

**TESTIMONY OF ROBERT J. HALSTEAD
ON BEHALF OF
THE STATE OF NEVADA**

**BEFORE THE
SUBCOMMITTEES ON HIGHWAYS AND TRANSIT AND RAILROADS
OF THE
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
U.S. HOUSE OF REPRESENTATIVES**

APRIL 25, 2002

I am Robert J. Halstead, Transportation Advisor, Agency for Nuclear Projects, State of Nevada. I have worked on nuclear waste transportation issues for the past 24 years. I have been Transportation Advisor to the Nevada Agency for Nuclear Projects since 1988. My primary responsibility is assessment of the impacts and risks of transporting spent nuclear fuel and high-level radioactive wastes to the proposed Yucca Mountain repository site. In addition to reviewing the U.S. Department of Energy's Draft and Final Environmental Impact Statements for Yucca Mountain, my recent work for Nevada includes managing contractor studies on the vulnerability of shipments to sabotage and terrorist attack, on the radiological consequences of severe highway and rail accidents, and on radiation exposures from incident-free shipments.

From 1983 to 1988, I was senior policy analyst for the State of Wisconsin Radioactive Waste Review Board, an agency created by the Wisconsin Legislature to represent the State in dealings with the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, other federal agencies, and nuclear electric utilities. I advised the Board and Wisconsin's congressional delegation on federal legislation that resulted in the Nuclear Waste Policy Act of 1982, and the Nuclear Waste Policy Amendments Act of 1987. I monitored on-going spent nuclear fuel shipments; evaluated transportation impacts of repository candidate sites in Wisconsin, Minnesota, and Michigan; and represented the Board on all matters pertaining to transportation.

From 1978 to 1983, I worked for the State of Wisconsin Energy Office. I evaluated utility plans for nuclear and coal-fired power plants, and represented the State in proceedings before the Public Service Commission of Wisconsin. I prepared policy recommendations on transportation of coal, petroleum, spent nuclear fuel, and low-level radioactive wastes.

I have also worked as a consultant on nuclear waste transportation and storage for the States of Minnesota, Tennessee, and Texas, and for the Law and Water Fund of the Rockies.

The U.S. Department of Energy's Final Environmental Impact Statement for Yucca Mountain

The Department of Energy (DOE) released the Final Environmental Impact Statement (FEIS) for the proposed Yucca Mountain Repository on February 14, 2002. The FEIS was available from DOE's website (www.ymp.gov) shortly thereafter. DOE apparently published no paper copies of

the FEIS for distribution to the public. DOE's transportation impact analyses are spread over more than 750 pages in the FEIS Summary, eight chapters, and four appendices. In order to obtain print-optimized files for the Summary, it is necessary to go to DOE's website and download 48,425 KB. To obtain the eight chapters and four appendices dealing with transportation and related issues, it is necessary to download more than 113,300 KB.

In the FEIS Summary, DOE has estimated the total projected inventory of commercial spent nuclear fuel (SNF), high-level radioactive wastes (HLW), and other wastes intended for repository disposal through 2046. This inventory, referred to by DOE as Module 2, includes 105,000 metric tons of heavy metal (MTHM) of commercial SNF, 2,500 MTHM of DOE SNF, 22,280 canisters of DOE HLW (equivalent to about 11,500 MTHM), 2,000 cubic meters of Greater-than-Class-C (GTCC) waste, and 4,000 cubic meters of Special-Performance-Assessment-Required (SPAR) waste. [FEIS, p. S-78]

Under DOE's Proposed Action, the following wastes would be shipped to Yucca Mountain over 24 years (2010-2033): 63,000 MTHM of commercial SNF, 2,333 MTHM of DOE SNF, and 8,315 canisters of DOE HLW (equivalent to about 4,667 MTHM). [FEIS, p. S-78] This means that at the end of DOE's Proposed Action, in 2034, there would still be 42,000 MTHM of commercial SNF stored at 63 nuclear power plant sites in 31 states, 167 MTHM of DOE SNF stored at DOE sites in 4 states, and 13,965 canisters of DOE HLW (equivalent to about 6,833 MTHM) stored at DOE sites in 3 States. Additionally, all of the projected GTCC and SPAR wastes would also still be stored at 63 commercial and 4 DOE sites in 32 states. [FEIS, Pp. S-78, A-2 to A-16, and J-10 to J-22]

