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Risk of radiation exposure from the Transportation of high-level nuclear waste

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Risk of Radiation Exposure from the Transportation of High-Level Nuclear Waste

by

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ABSTRACT

RISK OF RADIATION EXPOSURE FROM THE TRANSPORTATION OF HIGH-LEVEL NUCLEAR WASTE

by Lawrence Banks

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Transportation of high-level nuclear waste poses a potential risk of exposure from radiation to people of Las Vegas and the surrounding environment. 77,000 metric tons of waste is scheduled to start arriving at Yucca Mountain in 2010. For 24 years legal weight trucks will transport high-level nuclear waste through 109 cities with populations over 100,000. The population of Las Vegas is over 400,000 people. In all, legal weight trucks will cross 43 states traveling millions of highway miles (see appendix B). The U. S. Department of Energy estimates expected radiological risk from accidents would be no higher than 0.003 latent cancer fatalities in Clark County. In its analysis state specific data was used in RADTRAN to estimate transport risk to Nevada. The study looked at how route specific data has been applied in other studies using RADTRAN. A Lincoln County case study suggest national and state data underestimates risk of transportation of high-level nuclear waste.

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Chapter 1

Introduction

Yucca Mountain is located 100 miles northwest of Las Vegas on federally owned land. It is the only site under consideration by the United States Department of Energy (USDOE) as a permanent geological repository for disposal of high-level nuclear waste (HLNW). HLNW is the byproduct of uranium fuel that has been used in a nuclear reactor and is spent, or no longer efficient in generating power to produce electricity.

The waste will come from commercial nuclear plants and military facilities (Dilger, 1998). The site is scheduled to start accepting waste in 2010. Over the next 30 years 77,000 metric tons will travel millions of highway and rail miles crossing 43 states to Yucca Mountain (Dilger, 1998). If USDOE elects to transport HLNW by truck it would result in 96,300 shipments crossing 109 cities with populations over 100,000 people. The movement of HLNW by rail, legal weight truck (LWT), or a combination of both poses a potential risk of exposure to people of Las Vegas and the environment. A release of radiation caused by an accident would contaminate a 42 square mile area requiring up to a year to clean with an estimated cleanup cost of 650 million dollars (Dilger, 1998).

USDOE estimates the expected radiological risk from accidents over the life span of the project would be no higher than 0.003 latent cancer fatalities in Clark County Nevada (USDOE, 2002). One reason for this assumption is DOE transportation record of safely moving small quantities spent nuclear fuel in the U. S. Another reason for this assumption is based on calculated results DOE obtained from using RADTRAN.

RADTRAN is a transport risk code developed by Sandia National laboratory and used by DOE as an analytical tool to assess health and economic risk of transporting radioactive material (Souleyrette, & Pryor, 1991). The model incorporates user determined input parameters for demographic, meteorological, transportation and packaging data to calculate expected consequences of accident and incident free risk of transporting radioactive material (Weiner, 2003). RADTRAN allows the user to input population density and accident conditions for links, or segments of a transport (Brogan, Cashwell, and Neuhauser, 1989). The code also employs default parameters derived from national data. The values for national parameters are often used when it becomes difficult and/or too expensive to obtain more route specific data. Brogan, et al. (1989) indicates the use of national data is adequate for analysis of transport risk on a large scale; however, such default parameters may under or overestimate risk to states and local routes if conditions differ significantly from national averages. Isolated or very short transport routes require detailed route specific data (Mills & Neuhauser, 1999).

Transport risk models like the one used by DOE describe the potential risk associated with transporting radioactive material by various modes of transportation. Risk in this context is defined as a probability of an adverse effect or an assumed threat to persons, the environment, and/or property due to some hazardous material (Kofi Assente-Duah, 1993).

Because input variables can change with local conditions input data specific to parameters such as population density, accident rates and zonal (road type) are important elements of a transport risk model.

The purpose of this thesis is to determine whether different data input affects the Department of Energy's (DOE) calculations of potential risk of radiation exposure from the transportation of high level nuclear waste (HLNW) by large truck to Yucca Mountain.

