NUREG-1437
Vol. 1, Addendum 1

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Main Report
Section 6.3—Transportation
Table 9.1 Summary of findings on NEPA issues for license renewal of nuclear power plants

Final Report

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

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Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
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ABSTRACT

This addendum to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* documents the staff's analysis of the potential cumulative impacts of transporting spent nuclear fuel in the vicinity of a single high-level waste repository, and summarizes the staff's analyses undertaken to determine whether the environmental impacts of the transportation of higher enrichment and higher burnup spent nuclear fuel are consistent with the values of 10 CFR 51.52, Table S-4. The intent of the study is a generic analysis of the cumulative impacts associated with transportation of spent nuclear fuel as a result of nuclear power plant license renewal. The results of the analysis will be used to amend 10 CFR Part 51.53 and Appendix B to Subpart A of 10 CFR Part 51, and is not intended to support any other regulatory decision by the NRC. This addendum also includes an appendix that summarizes comments on the draft of the addendum, and documents the staff's responses to those comments.

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ACRONYMS AND ABBREVIATIONS

CFR	*Code of Federal Regulations*
cm	centimeter
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EIS	environmental impact statement
FR	*Federal Register*
ft	foot
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437)*
HLW	high-level waste
in	inch
km	kilometer
lb	pound
LRFC	lifetime risk of fatal cancer
m	meter
mrem	millirem
mSv	millisievert
MTHM	metric tons of heavy metal (a conventional unit for high-level nuclear waste)
MT	metric ton [i.e., 1000 kilograms (about 2200 pounds)]
MTU	metric tons uranium
MWd	megawatt-days
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
SNF	spent nuclear fuel
Sv	sievert

1. INTRODUCTION

1.1 PURPOSE OF THE ADDENDUM

This Addendum to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, May 1996, supplements the analyses reported in Section 6.3 "Transportation," and especially Section 6.3.2, "Table S-4–Environmental Impacts of Transportation of Fuel and Waste to and From One Light-Water-Cooled Nuclear Power Reactor" of that report. The analyses reported in this addendum specifically address whether the environmental impacts of the transportation of higher enrichment and higher burnup spent nuclear fuel are consistent with the values of 10 CFR 51.52, Table S-4 as applicable to license renewal, continue to be applicable given that it is likely that spent fuel will be shipped to a single destination, such as the proposed repository at Yucca Mountain in Nye County, Nevada, and given that spent fuel shipments will involve higher enrichment and higher burnup fuel than was assumed in calculating the impacts shown in Table S-4. The analyses reported in this Addendum provide the basis for amending the U.S. Nuclear Regulatory Commission's (NRC) regulations for addressing the environmental impacts associated with the transportation of fuel and waste to and from a commercial nuclear power plant within the context of the license renewal review process. The amendment is to the provisions in 10 CFR 51.53(c) and in Appendix B to Subpart A of 10 CFR Part 51 which specify how Table S-4 is to be used in individual license renewal reviews. The values in Table S-4 are found to be bounding when accounting for spent fuel shipments to a single destination and for the shipment of higher enriched and higher burnup fuel. The amendment affects only the provisions in §51.53(c) and Appendix B to Subpart A that govern the use of impact values codified in 10 CFR 51.52 as it applies to reviews to renew the operating license of individual nuclear power plants. It is not intended that this Addendum support any other regulatory decision by the NRC.

1.2 SCOPE OF THE ADDENDUM

In NUREG-1437, Section 6.3 ("Transportation"), the radiological and nonradiological environmental impacts resulting from transportation of low-level radioactive waste and mixed waste[1] to off-site disposal facilities and of spent fuel to a monitored retrievable storage facility or a permanent repository were assessed. The environmental impacts from the transportation of fuel and waste attributable to license renewal were found to be small when they are within the impact parameters identified in 10 CFR 51.52. The findings in NUREG-1437 were codified in an amendment to 10 CFR Part 51 published in the *Federal Register* on June 5, 1996 (61 FR 28467). Public comments were solicited on the use of Table S-4 and several other areas of the final rule. This comment process identified two questions that should be addressed generically rather than requiring each license renewal applicant to address them individually. The first question is whether the environmental impact values contained in Table S-4 are still appropriate for use in license renewal reviews if spent fuel is transported to a single destination such as the candidate repository at Yucca Mountain, Nevada, even though the values in Table S-4 were developed from data reflecting spent fuel

[1]Mixed waste is low-level radioactive waste that also contains chemically hazardous constituents.

shipments to several destinations. The second question is whether the environmental impact values contained in Table S-4 are still appropriate for use in license renewal reviews given that applicants will be shipping spent fuel that is more highly enriched and irradiated longer than is accounted for in the analysis to develop Table S-4. Paragraph 51.52(a) requires a plant-specific analysis of transportation impacts if the uranium-235 enrichment exceeds 4 percent or if the average level of irradiation exceeds 33,000 megawatt-days per metric ton of uranium (MWd/MTU). The analyses in this Addendum are limited to these two questions. Numerous public comments that question the scope of the analyses were submitted on the draft Addendum. These comments and the NRC responses found in Appendix 1 provide further understanding of the purpose and scope of this Addendum to NUREG-1437.

1.3 BACKGROUND

On June 5, 1996, the Commission published in the *Federal Register* (61 FR 28467) a final rule amending its environmental protection regulations in 10 CFR Part 51 to improve the efficiency of the process of environmental review for applicants seeking to renew a nuclear power plant operating license for up to an additional 20 years. The rulemaking was based on the analyses reported in NUREG-1437 and was initiated with the objectives of (1) improving the efficiency of the license renewal process by drawing on the considerable experience of operating nuclear power plants in generic assessments of many of the environmental impacts, (2) reporting the analyses and findings in NUREG-1437, (3) codifying the findings in the Commission's environmental protection regulations so that repetitive reviews of those impacts that are well understood could be avoided.

In the statement accompanying the final rule, the Commission solicited comments on the treatment of low-level waste storage and disposal impacts, the cumulative radiological effects from the uranium fuel cycle, and the effects from the disposal of high-level waste (HLW) and spent fuel. The final rule would not become effective until these comments had been considered. A number of commentors argued that the requirements for the review of transportation of high-level waste in the rule were unclear with respect to (1) the use and legal status of 10 CFR 51.52, "Environmental effects of transportation of fuel and waste—Table S-4," in plant-specific license renewal reviews; (2) the conditions that must be met before an applicant may adopt Table S-4; and (3) the extent to which the generic effects of transporting spent fuel to a high-level waste repository should be considered in a plant-specific license renewal review.

After considering the comments received on the rule, the Commission republished the rule in the *Federal Register* on December 18, 1996 (61 FR 66537). The rule at 10 CFR 51.53(3)(c)(ii)(M) continued to require that "The environmental effects of transportation of fuel and waste shall be reviewed in accordance with 10 CFR 51.52." However, because of the comments received, the Commission added to that paragraph the requirement that

> The review of impacts shall also discuss the generic and cumulative impacts associated with transportation operation in the vicinity of a high-level waste repository site. The candidate site at Yucca Mountain should be used for the purpose of impact analysis as long as that site is under consideration for licensing.

Also in response to the comments, the Commission stated that

> As part of its effort to develop regulatory guidance for this rule, the Commission will consider whether further changes to the rule are desirable to generically address: (1) the issue of cumulative transportation impacts and (2) the implications that the use of higher burn-up fuel have for the conclusions in Table S-4. After consideration of these issues, the Commission will determine whether the issue of transportation impacts should be changed to Category 1.[2]

Chapter 6 of NUREG-1437 addresses the environmental impacts associated with the management of radiological and nonradiological wastes resulting from license renewal. Section 6.3, "Transportation," addresses the environmental impacts resulting from the shipment of (1) low-level radioactive waste and mixed waste[3] to off-site disposal facilities, (2) fresh fuel to the plant, and (3) spent nuclear fuel (SNF) from the plant to a monitored retrievable storage facility or permanent repository. Section 6.3 also provides an assessment of the applicability to license renewal of 10 CFR 51.52. In Section 6.3.4, the NRC concluded that "The environmental impacts from the transport of fuel and waste attributable to license renewal are found to be small when they are within the range of impact parameters identified in Table S-4." This finding was codified in Table B-1, "Summary of findings on NEPA issues for license renewal of nuclear power plants," of Appendix B to Subpart A of 10 CFR Part 51 in order to extend the use of Table S-4 to license renewal reviews. There were, however, certain circumstances not accounted for in the original analyses supporting Table S-4 and not adequately treated in the 1996 amendment for license renewal.

Summary Table S-4 was published in 10 CFR Part 51 to be used by an applicant for a nuclear power plant construction permit in its environmental report and by the NRC in its environmental impact statements. Table S-4, which accounts for the environmental effects of transportation of fuel and waste to and from the nuclear power plant, was intended to be a generic statement of transportation impacts that can be adopted in the review of any plant, as long as certain conditions identified in Part 51 are met. The environmental impact values in Table S-4 were developed from information available from actual shipments from nuclear power plants to a number of different destinations. Because a single destination at Yucca Mountain is now under consideration, it is necessary to determine whether it is reasonable to continue using the environmental impact values in Table S-4 in license renewal reviews. This Addendum provides the assessment to make that determination.

The environmental implications of the use of more highly enriched and higher burnup fuel than is considered in 10 CFR 51.51 (Table S-3) and in 10 CFR 51.52 (Table S-4) are assessed in NUREG-1437, Section 6.2.3. However, the analysis and conclusions relative to Table S-4 are not brought forward to Section 6.3, "Transportation." This Addendum corrects that omission and expands the assessment of the impacts of transportation of higher

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[2] In NUREG-1437 and in the rule, Category 1 issues are those environmental issues for which the analysis and findings have been determined to be applicable to all nuclear power plants or to plants with specific types of cooling systems or other common plant or site characteristics. Absent new information that significantly changes the finding, these generic findings may be adopted in plant license renewal reviews. Category 2 issues are those environmental issues for which the analysis did not result in a finding common to all plants or to plants with common characteristics. Plant-specific reviews are required for Category 2 issues.

[3]Because only the radiological aspects of transportation are of interest here, in the remainder of this report, mixed waste will not be distinguished from other low level-waste.

enriched and higher burnup fuel. Previously, if fuel enrichment was to exceed 4 percent and burnup was to exceed 33,000 MWd/MTU during the license renewal period, the applicant had to provide a full review of the environmental impacts of transportation of fuel and waste to and from the reactor. For a number of years, licensees have been moving to the use of higher enriched fuel and longer burnup of that fuel than was specified for Table S-4. This Addendum contains an assessment of transportation of fuel having a uranium-235 enrichment of up to 5 percent and irradiated up to 62,000 MWd/MTU. That assessment indicates that the values shown in Table S-4 continue to be a reasonable estimate of environmental impacts of transportation of fuel and waste for the purpose of license renewal reviews.

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2. CUMULATIVE IMPACTS OF SPENT NUCLEAR FUEL TRANSPORTATION

The purpose of this analysis is to determine whether the Commission can reach a generic conclusion about the cumulative impacts of spent fuel transport in the vicinity of a repository due to the renewal of a nuclear power plant operating license. If the Commission can reach such a conclusion, the issue can be designated a Category 1 issue and the finding codified in 10 CFR Part 51. For an issue to be designated Category 1, the following criteria must be met:

> (1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic;
> (2) A single significance level (i.e., small, moderate, or large) has been assigned to the impacts (except for collective off site radiological impacts from the fuel cycle and from high level waste and spent fuel disposal[4]); and
> (3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

Section 2.1 is a description of the status of the Yucca Mountain site as a potential geologic repository in order to provide a context for the analysis.[5] Section 2.2 describes the approach employed by the NRC staff to analyze the cumulative effects of SNF transport in the vicinity

[4]This exception only applies to the two entries in Table B-1 labeled "Offsite radiological impacts (collective effects)" and "Offsite radiological impacts (spent fuel and high level waste disposal).

[5] Any generic conclusions by the Commission concerning the cumulative impacts of transportation associated with nuclear power plant license renewal would in no way affect any U.S. Department of Energy (DOE) decision concerning the suitability of Yucca Mountain, any consideration that DOE may give to transportation impacts in making that decision, and is not intended to support any other regulatory decision by the NRC.

of the proposed repository due to the renewal of a nuclear power plant operating license. Section 2.3 presents the results of those analyses, Section 2.4 discusses impacts of additional radioactive waste shipments, and Section 2.5 presents a summary of SNF transport impacts. Finally, Section 2.6 examines the potential for environmental justice issues related to radioactive waste transport in Clark County, Nevada.

2.1 BACKGROUND ON THE PROPOSED HLW REPOSITORY

The Nuclear Waste Policy Act of 1982 (NWPA) gave the U.S. Department of Energy the responsibility for finding a site for disposal of commercial SNF and other high-level waste, and for building and operating an underground disposal facility called a geologic repository. In 1987, Congress amended the NWPA and directed DOE to study only Yucca Mountain, Nevada, to decide whether it is suitable for a repository for high-level nuclear waste. Under the NWPA, DOE has been studying Yucca Mountain for 15 years as a potential geologic repository for the disposition of the nation's spent nuclear fuel and high-level radioactive waste. However, a number of decisions remain to be made before Yucca Mountain could ever be considered for development of a repository; any one of these decisions can stop the approval process. The Secretary of Energy plans to make a decision in 2001 on whether to recommend the site to the President for development as a repository. If DOE finds the Yucca Mountain site suitable and recommends the site, then the President must decide whether to recommend the site to Congress. If the President recommends the site and if Nevada submits a notice of disapproval, then Congress must decide whether to allow the recommendation of the President to take effect. Only if the decisions remaining to be made ultimately support development of a repository at Yucca Mountain, then DOE would submit a license application to the NRC. If the repository is licensed, then SNF and HLW would be shipped to the site using only NRC-certified transportation packages.

2.2 APPROACH TO ANALYSIS

The staff's overall approach was to use NRC's current knowledge base and transportation experience, to develop assumptions that reasonably estimate and bound the risks associated with the increased number of spent fuel transports that might occur if license renewal of nuclear power plants were to occur. These assumptions are generic in nature, meaning they could be applied to any licensed nuclear power plant. The NRC staff made a number of 'conservative' assumptions, which means that the assumptions would lead to an overestimate of what the NRC staff believes to be the actual impacts. Examples of where the NRC staff believes conservative assumptions have been used appear later in this section. The goal is for the results to be used by a license renewal applicant as it would any other Category 1 issue.

In accordance with the NWPA, DOE is required to prepare an environmental impact statement (EIS) for Yucca Mountain. The EIS will consider the proposal to construct, operate, and eventually, close a repository at Yucca Mountain. See DOE Notice of Intent (60 FR 40164). DOE is expected to assess national and regional (i.e., within the State of Nevada) transportation options that cover the full range of operating conditions relevant to potential impacts to human health and the environment.[6] In its response to public scoping comments, DOE indicated that its draft EIS transportation analysis would include both truck and rail transport, and use Department of Transportation routing regulations and representative routes and actual route characteristics. Thus, DOE's expected transportation analyses will be detailed; however, DOE does not plan to complete its final EIS until 2000. DOE recently issued its draft EIS for a 180-day public comment period beginning on August 13, 1999.

This analysis aims to address the cumulative impacts of SNF transportation to a HLW repository from a generic perspective.[7] Because Congress, at this time, has directed DOE to study only Yucca Mountain for the proposed repository, the NRC staff began with the assumption that all SNF would be transported through Clark County, Nevada (i.e., the Las Vegas area) en route to the repository. This assumption is conservative in several ways. First, current law would not allow more than 70,000 metric tons of heavy metal (MTHM), with an estimated ~63,000 MTHM of that total being from commercial SNF, to be disposed of at Yucca Mountain. Nevertheless, the NRC staff used estimates of quantities of SNF that would need to be disposed of that are considerably larger than the 63,000 MTHM for the purpose of evaluating the entire inventory of SNF produced by nuclear power plants. Second, there are other routes to Yucca Mountain rather than through Clark County, but none of the other routes would encounter as high a population as found in Clark County. The NRC staff also adopted this assumption because—whether Yucca Mountain or another site is selected for a repository— estimates of transportation impacts are maximized in the case where all SNF is transported through a major metropolitan area. The NRC staff believes it important to emphasize that, while conservative, the assumption may not be at all representative or realistic.