Because there are currently no plans for a second repository, the State of Nevada believes that DOE's Module 2 inventory is the most appropriate basis for assessing Yucca Mountain transportation impacts and risks. Nevada's analysis of DOE's proposed Yucca Mountain transportation system is therefore based on the 38-year (2010-2048) shipment numbers provided in Appendix J of the FEIS [Tables J-1, J-4, J-5, J-6, J-7, J-9, and J-27]

Yucca Mountain Shipment Modes and Numbers of Shipments

DOE's "mostly legal-weight truck scenario" is the only transportation scenario which is currently feasible. At present, there is no railroad access to Yucca Mountain. The feasibility of long-distance heavy haul truck (HHT) transport of rail casks is unproven. All 72 power plant sites and all 5 DOE sites can ship by legal-weight truck. If the repository goes forward, there would be more than 108,500 cross-country truck shipments of spent nuclear fuel and high-level radioactive waste over 38 years. That works out to 2,855 truckloads per year over 38 years. By comparison, over the past 40 years, there have been less than 100 shipments per year in the United States.*

Even if DOE is able to develop rail access, there would still be tens of thousands of shipments. DOE acknowledges that 25 of the 72 power plant sites cannot ship directly by rail. Nevada studies show that number could be up to 32 sites. The combined truck and rail total of commercial SNF shipments would be 36,400 if 25 sites ship by truck, and 42,300 if 32 sites ship by truck. All 5 DOE sites can ship by rail, and are projected to make 5,700 rail shipments over

38 years. The combined total of truck and rail shipments, from 72 utility sites and 5 DOE sites, would be 42,100 to 47,000, over 38 years, or an average of 1,100 to 1,240 per year.

In the FEIS, DOE designates the "mostly rail scenario" as the preferred mode for repository shipments. Under this scenario, 6 power plant sites would ship by truck, and all other sites would ship by rail, resulting in 3,122 truck shipments and 18,935 rail shipments, or a combined total of 22,057 cross-country shipments over 38 years. To this total must be added 3,000 barge shipments and 1,600 HHT shipments from 24 reactor sites, which cannot otherwise ship by rail. [FEIS, Pp. J-10 to J-12]

If there is no rail access to Yucca Mountain, there would be another 18,935 HHT shipments in Nevada, each of which would be considered a separate shipment requiring a separate State permit. If DOE ships by general freight service to a rail spur in Nevada, the casks will have to be switched out, parked on a siding, and reassembled into new trains. Assuming 3 to 5 casks per train trip to the repository, there would be an additional 3,800 to 6,300 rail shipments in Nevada. If DOE decides to use dedicated trains, averaging 3 casks per train, and makes direct deliveries to the repository via a new rail spur, the total number of rail shipments (as opposed to cask-shipments) could be reduced to about 6,300 over 38 years. The actual number of "shipments" under the "mostly rail scenario" could therefore range from 14,000 to 45,600, or an average of about 370 to 1200 per year, for 38 years.

However, all of the available evidence indicates that DOE's "mostly rail scenario" is unlikely to occur. The FEIS assumes that DOE can ship thousands of casks by barge into Boston, New Haven, Newark, Jersey City, Wilmington (DE), Baltimore, Norfolk, Miami, Milwaukee, Muskegon, Omaha, Vicksburg, and Port Hueneme (CA). Barge shipments would raise a host of concerns about accidents, including criticality accidents, terrorism, sabotage, and port security generally. The FEIS also assumes that DOE can make 1,600 cask shipments from reactors in 7 states to rail lines using 220-foot-long, slow-moving heavy haul trucks, each of which will require special state permits and route approvals.