This thesis will be structured in the following manner: Chapter 2 will contain a review of literature relevant to transportation of HLNW. Chapter 3 will describe the methods used to collect data. Chapter 4 will be used to present results of the data collected. Chapter 5 discusses the data collected. Chapter 6 presents a conclusion to the thesis.

Chapter 2

Literature Review

This section is a summarization of relevant findings from review of literature pertaining to transportation of high-level nuclear waste (HLNW).

Probabilistic risk models (PBR) describe the potential risk associated with transporting radioactive material by various modes of transportation. The most widely used PBR is RADTRAN IV. Developed by Sandia National laboratories in New Mexico, it is a computer-based tool used by the Department of Energy to estimate the potential risk of exposure from transporting HLNW to Yucca Mountain.

Souleyrette and Pryor (1991) discuss the complex procedure of inputting the enormous amount of data required to run the program. They describe the two modules, accident and incident free, and various parameters that are used in the model.

Route specific data such as population density, accident rates, and zonal (road) types are important parameters in a PBR. This is because the parameter values change with local conditions and could be different than those of national averages. Different parameter values could over or underestimate the potential risk of exposure.

Sathisan and Maadhavapeddi (1995) showed how different data could give different estimates of risk of exposure. Their study conducted on Lincoln County, Nevada compared the difference between DOE data inputs and route specific inputs of the study area. They recreated the DOE application of RADTRAN IV using the same parameters but different values. Parameter values that were more specific to the study area showed a higher level of risk of exposure from transportation of HLNW. The parameters shown to be the most sensitive were population density, accident rates and zonal type.

Brogan, Cashwell, and Neuhauser created a hypothetical situation to asses the effects of route specific data in RADTRAN. The purpose was to determine how the uses of data characteristic to local conditions best estimates transportation risk. The study indicates default national averages employed in RADTRAN are acceptable parameter values when estimating transport risk on a universal scale. The use of non-route specific data has the potential to underestimate the risk associated with local communities. Brogan et al (1989) reported national averages are used more because of difficulty of expense in obtaining route specific data.

Bartolo and Dilger of the Transportation Research Center conducted research for Clark County Nuclear Waste Repository Program to identify those areas with the most potential to be the site of a major accident involving transportation of HLNW. Their 1993 study identified routes using DOT requirements that would serve as primary and alternate routes for use by truck. Out of eighteen high accident segments nine were located on I-15. Each segment identified had different accident data which would be used in a transport risk model. The segments identified in their studied comprised a six mile stretch that included an area adjacent to the resort section of the Las Vegas strip.

Mills and Neuhauser (1998) described procedures used to calculate risk of exposure for a transport accident. In their analysis of population density in RADTRAN IV it was reported national averages accurately estimated transport risk when the route was hundreds of kilometers long. The uses of data representative of local conditions are required when the route is very short or isolated.

Chapter 3

Methods

This study reviewed literature of USDOE final environmental impact statement (FEIS) and two studies regarding transportation of high-level nuclear waste (HLNW). Data were collected on population density and accident rates their relationships to estimated transport risk.

U. S. Department of Energy FEIS appendix contained methods and results of estimated transport risk to Yucca Mountain from legal weight trucks. Appendix J lists the input parameters USDOE used in its analysis. This section of the FEIS contains potential and alternative routes to be used by legal weight trucks in Nevada.

The Lincoln County case study was used to compare the use of route specific data in RADTRAN. The authors of the Lincoln County study used RADTRAN IV to evaluate the effects of route specific data compared to that of national averages used by USDOE. The purpose for their study was to evaluate how data representative of Lincoln County would affect USDOE calculations of transport risk to Yucca Mountain.

I obtained population density data from the U. S. Census bureau for Nevada, Clark County and Las Vegas. Since population density has been described as a sensitive parameter in RADTRAN I reviewed U.S. Census Bureau data for population data on the state of Nevada, Clark County and Las Vegas. The data was used to show differences in population demographic differences.

Accident rates were obtained from the Nevada Department of Transportation database. I collected data on Nevada state highway characteristics only. Information on the identified alternative route I-215 Beltway was not available.