Transportation to Yucca Mountain or another repository site may make heavy use of rail transportation, for example, because rail transport is expected to be less costly than truck transport. The overall radiological impacts of rail as compared to highway shipments may be lower. In part, this is because of the higher capacity of rail cars which allow fewer shipments and because population densities along most rail routes are typically lower than along the interstate highways that trucks would use to transport SNF. Additionally, when non-radiological accident rates between truck and rail shipments are normalized for payload size and mileage, the accident rate for rail shipments is about 3 percent of the comparable accident rate for truck shipments (Dyer and Reich1993). Evaluation of cumulative impacts in the vicinity of Las Vegas carried out in this analysis, therefore, represents an upper bound because it assumes all SNF would move by legal-weight truck rather than by rail or by a combination of rail and truck to reach the repository.[8] Further, to ensure that the impacts

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[6] DOE's Notice of Intent indicates that its analyses of impacts of regional transportation issues will include (a) technical feasibility, (b) socioeconomic impacts, (c) land use and access impacts, and (d) impacts of constructing and operating a rail spur, a heavy haul route, and/or a transfer facility. 60 FR 40168.

[7] After DOE's publication of the final EIS for Yucca Mountain, the Commission will consider whether the information contained therein would be considered new and significant in the context of decisions related to the renewal of nuclear power plant operating licenses such that some additional action may be required.

[8] The NRC staff did not consider conservative analyses that would be outside the reasonable range of assumptions, e.g., routing shipments on indirect routes through densely populated areas. While the NRC staff did make many conservative assumptions, consistent with U.S. Department of Transportation regulations for highway route controlled quantities of nuclear materials (49 CFR 397.101), the NRC staff assumed that the

estimated here are conservative, the NRC staff assumed that shipments would be by legal-weight trucks rather than heavy-haul trucks because fewer shipments would be required if heavy-haul trucks were used.

To examine the effects of license renewal, the NRC staff used two estimates of SNF that would be transported to the repository. The first was based on the assumption that no nuclear plants have their licenses renewed, and the second was based on the assumption that all existing nuclear plants would operate for the full duration of a 20-year license renewal period. This means that the amount of SNF shipped for the license renewal case was assumed to be 50 percent greater than the amount of SNF for the no-license renewal case. The assumption used for the license renewal estimate is conservative because some plant owners have already decided not to request renewal of plant operating licenses.

As noted above, the NWPA prohibits DOE from accepting more than 70,000 MTHM of HLW at the Yucca Mountain repository, only 63,000 MTHM of which would be SNF. Based on this limit, DOE estimates on the order of 37,600 truck shipments of SNF to Yucca Mountain, assuming all SNF travels by truck in legal-weight casks (K. Skipper, Yucca Mountain Site Office, personal communication to D. P. Cleary, NRC, July 11, 1997). For this analysis, the NRC staff assumed that all current and committed SNF, about 84,000 MTHM, would be disposed of at Yucca Mountain. [The Nuclear Waste Technical Review Board (1997) made a very similar estimate of current and committed SNF.] Using DOE's estimated number of shipments and the total amount of SNF leads to an estimate of the order of 50,000 truck shipments without license renewal. Assuming all plants renew their licenses and operate for an additional 20 years, the estimate is on the order of 75,000 truck shipments.[9]

The analysis used the RADTRAN computer code (Section 2.2.3) to estimate the radiation doses to the people of Clark County and to transportation workers. The route and population density numbers used by RADTRAN computer code were generated by the HIGHWAY computer code and modified by the NRC staff to account for population growth (Section 2.2.1). The human health implication of the radiological exposures were estimated by use of BEIR V radiation-dose-to-cancer-risk factors (Section 2.2.3). The risk of non-radiological accidents were estimated by using U.S. Department of Transportation statistics (Section 2.3.2).

2.2.1 Transportation and Route Scenarios

The HIGHWAY computer code (Johnson et. al. 1993) was used to select routes. The HIGHWAY computer code models the U.S. highway system. Its data base includes all interstates, most U.S. highways, and many State, county, or local roadways. It represents about 380,000 km [240,000 miles] of roadway. Several different routing options are available in the highway program, including probable commercial routes, routes on the interstate highway system, routes that bypass major urban areas, and preferred routes designated by the States. Additional detailed routing analysis can be performed by blocking individual or

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trucks would be routed on interstate highways to the maximum possible extent.

[9] Although these estimates exceed the 70,000 MTHM limit for the first repository in the NWPA, they represent conservative assumptions (i.e., overestimates) that would define an upper bound of potential impacts for a repository at Yucca Mountain.

sets of highway segments or intersections contained in the data base, a feature the NRC staff utilized to analyze the downtown routes.

The selection of preferred routes assumes that each shipment consists of highway-route-controlled quantities of radioactive materials. Travel time is optimized based on maximum utilization of the interstate highway system, with preference given to bypasses around major cities, except where alternate routes have been designated by state officials. Selected information considered by the NRC staff in using the HIGHWAY computer code is given in Appendix 2. These inputs and outputs provide a detailed listing of each highway route as well as mileage and population density zones considered in the analysis.

A beltway is being constructed in Clark County (Clark County 1997) which is expected to consist of three connected segments including a southern, western, and northern route; these segments will create a freeway “ring” around the Las Vegas Valley to route vehicles around, rather than through, the congested urban core (Figure 1). The southern segment of the beltway is being built in sections, with each segment opening to traffic upon completion. The first phase of the project, from I-15 to McCarran Airport (Airport Connector), was opened in 1994. The second section, from Warm Springs Road to Windmill Lane, opened to traffic in Oct. 1995. In Feb. 1997, the third portion of the project— from Windmill Lane to Eastern Ave.—became fully operational. The fourth section of the southern beltway, Eastern Ave. to Pecos Road, was completed in 1997.

The proposed northern and western beltway is expected to be a 10-lane facility with adequate right-of-way to permit construction of a fixed guideway facility (e.g., a commuter rail line). This is called the “ultimate facility” and will require a right-of-way width of 107 to 137 m [350 to 450 ft], plus land for interchanges or access to other transportation facilities.

Because the beltway is expected to be complete before the repository begins operation and because regulations require that spent fuel shipments use bypasses where possible, analysis of transportation on the route through downtown on the current interstate system yields higher exposure estimates than might actually occur. In addition, there are two plausible routes into Clark County; from the south on I-15, and from the northeast on I-15. SNF from western and southwestern states would likely arrive via the southern route. SNF from eastern states would likely arrive via the northeastern route. To ensure that the conclusions of this analysis are conservative, the NRC staff analyzed scenarios in which all SNF arrived via the northeastern route and scenarios in which all SNF arrived via the southern route. The combination of the northeastern and southern scenarios, and the downtown and beltway scenarios gives four transportation route scenarios that were analyzed by the NRC staff.

The NRC staff analyzed the potential impacts of SNF transport along the four routes (illustrated in Figure 2). The route named “from the northeast through downtown” starts at the Arizona-Nevada state line and follows I-15 to near downtown Las Vegas and then proceeds northwest on U.S. 95 beyond the northwestern corner of Clark County, Nevada. The route named “from the south through downtown” starts at the California-Nevada state line and proceeds north on I-15 to near downtown Las Vegas and then proceeds northwest on U.S. 95 through the northwestern portion of Clark County. The other routes are similar to the first two except each route will use the I-215 beltway that is currently planned and under construction around the north, west, and southern portions of the Las Vegas metropolitan area. The route named “from the northeast using the beltway” follows I-15 from the

Figure 1. Proposed Las Vegas beltway. *Source:* Clark County Department of Public Works informational drawing, http://www.co.clark.nv.us/PUBWORKS/gif/beltmap.jpg (accessed Oct. 14, 1997).

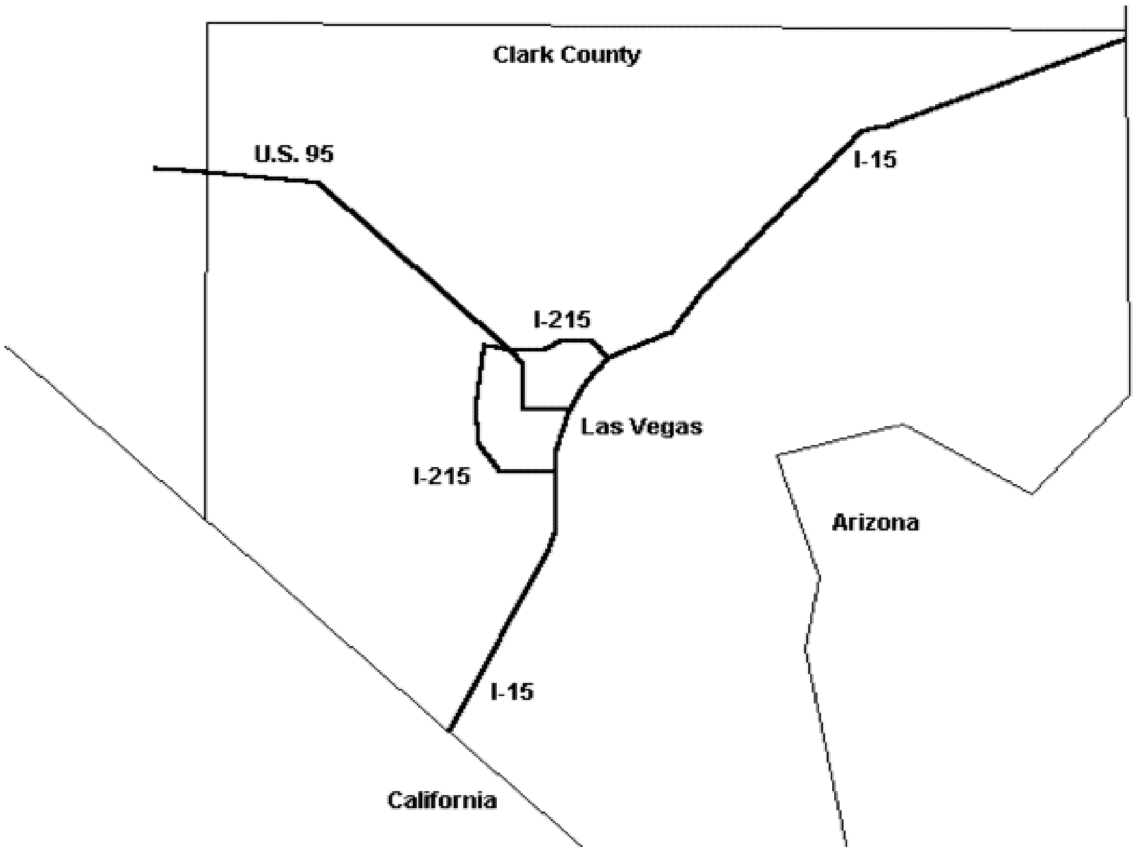

Figure A.2. Routes analyzed in this study. 1 = from the northeast through downtown (I-15 to 95), 2 = from south through downtown (I-15 to 95), 3 = from the northeast using the Beltway (I-15 to I-215 to 95), 4 = from the south using the Beltway (I-15 to I-215 to 95).

Arizona-Nevada border to the northeastern part of the Las Vegas metropolitan area and then follows the planned I-215 across the northern portion of Las Vegas. In the northwestern part of the Las Vegas metropolitan area, the route exits I-215 and continues northwest on U.S. 95 out of Clark County. The route named "from the south using the beltway" follows I-15 from the California-Nevada border to Las Vegas, near the southwestern corner of the McCarran International Airport and then proceeds west and then north on I-215. At the junction with U.S. 95, the route leaves I-215 and proceeds northwest out of Clark County.

2.2.2 Analysis of Routes Using the HIGHWAY Model

The total travel distance, the fraction of travel in each population density zone, and the average population density of each zone are necessary inputs to the RADTRAN computer code. HIGHWAY computer code was run using 1990 census block group data, the latest suitable data available. For each route segment, the HIGHWAY computer code uses the characteristics and populations of the census block to assign the segment to one or more of 12 population density zones. For each route segment, the NRC staff reassigned the route segment to higher population density categories in an attempt to represent future population growth of Clark County. The routing data from the HIGHWAY computer code, which makes use of 12 population density zones, were collapsed into 3 zones (i.e., rural, suburban, and urban) to simplify the analysis performed by the RADTRAN computer code. The results of the process are displayed in Table 1. The columns entitled "1990 population" display the input that the RADTRAN computer code would have considered based on 1990 Census data. The columns entitled "Future population" display the input that was considered using the RADTRAN computer code analysis for this Addendum. The parameters in the "future population" columns are based only on the staff's anticipation of substantial future population growth. Given that SNF shipments would occur over perhaps 40 to 60 years beginning about 2010, forecasting of population densities and highway routes are more reasonable assumptions than relying on the populations reported in the 1990 Census.

2.2.3 The RADTRAN Model

The RADTRAN computer code (Neuhauser 1984, 1992) was used to model the incident-free radiological exposure and the probabilities and consequences of radiological releases resulting from accidents. The incident-free risks are dependent on the radiation dose rate from the shipment, number of shipments, package dimensions, route distance, vehicle speed, and population densities along the travel routes. The accident risks are dependent on the radiological inventory, accident severity, probability of occurrence for each accident category, and the amount of inventory of radioactive material released, aerosolized, and inhaled, as well as the dispersibility of the material based upon the chemical and physical properties. Selected information considered by the NRC staff in using the RADTRAN computer code is given in Appendix 3.

For incident-free transportation, the RADTRAN computer code calculates total body doses for the transport crew and for the general public. The NRC staff assumed that the radiation source is characterized for the analysis by the radiation dose rate at 1 m from the transportation package surface. The regulatory limit found at 49 CFR 173.441 is 0.1 mSv/hour [10 mrem/hour] at 2 m [6.6 ft] from the outer lateral surfaces of the vehicle. The NRC staff assumed 0.13 mSv/hour [13 mrem/hour] at 1 m [3.3 ft] rate because it corresponds to 0.10 mSv/hour [10 mrem/hour] at 2 m [6.6 ft], the regulatory limit. This analysis used the conservative assumption that for all shipments the radiation level would be at exactly the regulatory limit. Based on shipping experience, actual radiation levels are expected to be lower than the regulatory limit level that was assumed in this analysis.

The NRC staff made the conservative assumption that the transport crew consists of four people, two in the cab of the truck and two in an escort vehicle. The NRC staff assumed that each of these persons would be exposed at the 0.02 mSv/hour (2 mrem/hour) regulatory limit (found at 49 CFR 177.842) that applies in the cabs of motor vehicles. The people in the vehicle would realistically be expected to receive substantially less dose than the escort drivers because the occupants of the escort vehicle would be farther from the SNF package than the drivers. The NRC staff also made the conservative assumption that the escort vehicle and its two occupants would accompany the truck the entire time it was in Clark County. This assumption results in the situation where the escort vehicle accompanies the truck for a longer distance than required by NRC. Consequently, these assumptions lead to an overestimate of the doses to the transport crew.

Table 1. Transportation route parameters for RADTRAN analysis

		1990 population [a]		Future population [b]	
	Roadway population density zone [c]	Distance (km)	Average population density (persons/km^2)	Distance (km)	Average population density (persons/km^2)
From northeast using beltway	Rural	217.6	1.9	183.6	3.8
	Suburban	1.3	89.8	23.0	453.3
	Urban	0.0	NA	12.2	2505.6
	Total [d]	218.9		218.9	
From northeast through downtown	Rural	204.5	1.7	183.8	3.9
	Suburban	14.3	604.6	31.4	463.5
	Urban	11.3	2,231.8	15.0	2531.9
	Total [d]	230.1		230.1	
From south through downtown	Rural	141.5	2.2	118.0	6.2
	Suburban	15.4	431.8	25.1	371.2
	Urban	8.9	2259.6	22.7	3210.3
	Total [d]	165.8		165.8	
From south using beltway	Rural	149.8	3.8	118.0	6.2
	Suburban	24.8	342.9	33.2	491.3
	Urban	2.6	1764.7	25.9	2498.0
	Total [d]	177.0		177.0	

[a] Based on the HIGHWAY computer code analysis of 1990 Census data.

[b] Based on NRC staff estimate of future population densities along routes. The NRC staff used these values in the RADTRAN computer code analyses.

