAA) weather radio warning coverage for Colorado is broadcast from six stations (DOC,1985). Broadcasts--taped messages repeated every 4-6 minutes and revised every 1-3 hours (more frequently if necessary)--contain the latest weather information fron NWS offices. Information is tailored to serve the needs of people in each station's receiving area. Special warning messages can be inserted, interrupting routine broadcasts. The Denver NWS office thus supplies the I-70 route with information from stations broadcasting out of Denver and Grand Junction.

For real-time weather reports, truckers are often their own best source of weather information; they provide each other (via CB radios) with information and descriptions of weather conditions along their routes, as well as information concerning road conditions, accidents, and road closures.

Computer Model

Rationale

Perhaps the main inference following from a study of the transportation of high-level nuclear wastes is that an accident may occur at any point along the transport route at any given time. Working from this assumption, it is apparent that state and local emergency preparedness activities would be aided by knowledge of those locations where an accident is highly likely to happen, the natural disasters whose occurrence could hamper evacuation efforts, the population distribution along the route, and the possible response/evacuation routes.

A computer model--containing data on accident frequency and location; special facilities; terrain; routes for response/evacuation; and present/projected road condition (including the effects of truck traffic)--could be developed to pinpoint those portions of the transport route that are most "sensitive." A sensitive location would exist where the potential for an accident is high, response and evacuation are difficult due to a limited choice of routes besides the main route, weather-related hazards (e.g., flash flooding, winter storms) would hamper emergency activities, and the existence of special facilities and/or seasonal populations complicate response.

Creating a computer model having the ability to identify these types of sensitive locations would be time consuming, requiring a significant amount of data collection and analysis. For example, one would have to decide whether a portion of the route with a large year-round population that could be easily evacuated, without natural hazards, with "average" accident rates, and with medium average daily traffic (ADT) was more or less sensitive than a section with a population that fluctuated due to seasonal recreation, with limited evacuation routes, "average" accident rates, and low ADT. A weighting system would have to be devised to reflect the exact natures of sensitive locations. Accident rates would have to be averaged over a sufficient time span to factor out highs and lows to present an accurate picture of accident data. This data might be further limited to include only large trucks, though a true picture of a location's sensitivity could be altered.

For the purpose of demonstration, a simple computer model was developed for the I-70 route to show how it is possible to identify sensitive locations using existing or easily generated data.

Data Base

The data base consists of three main collections of information--data on accidents, road conditions, and evacuation capabilities. The accident and road condition data, covering all types of vehicles, are limited to 1983, while the information on evacuation should hold over time, barring the construction of new roadways.

Colorado Department of Highways Data. During odd numbered years the Colorado Highway Department collects data on "Accidents and Rates on State Highways" and "Road Conditions." The accident data is collected for lengths of road which are identified by milepoints which correspond to the terminus of a given section. Sections are not of even length, and are identified as being urban or rural. Numbers of accidents--including property damage only (pdo) accidents, injury accidents, fatal accidents, and total accidents--are listed by milepoint. Accident rates--for injuries, fatalities, and total numbers of accidents--are computed based on the number of accidents per vehicle miles traveled during one year.

Road condition data, listed by mile, comprises various information including: ADT, environmental zone, equivalent daily load, a rutting factor, a roughness parameter, percent cracking, condition state, and projected maintenance action. The condition state, rated on a scale of 1-9, is calculated based on the amount of rutting and percent of surface cracking. These ratings can also be translated to good, fair, or poor road condition. The condition of a one-mile increment of road (identified by a milepost) is used to determine the maintenance it should receive: routine, minimum, or major. The road condition data lists the condition for the year the data was collected (Year 1), the maintenance action proposed for Year 1, and projects road conditions for Years 2-7 and maintenance actions for Years 2-6. The model used for the projections is based on current traffic; it does not take future increases or decreases into account. In the most recent survey, data are missing for mileposts 119 to 131 because this portion of I-70 was a projected route (presently under construction) through Glenwood Canyon.