Chapter 4

Results/Analysis

The USDOE FEIS appendix J identified two potential routes for transportation of HLNW by legal weight truck. These routes were selected by USDOE using current Department of Transportation regulations.

Table 1 shows the distance traveled for each zonal type for the two routes. The northern route has a total distance of 207.4 kilometers, of which 187.5 are in rural areas and 0 kilometers are in urban areas. The southern route has a total of 168.8 kilometers of distance traveled with 126.9 kilometers in rural areas. Table 1 shows that most of the travel of HLNW will occur in rural zonal areas.

Route	Urban (Km)	Suburban (Km)	Rural (Km)	Total (Km)
Northern	0.0	19.9	187.5	207.4
Southern	0.0	41.9	126.9	168.8

Table 1: Distance waste will travel in Nevada by zone type

Table 2 shows the population demographics of each zonal type at 800 meters from the potential transport routes. The northern and southern suburban routes have a population density of 577 persons per square kilometers. There is no urban population that will be potentially exposed along the transport route. The zero population density reflects the distance traveled in table 1. USDOE used in its analysis of transportation risk state population data derived from the U. S. Census Bureau. The 1990 data was expanded to 2035 the year transportation activities are planned to end.

Route	Urban	Suburban	Rural
Northern	0.0	577	10.6
Southern	0.0	577	3.5

Table 2: Estimated population density along the Nevada transport route by zone type using state specific data (person per square mile)

The population density USDOE used in its analysis for transport risk is not representative of local conditions. Table 3 shows the comparison in population demographics between state of Nevada, Clark County and Las Vegas. Population density is drastically different between the three areas. Las Vegas has a population density of 4229.5 compared to 173.9 and 18.2 for county and state respectively. The population density of Las Vegas is described as an urban area.

Demographic Area	2000 population (source US Census Bureau)	Percent change (1990-2000)	Population density (per-square mile)	Total area (Square miles)
Nevada	1,998,257	66.3	18.2	109,826
Clark County	1,375,765	85.6	173.9	7910
Las Vegas	478,434	81.8	4229.5	113.13

Table 3: State, county and city demographics

Figure 1 shows potential transport routes, I-15 north and south, identified by USDOE in its FEIS. The routes travel through Las Vegas and connect with I-95 near downtown Las Vegas. The inset is an alternative route identified by USDOE. I-215 Beltway will take legal weight trucks transporting HLNW away from the more heavily populated areas of Las Vegas. This route has not yet been designated by the state of Nevada as an alternative route under Department of Transportation regulations. Unless the state of Nevada designates a route the potential routes identified by USDOE will be used.