[c] "Rural" is defined as populations less than 54 persons/km^2 (140 persons/mi^2). "Suburban" is defined as population densities between 54 and 1,284 persons/km^2 (140 and 3325 persons/mi^2). "Urban" is defined as population densities greater than 1,284 persons/km^2 (3325 persons/mi^2).

[d] Totals may not match sums of entries because of rounding.

In comments on the draft Addendum 1, the public expressed concerns about radiation doses to truck inspectors at ports of entry and doses to the public during periods when the highways are particularly congested. While there are a number of ways to reduce the magnitude of such exposures, the NRC staff introduced two additional conservative assumptions into the RADTRAN computer code analysis to account for these concerns. First, the NRC staff assumed that the trucks would travel at lower speeds than is typical for interstate highway travel; 55 mph in rural areas, 25 mph in suburban areas, and 15 mph in urban areas. Second, the NRC staff assumed that the trucks made stops at a rate of 0.011 hours/km of travel. Because each truck traveled at least 165.8 km (104 mi), every truck was assumed to stop for at least 1.8 hours (109 minutes). Further, the NRC staff assumed that for the entire stop period, 30 members of the public were located 20 m (66 feet) from the truck, and that all members of the transport crew continued to receive 2 mrem/hour during the stop. As a practical matter, the NRC staff believe that these conditions would seldom be exceeded for an individual shipment, and that typical shipments would move at normal highway speeds throughout the urban and suburban areas, and that shorter, less frequent stops would be the norm.

Each truck shipment of multiple fuel assemblies was modeled as a single package with a homogeneous distribution of the radiological inventory. Both point- and line-source approximations were used based upon the distance between the exposed individuals and the radiation source. The characteristic dimension (known in the RADTRAN computer code as the variable PKGSIZ) is the largest linear dimension of the configuration and is used in the line-source approximation to calculate total dose; 5 m [16.5 ft] was the assumed length of the source. The radiation dose to the public from the casks was assumed to consist entirely of gamma radiation for calculation of the incident-free dose. This assumption is appropriate since the regulatory limits were used and the neutron and gamma radiation is attenuated at nearly identical rates up to about 700 m (2,296 feet) (neutrons are attenuated more rapidly beyond 700 m).

For releases of radioactive material resulting from postulated accidents, the RADTRAN computer code uses a dispersibility category to determine the fractions of the total inventory that are aerosolized and respirable. The analysis reflects the dispersibility category for each isotope and considered the release fractions based on the type of package as a function of accident severity.

Accident risks include acute fatalities and latent risk of fatal cancer (from chronic exposure) for both the current and future generations. The accident risk (expected value of dose from accidents) is the summation of the products of estimated dose for each accident severity category and the associated probability of occurrence for the category. To provide a conservative estimate of potential accident effects, the NRC staff assumed high burnup fuel (62,000 MWd/MTU). Table 2 lists the characteristics of SNF assumed for the accident analysis.

Radiation exposures are reported as collective dose to a population (person-Sv [person-rem]) and the dose to the maximally exposed individual (mSv [mrem]). Health risks from exposure to radiation are reported as estimated lifetime risk of fatal cancer (LRFC) resulting from incident-free transportation of SNF and from highway accidents involving potential radiation releases. Expected fatalities from truck accidents not involving radiation releases are also reported.

A National Academy of Sciences report (NAS 1990, Table 4-2), commonly called the BEIR V report, gives estimates of the number of cancer deaths expected to occur from a continuous exposure of 10 mSv/year [1 rem/year] above background from age 18 until age 65. This value results in a risk factor of 4.0×10^{-2} LRFC per person-Sv [4.0×10^{-4} LRFC per person-rem] that is most applicable to occupational exposure. The BEIR V report also estimates the number of cancer deaths expected to occur from a continuous lifetime exposure of 1 mSv/year [100 mrem/year] above background, which results in a risk factor of 5.0×10^{-2} LRFC per person-Sv [5.0×10^{-4} LRFC per person-rem] that is most applicable to exposure of the general public. The general public LRFC risk factor is slightly higher than the occupational risk factor because the general public dose is assumed to be experienced by people of all ages while the occupational exposures are assumed to be experienced only by people from age 18 until age 65. Children and adolescents are presumed to be more susceptible to radiation-induced health effects than adults.

Table 2. Radionuclide inventory for the SNF shipments[1]

Isotope	PWR fuel in GA-4 cask (Curies)	Physical/ chemical group	Dispersibility category	Isotope	PWR fuel in GA-4 cask (Curies)	Physical/ chemical group	Dispersibility category
^{51}Cr	7.40E-16	SOLID	2	^{127m}Te	2.12E-01	SOLID	2
^{54}Mn	4.80E+01	SOLID	2	^{134}Cs	1.09E+05	VOLATILE	7
^{55}Fe	3.82E+03	SOLID	2	^{137}Cs	3.21E+05	VOLATILE	7
^{59}Fe	3.84E-10	SOLID	2	^{137m}Ba	3.03E+05	SOLID	2
^{58}Co	3.67E-04	SOLID	2	^{141}Ce	2.71E-11	SOLID	2
^{60}Co	1.20E+04	SOLID	2	^{144}Ce	2.21E+04	SOLID	2
^{85}Kr	1.96E+04	GAS	10	^{144}Pr	2.21E+04	SOLID	2
^{89}Sr	1.42E-05	SOLID	2	^{147}Pm	9.17E+04	SOLID	2
^{90}Sr	2.20E+05	SOLID	2	^{154}Eu	1.77E+04	SOLID	2
^{91}Y	5.81E-04	SOLID	2	^{238}Pu	1.72E+04	SOLID	2
^{95}Zr	1.78E-04	SOLID	2	^{239}Pu	7.09E+02	SOLID	2
^{95}Nb	1.24E-02	SOLID	2	^{240}Pu	1.32E+03	SOLID	2
^{103}Ru	2.40E-08	VOLATILE	7	^{241}Pu	2.88E+05	SOLID	2
^{106}Ru	4.04E+04	VOLATILE	7	^{241}Am	3.17E+03	SOLID	2
^{125}Sb	5.80E+03	SOLID	2	^{242}Cm	1.14E+02	SOLID	2
^{125m}Te	1.63E+02	SOLID	2	^{244}Cm	2.18E+04	SOLID	2
^{127}Te	2.09E-01	SOLID	2				
				Total	1.52E+06		

[1]Based on an ORIGEN-ARP computer code calculation performed by B. Broadhead, Oak Ridge National Laboratory, on June 10, 1999. The ORIGEN-ARP computer code was used to generate an updated radionuclide source term that assumed a specific power of 28.3 MW/MTU, a burnup of 62,000 MWd/MTU in 4 fuel cycles, cycle length of 548 days with no downtime between each cycle, 5 year cooling time, 5% fuel enrichment, and cross sections libraries for a 15 × 15 pressurized water reactor fuel assembly.

Because doses fall off quickly with distance from the route, persons close to the route receive and account for much more of the population dose than those who live some distance from the route. The contributions to population doses from exposure to persons living more than 0.8 km [0.5 mile] from the route is negligible. Thus, the affected population was assumed to be residents of and visitors to Clark County, Nevada within 0.8 km [0.5 mile] of the route assumed to be followed by the trucks transporting SNF.

2.3 CUMULATIVE HEALTH RISKS OF SPENT FUEL TRANSPORTATION

Health risks associated with SNF transport include both those associated with radiation exposure and the nonradiological risks associated with the assumed movement of trucks carrying SNF through the Clark County, Nevada area (i.e., traffic accidents).

2.3.1 Radiological Risks

Radiation exposure can occur in two ways—exposure to radiation emitted by the SNF cask during routine (incident-free) transport and exposures in the event of an accident that leads to release of radioactive material. For incident-free transportation, the NRC staff used the RADTRAN computer code to calculate total body doses to the transport crew and the general public. The radiation source is characterized for the RADTRAN computer code by the radiation dose rate at 1 m from the package surface.

Potential radiological accident effects include both acute fatalities resulting from very high radiation exposure (that might occur in the unlikely event of failure of an SNF shipping container or cask), and the LRFC resulting from radiation exposure that occur some time after the postulated accident. Accident risk is estimated by summing the product of estimated dose and the associated probability of occurrence for each of the accident-severity categories analyzed by the RADTRAN computer code.

The cumulative radiation exposure estimated by the NRC staff is provided in Table 3. The corresponding transportation health risks are provided in Table 4. Radiation doses to the population and transport crews were converted to LRFC using the risk coefficient suggested by the National Academy of Sciences (ICRP 1991; NAS 1990). It is important to note that LRFC figures represent cumulative health risks to the entire population exposed to radiation from the shipments. More simply put, the LRFC figures represent the additional number of total potential fatalities assumed within the Clark County population due to the shipment of all of the SNF over the entire life of the transportation campaign to the repository. Table 4 shows that, using the bounding assumptions for this study, between 2 and 3 excess fatal cancers are predicted. The sum of incident-free and accident risks is 2.592 LRFC for the southern route using the beltway; other scenarios have lower estimated risks. More simply put, the LRFC figures represent the additional number of total potential fatalities assumed within the Clark County population due to the shipment of all of the SNF over the entire life of the transportation campaign to the repository. Table 4 shows that, using the bounding assumptions for this study, between 2 and 3 excess fatal cancers are predicted. The sum of incident-free and accident risks is 2.592 LRFC for the southern route using the beltway over the entre life of the transportation campaign to the repository; other scenarios have lower estimated risks.

To put this risk into perspective, the average incidence of lifetime fatal cancer in the U.S. is about 0.25 [25 percent]. Assuming a Clark County population of about 1,600,000 and an average life expectancy of 70 years, this lifetime incidence of fatal cancer would correspond to about 5,700 LRFC/year. Also, in the Clark County area, the average radiation exposures resulting from cosmic and naturally occurring terrestrial gamma radiation are 0.75 to 0.77 mSv/year [75 to 77 mrem/year].[10] Assuming a Clark County population of about 1,600,000 this natural radiation leads to a risk estimate of about 60 LRFC/year. The average annual excess risk to the Clark County population from SNF transport is less than 0.050 LRFC/year which is a risk estimate of 1,200 times less than the estimate for background radiation and more than 100,000 times less than the average incidence of fatal cancer due to all causes.

The highest estimated risk to the crews is 0.852 LRFC. This already-small risk would be spread over the 40- to 60-year period during which SNF would be transported to the repository. On an annual basis, the crew risk averages about 0.014 LRFC per year of SNF transport as a result of radiation exposures.

[10] This outdoor dose rate estimate was provided by H. L. Beck (H. L. Beck, Director, Environmental Sciences Division, Environmental Measurements Laboratory, U.S. Department of Energy, New York, personal communication via electronic mail to A. K. Roecklein, NRC, Rockville, Maryland., Nov. 4, 1998) and based on extensive background radiation measurements summarized, in part, in NCRP Report No. 94, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, National Council on Radiation Protection and Measurements, Bethesda, Maryland., Dec. 30, 1987.

Table 3. Estimated cumulative radiation exposure resulting from SNF transport in Clark County [a]

	Radiation exposure (person-Sv)[b]		
	Incident-free transport		Transport accidents
	Crew [c]	Public [d]	Public
From northeast using beltway without license renewal	12.8	27.7	3.05
From northeast using beltway with license renewal	19.3	41.4	4.57
From northeast through downtown without license renewal	14.2	29.0	4.02
From northeast through downtown with license renewal	21.3	43.5	6.03
From south using beltway without license renewal	13.2	29.0	5.42
From south using beltway with license renewal	19.7	43.7	8.13
From south through downtown without license renewal	11.8	27.4	4.65
From south through downtown with license renewal	17.7	41.1	6.97

[a] Transportation risks were calculated using RADTRAN version 4.0.19.SI, dated March 16, 1999. Access to RADTRAN 4 was furnished on TRANSNET computer system by the U.S. Department of Energy's Transportation Technology Center at Sandia National Laboratories.

[b] 1 person Sv = 100 person-rem.

[c] Transport crew size was assumed to be 4 persons (2 people in the truck and 2 people in the escort vehicle). Crew dose is for the time spent driving In Clark County, approximately 166 to 230 km (approximately 100 to 145 miles); the dose involved in driving to Clark County is not included.

[d] The incident-free risk to the public does not include the risk to the crew.

Table 4. Cumulative radiological transportation risks resulting from SNF transport in Clark County[a]

	Estimated lifetime risk of fatal cancer (LRFC)[b]		
	Incident-free risk		Accident risk
	Crew[c]	Public[d]	Public
From northeast using beltway without license renewal	0.512	1.385	0.153
From northeast using beltway with license renewal	0.772	2.070	0.229
From northeast through downtown without license renewal	0.568	1.450	0.201
From northeast through downtown with license renewal	0.852	2.175	0.302
From south using beltway without license renewal	0.528	1.450	0.271
From south using beltway with license renewal	0.788	2.185	0.407
From south through downtown without license renewal	0.472	1.370	0.233
From south through downtown with license renewal	0.708	2.055	0.349

[a] Transportation risks were calculated using RADTRAN (v. 4.0.19.SI., dated March 16, 1999. Access to the RADTRAN computer code was furnished on TRANSNET computer system by the U.S. Department of Energy's Transportation Technology Center at Sandia National Laboratories.

[b] For crew members, the dose conversion factor was 0.0004 estimated lifetime risk of fatal cancer (LRFC) per person-rem, and for the general public, 0.0005 LRFC per person-rem. The U.S. average lifetime risk of fatal cancer from all causes is approximately 0.25.

[c] Transport crew size was assumed to be 4 persons (2 people in the truck and 2 people in the escort vehicle). Crew dose is for the time spent driving In Clark County, approximately 166 to 230 km (approximately 100 to 145 miles); the dose involved in driving to Clark County is not included.

[d] The incident-free risk to the public does not include the risk to the crew.

The hypothetical maximally exposed individual would for incident-free transport receive 0.40 mSv [40 mrem] for the duration of shipments, about 0.16 percent of the average 70-year dose from background sources.[11] The maximally exposed individual radiation dose is based on a hypothetical individual member of the public located in the open (i.e., without the shielding offered by buildings or vehicles) 30 m [98 ft] from the highway during the entire duration of shipments (a very conservative assumption). This dose is the estimated risk from incident-free transport.

The above estimates of radiation dose are consistent with the doses reported in 10 CFR Part 51, Table S-4. Table S-4 reports estimates of 0.04 person-Sv [4 person-rem] per reactor year for transportation workers, and 0.03 person-Sv [3 person-rem] per reactor year for the general public. Assuming that 100 nuclear power plants operate for 60 years, Table S-4 leads to estimated occupational and general public doses of 240 person-Sv [24,000 person-rem] and 180 person-Sv [18,000 person-rem] for transportation workers and the general public, respectively. Comparing these dose estimates with the highest corresponding doses in Table 3 shows that the estimated cumulative dose to the general public from incident-free transportation of all SNF through the Las Vegas area is less than 25 percent of the cumulative dose from all fuel and waste transportation calculated from Table S-4. In light of the many conservative assumptions made in this analysis, the NRC staff concludes that the radiological impacts of the shipment of SNF are small and are acceptably addressed using the generic impacts methodology of Table S-4 for individual nuclear power plant operating license renewal purposes.

2.3.2 Nonradiological Risks

The NRC staff assessed the impacts of nonradiological truck accidents that may occur during the transport of SNF to the repository. A nonradiological accident is a truck accident in which the property damage, injuries or fatalities are caused by the force of the impact; no release of or exposure to radiological materials occurs as a result of the truck accident. Data on national accident statistics have been compiled from a number of sources by the U.S. Department of Transportation (DOT), Bureau of Transportation Statistics, between 1975 and 1995. Since 1990, data have been collected on the number of accidents, injuries, and fatalities per 100 million truck-miles (DOT 1999). Based upon the accident rate data from 1990 to 1995, the average rate of large truck accidents is 145 per 100 million truck-km [233 per 100 million truck-miles], the average rate of injury is 13 per 100 million truck-km [21 per 100 million truck-miles], and the average fatality is 0.26 per 100 million truck-km [0.42 per 100 million truck-miles]. On the basis of these statistics—along with the HIGHWAY computer code route data—the expected number of nonradiological accidents, injuries, and fatalities is calculated as shown in Table 5 for shipments during the 40-year (without license renewal) and 60-year (with license renewal) repository operations period. Over a 40- or 60-year

[11] The background radiation dose is assumed to be 3.6 mSv/year [360 mrem/year], the current estimate given for average background radiation dose in the U.S. The value is based upon the following assumptions from the National Council on Radiation Protection and Measurements as summarized in Eisenbud and Gesell (1997). Doses are given in mSv/year:

Cosmic radiation that reaches the earth at sea level	0.27
Radiation from the natural elements in the earth	0.28
Radon gas in the home from ground sources	2.00
Radiation in the human body from food and water	0.39
Average medical exposure	0.25 to 0.55
Consumer products (e.g., smoke detectors)	0.10

period, these risks amount to very small annual risks; less than 0.0015 fatalities per year (with or without license renewal).