Data Compiled for Computer Model. Information on population, terrain, and evacuation access are included in the evacuation data used in the model. The data are listed for each milepoint and milepost. Population was estimated for a one kilometer wide band along the route. Terrain classifications, interpolated from topographic maps, fell into one of nine categories ranging from rolling prairie to deep, narrow valleys/canyons with connecting valley(s), to pass summits. Maps were also used to determine evacuation access; lengths of road were classified according to one of five evacuation access codes:

1 = numerous evacuation routes available
2 = limited evacuation routes available
3 = limited evacuation route--1 or more seasonal
4 = major evacuation routes parallel to interstate, some seasonal
5 = all evacuation roûtes parallel to or are I-70 or U.S. 6

The accident data set was altered slightly with the addition of the category of "town" to the urban/rural area classification.

How to Use the Model

The computer model breaks the I-70 route into four routes: East I-70, Eisenhower Tunnel, West I-70, and Loveland Pass. Each of these routes can be examined in total or in sections. A section is determined by the choice of milepost values (in the model "milepost" is a generic term for milepoints and mileposts). Once a portion of a route is selected there are four categories of data that can be viewed:

1) accident data;
2) road condition state and maintenance summary;
3) evacuation data;
4) all variables listed by milepost.

A fifth category, general road data, is included, but the data is not currently ready for display.

Identifying Sensitive Locations

Sensitive locations are those portions of the I-70 route where any one of the three accident rates is "high" and evacuation is difficult. Emergency response and evacuation is considered difficult for any type of location except those for which evacuation routes are numerous. Evacuation poses the greatest problems for emergency personnel when the evacuation route is either I-70 or U.S. 6.

An accident rate is considered "high" based on an interpretation of State Highway Department data sheets indicating "higher" accident rates. The accident rates used to locate sensitive sections of the route are an injury rate $\geq .85 \times 10^{-6}$, a fatality rate $\geq 6.50 \times 10^{-8}$, or a total rate $\geq 3.00 \times 10^{-6}$. Sensitive locations are listed in Table 7 and shown in Figure 8.

TABLE 7

SENSITIVE LOCATIONS ON THE I-70 ROUTE: AN EXAMPLE USING 1983 DATA

milepoint	accident rates injury	fatal	total	evacuation ADT	population	access
	$x10^{-6}$	$x10^{-8}$	$x10^{-6}$			
EAST70						
258.614 (to 256.018)	.83	6.60	1.82	33,200	5442	parallel/=
244.283 (to 241.381)	.79	.00	3.13	24,200	0	limited
239.695 (to 238.935)	1.11	.00	2.59	22,200	515	limited
227.924 (to 225.650)	.48	6.89	2.20	17,300	515	limited
LOVELAND PASS						
228.733 (to 224.884)	2.14	.00	3.20	1,350	25	limited
224.884 (to 216.497)	1.21	.00	2.42	1,350	0	US 6
216.497 (to 215.220)	2.01	.00	4.68	3,150	300	US 6
214.620 (to 213.417)	1.00	.00	2.01	8,400	200	US 6
211.740 (to 210.940)	1.56	.00	1.87	8,800	225	US 6
WEST70						
197.859 (to 195.252)	.63	9.06	1.72	12,600	0	parallel/=
189.963 (to 179.857)	.85	5.32	2.93	10,000	0	parallel/=
173.310 (to 171.237)	.40	6.69	2.21	19,500	752	parallel/=
171.237 (to 168.778)	.88	.00	2.63	12,800	830	limited
130.950 (to 121.500)	.70	13.95	2.56	6,200	0	parallel/=