The FEIS "mostly rail scenario" also assumes that DOE can construct a new rail spur to Yucca Mountain, 99 to 344 miles in length, at a cost of more than \$1 billion. Even the shortest of the five spur options would be the largest new rail construction project in the United States since World War I. Environmental approvals, right-of-way acquisition, and litigation could delay rail construction for 10 years or more. The alternative, delivery of large rail casks by 220-foot-long, heavy haul truck (HHT), over distances of 112 to 330 miles on public highways, is probably not feasible. HHT route constraints include highly congested segments through rapidly urbanizing areas, and steep grades and sharp curves through high mountain passes. All of the potential HHT routes would require substantial upgrading, and would likely cost more than a rail spur.

Moreover, certain programmatic and policy factors favor truck shipment, especially during the first 10-15 years of repository operations. DOE's "hot repository" thermal loading strategy may require truck shipment of 5 year-cooled SNF. Some utilities may exercise contract options to ship 5 year-cooled SNF from storage pools by truck, rather than shipping older SNF by rail. DOE's transportation privatization plan does not require transportation service providers to ship

oldest fuel first or to maximize use of rail. Indeed, under DOE's fixed-cost contracting approach to privatization, rail transportation may not be cost-competitive with legal-weight at many sites.

Yucca Mountain Transportation Routes

In the Draft EIS, DOE chose to conceal the specific routes used for impact and risk analyses in Chapter 6 and Appendix J. DOE did not identify the routes in its Federal Register notice nor in its public notices of scheduled hearings. During the public hearings that began in September, 1999, DOE provided some state-specific transportation maps at individual hearings around the country. But DOE did not release national maps showing the full cross country routes from shipping sites to Yucca Mountain until sometime in late January, 2000, near the end of the public comment process

In the Final EIS, DOE decided to reveal the routes used for risk and impact analysis. The DOE national map of highway routes is shown in Exhibit A. These routes were generated by the HIGHWAY computer model, and generally represent the quickest truck travel routes consistent with the current Federal routing regulations (HM-164). DOE refers to these as "representative routes." However, with two exceptions, DOE's cross-country routes agree with the highway routes identified in previous routing studies by DOE and Nevada contractors. Absent additional state designation of preferred alternatives or DOE policy decisions, we believe that these are the most likely highway routes to Nevada, with two notable exceptions.

In between publication of the Draft and Final EISs, the State of Colorado exercised its authority under U.S. DOT regulations to prohibit SNF and HLW shipments on I-70 west of Denver. Colorado took this action to avoid shipments through the Eisenhower and Glenwood Tunnels. Under the Colorado designation, shipments would be diverted north or south on I-25. Nevada routing analyses show that the new preferred route to Yucca Mountain for shipments using I-70 would be through the Northeastern Denver metropolitan area to I-25, then connecting with I-80 at Cheyenne, Wyoming. For reasons we do not understand, DOE's FEISmap has the trucks on I-70 turning north on I-29 to connect with I-680/I-80 near Omaha, so that the major stream of shipments from the Southeastern region avoids Colorado altogether. Preliminary analysis indicates that DOE's route choice could add more than 20 miles to each of tens of thousands of shipments, compared to the new preferred route in Colorado. We are continuing to study this route.

A second DOE highway route of concern was called to our attention by the State of Pennsylvania. DOE's FEIS map shows shipments from six reactor sites using the Pennsylvania Turnpike (I-76) West of Harrisburg. Pennsylvania authorities informed us that all placarded hazardous material shipments must use bypasses to avoid four tunnels along this segment of the Turnpike, and that no SNF shipments have ever used this route. It is not clear how DOE could have missed these restrictions, since the Pennsylvania bypass requirements are clearly stated in a U.S. DOT guidance document cited as a reference in the FEIS. We are continuing to study this route also.

Otherwise, DOE's FEIS routes agree with those identified by Nevada as most likely routes to Yucca Mountain. The primary truck routes out of New England and the Middle Atlantic states converge on I-80/90 near Cleveland, pick up shipments from Midwestern reactors, and follow I-80 west from Chicago through Des Moines, Omaha, Cheyenne, and Salt Lake City to I-15.