The NRC staff also estimated the potential human health effects of vehicle emissions of transport trucks and escort vehicles using conservative assumptions. DOE/EIS-0200-F (page E-32) presents a risk factor for latent mortality from pollution inhalation for truck travel in an urban area; 10 per 100 million truck-km (16 per 100 million truck-miles). DOE reports that no similar estimates are available for rural and suburban areas. However, comparable estimates would be much lower in suburban and rural areas because they are much less densely populated than urban areas. To develop a conservative estimate, the NRC staff assumed that escort vehicles had emissions as large as the large trucks that haul SNF. Further, the NRC staff applied the risk factor to both the urban and suburban areas. The route with the largest distance of combined urban and suburban travel was the south by the beltway route, 59.1 km (36.9 miles) (Table 1). For the license-renewal scenario, an estimate on the order of 75,000 shipments yields total vehicle travel distance of 17.8 million km (11.1 million miles) including both repository-bound and return trips for both the transport truck and the escort vehicle. Using the risk factor reported by DOE yields an expected 1.8 latent mortalities due to pollutant emissions by the transport trucks and escort vehicles for the entire campaign. Assuming a 40-year campaign, this estimate yields an expected 0.045 latent mortalities per year.

To develop a conservative estimate of the potential impact of SNF transport in Clark County, the NRC staff assumed that trucks would make 150,555 trips through the county over the campaign, assuming the license-renewal scenario (approximately 75,000 shipments plus return trips). An equivalent number of trips would be made by an escort vehicle. Using the longest route (Table 1), the one-way distance traveled would be 230.1 km (143 miles) per vehicle. Assuming all SNF transport occurs over a 40-year period, SNF transport in Clark County would involve 0.86 million vehicle km (0.54 million vehicle miles) for the trucks and the same number of vehicle kilometers for escort vehicles. The Nevada Department of Transportation (NDOT)[12] reports that in 1997 it maintained 839 miles of the 4559 miles of improved road in Clark County, and that NDOT-maintained, Clark-County roads carried 8,611 million vehicle-km (5,382 million vehicle-miles) of travel, about 56 percent of the total vehicle miles of travel in the county. Assuming that SNF shipments occur only on the NDOT-maintained roads and that highway travel does not increase before SNF shipments begin, commercial SNF transport (including both the trucks and the escort vehicles) would account for only about 0.02 percent of the vehicle miles traveled each year on NDOT-maintained roads in Clark County and slightly more than 0.01 percent of the total vehicle miles traveled in the county in a year.

The use of public roads by trucks transporting spent fuel will be required to comply with State of Nevada and local laws regulating vehicle weight and operation. All trucks are subject to registration fees and fuel taxes that have been designed to cover the costs of maintaining and repairing public roads. The use of roads for transporting spent fuel could result in additional road repair and maintenance costs, but such use would also generate additional revenues. Truck registration fees increase according to vehicle weight. The tax on diesel fuel is also designed to recover the costs of maintaining public highways. Because state

[12]*State of Nevada Transportation Facts and Figures.* Operations Analysis Division, Nevada Department of Transportation, January 1999. Accessed at http://www.nevadadot.com/about/fact/, July 23, 1999.

laws regulate and tax trucks operating in the state, the NRC staff believes that trucks transporting SNF will not cause damage and repair costs that are incommensurate with the taxes and fees the operators must pay.

Table 5. Total non-radiological truck fatalities, injuries, and accidents resulting from SNF shipments [a]

Scenario	Fatalities	Injuries	Accidents
From northeast using beltway without license renewal	0.057	2.87	31.8
From northeast using beltway with license renewal	0.086	4.30	47.7
From northeast through downtown without license renewal	0.060	3.01	33.4
From northeast through downtown with license renewal	0.090	4.52	50.2
From south using beltway without license renewal	0.046	2.32	25.7
From south using beltway with license renewal	0.070	3.48	38.6
From south through downtown without license renewal	0.043	2.17	24.1
From south through downtown with license renewal	0.065	3.26	36.2

[a] Estimates are based on mileages from the HIGHWAY computer code, and on accident, injury and fatality rates from DOT (1999).

2.4 CUMULATIVE IMPACTS OF ADDITIONAL RADIOACTIVE WASTE SHIPMENTS

In addition to SNF shipments to the proposed repository at Yucca Mountain, DOE is planning to ship quantities of high level waste (HLW) to the repository and may also ship substantial quantities of low-level radioactive wastes (LLW) to the Nevada Test Site (NTS) for disposal. These shipments would most likely be routed through Clark County, in a manner similar to the routing of SNF analyzed above. To estimate the potential cumulative effects of shipments to the NTS as well as the proposed repository, the NRC staff utilized information published in DOE's waste management programmatic EIS (DOE/EIS-0200-F) and DOE's programmatic spent nuclear fuel management EIS (DOE/EIS-0203-F). To assure that cumulative impacts are not underestimated, the NRC staff selected those alternatives in the EIS that led to the highest numbers of shipments to the NTS or Yucca Mountain.

DOE estimated that there would be up to 24,000 HLW shipments[13] to Yucca Mountain and up to 268,000 LLW shipments[14] to NTS, and up to 6,815 SNF shipments to NTS.[15] DOE assumed that the HLW shipments would have radiation doses equal to the legal limit

[13] This estimate comes from DOE/EIS-0200-F; Table 9.16-1, Centralized Alternative.

[14] This estimate is composed of 257,000 truck shipments of LLW to the Nevada Test Site and 11,000 shipments of low-level mixed waste (DOE/EIS-0200-F; Table 7.16-2, Centralized-2 Alternative and Table 6.16-2, Regionalized-3 Alternative).

[15] This estimate comes from DOE/EIS-0203-F, Table I-2, for the Centralization at NTS alternative.

(10 mrem/h at 2 m) and that LLW would have dose rates of 1 mrem/h at 1 m. To estimate the radiological effects of these shipments, the NRC staff assumed that each DOE SNF, HLW or LLW shipment was equal to a shipment of commercial SNF. For the radiological impacts of LLW, the assumption is very conservative because, as indicated by DOE's estimate of 1 mrem/hour (0.01 mSv/hour) at 1 m, LLW is generally much less radioactive than SNF. For non-radiological effects, the NRC staff assumed that each shipment would have the same effect regardless of what material was being transported.

Using highest doses and cancer risks in Tables 3 and 4 and the assumptions above, the NRC staff estimated the doses and LRFCs for shipment of DOE radioactive waste through Clark County. As shown by Tables 6 and 7, the cumulative doses and expected cancer fatalities continue to be small compared to the risk of cancer from other causes.

The non-radiological cumulative effects of radioactive waste shipment through Clark County are dominated by the very large number of LLW shipments. All SNF and DOE radioactive waste and SNF shipments through Clark County would total to more than 374,000 shipments, almost 5 times as many as SNF shipments with license renewal. Thus, between 125 and 250 non-radiological truck accidents can be expected during the 374,000 shipments of radioactive wastes through Clark County. The expected number of accident fatalities is between 0.22 and 0.46 for all shipments of radiological waste over all the years the shipments would occur. Assuming these shipments occurred over a 40-year period, between 3 and 6 traffic accidents involving trucks transporting all types of radioactive waste materials would be expected in an average year, and there would be a very small chance that a fatality would result in any one year.

2.5 SUMMARY OF SNF TRANSPORT IMPACTS

As shown in Table 4, the conservatively estimated LRFC assumed to result from radiation exposure related to transportation of SNF in Clark County over the entire 40-60 year life of the transportation campaign to the repository is between 1.6 and 2.6 (including the risk due to potential accidents) or less than 0.05 LRFC/year. For comparison, it is estimated that there would be about 5700 LRFC for each year in Clark County from causes unrelated to SNF transport.

Non-radiological truck-vehicle accidents are possible as a result of transporting SNF through Clark County. The probability of a fatality is estimated to be less than 0.090 under all scenarios. For license renewal, the combined radiological and non-radiological risk to the general public is estimated to be between about 2.3 and 2.6 fatalities over the entire course of SNF transport through Clark County, including incident-free and accident risks. Without license renewal, the estimated is between about 1.5 and 1.8 fatalities.

The above analysis shows that, even with conservative assumptions, the cumulative radiological and accident risks of SNF transport in Clark County are small. It also shows that alternative assumptions are bounded by this analysis and would result in even smaller human health impacts. Transporting SNF by rail rather than by truck would reduce human health effects by reducing the number of shipments and the likelihood of accidents. Shipping SNF via the proposed beltway would reduce health impacts compared to shipping via the current interstate highway system. In addition, shipping SNF via the proposed beltway would reduce health impacts compared to shipping via the current interstate highway system. The implementation of such mitigative measures must await future decisions that fall well outside of the scope of this rulemaking. DOE will address transportation impacts, mitigation measures, and alternative transportation modes in its EIS for the proposed repository at Yucca Mountain.

Table 6. Estimated cumulative radiation exposure resulting from transport of SNF and DOE radioactive waste in Clark County[a]

	Radiation exposure (person-Sv)[b]		
	Incident-free transport		Transport accidents
	Crew[c]	Public[d]	Public
Highest values from Table 3	21.3	43.7	8.13
Doses from DOE HLW shipments	6.8	13.9	2.59
Doses from DOE LLW shipments	75.8	156.0	28.9
Doses from DOE SNF shipments	1.9	4.0	0.74
Maximum cumulative dose from all radioactive waste shipments	84.0	218.0	40.3

[a] Transportation doses were calculated using the RADTRAN computer code(version 4.0.19.SI, dated March 16, 1999). Access to the RADTRAN computer code was furnished on TRANSNET computer system by the U.S. Department of Energy's Transportation Technology Center at Sandia National Laboratories.
[b] 1 person Sv = 100 person-rem.
[c] Transport crew size was assumed to be 4 persons (2 people in the truck and 2 people in the escort vehicle). Crew dose is for the time spent driving In Clark County, approximately 166 to 230 km (approximately 100 to 145 miles); the dose involved in driving to Clark County is not included.
[d] The incident-free dose to the public does not include the dose to the crew.

Table 7. Cumulative radiological transportation risks resulting from transport of SNF and DOE radioactive wastes in Clark County[a]

	Estimated lifetime risk of fatal cancer[b]		
	Incident-free risk		Accident risk
	Crew[c]	Public[d]	Public
Highest values from Table 4	0.85	2.19	0.41
Risks from DOE HLW shipments	0.27	0.69	0.13
Risks from DOE LLW shipments	3.0	7.8	1.5
Risks from DOE SNF shipments	0.8	0.2	0.09
Maximum cumulative risk from all radioactive waste shipments	3.9	10.9	2.1

[a] Transportation risks were calculated using the RADTRAN computer code (v. 4.0.19.SI., dated March 16, 1999). Access to the RADTRAN computer code was furnished on TRANSNET computer system by the U.S. Department of Energy's Transportation Technology Center at Sandia National Laboratories.
[b] For crew members, the dose conversion factor was 0.0004 estimated lifetime risk of fatal cancer (LRFC) per person-rem, and for the public, 0.0005 LRFC per person-rem.
[c] Transport crew size was assumed to be 4 persons (2 people in the truck and 2 people in the escort vehicle). Crew dose is for the time spent driving In Clark County, approximately 166 to 230 km (approximately 100 to 145 miles); the dose involved in driving to Clark County is not included.
[d] The incident-free risk to the public does not include the risk to the crew.

2.6 ENVIRONMENTAL JUSTICE

Environmental justice refers to a Federal policy in which Federal actions should not result in disproportionately high and adverse environmental impacts on low-income or minority populations. Executive Order 12898 (59 FR 7629) directs Federal executive agencies to consider environmental justice under NEPA. Although the Executive Order does not apply to the NRC, an independent agency, the NRC has stated that it will comply with the Executive Order.

As explained earlier, only people within 0.8 km [0.5 mile] of the route followed by the trucks transporting SNF would receive any appreciable radiation dose, even under accident scenarios. Consequently, the NRC staff examined available data on low-income and minority populations within that distance along transportation routes to determine if there was reason to suspect that SNF transport impacts might fall disproportionately on low-income or minority groups. To this end, the NRC staff examined the racial, ethnic and population characteristics of Clark County as a whole and the same characteristics of the transportation routes.

Table 8 describes the overall racial and ethnic characteristics for the population groups in Clark County (Bureau of the Census 1990).[16]

Nevada is one of the fastest growing states in the U.S., with Clark County growing faster than any other Nevada county. The 1990 census listed 741,459 people as living in the county (Census Bureau Database C90STF1A; http://venus.census.gov/cdrom/lookup/929978369, accessed June 21, 1999). Clark county's projected 1999 population was 1,337,400, and the projected 2004 population is 1,656,840 (Nevada State Demographer June 1, 1998). Las Vegas accounted for most of the County's growth. In July 1998, an estimated 448,244 persons resided in Las Vegas, a 6 percent increase since July 1997. In addition to residents, Las Vegas has many visitors staying in hotels.

Table 9 reports the percentage of ethnic and racial groups living within 0.5 mile (0.8 km) of the transportation routes. These data were assembled using an Oak Ridge National Laboratory computer program that integrates Map-Info™ with the Census Bureau data available on CD-ROM (U.S. Census Database C90STF1A, 1990). 1990 data were used to be consistent with the population density estimates used in the HIGHWAY computer code. Table 9 shows that only for the route from the northeast through downtown would the fraction of a minority within the 0.8-km (0.5-mile) corridor adjacent to the route be significantly higher than the county average.

[16] Per Office of Management and Budget 1998 Directive No. 15, the Census Bureau uses four race categories (White, Black, American Indian and Alaska native, Asian and Pacific Islander) and two ethnicity categories, Hispanic and non-Hispanic (Bureau of the Census 1998).

Table 8. 1990 distribution (in percent) of racial and ethnic population groups in Clark County, Nevada

	White	Black	American Indian & Alaska native	Asian & Pacific Islander
Non-Hispanic	75.4	9.3	0.7	3.3
Hispanic	5.9	0.3	0.1	0.2
Total	81.3	9.6	0.8	3.5

Source: U.S. Census Bureau, 1990. Database C90STF1A, Summary Level State—County. http//venus.census.gov/cdrom/lookup

Table 9. Ethnic and racial groups (in percent) living within 0.5 mile (0.8 km) of the transportation routes

	White	Black	American Indian & Alaska native	Asian & Pacific Islander
From the northeast using beltway				
Non-Hispanic	82.9	6.1	1.0	1.8
Hispanic	4.3	3.6	0.1	0.03
From the northeast through downtown				
Non-Hispanic	61.7	25.2	0.7	2.2
Hispanic	4.8	0.4	0.1	0.2
From south using beltway				
Non-Hispanic	88.6	2.7	0.7	2.2
Hispanic	4.1	0.06	0.04	0.06
From south through downtown				
Non-Hispanic	77.5	9.2	0.7	2.8
Hispanic	5.4	0.2	0.1	0.2

Source: U.S. Bureau of the Census. 1990. U.S. Census Database C90STF1A, 1990.

The NRC staff also examined the distribution of low-income populations. The 1995 median family income for Nevada families was estimated to be $36,300; Clark County was slightly above the State average with a median family income of $38,184 (U.S. Census Bureau, http://www.census.govdgi-bin/hhes/saipe93/gettable.p1, Table C95-32; accessed June 23, 1999). The estimated number of persons living below the poverty level for 1989 in Clark County was 76,737, representing approximately 10.4 percent of the total population (the figures are based on 1990 Census data). Compared to the U.S. average, the State of Nevada has been substantially below the national average in percentages of people living in poverty. For 1995 through 1997, 13.6 percent of the U.S. population lived in poverty, while 10.1 percent of the residents in Nevada lived in poverty (Bureau of the Census 1999).