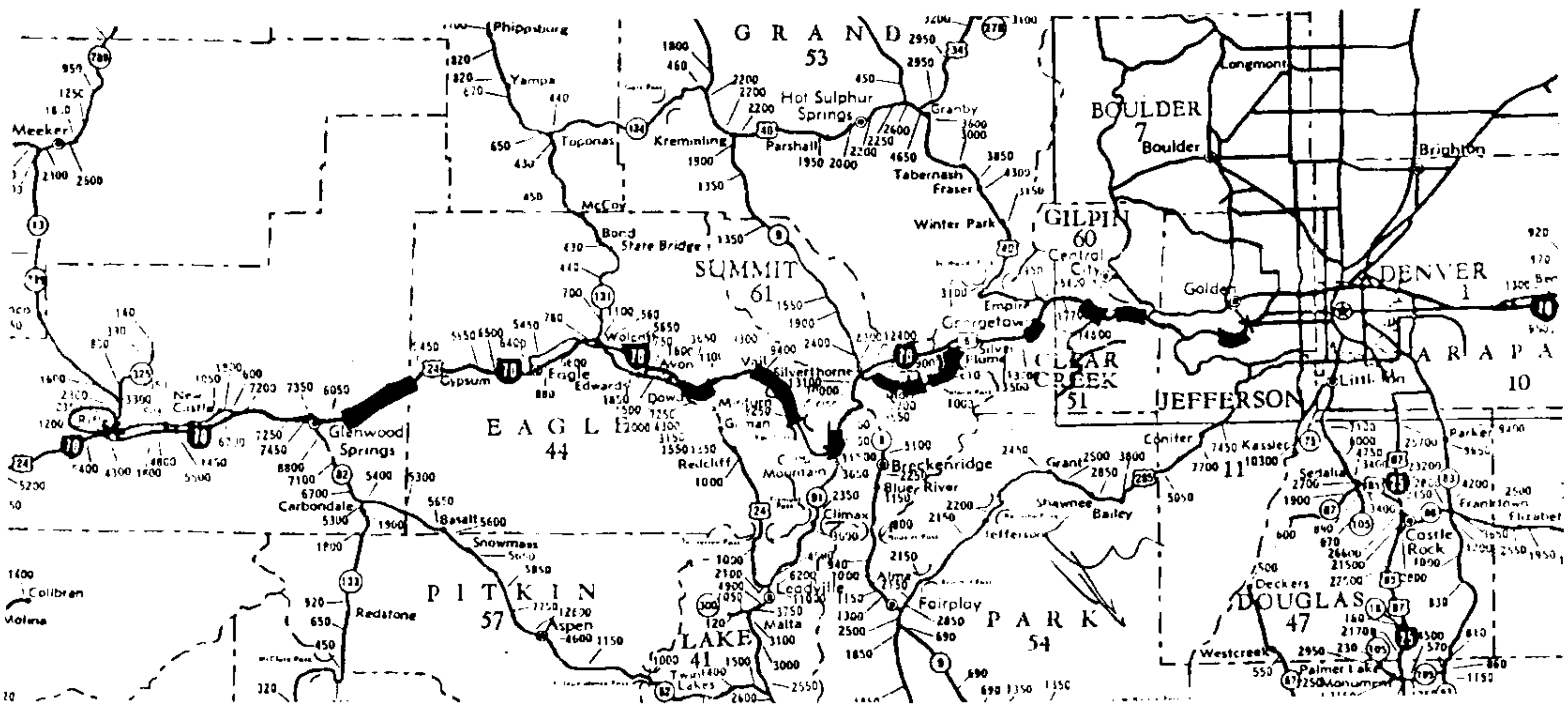

FIGURE 8

SENSITIVE LOCATIONS AS DETERMINED BY COMPUTER MODEL

CONCLUSIONS

This paper has explored a number of themes in varying levels of detail, and it may be useful to summarize the main points. In the first instance, the argument above has emphasized the importance of examining the HLNW tranportation question, both as a central factor within the management of nuclear materials, and as an issue with dynamic political and policy overtones. Second, and following on from the first statement, we have argued that if hazardous materials are to be transported around the country, then it is important that close attention be paid to the ways in which the population assesses risk and interprets the dangers that they believe themselves to be facing. Third, and perhaps most important, we have also demonstrated that the successful management of material transport lies in the understanding of local issues, local conditions, and local circumstances. As we have shown at length in the various Colorado examples, the successful management of accidents and possible evacuations lies with the personnel who possess such localized knowledge.