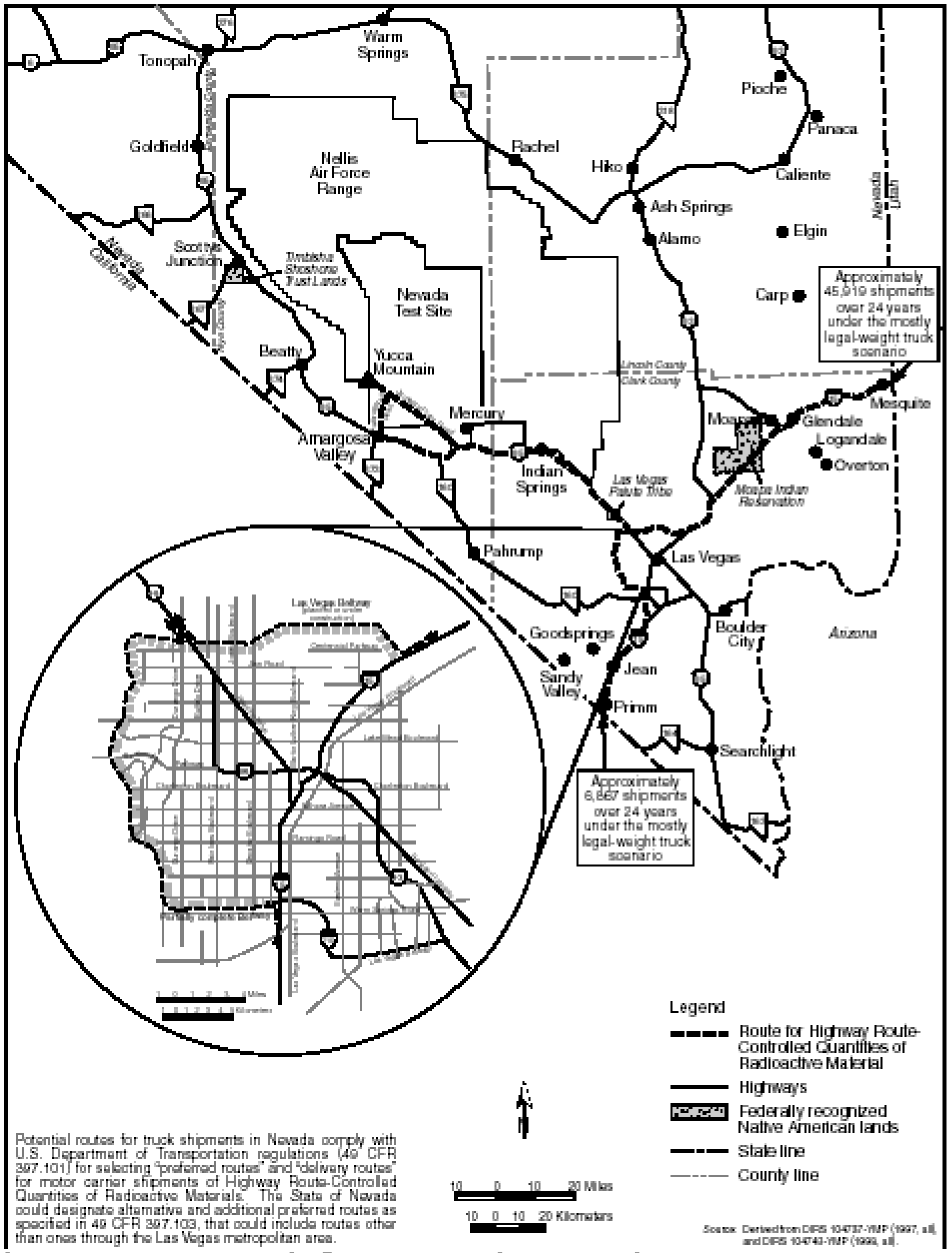

Figure 1: Potential routes in Nevada. Source DOE FEIS

The potential transport routes identified by doe are I-15 north and south that connect with I-95 in an urban area of Las Vegas.

USDOE used state accident rates in RADTRAN to estimate transport risk. The average vehicle miles (AVM) traveled in Nevada in 2000 was over 17 million with a total of 58,741 crashes reported. The AVM for Clark County and Las Vegas was not available. In cases where local data is not available RADTRAN uses default data to estimate accident rates.

The Lincoln County case study was conducted to compare the effects of route specific data to the national averages used by USDOE in an analysis of transportation of HLNW to Yucca Mountain. The authors of this study used an updated version of RADTRAN with USDOE original input parameters and compared the results for any differences in estimated risk levels.

Table 4 shows the percentage of travel that would take place along the transport route. Using route specific data in its analysis the authors of the study estimated 98% of waste would travel through Lincoln County compared to 83.7% using national averages. The data in this table indicates that route specific data is more accurate in describing zonal conditions along a transport route.

Zone	USDOE	Lincoln County
Rural	83.7	98
Suburban	15.2	2
Urban	1.1	0

Table 4: Percentage of population distribution along the transport route

Table 5 shows the accident rate scenario along a transport route. To best represent local conditions the transport route was separated into links, or segments according to zonal type. Links are determined by accident rates and population density along a transport route. The study used in its analysis population density and accident data that were representative of Lincoln County. The results of the study indicate the use of national averages underestimates the risk of transporting high-level nuclear waste in Lincoln County.