The primary truck routes out of the South are I-75 from Florida, I-24 from Atlanta, and I-64 from Virginia. These routes converge on I-70 near St. Louis, and follow I-70 west through Kansas City and Denver to I-25, then join I-80 near Cheyenne..

The primary route from the Pacific Northwest is I-84 to I-15 in Utah. Other major routes are I-40 and I-10 from the MidSouth and I-5 in California. These routes converge on I-15 in Southern California.

As with highway routes, DOE chose to conceal the rail routes analyzed in the Draft EIS DOE until late January 2000, near the end of the public comment process. In the Final EIS, DOE decided to reveal the rail routes used for risk and impact analysis. The DOE national map of rail routes is shown in Exhibit B. These routes were generated by the INTERLINE computer model, and generally represent the most direct routes to Nevada consistent with the current industry practice of maximizing freight-miles on the originating railroad.

Since DOE has not yet identified a preferred rail destination in Nevada, the map shows all potential cross-country routes from the 77 sites. For about 85 percent of the originating locations, the most likely route is unchanged by the Nevada destination. DOE's rail routes to Nevada generally agree with the rail routes identified in previous routing studies by DOE and Nevada contractors. While mergers and other rail industry developments would continue to affect routing, Nevada believes that the FEIS map shows the most likely rail routes to Nevada.

The primary rail routes out of New England and the Middle Atlantic states are the former Conrail mainlines from Buffalo and Harrisburg to Cleveland and Chicago. These shipments switch to the Union Pacific near Chicago, are joined by shipments from Midwestern reactors in Illinois and Iowa, and continue west via Fremont, Gibbon, Cheyenne, and Salt Lake City to Nevada.

The primary routes out of the South are the CSXT from Atlanta to East St. Louis, and the Norfolk Southern from Atlanta to Kansas City via Birmingham and Cairo. These two streams merge on the Union Pacific in Kansas City, and in turn merge with the northern UP shipments at Gibbon, Nebraska. Other major rail routes are the UP from Oregon via Boise, and the UP and BNSF from California and the Southwest via San Bernardino and Daggett.

The potential highway and rail routes identified in DOE's Final Environmental Impact Statement could affect 45 states and the District of Columbia. More than 123 million people currently live in the 703 counties traversed by DOE's highway routes, and 106 million live in counties along DOE's rail routes. DOE predicts that between 10.4 and 16.4 million people will live within one-half mile of a transportation route in 2035.

Yucca Mountain Routine Transportation Impacts

Ninety percent of the waste shipped to Yucca Mountain will be spent fuel from nuclear power plants. This irradiated reactor fuel gives off deadly, penetrating gamma and neutron radiation. Extraordinary precautions and effective shielding are required in order to safeguard workers and the public from its lethal effects. A person standing one yard away from an unshielded, 10 year old fuel assembly, for example, would receive a lethal dose of radiation (600 rem) in less than five minutes and would incur significant health damage in less than a minute.

NRC regulations allow a certain amount of neutron and gamma radiation to be emitted from shipping casks during routine operations and transport (1,000 mrem/hr at the cask surface and 10 mrem/hr 2 meters from the cask surface). The dose rate allowed under NRC regulations results in near-cask exposures of about 2.5 mrem per hour at 5 meters (16 feet), in measurable exposures (less than 0.2 mrem per hour) at 30 meters (98 feet), and calculated exposures (less than 0.0002 mrem per hour) at 800 meters (one-half mile) from the cask surface. [FEIS, p. J-38] Cumulative exposures at these rates can result in adverse health affects for some workers and some members of public. Moreover, the very fact that these exposures would occur has been shown to cause adverse socioeconomic impacts, such as loss of property values, even though the dose levels are well below the established thresholds for cancer and other health effects.