These conclusions may not seem particularly startling or insightful; after all, it is the very basis of emergency management to manage accidents within the local context. However, and as we have shown at length within this paper, there is a fundamental tension within the way in which the nuclear waste transport process is managed. That tension lies with the imposition of routes and regulations by the federal government upon lower levels of political organization--an imposition which places particular burdens upon the latter but which provides little in the way of material support. As we have seen, federal agencies dictate the principles of routing, but provide little in the way of control of the trucking industry. In terms of the examples that we have explored in this paper, this control of the movement of HLNW at the federal level removes from the lower levels of organization the ability to manage hazardous materials in the most effective manner, because it limits their ability to choose local routes which may be of lower objective quality, but which are easier to deal with in times of emergency.

We are, of course, aware of the reasons that lie behind federal preemption--namely the concern that local jurisdictions will play some game of "Not in My Back Yard" if they are permitted to determine the routing question. This does however miss the point that we have been at pains to eleborate within this paper--namely that the present system of preemption is capable of creating a great deal of political opposition to the management of waste in general and its transport in particular. That is to say, the inability to control routing may well produce a climate within which large numbers of residents become opposed to the transport of HLNW, because they receive no satisfactory assurances that the transportation can be effectively managed, and because they see no benefits to their own communities. In such situations, it seems very likely that general opposition to nuclear waste transport could readily become another aspect of a more specific and widespread opposition to nuclear power. We do not want in this paper to comment on the desirability or otherwise of nuclear power, but we do want to emphasize the vulnerability of this sector in light of the problems facing the transportation of high-level nuclear waste materials.

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APPENDIX A

SPECIFIC DATA NEEDS FOR ROUTE COMPARISON FACTORS

Source: DOT, 1984a

Primary Route Comparison Factors

Normal Radiation Exposure

This dosage is calculated using the cumulative dose to: persons residing along the route, passengers in other vehicles, the truck crew, and people at the truck stops where the hauler stops. Population density is calculated using a zero to five mile band along the route.

Persons residing along the route.

DATA: average population density (people/sq. mi.)
length of route (miles)
average vehicle speed (mph)

Passengers in other vehicles.

DATA: length of route
average traffic count (vehicles/hr)
average vehicle speed
distance between opposing traffic lanes (ft)
vehicle separation distance (ft)

Truck crew.

DATA: length of route
average vehicle speed

People at truck stops.

DATA: length of route
average vehicle speed

Public Health Risks from Accidents

These risks are calculated using the release frequency and accident consequence. The best overall indicator of accident frequency is the accident rate since it is the preferred inherent component of accident frequency. The accident's consequences will have many identical factors for the two alternate routes (e.g. atmospheric conditions, quantity and type of material being transported). The population exposed to radioactivity is determined using an approximately 25 square mile area from any given point along a route. The level of detail for each analysis can vary with the type of analysis being performed; that is where the routes travel. A five mile band with a multiplier of 1.0 would be best for an urban area. Health consequence band multipliers of 0.75 and 0.25 could be used for urban and rural areas respectively. The overall accident risk factor for any given route will be the product of the release frequency and the accident consequence numbers.

Accident release frequency.

These are listed in decreasing order of desirability.

DATA: #1. accident rate
#2. hazardous material truck driver fatality rate
#3. general truck driver fatality rate
#4. hazardous material truck fatality accident rate
#5. general truck fatality accident rate
#6. general vehicle traffic fatality rate
#7. general traffic accident rate
#8. accident rate predictive models
#9. length of route

Accident consequence.
DATA: population
maps
census data
health consequence

Economic Risk from Accidents
Economic risk is calculated using two measures: accident release frequency and economic-release consequence measure. The same accident rate used to determine the public health risk must be used in this instance.

Economic-release consequence measure.
DATA: type of property along route
1. farmland
2. residential
3. single family
4. multi-family
5. commercial
6. parks
7. public areas

NOTE: The 0-5 mile and 5-10 mile bands used each have consequence multipliers for each land use type that are proportional to the decontamination costs for each land use type.

Secondary Route Comparison Factors

Emergency Response
The primary factors influencing the effectiveness of emergency response are: personnel, timing, planning, and equipment. These factors are all location dependent. First order response typically takes a few minutes while secondary response requires minutes to hours to accomplish. Secondary response depends on preplanning, equipment availability, and the distance to be traveled. It is not necessary to exactly determine these parameters as routes can be compared using relative rankings that are based on arbitrarily established scales.