Link	USDOE	Lincoln county
1	4.08-08	0.18
2	4.08-08	0.26
3	4.08-08	0.46
4	8.1E-07	0.46
5	8.1E-07	0.32
6	4.08-08	0.37

Table 5: Accident rate scenario along the transport route

In its analysis of spent nuclear by legal weight truck to the Waste Isolation Pilot Plant (WIPP), the Environmental Evaluation Group (EEG) employed route specific data in RADTRAN IV to estimated transport risk to Albuquerque, New Mexico. The group identified 43 segments of the transport route with different characteristics based on population density and accident rates.

Route specific data was used because it was believed to represent conditions along the transport route. The analysis of WIPP was the first of any kind where route specific data was used in RADTRAN.

Chapter 5

Discussion

The data presented in the previous chapter does not fully support my hypothesis that route specific data will over or underestimate USDOE assumption of estimated risk of radiation exposure from the transportation of high-level nuclear waste by legal weight truck to Yucca Mountain.

In its analysis of transport risk USDOE used state data in RADTRAN. The population density was from the 1990 census data expanded to 2035 the year transportation of HLNW to Yucca Mountain is expected to end and the site closes. The state population density was increased to 40% based on state population growth. Nevada population differs from Las Vegas. Las Vegas had an increase of 85.5% between 1990 and 2000. By using such data USDOE is assuming population density and accident rates are uniform 800 meters along the transport route. However, table 3 from the previous chapter shows that population demographics vary among state, county and local conditions.

The location of accidents associated with legal weight trucks transporting HLNW cannot be predicted. Analyses of the routes identified by USDOE in its FEIS indicate they will traverse through heavily populated areas of Las Vegas. It is possible for an accident to occur in an urban area.

In its analysis USDOE assumed population density is uniform along the transport route. It does not take into consideration the population of Las Vegas with added visitors each day. A majority of visitors accumulate within 800 meters (0.5 mile) of the potential transport route identified by USDOE.

The Lincoln County study suggests there is a correlation between population density and accident rates estimated transport risk. This study indicates that non-route specific data does not accurately describe conditions along a transport route.

In its analysis of transport risk to WIPP, EEG-46 reported use of route specific data in RADTRAN accurately describes estimated risk along the transport route. This was a first of its kind study where local conditions were used in RADTRAN.

There are many uncertainties in the transportation program. For example, there is no definite route identified by USDOE as primary or alternate routes to transport HLNW. Therefore USDOE uses in its analysis routes that meet 49CRF standards. Department of Transportation 49CFR governs route selection for truck shipments of HLNW (Mills & Neuhauser, 1998). The entire portion of the route which included population density and accident rates were used as parameters for RADTRAN. As the

Lincoln study indicates local route characteristics are important parameters.

Chapter 6

Conclusion

The USDOE transportation program is very important to Clark County for several reasons. Transporting HLNW by legal weight truck poses a threat to people along the transport route due to its high radioactivity. Persons living along the transport route and sharing the road in urbanized areas like Las Vegas can expect to receive small amounts of radiation from routine shipments. If an accident were to occur causing a release of radiation, people would be at greater risk. USDOE argues the transportation program is safe and they estimate an accident could not occur in an urban area.

Future studies should include an analysis of transportation risk using parameters that represent conditions in Las Vegas.

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APPENDIX: A

Glossary

Accident: an unplanned sequence of events that results in undesirable consequences.

Geologic Repository: a system of disposing of radioactive waste in excavated geologic media, including surface and subsurface areas of operations and the adjacent part of the geologic setting that provides isolation of the radioactive waste in the controlled area.

Latent cancer Fatality: a death resulting from cancer that has been caused by exposure to ionizing radiation. For exposures that result in cancers, the general accepted assumption is that there is a latent period between the time an exposure occurs and the time a cancer becomes active.

Legal Weight Truck: a truck with a gross vehicle weight (both truck and cargo) of less than 80,000 ponds. The loaded weight limit for commercial vehicles operated on public highways without special state permits.

Radiation: the emitted particles from the nuclei of radioactive atoms.

Risk: the product of the probability that an undesirable event will occur multiplied by the consequences of the undesirable event.

Spent nuclear fuel: the by-product of nuclear power plants that is no longer useful for producing energy.

Shipment: the movement of properly prepared (loaded, unloaded, or empty) cask from one site to another.