Accurately examining income distribution is difficult because the poverty data are aggregated over larger areas than are data for ethnic and racial groups. On the basis of 1990 census data, the NRC staff estimated the percent of the populations in poverty along the routes as shown in Table 10. The only route that would encounter higher than the U.S. average of low-income persons is the route from the northeast through downtown.

Table 10. Fraction of persons along the transportation routes who are in poverty (percent) [a]

From the northeast using beltway	8.3
From the northeast through downtown	14.8
From the south using beltway	6.8
From the south through downtown	10.9
County as a whole	10.4

[a] Based on 1990 census data.

The analysis suggests that the routes through downtown may run through areas containing a higher proportion of low-income and minority groups than the beltway routes. However, as discussed in Sections 2.3 and 2.4, the radiological and nonradiological impacts of transportation of SNF are small. In addition, these small impacts are dispersed throughout the entire routes and do not appear to fall disproportionately in any one area. Based on the above analysis the NRC staff concludes the overall impacts of transportation of SNF will not likely be disproportionately high or adverse for any minority or low-income population.

3. IMPLICATIONS OF HIGHER BURNUP FUEL FOR THE CONCLUSIONS IN TABLE S-4

3.1 BACKGROUND

The license renewal rule amending 10 CFR Part 51 promulgated on December 18, 1996 (61 FR 66537) gave license renewal applicants the responsibility to comply with the existing requirements of 10 CFR 51.52. Section 51.52(a) specifies six conditions that must be met in order for an applicant to adopt the values in Table S-4 of that section, which represent the contribution of transportation to the environmental costs of licensing the reactor. If the six conditions are not met, an applicant must submit a full analysis of the environmental impacts of transportation of fuel and waste in accordance with §51.52(b). Two of the conditions limit the fuel enrichment level and the burnup level . Paragraph 51.52(a)(2) requires a uranium-235 enrichment not exceeding 4 percent by weight in the fuel. Paragraph 51.52(a)(3) requires that "The average level of irradiation of the irradiated fuel from the reactor does not exceed 33,000 megawatt-days per metric ton, and no irradiated fuel assembly is shipped until at least 90 days after it is discharged from the reactor." These two limiting conditions have been exceeded through nuclear power plant license amendments permitting incremental increases in the burnup of fuel. During the 1990s, the NRC has reviewed and approved vendor topical reports requesting approval for higher burnup level. (Letter from M. J. Virgilio, NRC, to N. J. Liparulo, Westinghouse Electric Corporation, "Acceptance for Referencing of Topical Report WCAP-12488, 'Westinghouse Fuel Criteria Evaluation Process," dated July 27, 1994; FCF-BAW 10186P-A, "Extended Burnup Evaluation," June 12, 1997; and Memorandum from T. E. Collins to B. W. Sheron, "Waiver of CRGR Review of EMF-85-74(P), Revision O, Supplements 1 and 2 Safety Evaluation," dated February 9, 1998). Approved average burnup for the peak rod now ranges from 50,000 to 62,000 MWd/MTU. The higher burnup levels are associated with uranium-235 enrichment levels of up to 5 percent by weight. Thus, it is likely that at the time of a submittal of a license renewal application, many nuclear power plants will be operating at higher fuel burnup and will be using higher enrichment fuel.

Further, the assumed minimum time for shipping spent fuel of 90 days after discharge from the reactor was based on the assumption that the spent fuel would be shipped to a reprocessing facility. Reprocessing spent fuel is currently not a reasonable assumption. Currently, the reasonable assumption is that spent fuel will be shipped to an interim storage facility or to an ultimate repository and would have been discharged from the reactor at least 5 years earlier and, in some cases, as many as 40 years earlier. In fact, the current practice of NRC issuing certificates of compliance for casks used for shipment of power reactor fuel is to specify 5 years as the minimum cooling period. The assumption of 5-year cooling is an extremely conservative assumption. For example, there is almost 40,000 tons of spent fuel in storage now, some of which has been stored for decades. At the earliest, if Yucca Mountain were found suitable and if DOE were successful in obtaining an NRC license, it will be at least 11 years from now until Yucca Mountain would be ready to accept spent fuel for storage. It would take many years to work off the backlog of stored spent fuel.

3.2 ANALYSES

Because many nuclear power plants are now operating with higher enriched fuel irradiated to higher burnup levels, motivated in part by a desire to minimize spent fuel inventory, and because of public concerns about transportation impacts of higher burnup SNF, the NRC staff examined recent technical literature on, and performed additional analyses of the characteristics of higher burnup SNF. The analyses summarized below address two questions: the extent to which higher burnup SNF might have greater incident-free transportation impacts than spent fuel with the characteristics assumed for Table S-4, whether accidents involving higher burnup SNF might have unacceptable impacts, and whether accidents involving higher burnup SNF might cause criticality during a transportation accident.

For incident-free transportation, the principal concern is whether, because of its different radiological composition, higher burnup fuel would require more shipments and larger transportation impacts than predicted by Table S-4. Quantification of the radiation emissions for reactor fuels is a complex process. However, there are several insights that allow for scaling of the radioactive emissions from one burnup level to another. For the gamma-ray sources, the scaling due to burnup is a linear relationship, i.e. a doubling of the burnup yields, a doubling of the gamma-ray emissions and, typically, a doubling of the dose rate due to gamma rays. The scaling for neutrons is not linear. Neutron emissions increase as the fourth power of the burnup ratios given the same initial enrichments; that is, doubling burnup increases the neutron emissions rate about sixteen times. In practice, however, higher burnup fuels require higher initial enrichments, such that neutron emissions typically increase as the square or cube of the burnup ratios. For example, analysis by Parks et al. (1987) showed that for a 35,000 MWd/MTU and a 60,000 MWd/MTU (burnup ratio 1.71) the neutron emissions ratio is 4.28 (less than the third power of the burnup ratio).

The increase in the total radiation dose rate due to higher burnup is complicated because the total dose rate is the sum of the gamma-ray and neutron dose rates. For nominal burnups, the dose rates at the surface and 2-m from the surface are approximately 90 percent gamma-rays and 10 percent neutrons. Indeed, Westfall et al. (1990) found that for a transportation cask that was designed for use in DOE spent fuel applications, the calculated total dose rate at 2 m for 60,000 MWd/MTU SNF was 2.19 times larger than for 35,000 MWd/MTU SNF. Thus, the total dose from a full cask of 60,000 MWd/MTU SNF would be about twice as large as the dose from a full cask of 35,000 MWd/MTU SNF. Assuming an additional increase in maximum burnup to 62,000 MWd/MTU would not invalidate that assumption given the small increase in burnup from 60,000 MWd/MTU.

The most obvious way to compensate for a doubling of the 2-m dose rate would be to halve the cask payload. This would increase the number of shipments required, but is unlikely to be pursued because of the economic and other pressures to minimize spent fuel transportation activities. In addition, under this scenario, a cask would be partially loaded (i.e. derated) with the remaining locations in the basket left empty. However, because the cask would have to be certified for higher burnup to carry even a partial load, the license submittal could easily analyze the use of inserts, which would drastically reduce the external doses with less impact on cask capacity.

There are, however, less costly ways to accommodate higher burnup fuels. Broadhead et. al. (1992) showed that by using a modified basket and by derating the cask 15 percent (an 18-assembly payload vs a 21-assembly payload) a cask with 5-year-cooled 60,000 MWd/MTU spent fuel had a lower dose rate than a 21-assembly cask containing 35,000 MWd/MTU fuel that had cooled 5 years. While the dose rates of higher-burnup fuels decline more slowly than 35,000 MWd/MTU fuel, Broadhead et al. also showed that increasing cooling times from 5 to 15 years compensates for an increase in burnup from 35,000 to 60,000 MWd/MTU. That is, a cask designed for 5-year-cooled 35,000 MWd/MTU spent fuel should be capable of accommodating 15-year-old 60,000 MWd/MTU spent fuel without derating. Thus, where on-site storage of SNF is not too costly, transportation costs and impacts can be minimized by allowing higher burnup SNF to cool 15 years before disposal.

The above two scenarios present cases where the high burnup fuels can be placed into standard casks with little or no cask derating, while meeting radiation limits outside of the cask. Under these scenarios, the actual number of trips to a repository would be *decreased* because the number of spent fuel assemblies required for given amount of power would be smaller with higher burnup fuel. There are other scenarios in which the number of required trips is reduced by "blending" of cask loadings, in which higher-burnup fuel assemblies are placed in the middle of the cask, while lower burnup assemblies are place near the edge of the cask cavity region to absorb radiation from the inner assemblies. While this scenario appears feasible, it has not yet been approved by NRC. A totally new cask specifically designed for high-burnup fuel is another possibility. It would only be conjecture to discuss the results of such a cask design effort, but the modified cask basket described in Broadhead et al. indicates that such a design could have little impact on the cask payload. Thus, for higher burnup fuel that is allowed to cool for at least five years before shipping, reasonable, cost-effective measures can assure that radiation limits from SNF casks can be met without increasing the number of SNF shipments. Consequently, the NRC staff concludes that use of higher burnup fuel would not lead to incident-free transportation impacts that are larger than those predicted by Table S-4.

To answer the question of how higher burnup fuel would affect accident doses, the NRC staff used the characteristics of 5 percent enriched fuel that had been burned for 62,000 MWd/MTU in its RADTRAN analysis to estimate health risks associated with accidents that release radioactive materials from a transportation cask (Table 2). The results of the analysis (Tables 3 and 4) show that higher burnup fuel has doses and health risks that are less than 15 percent of incident-free doses and health risks, and small as characterized by Table S-4.

The NRC staff also examined unlikely accident scenarios involving higher burnup fuel to determine if they could lead to a nuclear criticality event. The NRC staff examined two scenarios: failure of fuel cladding and failure of a portion of the neutron absorption material while the fuel remains in its original position. Because fuel rods are arranged in near optimum configurations for establishing and maintaining nuclear fission reactions, if the fuel cladding failed, the cask filled with water, and the fuel pellets crumbled into a pile or any other arrangement, the fuel would be farther from criticality than while they were in their original arrangement. Thus, failure of fuel cladding could not cause a criticality event.

The second hypothetical accident scenario has the neutron absorption effect at the end of the cask basket somehow lost while the fuel lattice structure remains intact. In this scenario, the fuel would remain in its optimum (for criticality) configuration, but the cask basket material which absorbs neutrons is removed from 15 cm (6 in.) of the end of the fuel rods. Analysis of several burnup levels showed that nuclear criticality would not occur, even if the cask were filled with water. Consequently, the NRC staff concludes that higher burnup SNF offers no greater criticality concerns, even in the event of unlikely occurrences.

3.3 CONCLUSIONS

Most nuclear plants are now operating with higher enriched fuel irradiated to higher burnup levels than anticipated by the analyses that led to the impact levels identified in Table S-4. The NRC staff has extensively studied the environmental impacts associated with fuel enrichment up to 5 percent uranium-235 and fuel burnup to 60,000 MWd/MTU and has found that these impacts are no greater than and likely less than the impacts described in 10 CFR 51.52(c), provided that higher burnup fuel has been removed from the reactor for at least five years before it is shipped off site.

The analysis described above showed that higher enriched, higher burnup fuel would not increase incident-free-transportation or transportation-accident impacts, and that criticality could not occur during transportation of higher burnup SNF under any foreseeable circumstance. The higher burnup levels are associated with uranium-235 enrichment levels of up to 5 percent by weight. An increase in burnup from 60,000 MWd/MTU to 62,000 MWd/MTU will not significantly change dose levels associated with spent fuel transportation and may slightly reduce the number of shipments. Therefore, the impacts identified in Table S-4 bound the transportation impacts of higher enriched, higher burnup SNF. These conclusions are applicable to any nuclear power plant license renewal application provided higher burnup fuel has cooled at least 5 years before it is shipped off the reactor site.

4. SUMMARY AND CONCLUSIONS

This Addendum to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, May 1996 supplements the analysis reported in Section 6.3 "Transportation," and especially Section 6.3.2, "Table S-4–Environmental Impacts of Transportation of Fuel and Waste to and From One Light-Water-Cooled Nuclear Power Reactor." This document addresses two questions generically. The first question is whether the environmental impact values contained in Table S-4 are still appropriate for use in license renewal reviews if spent fuel is transported to a single destination such as the candidate repository at Yucca Mountain, Nevada, even though the values in Table S-4 were developed from data reflecting spent fuel shipments to several destinations. The NRC staff found that the cumulative impacts of SNF transport to a single repository are small for all plants shipping spent fuel with characteristics specified in 10 CFR 51.52(c), Summary Table S-4 and for spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU, provided higher burnup fuel is cooled for at least 5 years before being shipped off site.

The second question is whether the environmental impact values contained in Table S-4 are still appropriate for use in license renewal reviews given that applicants will be shipping spent fuel that is more highly enriched and irradiated longer than is accounted for in the analysis to develop Table S-4. The NRC staff analyzed the extent to which transportation of higher burnup SNF would cause impacts that exceed those identified in Table S-4 for incident-free transport, and for hypothetical accidents causing release of radionuclides. The NRC staff found that even under conservative higher burnup conditions, the impacts of SNF transport would not exceed those identified in Table S-4. Consequently, the NRC staff concludes that Table S-4 applies to spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU, provided higher burnup fuel is cooled for at least 5 years before being shipped off site.

The conclusions reached in these assessments provide the bases for revising the findings and the category designation of the Transportation issue in Table 9.1, "Summary of findings on NEPA issues for license renewal of nuclear power plants," of NUREG-1437. The environmental impacts associated with these issues are applicable to all plants, the impacts are small, mitigation has been considered, and additional plant -specific mitigation measures are not warranted. The findings and category designation for the transportation issue (NUREG-1437, p. 9-15) is revised as follows:

Issue	Sections	Category	Findings
Transportation	Addendum 1, 2.4 3.3	1	SMALL. The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4--Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in §51.52.

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6. LIST OF PREPARERS

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APPENDIX 1

STAFF RESPONSES TO PUBLIC COMMENTS ON ADDENDUM 1 AND THE PROPOSED RULE

THE SCOPING PROCESS

The proposed amendments to 10 CFR 51.53(c)(3)(ii)(J) and (M) were published in the *Federal Register* on February 26, 1999 (64 FR 9884–88), and a 60-day comment period that ended on April 27, 1999, was provided. A Notice of Availability for NUREG-1437, Vol. 1, Addendum 1 appeared in the same issue of the *Federal Register* (64 FR 9889) and included a solicitation for public comments through April 27, 1999.

Thirty-one comment letters were received on the proposed rule from power reactor licensees, State and local Government agencies, the nuclear power industry and its legal affiliations, a public interest group, and an individual. Most of the comments were from the State of Nevada, Clark and Nye Counties, Nevada, and local government entities in Nevada. These comments focused on the NRC not involving Nevada in scoping and designing the study in Addendum 1 and on perceived deficiencies in the scope and thoroughness of the analysis in the Addendum. The State of Utah also submitted extensive comments that focused on concerns with the scope and thoroughness of the supporting analysis in Addendum 1, including the lack of consideration of the proposed Private Fuel Storage Facility at Skull Valley, Utah. Industry comments focused on clarifications in the rule language.