The FEIS acknowledges that routine radiation from shipping casks poses a significant health threat to certain transportation workers. In the most extreme example, motor carrier safety inspectors could receive cumulative doses (200 rem over 24 years) large enough to increase their risk of cancer death by 10 percent or more, and their risk of other serious health effects by 40 percent or more. DOE proposes to control these exposures and risks by severely restricting work hours and doses for certain jobs. [FEIS, Pp. J-44 to J-45]

Yucca Mountain Transportation Accident and Terrorism Impacts

In the Draft and Final EISs, DOE acknowledges that a very severe highway or rail accident, or a successful terrorist attack using high energy explosives, could release radioactive materials from a shipping cask, resulting in radiation exposures to members of the public and latent cancer fatalities (LCFs) among the exposed population

In the Draft EIS, DOE evaluated a " maximum reasonably foreseeable accident scenario" involving a rail at a generic urban location. Following the accident severity categories designated by the NRC Modal Study, DOE estimated the consequences of the most severe (category 6) rail accident using the RISKIND computer code. DOE estimated that the accident would release and disperse enough radioactive materials to inflict a collective population dose of 61,000 person-rem (enough to give 61,000 persons a one rem dose) and cause about 31 latent cancer fatalities.

In the Final EIS, DOE changed the basis of its transportation risk assessment, relying solely upon a controversial new NRC contractor report prepared by Sandia National Laboratories (NUREG/CR-6672). As a result, DOE's estimated consequence of the " maximum reasonably foreseeable accident scenario" involving a rail cask was reduced to a collective dose of 9,900 person-rem and 5 latent cancer fatalities. [FEIS, Pp. 6-45 to 6-47, 6-49 to 6-50]

The FEIS acknowledges that the July 2001 Baltimore rail tunnel fire was so severe that it would have resulted in a release of radioactive materials if a rail cask had been involved. [FEIS, p. 6-50] The FEIS also acknowledges that clean-up costs following a severe transportation accident could range from \$300,000 to \$10 billion. [FEIS, p. J-73]

As part of its review of the Draft EIS, the State of Nevada commissioned several SNF accident consequence analyses by Radioactive Waste Management Associates (RWMA). In 2000, RWMA reexamined the DEIS truck and rail accident estimates, using the RADTRAN and RISKIND computer models and a range of credible alternative assumptions. In 2001, RWMA estimated the consequences of a rail SNF accident similar to the July 2001 Baltimore rail tunnel fire. Also in 2001, RWMA studied the consequences of credible worst case truck and rail accidents at representative urban and rural locations along potential Nevada highway routes. These studies concluded that DOE systematically underestimated the consequences of severe transportation accidents. The results of these studies are reported in State of Nevada impact report, A Mountain of Trouble, which can be accessed on the web at www.state.nv.us/nucwaste, or obtained in hardcopy by request from the Nevada Agency for Nuclear Projects (phone: 775-687-3744).

The Nevada-sponsored study of the July 2001 Baltimore rail tunnel fire concluded that it would have resulted in significant release of radioactive materials. It burned for more than three days with temperatures as high as 1500°F. A single rail cask in such an accident could have released enough radio-cesium to contaminate an area of 32 square miles. Failure to cleanup the contamination, at a cost of \$13.7 billion, would cause 4,000 to 28,000 cancer deaths over the next 50 years. Between 200 and 1,400 latent cancer fatalities would be expected from exposures during the first year.

In both the Draft and Final EISs, DOE acknowledges that SNF truck casks are especially vulnerable to terrorist attack and sabotage. DOE and NRC testing in the 1980s demonstrated that a high-energy explosive device (HED) such as a military demolition charge could breach the wall of a truck cask. DOE sponsored a 1999 study of cask sabotage by Sandia National Laboratories (SNL) in support of the DEIS. The SNL study demonstrated that HEDs are "capable of penetrating a cask's shield wall, leading to the dispersal of contaminants to the environment." [DEIS, p. 6-33] The SNL study also concluded that a successful attack on a truck cask would release more radioactive materials than an attack on a rail cask. [DEIS, p. 6-34]

In the Draft EIS, DOE estimated that a successful attack on a GA-4 truck cask in an urbanized area under average weather conditions would result in a population dose of 31,000 person-rem, causing about 15 cancer fatalities among those exposed to the release of radioactive materials. In the Final EIS, DOE updated its sabotage analysis, assuming the cask contained more radioactive SNF and assuming a higher future average population density for U.S. cities. The Final EIS estimated that the same successful attack on a truck cask would result in a population dose of 96,000 person-rem and 48 latent cancer fatalities. [FEIS, Pp. 6-50 to 6-52] In neither case did DOE evaluate any environmental impacts other than health effects. In particular, DOE ignored the economic impacts of a successful act of sabotage in both the Draft and Final EIS.