Yucca Mountain Site: the area on which DOE would build the majority of facilities or cause the majority of land disturbances related to the proposed repository.

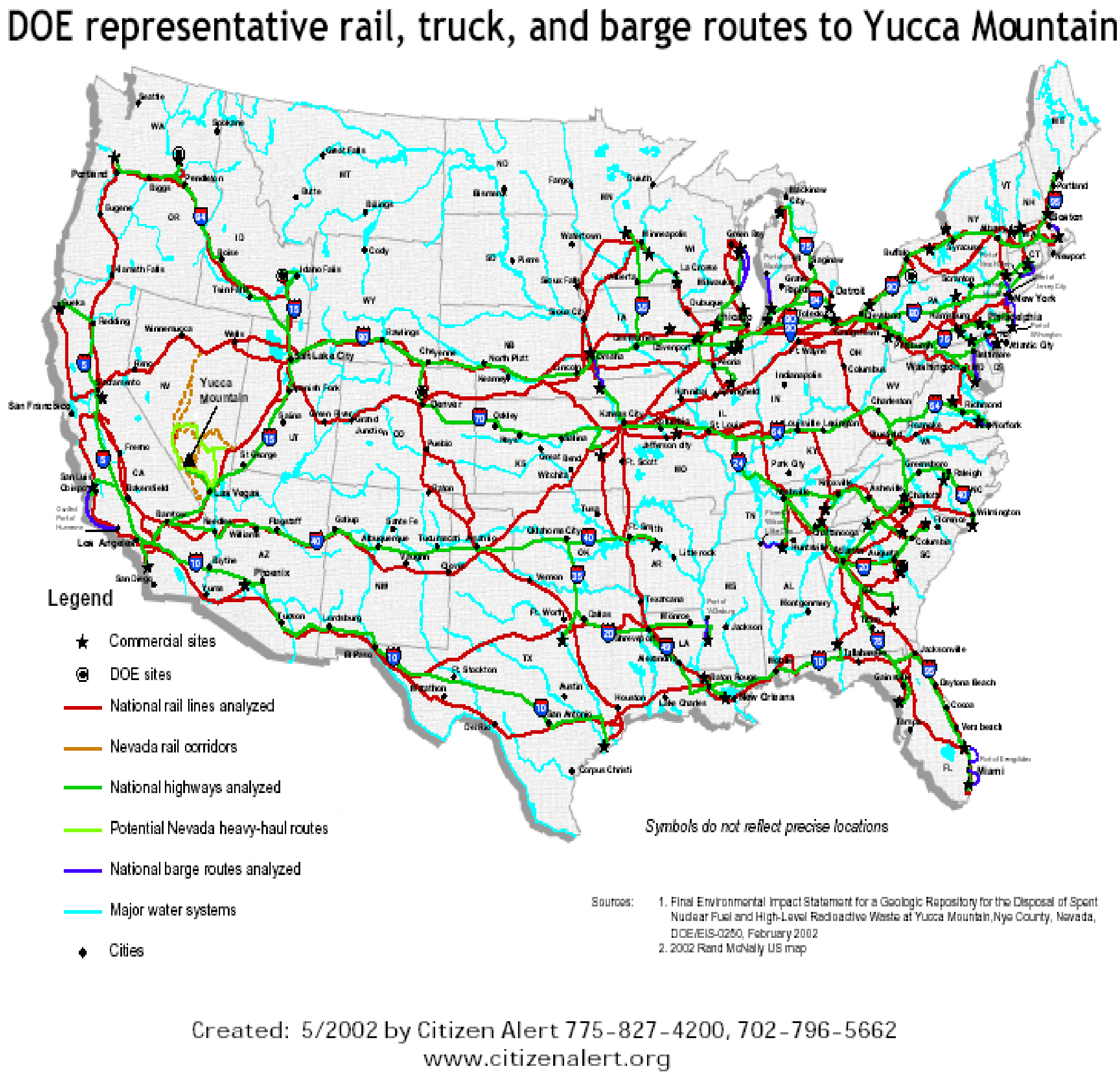

Figure 2: Potential national transportation routes to transport high-level nuclear waste to Yucca Mountain