Written comments were received from the following agencies, organizations, and individuals:

- Baltimore Gas and Electric Company
- The Honorable Richard H. Bryan, United States Senator
- Carolina Power & Light Company
- Chattooga River Watershed Coalition (Nicole Hayler)
- Clark County, Nevada, Department of Comprehensive Planning, Nuclear Waste Division (two submissions)
- Eureka County, Nevada, Yucca Mountain Information Office
- Alice Fessenden, City Council member, City of Mesquite, Nevada
- Florida Power and Light Company
- Jan Laverty Jones, Mayor, City of Las Vegas
- Mineral County, Nevada, Nuclear Projects Office
- Nuclear Energy Institute
- Nye County, Nevada, Department of Natural Resources and Federal Facilities
- Part 51 Utility Group (consists of Commonwealth Edison Company, Duke Energy Corporation, and Southern Nuclear Operating Company). Comments submitted by Winston & Strawn, counsel to the Part 51 Utility Group
- PECO Nuclear (A Unit of PECO Energy)

- Jon C. Porter, Nevada State Senator
- Kristin Shrader-Frechette, Professor, University of Notre Dame
- Southern Company (Southern Nuclear Operating Company, Inc.)
- State of Florida, Department of Community Affairs, (cover letter and six comment forms from reviews coordinated by the Florida State Clearinghouse)
- State of Nevada, Agency for Nuclear Projects (two submissions)
- State of Nevada, Department of Transportation. Submitted by the Nevada State Clearinghouse
- State of Nevada, Division of Water Resources. Submitted by the Nevada State Clearinghouse
- State of Utah (2 submissions). Comments submitted on behalf of the State by Harmon, Curran, Spielberg and Eisenberg, LLP
- Tennessee Valley Authority
- TU Electric
- Virginia Power
- White Pine County, Nevada, Nuclear Waste Project Office (2 submissions)
- Abigail Johnson, Yucca Mountain Information Office

RESPONSES TO COMMENTS

The written comments have been summarized and grouped into issue categories. As a result of the NRC staff's review of all written comments, some modifications and clarifications have been incorporated into Addendum 1—notably, the use of more conservative assumptions in the analyses and a fuller explanation of those analyses. In addition, the rule language has been edited for clarification. The NRC staff has also prepared responses, given below, to the issues raised by the commentors.

Issue 1—Public Notice

Comment: The titles of the notices published in the *Federal Register* were inaccurate and misleading because they do not clearly indicate the subject matter of the proposed rule and Addendum 1 that addresses transportation of spent nuclear fuel.

Response: The NRC believes that the titles properly reflect the regulatory action being taken. As required by NRC regulations,[17] a notice of the proposed rule and a Notice of Availability of Addendum 1 were published in the *Federal Register* (64 FR 9884 and 64 FR 9889, February 26, 1999). While the notice's title did not include the specific term "transportation" the titles define the subject matter of the regulation to be affected; the title of the proposed rule is "Changes to Requirements for Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." The title of the Notice of Availability is "Changes to Requirements for Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, Availability of Supplemental Environmental Impact Statement." Addendum 1 supplements specific sections of NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (May 1996). This limited function is indicated by the title of Addendum 1, *Generic Environmental Impact Statement for License Renewal of Nuclear*

[17]10 CFR 2.804, "Notice of proposed rulemaking" and 10 CFR 51.117, "Draft environmental impact statement–notice of availability."

Plants: Main Report Section 6.3—`Transportation,' Table 9.1 `Summary of findings on NEPA issues for license renewal of nuclear power plants,' Draft Report for Comment.

The rule change and the supporting Addendum 1 affect only the plant-specific environmental analysis required to be submitted in the Environmental Report of an applicant for the renewal of a nuclear power plant operating license and the plant-specific supplemental environmental impact statement prepared by the NRC. Even though the analysis in Addendum 1 focuses on spent-fuel shipments converging on the proposed repository at Yucca Mountain, Nevada, that analysis and the resulting rule affect only the review requirements for renewal of an individual nuclear power plant operating license. It is not intended that Addendum 1 or the revised rule support any other regulatory decision by the NRC.

Issue 2—Communications

Comment: NRC failed to consult with Nevada State agencies, Nevada local governments, and with Nevada Indian Tribes.

Response: As discussed above, a variety of organizations and government agencies submitted substantive comments in response to the proposed rule. The NRC has considered these comments and, in many cases, altered its analysis as a result of this input. Prior to issuance of the proposed rule for comment, however, the NRC did not seek any pre-publication input from Nevada state agencies, Nevada local Governments, and Nevada Indian Tribes for the following reasons. First, the rule involves a narrow aspect of the environmental review of individual nuclear power plant license renewal decisions, which is a regulatory decision completely separate from the regulatory requirements that will guide the NRC licensing review of a HLW repository and from the decision process leading to a DOE site recommendation on Yucca Mountain, Nevada, the site DOE currently has under study. This rule amends the December 18, 1996, rule with respect to two questions not adequately answered:

1. Are the current environmental impact values in Table S-4, based on several destinations, still reasonable to incorporate in a license renewal review that assumes a single destination for spent fuel at Yucca Mountain, Nevada?

2. Are the current environmental impact values in Table S-4 (which are based on fuel enriched to no greater than 4 percent, the average level of irradiation of spent fuel not exceeding 33,000 MWd/MTU, and shipment no less than 90 days after discharge from the reactor) still reasonable to incorporate in a license renewal review of plants that may use fuel enriched up to 5 percent and potentially ship spent fuel with a burnup of up to 62,000 MWd/MTU?

The amendment has no direct regulatory impact on any entity within Nevada. The selection of Yucca Mountain for the generic evaluation of transportation impacts was made because that site is currently the only one under consideration for a high-level-waste (HLW) repository. Before HLW is actually transported to Yucca Mountain, Nevada, the State, local Governments, Indian Tribes, and the public have the opportunity to provide input on site-specific transportation impacts by commenting on DOE's draft EIS for the proposed repository at the Yucca Mountain site, which was made available for a 180-day comment period beginning on August 13, 1999 (http://www.ymp.gov).

Also, the need for and scope of the current rule amendment were identified within the context of a preceding rulemaking that specified the plant-specific content of the environmental review of applications for the renewal of individual nuclear power plant operating licenses. The previous final rule was published in the *Federal Register* first on June 5, 1996 (61 FR 28467), and again with minor modifications on December 18, 1996 (61 FR 66537). The Commission stated in the December *Federal Register* notice, "as part of its efforts to develop regulatory guidance for this rule, the Commission will consider whether further changes to the rule are desirable to generically address: (1) The issue of cumulative transportation impacts and (2) the implications that the use of higher burn-up fuel have for the conclusions in Table S-4. After consideration of these issues, the Commission will determine whether the issue of transportation impacts should be changed to Category 1."

Issue 3—Transportation Analysis

Comment: NRC failed to consult relevant Yucca Mountain transportation risk and impact studies.

Response: The publications cited by commentors have been reviewed for information that may be of direct use within the limited focus and purpose of the current rule. Most of the information in these documents was found to be potentially more relevant to a detailed site-specific review of Yucca Mountain than to the generic analysis for this rule. That information has been brought to the attention of those organizational units within the NRC responsible for activities relating to DOE's study on the Yucca Mountain site so they can appropriately consider the information in any future prelicensing activities involving Yucca Mountain. Specific to the current rule, the demographic data used as inputs to the RADTRAN computer code, which was used to generate the impact analysis in Addendum 1 were more current than data used in many of the studies cited by the commentors.

Comment: NRC failed to consult the full spectrum of transportation mode and route scenarios.

Response: The purpose of this rule and associated analysis is to reach conclusions regarding the likely environmental impact of license renewal. As noted above, this amendment is an addition to generic assessments of license renewal environmental impacts already codified in the Commission's regulations at 10 CFR Part 51, Subpart A, Appendix B. It is not an environmental impact statement for a repository at Yucca Mountain for which DOE is responsible and, as such, does not delve into the expansive range of different transportation modes and route scenarios that would be considered in the context of a decision on Yucca Mountain as the possible site for the facility itself. Instead, the NRC has sought to determine a conservative estimate of the likely impacts from transporting fuel and waste generated, during the license renewal term, in the vicinity of a potential repository. In doing so, the NRC considered only those transportation modes and route scenarios that would likely result in the greatest impacts. For the proposed rule, the NRC staff—in consultation with the DOE staff—determined that truck shipments through densely populated areas of Clark County, Nevada, would have the highest potential impacts among the alternative transportation scenarios and modes that would receive serious consideration in decisions relating to the suitability of the site undergoing study for a repository at Yucca Mountain. The NRC continues to believe that using these route scenarios and modes to generate conservative estimates is reasonable for the purpose of this rulemaking.

Comment: There was insufficient consideration of routine transportation radiological risks due to use of an average dose rate lower than the regulatory limit.

Response: The RADTRAN analysis reported in the final Addendum 1 has been modified to use the most conservative assumption that the radiation levels for all shipments are at the regulatory limit of 0.1 mSv/hour [10 mrem/hour] at 2 m [6.6 ft] from the shipment vehicle surface. As noted in Section 2.2.3 of Addendum 1, this assumption is sufficiently conservative to bound the analysis of routine transportation radiological risk and allow a reasonable assessment of that risk. Actual average radiation levels and associated doses would be much lower because shipments must be designed so that the regulatory limits are not exceeded. The use of the regulatory limits in the revised analysis results in higher dose estimates for incident-free transportation. However, these revised estimates are still small as defined in 10 CFR Part 51, Subpart A, Appendix B. Consequently, the conclusion regarding the radiological risks of routine transportation remains valid.

Comment: There was insufficient consideration of routine transportation radiological risks to members of the public residing, working, or institutionally confined at locations near shipping routes.

Response: The analysis encompasses members of the public residing, working, or institutionally confined at locations near shipping routes by assuming that the resident population along the transportation routes is exposed to every shipment. The text of Sect. 2.3 of Addendum 1, has been revised to state this assumption and its effects on the revised analysis more clearly. In addition, more conservative assumptions of truck speed have been used in the revised RADTRAN analysis conservatively thus extending the exposure time to individuals along the transportation route. These assumptions further ensure that members of the public cited by the commentors would be encompassed by the dose and risk assessments. As expected, the use of these more conservative assumptions leads to higher estimates of radiation dose to the public. However, these revised dose estimates remain well below regulatory limits for members of the public and small compared to natural background and other sources of radiation exposure.

Several commentors indicated that Addendum 1 should focus on unique and location-specific circumstances of the transportation routes and population centers. However, the analysis in Addendum 1 is generic and was designed to support only the limited scope of the decision regarding this rule change. The NRC believes that the routes chosen represent a conservative analysis due to the higher number of people who live along these routes. Because the purpose of this rule is to provide a generic analysis for the limited purpose of determining the likely impact of transportation during the license renewal term, the large analytical effort required for the identification of specific population locations and traffic circumstances is not warranted within the context of the current rule. Although the comments raise valid issues, those concerns should be resolved within the context of studying, and making decisions concerning, the suitability of the candidate repository site at Yucca Mountain and regulatory requirements governing transportation of spent fuel.

Comment: There was insufficient consideration of radiological risks resulting from traffic gridlock incidents.

Response: Traffic gridlock incidents are not specifically analyzed in NUREG-1437 because of the limited scope and generic nature of the analysis (see response to comment on consideration of risks to members of the public, above). However, the revised RADTRAN analysis includes approximately two hours of stationary time in Clark County (during a 100 to 140 mile trip depending upon the route) for each truck shipment; and traffic gridlock could be one of the reasons for the truck being stationary.

To a limited extent, the incorporation of more conservative assumptions of truck speed into the revised RADTRAN analysis compensates for an analysis of traffic gridlock by allowing for increased exposure time at any given point during transport. As noted earlier, these revised assumptions lead to higher but still small dose estimates. In addition, the routes used in the analysis in Addendum 1 were deliberately chosen to maximize estimated dose. Actual routes would be less likely to have significant areas where traffic gridlock occurs. The selection of the actual routes, for example, would comply with the U.S. Department of Transportation's Federal Highway Administration regulations (49 CFR Part 397, Subpart D) that require minimizing the time in transit (i.e., avoiding periods of great traffic congestion) for routing radioactive shipments.

Comment: There was insufficient consideration of routine transportation radiological risks to vehicle inspectors and escorts.

Response: The RADTRAN analysis in the revised Addendum 1 conservatively uses the regulatory dose rate limit of .02 mSv/hour (2 mrem/hour) for the vehicle crew. In addition, a discussion of potential doses to escorts has been included in Addendum 1, Section 2.2.3. In the analysis, both the escorts and drivers are assumed to be exposed to the regulatory limit, although the dose to the escorts would realistically be less than that to the drivers. Even with these more conservative assumptions, the estimated dose and risk to the crew are small and below regulatory limits.

The risk to vehicle inspectors would be encompassed by the addition of stationary time for the transport truck in Clark County (see response to comment about traffic gridlock, above). Again, the estimated dose and risk are increased by the use of more conservative assumptions; but they remain small and below regulatory limits.

Comment: There was insufficient consideration of severe transportation accident risks.

Response: The Commission has evaluated the potential radiological hazards of severe transportation accidents involving truck and rail spent nuclear fuel (SNF) shipments (NUREG/CR-4829, " Shipping Container Response to Severe Highway and Railway Accident Conditions" February 1987, commonly referred to as the modal study). The modal study evaluated SNF shipping casks certified to NRC standards against thermal and mechanical forces generated in actual truck and rail accidents. This evaluation included an assessment of cask performance for a number of severe transportation accidents, including the Caldecott Tunnel fire. The modal study concluded that there would be no release in 994 of 1,000 real accidents, and that a substantially lower fraction of accidents could result in any significant release. These results when combined with the probability of a severe accident involving a shipment of SNF, demonstrate that the overall risk associated with severe accidents of SNF shipping casks is very low. The results of the modal study were factored into the analysis for this rulemaking, as an input to the RADTRAN computer code. Additional analyses were performed to address the possible impacts of accidents involving higher burnup fuel.

The consequences associated with an individual SNF shipment have an upper bound, based on the amount of material in the package, the availability of mechanisms to disperse the radioactive contents, the locations and number of receptors, and post-event intervention than would occur. Further, this upper bound in transit might reasonably be expected to be less than that at the origin or destination points (where more SNF would be stored), and some events themselves might be expected to have greater consequences than the damage they cause to the SNF cask. The NRC recognizes that there are some conceivable events (not necessarily traditional 'transportation accidents'), that might be hypothesized to occur to a SNF cask while in transport. Even though these events have an extremely low probability of occurring, they might result in high consequences if they were to occur. The NRC considers these events to be remote and speculative and thus, does not call for detailed consideration. Because the NRC traditionally considers risk to be the product of the probability of an event and its resultant consequences, events with such low probability of occurring have a negligible contribution to the overall risk. In addition, as the probabilities of the events become very low, the value of insights to be gained, for use in regulatory decisions, is not apparent.

Comment: The study underestimates Clark County's residential population and growth rate. In addition, the study does not account for the large nonresident population, resulting in underestimates of risk and impacts.

Response: In keeping with the generic nature and limited intent of the analysis, the original analysis used best available data and best estimates of existing population and population growth rates. In response to commentors' concerns and to reflect the potentially large population growth rate of Clark County, the NRC staff has incorporated higher population estimates into the analysis to provide conservative (higher than best estimate) assessments of potential impacts. However, as indicated by the comment, the task of estimating the impacts on the area population is more complex than assuming a population growth rate. Both the rate of growth of the population and changes in location of the population within the county are important. As stated in Addendum 1, populations within a half mile of the transportation route are the most affected by the transportation activities. Therefore, in order to ensure that the size of the affected population is conservative, the NRC staff's analysis not only increases over time the existing population densities along the assumed transportation routes, but also forecasts increased residential, business, and transient/tourist populations in the areas of likely development.

Issue 4—Cumulative Impacts

Comment: NRC failed to consider cumulative impacts of all spent fuel, HLW, and low-level-waste shipments.

Response: Table S-4 shows the environmental impacts of transportation of fuel and waste directly attributable to one nuclear power plant. The current rulemaking was narrowly focused on the question of whether the impact values given in Table S-4 would be different with spent fuel shipments converging on one destination, Yucca Mountain -- the candidate site under study by DOE for a repository, rather than several destinations. Table S-4 does not consider non-commercial power reactor shipments of fuel and waste. Nevertheless, a discussion of the cumulative impacts of transporting spent fuel, HLW, and low-level waste through southern Nevada has been added to Addendum 1 (Section 2.4). To estimate the potential cumulative effects of DOE shipments of LLW to the Nevada Test Site as well as shipments of HLW to a possible repository, the NRC staff used information published in DOE's Waste Management Programmatic EIS (DOE/EIS-0200-F) May 1997. To ensure that cumulative impacts are not underestimated, the NRC staff selected alternatives in the EIS that led to the highest numbers of shipments to the Nevada Test Site and Yucca Mountain. The results of the analysis indicate that the cumulative doses and expected cancer fatalities resulting from the civilian SNF and the DOE shipments are small compared to the risk of cancer from other causes.

Comment: Commentors stated that cumulative impacts along the Wasatch Front must be considered.