First order response.
1. get first responders to site
2. control immediate area
3. determine nature of hazard

Secondary response.
1. contact specialized technical personnel
2. get radiation monitoring equipment to site
3. get cleanup equipment to site

EXAMPLE. Establish scales for: response time, equipment availability, personnel hazardous material training, personnel availability. Sum these rankings to get the area total. Rank using a scale of 1 to 3 by land use type: city, town, rural, industrial.

Evacuation
Numerous factors contribute to an effective evacuation. These factors are ranked using a system which compares routes, as was done for emergency response. This approach is subjective and is intended for use only as a starting point for each route selection case. The scales and relative ranking of land use types are adjusted to fit each case.

Factors.

1. land use type
2. means of egress from structures/vehicles
3. level of pre-accident planning
4. effectiveness with which authorities implement response plans
5. nature of the threat
6. communication of need to evacuate
7. numbers of personnel needed
8. population density of the area (more difficult in low density areas resulting in longer evacuation times)
9. routes available for private autos from site (most common means of evacuation)
10. special facilities (detailed plans essential to minimize injuries and confusion)

EXAMPLE. Establish scales for number of people affected, availability and capacity of egress routes, availability of evacuation coordination personnel, time required for effective evacuation, impacts of evacuation on affected population. Rank, except for population, using scale of 1 to 3 by land use type: rural, suburban, urban, commercial, industrial. Sum ranks by land use type to get ranking factors. Multiply the ranking factor and the fraction of land use type within five miles of the route, for each land use type. Overall comparison factor is the sum of these products.

Special Facilities

These are localized areas having sufficient economic or public safety importance to require special consideration. They are unique and vital to local communities and include: schools, hospitals, prisons, nursing homes, churches, stadiums, and theaters. Parameters are determined and ranked for the routes being compared. In general, only those facilities within five miles of a route are considered.

Parameters.

1. radiation dose sensitivity of persons normally in facility
2. economic importance to local community
3. difficulty of evacuating people from facility

EXAMPLE. Factors to be assessed are dose response, economics, accident evacuation (the latter based on the parameters). Ranked using scale of 1 to 5 for each type of special facility. The sum of the rankings equals the overall facility factor for each type of facility. Compare routes by multiplying each facility factor by number of facilities along the route.

Traffic Fatalities and Injuries

Straightforward numerical estimates are needed for comparing routes. The easiest measure to use is fatalities and injuries per mile.

APPENDIX B

WORKSHEETS FOR APPLYING ROUTING GUIDELINES

Source: DOT, 1984a

A. Descriptive Data for Route

B. Normal Transport Exposure

C. Public Health Risk

D. Economic Risk

E. Emergency Response and Evacuation

F. Special Facilities

G. Traffic Fatalities/Injuries

H. Route Comparisons

A. DESCRIPTIVE DATA FOR ROUTE ___

ROUTE IDENTIFICATION:

TOTAL DISTANCE:

Accident Unit: ________

Segment	End-Points	Length	Average Speed	Pop.Count 0-5 Mile	Pop.Count 5-10 Mile	Daily Traffic Count	Daily Truck Count	Annual No. of ___	Accident Rate per ___	Accident Rate per ___

DESCRIPTIVE DATA FOR ROUTE ___

ROUTE IDENTIFICATION:

TOTAL DISTANCE:

Accident Unit: ________

Segment	End-Points	Length	Average Speed	Pop.Count 0-5 Mile	Pop.Count 5-10 Mile	Daily Traffic Count	Daily Truck Count	Annual No. of ___	Accident Rate per ___	Accident Rate per ___