Analyses prepared for Nevada by RWMA estimated sabotage impacts would be considerably greater than DOE's estimate. RWMA replicated both the Draft and Final EIS sabotage consequence analyses, using the RISKIND model for health effects and the RADTRAN model for economic impacts, the SNL study average and maximum inventory release fractions, and a range of population densities and weather conditions.

The Nevada-sponsored study of the Final EIS scenario concluded that an attack on a GA-4 truck cask using a common military demolition device could cause 300 to 1,800 latent cancer fatalities, assuming 90% penetration by a single blast. Full perforation of the cask, likely to occur in an attack involving a state-of-the art anti-tank weapon, such as the TOW missile, could cause 3,000 to 18,000 latent cancer fatalities. Cleanup and recovery costs would exceed \$10 billion.

Public perception of transportation risks could result in massive economic costs in communities along transportation routes. Even without an accident or incident, property values near routes could decline by 3% or more. In the event of an accident, residential property values along shipping routes could decline between 8% and 34 %, depending upon the severity of the accident.

Rail Shipments, Dedicated Trains, and Railroad Safety

Even if DOE is able to implement the "mostly rail" transportation plan, DOE's opposition to dedicated trains and other accident prevention measures raise grave concerns about DOE's commitment to transportation safety. The Association of American Railroads (AAR) has long contended that spent fuel should only be shipped in so-called special trains - dedicated or unit trains hauling only spent fuel and other radioactive materials, operating under special safety protocols such as speed restrictions (now 35 to 55 mph), buffer car specifications, and train passing rules.

Current USDOT regulations allow shipment of spent fuel casks in general freight service. The July 19-23, 2001, Baltimore rail tunnel fire has been cited as a prime example of the dangers of shipping spent fuel in mixed freight trains. The Baltimore fire has also rekindled calls for Federal regulation of spent fuel rail routing.

Nevada believes the following safety measures should be mandatory: (1) spent fuel should never be shipped in mixed freight trains; (2) spent fuel should always be shipped in dedicated trains; (3) these trains should operate under strict speed limits (35-55 mph) and special passing rules; (4) US DOT should regulate the selection of rail routes to minimize shipments through urban areas; (5) federal emergency response teams and security escorts should accompany all rail shipments at all times. DOE and the nuclear industry oppose these mandatory safety regulations.

Full-Scale Physical Testing for Spent Fuel Shipping Casks

NRC does not currently require full-scale physical testing of shipping casks as part of its certification process. Cask designers are allowed to demonstrate compliance with the NRC performance standards through a combination of scale-model testing and computer simulations. Nevada has long urged NRC to require full-scale testing as part of certification. Alternately,

Nevada has suggested that DOE require full-scale testing as part of the procurement process. NRC is currently proposing demonstration testing of a "representative" shipping cask as part of the Package Performance Study being conducted by Sandia National Laboratories. Nevada has not formally opposed NRC's proposal, but it is not an acceptable substitute for full-scale testing of each new cask design prior to certification.

Nevada has proposed a five-part approach to full-scale testing: (1) meaningful stakeholder participation in development of testing protocols and selection of test facilities and personnel; (2) full-scale physical testing (sequential drop, fire, puncture, and immersion) prior to NRC certification; (3) additional computer simulations to determine performance in extra-regulatory accidents and to determine failure thresholds; (4) reevaluation of previous risk study findings, and if appropriate, revision of NRC cask performance standards; and (5) evaluation of costs and benefits of destructive testing of a randomly-selected production model cask.