Response: The State of Utah maintains that a study similar to the one conducted for Las Vegas and Clark County must be conducted for the cumulative impacts along the Wasatch Front that would originate from the proposed Private Fuel Storage Facility to be located at Skull Valley, Utah. Such an analysis is beyond the scope of this generic rulemaking because the Commission directed that cumulative impacts attributed to transportation be analyzed only in the vicinity of Yucca Mountain. However, the NRC is currently reviewing a site-specific application for construction and operation of the proposed Private Fuel Storage Facility at Skull Valley in a separate regulatory action. A site-specific study of the cumulative impacts of transportation is part of that review. The study will be reported in a draft Environmental Impact Statement to be published for public comment. Its availability will be noticed in the *Federal Register.*

Issue 5—Legal Requirements

Comment: NRC failed to conduct a legally sufficient risk assessment. Use of a model such as RADTRAN is not in and of itself sufficient to meet the requirements of the National Environmental Policy Act. The NRC must consider consequences of low-probability, high-consequence accidents not included in RADTRAN, including unique local conditions, unforeseen events, sabotage, and human error in cask design. The NRC should adopt the comprehensive risk assessment approach for SNF and HLW transportation described in Golding and White, *Guidelines on the Scope, Content, and Use of Comprehensive Risk Assessment in the Management of High-Level Nuclear Waste Transportation* (1990).

Response: See the response above regarding consideration of severe accident risk (low probability, high consequence accidents) during transportation.

The NRC's regulatory program will continue to ensure that the risk of severe transportation accidents are minimized. Physical security for spent fuel transportation is regulated under 10 CFR 73.37. The regulatory philosophy is designed to reduce the threat potential to shipments and to facilitate response to incidents and recovery of packages that might be diverted in transit. Although the analysis supporting the current rule does not account for the potential for human error, activities related to the design, fabrication, maintenance, and use of transportation packages are conducted under an NRC-approved Quality Assurance Program. This helps to provide consistency in performance and helps reduce the incidence of human error. While a location-specific transportation risk assessment is included in the DOE EIS for the decisions relating to a possible Yucca Mountain repository, the NRC staff believes that the analysis conducted for this rulemaking provides an adequate consideration of the impacts from license renewal. Further, through its regulatory, licensing, and certification functions, the NRC has tried to ensure that transportation of SNF is performed safely with minimum risk to the public, and that vehicle crashes while transporting SNF do not result in severe accidents. Similarly, DOE is expected to ensure that the routes and procedures chosen for SNF transport to the repository provide ample protection of the public health and safety and the NRC reviews and approves the selected routes.

The analysis in Addendum 1 shows that even with conservative assumptions, the cumulative radiological and non-radiological accident risks of SNF transport in Clark County are small. However, there are a number of opportunities to further reduce human health impacts. These include transporting SNF by rail rather than by truck. This would reduce human health effects by reducing the number of shipments and the likelihood of accidents. In addition, shipping SNF via the proposed beltway would reduce health impacts compared to shipping via the current interstate highway system. The implementation of such mitigative measures must await future decisions that fall well outside of the scope of this rulemaking. In addition, for the purposes of individual license renewal rule decisions, no plant specific mitigation measures were found appropriate for addresses the impacts identified in the Addendum. The NRC staff notes that DOE addresses transportation impacts, mitigation measures, and alternative transportation modes in its EIS for the proposed repository at Yucca Mountain.

Issue 6—Socioeconomics

Comment: NRC failed to consider socioeconomic impacts .

Response: Several commentors raised an issue of public perception of risk of waste shipments and its effect on tourism and property values. Under the National Environmental Policy Act (NEPA), the NRC is obligated to consider the effects on the physical environment that could result from the proposed action. Effects that are not directly related to the physical environment must have a reasonably close causal relationship to a change in the physical environment. The Supreme Court ruling in Metropolitan Edison Co. v. People Against Nuclear Energy, 460 U.S. 766 (1983) has narrowly circumscribed, if not entirely eliminated, an agency's NEPA obligation to consider impacts arising solely from the public's perception that an agency's action has created risks of accidents. Accordingly, it is not necessary to consider the impacts on tourism and property values from the public's perception of risk.

The socioeconomic impacts of plant refurbishment and continued operation during the renewal period are discussed in the plant-specific supplement to the GEIS for each individual license renewal applicant. The NRC recognizes that there will likely be increased costs in the unlikely event of an accident. However, for the majority of transportation accidents that may occur, the associated costs are small. For the most severe accidents analyzed by the RADTRAN computer code, the costs could be substantial. Given the low probability of such accidents, the socioeconomic impacts of transportation of SNF do not alter the Commission's conclusions regarding the impacts of this issue.

Issue 7—Higher Burnup Fuel

Comment: There was insufficient consideration of extended fuel burnup issues.

Response: Section 3 of Addendum 1 addresses the issues associated with extended fuel burnup in detail. The NRC staff's analysis of higher burnup fuel examined the issues of radiation doses due to higher dose rates during shipment, higher radiation doses in the event of transportation accidents, and the potential for a criticality in the very unlikely event that high burnup fuel geometry is altered during a transportation accident.

The analysis done by the NRC staff concluded that higher burnup fuel would likely cause higher dose rates during transportation and that dose rates following transportation accidents with radiological releases would also increase, all other things being equal. However, despite the increased dose rates the potential impacts on the transport crews and the affected members of the public would still be acceptably small. The analysis of the potential for criticality following a change in fuel geometry as the result of a transportation accident determined that such an event was not a concern.

Issue 8—Environmental Justice

Comment: NRC failed to consider Environmental Justice.

Response: The analysis suggests that the routes through downtown Las Vegas, Nevada may run through areas containing a higher proportion of low-income and minority groups than the beltway routes. However, as discussed in Sections 2.3 and 2.4 Addendum, the radiological and nonradiological impacts of transportation of SNF are small. In addition, these small impacts are dispersed throughout the entire routes and do not appear to fall disproportionately in any one area. Based on the analysis performed the NRC staff concludes the overall impacts of transportation of SNF will not likely be disproportionately high or adverse for any minority or low-income population.

Issue 9—Regulatory Text

Comment: Several suggestions for clarifying the regulatory text were offered.

Response: The rule has been revised to make it clear that the environmental impact values in Table S-4 (10 CFR 51.52) may be used to account for the environmental effects of transportation of fuel and waste to and from a nuclear power plant at repository such as Yucca Mountain, Nevada, which is under consideration as a HLW repository. If, in the future, Yucca Mountain is removed from consideration as a HLW repository, the Commission will evaluate whether the generic analysis performed for the current rule is applicable to other sites that are considered. If fuel enrichment greater than 5 percent Uranium-235 and fuel burnup of greater than 62,000 MWd/MTU are approved by the Commission, the Commission will consider a rulemaking to assess the continuing generic applicability of Table S-4 to environmental reviews for license renewal.

Comment: The addition to the rule of local transportation impacts associated with continued operation of a plant during the license renewal period needs further clarification in the rule language and in the Supplementary Information.

Response: The rule was revised to clarify that the issue of "Public services, Transportation" in Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 involves the contribution of highway traffic directly attributable to refurbishment and continued operation of a plant during the license renewal period to changes in the service levels of highways in the vicinity of the plant. The majority of traffic directly attributable to a plant is commuting plant workers.

Comment: Paragraph (M) of 10 CFR 51.53(c)(3)(ii) should be deleted.

Response: The rule language has been amended and Paragraph (M) has been deleted. This change from the proposed rule was necessary in order to provide consistency with 51.53(c)(3)(ii), as this section only deals with Category 2 issues. Since the cumulative impacts of transportation of SNF in the vicinity of Yucca Mountain is no longer a Category 2 issue, inclusion in 51.53(c)(3)(ii) is no longer necessary.

Other Comments

This section addresses the comments that are not encompassed by the issue summaries and responses given above. In addition, some comments were received after the close of the comment period. These comments were reviewed, and most were found to be similar to comments already addressed by the issue summaries and responses. However, the comments that raised new ideas relevant to Addendum 1 are also presented in this section. For these late comments, revisions to Addendum 1 were necessarily minimal.

Comment: Addendum 1 assumes that truck transport would have the highest doses. This assumption is not necessarily valid. Also, a different route that avoids Las Vegas should be addressed. (A route through Nellis Air Force Base and down US-95 is being considered by DOE and it has been shown to have higher risks of accident fatalities and to increase the radiological risk.) Routes chosen in Addendum 1 do not bound the analysis properly.

Response: The transportation and route scenarios and their underlying assumptions were designed to reflect situations that most likely would result in highest doses in order to bound the analysis properly as the routes chosen for this analysis were the most populated routes in the state of Nevada. Also, as noted in an earlier response, the NRC staff consulted DOE in determining that truck shipments through densely populated areas of Clark County, Nevada, would have the highest potential impacts among the alternative transportation scenarios that would be given serious consideration in decisions relating to the suitability of the site undergoing study for a repository at Yucca Mountain.

The comment that a route from Nellis Air Force Base down US-95 is higher risk than those selected by the NRC staff provided no specific details concerning that assertion. In the NRC staff's view, any route that bypasses major centers of population will have significantly lower radiological impacts. With regard to traffic accident rates, while it may be true that certain routes will have accident rates that are higher than average, the average rates are low enough that modest increases from the average will not significantly change the staff's conclusions.

Comment: SNF from California would go through Las Vegas twice (in route to Skull Valley and subsequently to Yucca Mountain), resulting in increased risk.

Response: If the proposed SNF storage facility is licensed and built, some SNF may go through Clark County on the way to Skull Valley, Utah. The NRC staff has not analyzed this possible impact because it is not clear at this time that the proposed Skull Valley facility will be licensed or that the SNF would go through Las Vegas if the facility were built. In addition, SNF from California makes up only a small fraction of the SNF that would be shipped. The NRC staff concludes that the conservative assumptions used in the analysis more than compensate for minor changes in transportation plans that may develop for that fraction of the total SNF.

Comment: The NRC should provide affected parties with some statement of the regulatory effect of the interrelationships between the numerous other similar analyses.

Response: As a general matter, the National Environmental Policy Act (NEPA) requires all Federal agencies to perform an environmental review for certain actions they propose to conduct. In the context of nuclear waste management, several agencies have regulatory and operational responsibilities which may involve various proposed actions that, in turn, require the preparation of environmental impact statements (EISs). Inevitably, there may be a degree of overlap in the types of impacts discussed in these various EISs. However, the analysis developed by the NRC for the purposes of license renewal is not binding on future actions and associated environmental impact analyses.

The NRC proposed action that has triggered the preparation of this rulemaking and the associated analysis of environmental impact is the agency's responsibility to review applications for the renewal of nuclear power plant licenses. In light of the discrete purpose of this rulemaking, the NRC has sought to gauge the impacts of license renewal given the information currently available on those impacts including the transportation of spent fuel. Even though these impacts do not occur at the plant site during license renewal, the NRC has considered them here pursuant to its NEPA responsibilities.

Future EISs prepared by other agencies on proposed actions in the waste management arena (e.g., any recommendation by DOE on approval of the Yucca Mountain site for development of a repository) will undoubtedly address some of the same impacts covered by the analysis described in this notice. Some of these other impact statements are anticipated to be more detailed given their purpose and the availability of additional information in the future. This, however, does not diminish the adequacy of the NRC's action. This analysis is sufficient for the purpose it serves and it provides the Commission with the information needed to weigh the likely environmental impacts of SNF transportation for individual license renewals applications and reach informed decisions regarding the acceptability of these applications. The rule does not, however, dictate any particular result for future actions taken with regard to a waste repository or other waste management matters. Specifically, any generic conclusions by the Commission concerning the cumulative environmental impacts of transportation associated with nuclear power plants would in no way affect any DOE decision concerning the suitability of Yucca Mountain or any consideration that DOE may give to transportation impacts in making that decision.

Comment: Addendum 1 is not meaningful to the public. For example, it is impossible to determine if the spent fuel isotope inventory shown in the sample pages of the RADTRAN printout matches the fuel considered in the Addendum.

Response: In preparing Addendum 1, the NRC staff has attempted to write to a broad and diverse audience as much as possible. The NRC staff acknowledges that this rulemaking involves complicated, technical issues. However, the NRC staff has attempted to present these matters in the most clear manner possible. Addendum 1 has been revised and Table 2 provides the fuel isotope inventory that can be compared to the sample pages of the RADTRAN computer code printout.

Comment: The study area is inaccurately defined and the location of some cities is incorrectly stated.

Response: During the preparation of Addendum 1, the initial study area selected for analysis emphasized the urban areas in and near Las Vegas. Route selections were based in part on their proximity to those areas, not to county borders. However, in response to public comments, the study area was expanded to include the entire county. Consequently, the "entry" point for SNF shipments shifted to cities such as Mesquite.

Comment: Addendum 1 should discuss potential mitigation measures, not rely on the DOE Yucca Mountain EIS for that discussion.

Response: The analysis in Addendum 1 shows that, even with conservative assumptions, the cumulative radiological and non-radiological accident risks of SNF transport in Clark County are small. However, there are a number of opportunities to further reduce human health impacts. These include transporting SNF by rail rather than by truck. This would reduce human health effects by reducing the number of shipments and the likelihood of accidents. In addition, shipping SNF via the proposed beltway would reduce health impacts compared to shipping via the current interstate highway system. The implementation of such mitigative measures must await future decisions that fall well outside of the scope of this rulemaking. In addition, for the purposes of individual license renewal rule decisions, no plant specific mitigation measures were found appropriate for addressing the impacts identified in the Addendum. The NRC staff notes that DOE will addresses transportation impacts, mitigation measures, and alternative transportation modes in its EIS for the proposed action to develop a repository at Yucca Mountain.

Comment: Addendum 1 does not mention that the proposed repository which is the destination for shipments of spent nuclear fuel is in Nye County.

Response: A statement noting that the proposed Yucca Mountain repository is in Nye County has been added to Addendum 1.

Comment: No statements of baseline conditions are given in Addendum 1.

Response: Addendum 1 uses background and natural radiation levels as the baseline conditions against which dose estimates can be compared. Both are presented in Addendum 1 and are based in large part on information published by the National Council on Radiation Protection and Measurements.

Comment: The analysis in Addendum 1 is limited to human health effects. Other potential impacts should be considered.

Response: Addendum 1 was prepared to provide information regarding a proposed rule to determine whether the transportation of higher enriched, higher burnup fuel to a single destination is consistent with the values of Table S-4. Because the pertinent section of Table S-4 concerns impact values for human health effects, Addendum 1 concentrates on potential cumulative impacts to human health. However, Section 2.3 of Addendum 1 has been revised to look at the potentially most significant non-human health effect which is the potential increase in traffic volume in Clark County as the result of the transportation of SNF. The NRC staff conclusion is that the impacts are small.

Comment: The analysis assumes the use of the large-capacity GA-4/9 truck cask, which has not been certified and must be used in combination with specially designed trucks that have not been tested. It also assumes that these cask and truck systems will be available in sufficient quantity for the shipments. The commentor seeks assurance that the assumed truck cask system is feasible and that DOE's proposed regional service contractor approach would feasiblely result in the use of such a system for all shipments in the potential truck shipment campaign.

Response: The analysis done by the NRC staff assumes that an adequate number of certified casks would be available. Addendum 1 used extremely conservative assumptions regarding SNF shipments and casks to ensure that the analysis would lead to maximum dose estimates. For example, the analysis of incident-free transportation impacts assumes the use of legal-weight trucks for shipment of the SNF, which results in more and smaller shipments. For the accident analysis, the use of the largest-capacity casks was assumed in order to maximize the amount of SNF that would be involved in the accident. These parameters were intended to bound the parts of the analysis, not to describe parts of the actual SNF shipment protocol such as the specific casks that will be used.

Comment: The analysis appears to assume that oldest spent nuclear fuel would be shipped first to the repository. If so, how will institutional measures achieve this sequencing? If they do not, how will the maximum potential radioactive risk in shipment and storage or disposal be addressed?

Response: The spent fuel will be shipped in casks certified by the NRC. In fact, the current practice of NRC issuing certificates of compliance for casks used for shipment of power reactor fuel is to specify 5 years as the minimum cooling period in a certificate.

Comment: Addendum 1 uses national accident rate statistics. State and/or local rates would be more appropriate.