WORKSHEET ___ ROUTE ___ Sheet __ of __

B. NORMAL TRANSPORT EXPOSURE

$$D = \frac{PL}{v} C_1 + \frac{LT}{v^2} C_2 + \frac{LT}{v^3} C_3 + \frac{L}{v}$$

<u>Segment 1</u>

P = $C_1 = 6.7 \times 10^{-5}$

L = Avg Dist Opposing Lanes =

v = C_2 (Table 3.2-1) =

T = Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

D_1 = ________

<u>Segment 2</u>

P = $C_1 = 6.7 \times 10^{-5}$

L = Avg Dist Opposing Lanes =

v = C_2 (Table 3.2-1) =

T = Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

D_2 = ________

<u>Segment 3</u>

P = $C_1 = 6.7 \times 10^{-5}$

L = Avg Dist Opposing Lanes =

v = C_2 (Table 3.2-1) =

T = Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

D_3 = ________

<u>Segment 4</u>

P = $C_1 = 6.7 \times 10^{-5}$

L = Avg Dist Opposing Lanes =

v = C_2 (Table 3.2-1) =

T = Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

D_4 = ________

ROUTE TOTAL $D_1 + D_2 + D_3 + D_4$ =

WORKSHEET ___ ROUTE ___ Sheet __ of __

C. PUBLIC HEALTH RISK

Release Consequence

Segment	0-5 Mile Band: Pop.Count		Multiplier		Total	5-10 Mile Band: Pop.Count		Multiplier		Total
1	______	x	.75	=	____	______	x	.25	=	____
2	______	x	.75	=	____	______	x	.25	=	____
3	______	x	.75	=	____	______	x	.25	=	____
4	______	x	.75	=	____	______	x	.25	=	____

SUMMARY

Segment	0-5 mi		5-10 mi		Public Health Conseq Factor		AccProb (Acc Rate)		Segment Health Risk
1	_____	+	_____	=	________	x	_______	=	_________
2	_____	+	_____	=	________	x	_______	=	_________
3	_____	+	_____	=	________	x	_______	=	_________
4	_____	+	_____	=	________	x	_______	=	_________
							ROUTE TOTAL		_________

WORKSHEET ___ ROUTE ___ Sheet 1 of 2

D. ECONOMIC RISK

0-5 Mile Band	Segment 1			Segment 2		
Land Use Type	Area	Weight	Weighted Total	Area	Weight	Weighted Total
Farmland	___ x	.01 =	___	___ x	.01 =	___
Single Family Residential	___ x	.10 =	___	___ x	.10 =	___
Multi-Family Residential	___ x	2.00 =	___	___ x	2.00 =	___
Commercial	___ x	.15 =	___	___ x	.15 =	___
Parks	___ x	.03 =	___	___ x	.03 =	___
Public Areas	___ x	.05 =	___	___ x	.05 =	___
TOTALS						

0-5 Mile Band	Segment 3			Segment 4		
Land Use Type	Area	Weight	Weighted Total	Area	Weight	Weighted Total
Farmland	___ x	.01 =	___	___ x	.01 =	___
Single Family Residential	___ x	.10 =	___	___ x	.10 =	___
Multi-Family Residential	___ x	2.00 =	___	___ x	2.00 =	___
Commercial	___ x	.15 =	___	___ x	.15 =	___
Parks	___ x	.03 =	___	___ x	.03 =	___
Public Areas	___ x	.05 =	___	___ x	.05 =	___
TOTALS						

SUMMARY

Segment	0-5 Mile		(From Page 2) 5-10 Mile		Econ Conseq Factor		Econ Prob (Acc Rate)		Segment Econ Risk
1	___	+	___	=	___	x	___	=	___
2	___	+	___	=	___	x	___	=	___
3	___	+	___	=	___	x	___	=	___
4	___	+	___	=	___	x	___	=	___

Route Total ___

WORKSHEET ___ ROUTE ___ Sheet 2 of 2

D. ECONOMIC RISK (cont.)

5-10 Mile Band	Segment 1					Segment 2				
Land Use Type	Area		Weight		Weighted Total	Area		Weight		Weighted Total
Farmland	___	x	.001	=	___	___	x	.001	=	___
Single Family Residential	___	x	.04	=	___	___	x	.04	=	___
Multi-Family Residential	___	x	.20	=	___	___	x	.20	=	___
Commercial	___	x	.01	=	___	___	x	.01	=	___
Parks	___	x	.02	=	___	___	x	.02	=	___
Public Areas	___	x	.05	=	___	___	x	.05	=	___
TOTALS										

