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

Ann FitzSimmons

Overview and Conclusion by
Andrew Kirby

Institute of Behavioral Science
University of Colorado

July, 1987

Working Paper #59

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.

Further information about the research program is available from the following:

William E. Riebsame
Institute of Behavioral Science #6
University of Colorado
Boulder, Colorado 80309

Robert W. Kates
Graduate School of Geography
Clark University
Worcester, Massachusetts 01610

Ian Burton
Institute for Environmental Studies
University of Toronto
Toronto, Canada M5S 1A4

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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 trànsport 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.