Nevada believes that comprehensive full-scale testing would not only demonstrate compliance with NRC performance standards. It would improve the overall safety of the cask and vehicle system, and generally enhance confidence in both qualitative and probabilistic risk analysis techniques. It could potentially increase acceptance of shipments by state and local officials and the general public, and potentially reduce adverse social and economic impacts caused by public perception of transportation risks.

Nevada estimates that the cost of a full-scale regulatory fire test for a truck cask would be less than \$5 million. Comprehensive regulatory testing (drop, fire, puncture, and immersion) of a truck cask (up to 30 tons) would be between \$8 million and \$15 million. Comprehensive regulatory testing of a large rail cask (up to 125 tons) would cost \$12 million to \$25 million for the first cask, including the cost of required upgrading at the testing facility. By comparison, Nevada estimates the life-cycle cost of the repository transportation system at about \$9.2 billion.

None of the SNF shipping casks currently used in the United States have ever been tested full-scale. This fact was confirmed by NRC Chairman Richard Meserve in a letter to Senator Harry Reid dated April 2, 2002. DOE has no plans for full-scale testing of the casks which would be used for shipments to Yucca Mountain. DOE and the nuclear industry oppose mandatory full-scale testing.

*There were about 3,025 shipments in the United States between 1964 and 1997, about 92 per year. Reliable estimates of worldwide cask-shipments, through 1998, range from 24,000 to 40,041. Most of the international cask-shipments moved in trains carrying multiple casks, so the actual number of shipments would be considerably less, but precise information is unavailable. The estimate of 40,041 cask-shipments worldwide was published by the International Atomic Energy Agency in July 1999 and includes the following country totals: United Kingdom, 28,854; U.S.A, 2,425; Germany, 1,612; France, 1,570; Japan, 1,399; and Sweden, 900. Source: R. Pope, IAEA, "International Experience with SNF/HLW Transport," Presentation before the U.S. National Academy of Sciences, National Transportation Research Board, Washington, DC, September 11, 2000.

Nevada's transportation studies are available on the web at www.state.nv.us/nucwaste/trans.htm