5-10 Mile Band	Segment 3					Segment 4				
Land Use Type	Area		Weight		Weighted Total	Area		Weight		Weighted Total
Farmland	___	x	.001	=	___	___	x	.001	=	___
Single Family Residential	___	x	.04	=	___	___	x	.04	=	___
Multi-Family Residential	___	x	.20	=	___	___	x	.20	=	___
Commercial	___	x	.01	=	___	___	x	.01	=	___
Parks	___	x	.02	=	___	___	x	.02	=	___
Public Areas	___	x	.05	=	___	___	x	.05	=	___
TOTALS										

WORKSHEET ___ ROUTE ___ Sheet __ of __

E. EMERGENCY RESPONSE AND EVACUATION

EMERGENCY RESPONSE

Land Development Type	Area in 0-5 mi band Seg 1	Seg 2	Seg 3	Seg 4	Total	Route Fraction		Weight		Weight Total
City	___	___	___	___	___	___	x	___	=	___
Town	___	___	___	___	___	___	x	___	=	___
Rural	___	___	___	___	___	___	x	___	=	___
Industrial	___	___	___	___	___	___	x	___	=	___

(Total)
Comparison Factor ___

EVACUATION

Land Development Type	Area in 0-5 mi band Seg 1	Seg 2	Seg 3	Seg 4	Total	Route Fraction		Weight		Weight Total
Rural	___	___	___	___	___	___	x	___	=	___
Suburban	___	___	___	___	___	___	x	___	=	___
Urban	___	___	___	___	___	___	x	___	=	___
Commercial	___	___	___	___	___	___	x	___	=	___
Industrial	___	___	___	___	___	___	x	___	=	___

(Total)
Comparison Factor ___

WORKSHEET ___ ROUTE __ Sheet __ of __

F. SPECIAL FACILITIES

Type of Facility	Number of Facilities		Weighting Factor (Table 3.2-6)		Total
Children's Hospital	_____	x	_____	=	_____
Hospital	_____	x	_____	=	_____
Prison	_____	x	_____	=	_____
Nursing Home	_____	x	_____	=	_____
School	_____	x	_____	=	_____
Church	_____	x	_____	=	_____
Stadium	_____	x	_____	=	_____
Shopping Center	_____	x	_____	=	_____
Theater	_____	x	_____	=	_____

(Total)
Comparison Factor ______

WORKSHEET ___ ROUTE __ Sheet __ of __

G. TRAFFIC FATALITIES/INJURIES

Accident unit of measure: ________________________________

Segment	Segment Accident Rate		Segment Mileage		Total
1	_____	x	_____	=	_____
2	_____	x	_____	=	_____
3	_____	x	_____	=	_____
4	_____	x	_____	=	_____

(Total)
Comparison Factor _____

WORKSHEET ___ Sheet __ of __

H. ROUTE COMPARISONS

PRIMARY FACTORS	FACTOR VALUES		TOTAL FACTOR VALUES	NORMALIZED VALUES	
	Rte___	Rte___		Rte___	Rte___
Normal Radiation Exposure	___	___	______	___	___
Public Health Risk from Accidents	___	___	______	___	___
Economic Risk from Accidents	___	___	______	___	___
			Route Totals (FIGURE OF MERIT)	___	___

SECONDARY FACTORS	FACTOR VALUES		TOTAL FACTOR VALUES	NORMALIZED VALUES	
	Rte___	Rte___		Rte___	Rte___
Emergency Response	___	___	______	___	___
Evacuation	___	___	______	___	___
Special Facilities	___	___	______	___	___
Traffic Fatalities and Injuries	___	___	______	___	___

APPENDIX C

MINIMUM TRAINING PROGRAM FOR FIRST-ON-SCENE PERSONNEL

Source: Gunderloy et al., 1981

Basic Training

1. Fundamentals of radiation science
   - A. radioactivity defined
   - B. fundamental properties
   - C. units of measurement
2. Radiological safety
   - A. hazard assessment, including basic instrument use
   - B. defining the extent of a radioactive hazard
   - C. control techniques
3. Radioactive materials
   - A. characterization and hazards of common radionuclides
   - B. forms of common materials
   - C. handling hazards (absorption, inhalation, ingestion)
4. Review of transportation regulations governing shipment of radioactive materials by any carrier--49CFR173.389
   - A. transport groups
   - B. Type A and B quantities
   - C. special form radionuclides
   - D. package radiation level limits
   - E. package label criteria
   - F. vehicle placarding requirements
   - G. identification of nuclide shipments
   - H. special transport route requirements
   - I. evaluation of shipper documentation for hazards assessment
   - J. review and critique of selected accidents

Advanced Training

1. Review of basic nuclear science
   - A. symbols and nomenclature of the elements, nuclides, and isotopes
   - B. radioactivity
   - C. properties of particulate and electromagnetic radiation

2. Fundamentals of radiation detection
   A. instrument types
   B. instrument applications
   C. instrument limitations
3. Air sampling techniques
   A. collection of airborne particulates
   B. concentration determination
   C. air sampling in emergencies
4. Biological effects of exposure to radiation
   A. definition of dose terms
5. Radioactive materials
   A. characteristics and relative radiotoxicity of commonly transported radionuclides
   B. physical and chemical states of commonly transported radionuclides
6. Safe handling of radioisotopes
   A. radioisotope handling hazards, including absorption, inhalation, and ingestion
   B. the use of time, distance, and shielding factors for limiting exposures
   C. decontamination methods for people and for equipment
7. Review of transportation accidents that have involved radioactive materials
   A. refresher on packaging and shipping requirements
   B. causes and effects of accidents
   C. remedial actions and recovery

APPENDIX D

MAJOR I-70 ROAD CLOSURES IN THE STUDY AREA: FEBRUARY 1984 - FEBRUARY 1985

Date	Explanation
1984	
02/25	I-70 at Floyd Hill closed 3 hours for poor visibility and road conditions.
03/09	I-70 at Vail Pass closed 5 hours for poor driving conditions.
03/22	Loveland Pass closed for 26 hours for snowslides.
04/28	I-70 west of Denver closed for few hours because of snow. Loveland Pass closed for snowslide.
04/29	I-70 west of Denver closed for few hours because of snow. Loveland Pass closed for snowslide.
05/02	Loveland Pass closed for couple of hours for poor visibility.
05/16	I-70 near Vail closed for couple hours for rock and mudslides.
05/22	Loveland Pass closed 7 hours for snowslide.
05/25	I-70 in Glenwood Canyon closed 8 hours for water on highway.
05/26	I-70 at Vail closed 12 hours for rock/mudslide.
06/06	I-70 on Vail Pass closed for few hours for snowstorm.
06/07	I-70 in Glenwood Canyon closed 3 hours for rock slide.
07/24	I-70 near Georgetown closed 1 hour for rock and mudslides.
07/27	I-70 near Georgetown closed 1 hour for rock and mudslides.
08/03	I-70 at Silverthorne closed 3 hours for truck accident.
10/15	I-70 from S.H. 26 closed 13 hours for major snowstorm. I-70 at Georgetown closed at 1:37 p.m. for major snowstorm.
10/27	I-70 Silverthorne to Eisenhower Tunnel closed 3 hours for snowstorm.
11/03	Loveland Pass closed 4 hours for snowslides.
11/11	I-70 westbound closed 1/2 hour for accident in Eisenhower Tunnel.
12/12	Loveland Pass closed 7 hours for tanker truck accident.
12/18	Loveland Pass closed 1 hour for snowslide.

1985

01/20	Loveland Pass closed 2 hours for snowslide.
01/22	I-70 at Vail Pass closed 1 1/2 hours for snowslide.
01/23	Loveland Pass closed 1 hour for snowslide.
02/05	Loveland Pass closed 1 1/2 hours for snowslide.
02/10	I-70 near Edwards closed 6 hours for truck accident involving hazardous material. Loveland Pass closed 12 hours for 2 snowslides.

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