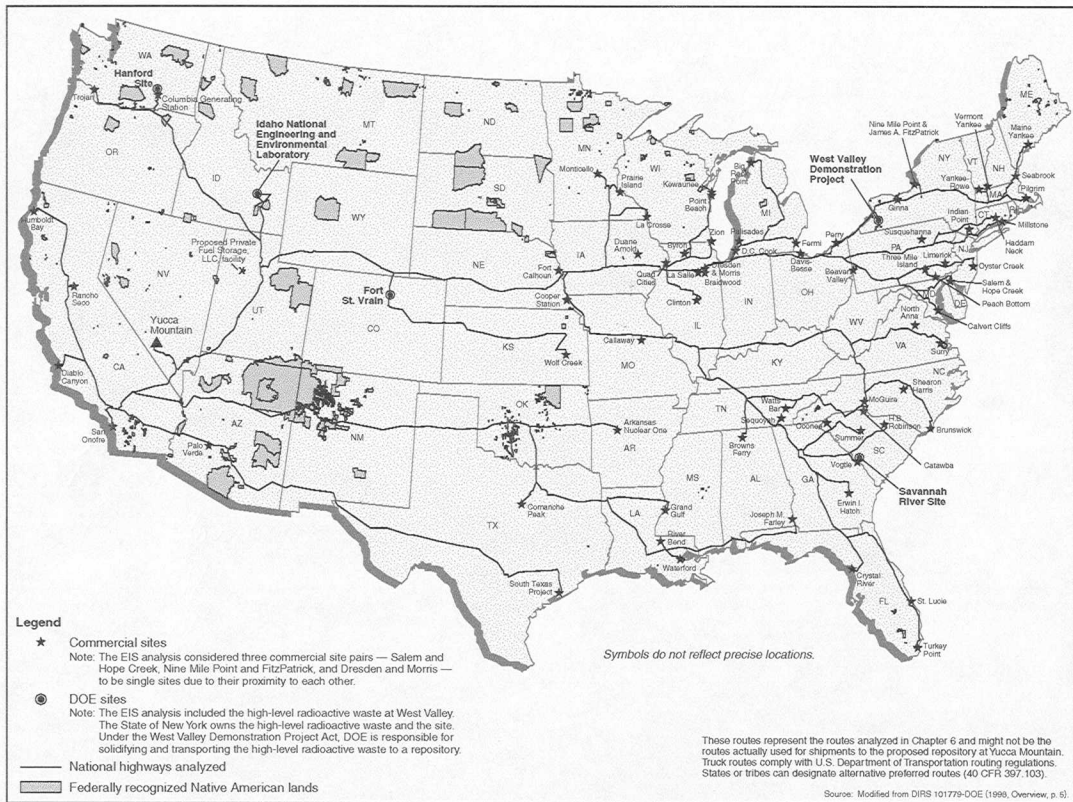


Figure J-5. Representative truck routes from commercial and DOE sites to Yucca Mountain analyzed for the Proposed Action and Inventory Modules 1 and 2.

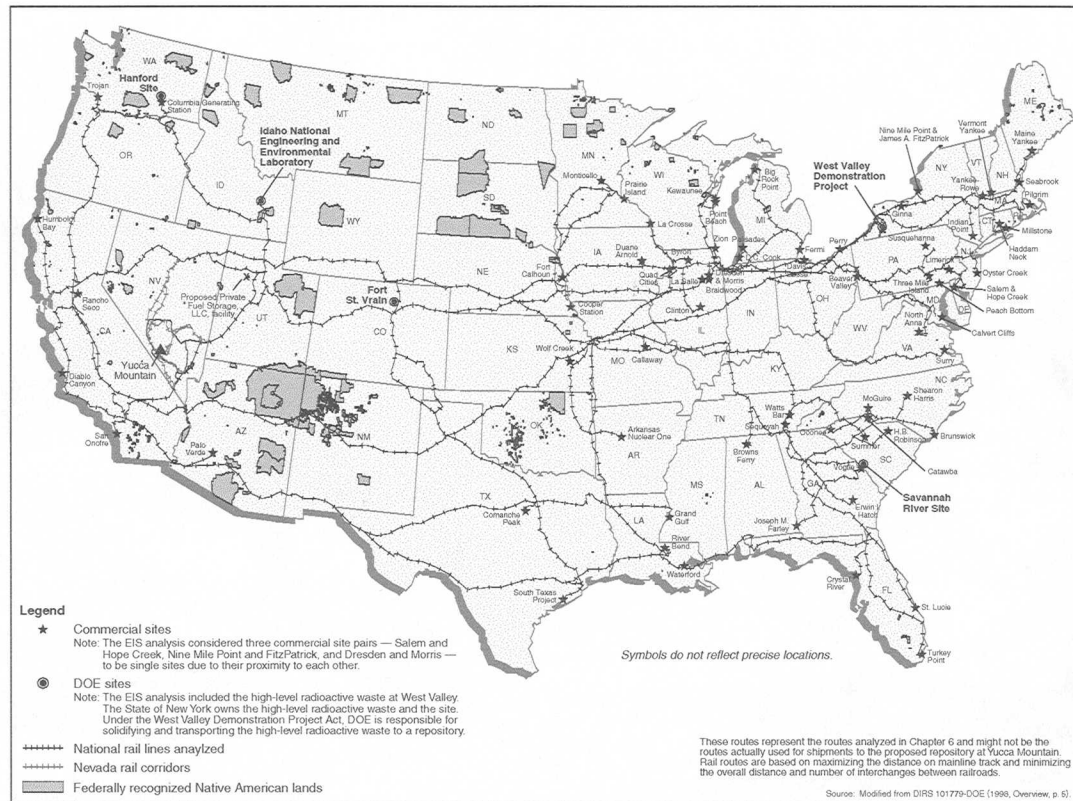


Figure J-6. Representative rail routes from commercial and DOE sites to Yucca Mountain analyzed for the Proposed Action and Inventory Modules 1 and 2.