Response: For the analysis of radiological accidents, data specific to Nevada were used in the RADTRAN computer code runs. However, for the analysis of non-radiological accidents, the NRC staff required data regarding not only accident rates but also injury and fatality statistics. Those data were not available except from the U.S. Department of Transportation.

Comment: Water resource supplies within boundaries of the State of Nevada belong to the public. All waters are subject to appropriation for the beneficial use only under state law.

Response: The water resources of the state will be unaffected by the transport of SNF through Clark County.

Comment: Report failed to provide conditions for informed consent which requires disclosure to those affected, their understanding , and voluntary acceptance.

Response: NRC regulations already contain values that the NRC considers to be acceptable environmental impacts from the shipment of SNF and other radioactive waste. In Addendum 1 the NRC staff is, in part, ensuring that the overall impacts of the transportation of the additional SNF that will be generated as the result of nuclear power plant license renewal are bounded, given the best information the NRC staff has at this time, by those values previously found acceptable. The values specified in the regulations are supported by analysis and were adopted into the regulations only after providing opportunity for public comment as part of the NRC's rulemaking process. As such, the NRC has followed all applicable legal requirements and appropriately carried out its responsibility to consider the environmental impacts of its license renewal decision.

Comment: The NRC staff uses "flawed" science as evidenced by factors including a questionable definition of risk which fails to account for severe accidents, use of misleading if not false average radiation dose rates, manipulation of dose rate data to obtain acceptable results and lack of empirical data especially that applicable to transportation of SNF.

Response: The decision before the Commission is whether the impacts of license renewal are so severe that they should preclude the option of license renewal. As such, the Commission has considered a reasonable estimate of impacts and not included remote and speculative scenarios that do not add to our regulatory decision (see also response to comment on severe accidents, above).

In the analyses described in Addendum 1 the NRC staff uses dose rates that reflect the applicable regulatory limit rather than average dose rates. Even with these very conservative assumptions for dose rates, transportation modes, transportation routes, and a number of other factors, radiation impacts on the transport crews and the general public were not only found to be within all regulatory limits but small as well and there was no need to adjust the assumptions.

Throughout Addendum 1 the NRC staff discusses the assumptions that were made and where applicable the empirical data used to support those assumptions is referenced. With respect to making judgements about the shipment of spent fuel the NRC staff has the benefit of data from over 40 years of experience in shipping SNF in this country as well as overseas.

Comment: High level waste management and transportation should not be a generic issue and Yucca Mountain should not be used for the study as DOE is behind schedule and it is not an approved site for SNF.

Response: Given that the potential environmental impacts of the transportation of SNF resulting from license renewal are similar for all nuclear power plants who seek to renew their operating licenses, and that the NRC staff's analysis contained in Addendum 1 concludes that the impacts are likely to be small, the Commission feels it is appropriate to reclassify the issue as a Category 1 issue. Use of Yucca Mountain, Nevada for purposes of the staff's analysis, as the destination of the SNF is appropriate as it is the only site presently under study. It must be emphasized that this generic environmental impact statement is required to make use of the best information available and at this time the assumption that Yucca Mountain is the destination is reasonable for purposes of the staff's analysis. If in the future, conditions change, the assumption made for this analysis may need to be reevaluated.

Comment: Need to consider the intermodal option being considered by Congress for Caliente, Nevada.

Response: Rather than speculate on which transportation option or options will ultimately be selected, the NRC staff has chosen a mode and routes to Yucca Mountain which in its judgement will have the greatest potential environmental impacts in order to do a bounding analysis for the purpose of this rulemaking.

Comment: The analysis needs to address the impacts of above ground nuclear weapons testing being done at the Nevada Test Site.

Response: For the purposes of considering the environmental impacts of license renewal, there does not appear to be a relevant connection between transportation impacts from civilian SNF and defense related weapons testing at the Nevada test site.

Comment: The analysis relies on assumptions that are 25-30 years old and that have a number of problems including omission of important radionuclides (Iodine-129, Chlorine-36 and Cobalt-60), unrealistic RADTRAN assumptions including inadequate consideration of severe accidents, outdated assumptions from NUREG-0170 and WASH-1238 including the failure to consider the degradation of cladding during extended dry storage, and failure to consider the rail-heavy haul truck option.

Response: With regard to the radionuclides, as indicated in Table 2 of Addendum 1, Cobalt-60 is considered. While both Iodine-129 and Chlorine-36 are long lived, neither is a significant contributor to overall dose. Iodine-129 has a very low specific activity and Chlorine-36 is a beta emitter.

The issue of the severity of accidents considered in the NRC staff's analysis was addressed in an earlier response to comment. The assumptions that are used in the NRC staff's analysis have been periodically reviewed and found adequate. The hypothetical accident conditions of 10 CFR 71.73 have been evaluated against actual conditions encountered in highway and railway accidents and were found to be bounding as documented in NUREG/CR-4829, February 1987, "Shipping Container Response to Severe Highway and Railway Accident Conditions." As noted in Table 3 of Addendum 1, the version of RADTRAN used is updated to March 1999.

Section 3 of Addendum 1 does consider the possible effect of cladding degradation on criticality in the context of increased burnup. That analysis would be equally applicable to any cladding degradation that might occur during prolonged dry storage of the SNF.

With regard to what is asserted to be inadequate consideration of the potential radiological impacts of the rail-heavy haul truck option, the NRC staff has analyzed the radiological impacts of the truck mode along various routes through and around Las Vegas and concludes that they are the limiting scenarios. The largest doses in the incident-free conditions are now to the public. If the rail-heavy haul transport scenario was adopted, a substantial portion of the public exposure would be avoided, since in this scenario, the slow moving heavy haul truck transport would not move through a major population center.

Comment: NRC must consider potential Indian Tribe claims of authority to regulate shipments across reservation lands.

Response: This analysis is a generic study that assumes certain routes for the purpose of evaluating environmental impacts. Because the purpose of this study is neither to propose nor approve routes, the NRC does not need to consider tribal claims of authority to regulate shipments in the context of this analysis.

Comment: The beltway is a county road, not part of the Federal highway system; it is not clear it can be used for shipments.

Response: The DOT regulations do not require that SNF shipments only use federal highways. Therefore, the NRC assumed that the beltway is a possible route around Las Vegas.

Comment: The NRC should address the implications of higher enrichment, higher burnup fuel for consequences of radiological sabotage, as NRC has done so far for the increase in burnup from 33,000 MWd/MTU to 40,000 MWd/MTU (see 49 FR 23867, Proposed Revisions to 10 CFR 73, Modification of Protection Requirements for Spent Fuel Shipments, 6/8/84).

Response: The NRC has not quantified the likelihood of the occurrence of sabotage in this analysis because the likelihood of an individual attack cannot be determined with any degree of certainty. Nonetheless, the NRC has considered, for the purposes of this environmental impact statement and rulemaking, the environmental consequences of such an event. In the determination of the consequences of such an event, higher burnup is only one factor. Based on the staff's study of higher burnup fuel (NUREG-1437, Vol.1, Addendum 1, Table 2), the consequences of a sabotage event involving such fuel could be larger than those in the studies referenced by the commentor. However, given that the consequences of the studies referenced by the commentor were small, even modest increases due to the effects of higher burnup fuel would not result in unacceptably large consequences. Because burnup is not the only factor that could affect the consequences of a sabotage event, the staff continues to study this area. Should new and significant information result from the further study, actions addressing such information will be considered.

Nevertheless, the extensive security measures required by NRC regulations make sabotage events extremely unlikely. Moreover, the casks required to be used to transport spent fuel are designed to withstand very substantial impacts during transport without loss of containment integrity. The cask designs should serve to further reduce the likelihood of release of radioactive material in the extremely unlikely event of sabotage. In view of the fact that NRC safeguards regulations make sabotage events extremely unlikely, and the fact that the cask designs themselves should make a release of radioactive material unlikely even were sabotage to occur, and based on our judgement that, in the extremely unlikely event that sabotage and releases did occur, the consequences from higher burnup fuel would not be unacceptably large, we have concluded that a more extensive study of higher burnup fuel consequences is not warranted for this environmental impact statement and rulemaking.

On June 22, 1999, the Nevada Attorney General filed a petition with the Commission which requested the NRC to amend regulations governing safeguards for shipments of spent nuclear fuel against sabotage and terrorism and to initiate a comprehensive assessment. In particular, the petition indicated that NRC should factor into its regulations the changing nature of threats posed by domestic terrorists, the increased availability of advanced weaponry and the greater vulnerability of larger shipping casks traveling across the country. If, as a result of reviewing this petition, the NRC reaches conclusions that are inconsistent with the results or assumptions in the present rulemaking, the Commission will need to revisit the analysis presented here.

APPENDIX 2

LISTINGS OF HIGHWAY ROUTES EXAMINED IN THIS STUDY

The following listings of the routes examined for this study have been captured from the HIGHWAY computer routing model developed at Oak Ridge National Laboratory (Joy and Johnson 1983, Johnson et al.1993).

Route 1. From I-15 northeast of Las Vegas through the spaghetti bowl.

```
                                      HIGHWAY  3.4
***************************************************************************************************

            AZNVI15 LITTOVER           NV       to       MERCURY        S  U95  LOCL NV

***************************************************************************************************
                     Leaving :  6/17/99 at 11:33 PDT Arriving:  6/17/99 at 13:47 PDT
                     Total Road Time:  2:14          Total Miles:  143.0

        Route Type: C with 2 Driver(s)   Time Bias:   .70  Mile Bias:   .30  Toll Bias:  1.00

        The following constraints are in effect:
           Route avoids links prohibiting truck use
           Route avoids ferry crossings

        Mileage by Highway Sign Type:
                Interstate:   82.0    U.S.:   61.0  State:     .0   Turnpike:     .0
                    County:     .0   Local:     .0  Other:     .0

        Mileage by Highway Lane Type:
              Limited Access Multilane:   94.0  Limited Access Single Lane:     .0
                     Multilane Divided:   49.0         Multilane Undivided:     .0
              Principal Highways:     .0   Through Highways:     .0   Other:     .0

                                    State Mileage
                                    -------------
                                     NV    143.0

          .0              AZNVI15 LITTOVER           NV         .0   0:00   6/17/99 at 11:33
        82.0  I15         LAS VEGAS         I15  I515 NV       82.0   1:08   6/17/99 at 12:41
        61.0  U95         MERCURY        S  U95  LOCL NV      143.0   2:14   6/17/99 at 13:47
```

MILEAGE WITHIN DENSITY LEVELS

State	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
NV	143.0	31.6	44.5	27.2	7.3	3.6	4.8	4.8	4.9	5.0	5.6	2.2	1.5
Route Total	143.0	31.6	44.5	27.2	7.3	3.6	4.8	4.8	4.9	5.0	5.6	2.2	1.5
Percentages		22.1	31.1	19.0	5.1	2.5	3.4	3.4	3.4	3.5	3.9	1.5	1.0

Basis: Estimated 2020 population

Route 1 (*continued*).

```
RADTRAN Input Data       Rural  Suburban     Urban

Weighted Population
     People/sq. mi.       10.0    1200.4    6557.7
     People/sq. km.        3.9     463.5    2531.9

Distance                                              Total
     Miles               114.2      19.5       9.3     143.0
     Kilometers          183.8      31.4      15.0     230.1
     Percentage           79.9      13.6       6.5

Basis (people/sq. mi.)    <139  139-3326     >3326   Estimated 2020 Population

Note: Due to rounding, the sum of the mileage in the individual
      population categories may not equal the total mileage shown
      on this report.
```

Route 2. From I-15 south of Las Vegas through the spaghetti bowl.

```
                                         HIGHWAY  3.4
**********************************************************************************************************

            CANVI15 NIPTSLOA            NV       to       MERCURY        S  U95  LOCL NV

**********************************************************************************************************
                     Leaving :  6/17/99 at 11:34 PDT Arriving:  6/17/99 at 13:18 PDT
                     Total Road Time:  1:45          Total Miles:  103.0

        Route Type: C with 2 Driver(s)   Time Bias:   .70  Mile Bias:   .30  Toll Bias:  1.00

        The following constraints are in effect:
           Route avoids links prohibiting truck use
           Route avoids ferry crossings

        Mileage by Highway Sign Type:
                Interstate:   42.0    U.S.:   61.0  State:     .0   Turnpike:     .0
                    County:     .0   Local:     .0  Other:     .0

        Mileage by Highway Lane Type:
              Limited Access Multilane:   54.0  Limited Access Single Lane:     .0
                     Multilane Divided:   49.0        Multilane Undivided:     .0
              Principal Highways:     .0   Through Highways:     .0   Other:     .0
```

Route 2. (*continued*).

State	Mileage
NV	103.0

.0		CANVI15 NIPTSLOA			NV	.0	0:00	6/17/99 at 11:34
42.0	I15	LAS VEGAS		I15	I515 NV	42.0	0:38	6/17/99 at 12:12
61.0	U95	MERCURY	S	U95	LOCL NV	103.0	1:45	6/17/99 at 13:18

MILEAGE WITHIN DENSITY LEVELS

State	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
NV	103.0	10.8	28.7	21.6	7.1	5.1	6.7	3.1	2.7	3.1	4.9	3.8	5.4
Route Total	103.0	10.8	28.7	21.6	7.1	5.1	6.7	3.1	2.7	3.1	4.9	3.8	5.4
Percentages		10.5	27.9	21.0	6.9	5.0	6.5	3.0	2.6	3.0	4.8	3.7	5.2

Basis: Estimated 2020 Population

RADTRAN Input Data	Rural	Suburban	Urban	
Weighted Population				
People/sq. mi.	16.0	961.3	8314.6	
People/sq. km.	6.2	371.2	3210.3	
Distance				Total
Miles	73.3	15.6	14.1	103.0
Kilometers	118.0	25.1	22.7	165.8
Percentage	71.2	15.1	13.7	
Basis (people/sq. mi.)	<139	139-3326	>3326	Estimated 2020 Population

Note: Due to rounding, the sum of the mileage in the individual population categories may not equal the total mileage shown on this report.

Route 3. From I-15 northeast of Las Vegas using bypass.

```
                              HIGHWAY  3.4
*****************************************************************************************************

            AZNVI15 LITTOVER            NV       to       MERCURY        S  U95  LOCL NV

*****************************************************************************************************
                     Leaving :  6/17/99 at 11:33 PDT Arriving:  6/17/99 at 13:38 PDT
                     Total Road Time:  2:06          Total Miles:  136.0

        Route Type: C with 2 Driver(s)   Time Bias:   .70  Mile Bias:   .30  Toll Bias:  1.00

        The following constraints are in effect:
           Route avoids links prohibiting truck use
           Route avoids ferry crossings

        Mileage by Highway Sign Type:
                Interstate:   87.0    U.S.:   49.0  State:     .0   Turnpike:     .0
                    County:     .0   Local:     .0  Other:     .0

        Mileage by Highway Lane Type:
              Limited Access Multilane:   87.0  Limited Access Single Lane:     .0
                     Multilane Divided:   49.0         Multilane Undivided:     .0
              Principal Highways:     .0   Through Highways:     .0   Other:     .0

                                    State Mileage
                                    -------------
                                     NV    136.0
```

.0		AZNVI15 LITTOVER		NV	.0	0:00	6/17/99 at 11:33
74.0	I15	N LAS VEGAS	NE I15 I215	NV	74.0	1:00	6/17/99 at 12:33
13.0	I215	LAS VEGAS	NW I215 U95	NV	87.0	1:12	6/17/99 at 12:45
49.0	U95	MERCURY	S U95 LOCL	NV	136.0	2:06	6/17/99 at 13:38

MILEAGE WITHIN DENSITY LEVELS

State	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
NV	136.0	31.6	44.5	27.2	7.3	3.5	4.3	3.1	3.1	3.8	4.7	1.7	1.2
Route Total	136.0	31.6	44.5	27.2	7.3	3.5	4.3	3.1	3.1	3.8	4.7	1.7	1.2
Percentages		23.2	32.7	20.0	5.4	2.6	3.2	2.3	2.3	2.8	3.5	1.3	0.9

Basis: Estimated 2020 population

Route 3. (*continued*).

```
RADTRAN Input Data       Rural  Suburban     Urban

Weighted Population
     People/sq. mi.       10.0    1174.1    6489.6
     People/sq. km.        3.8     453.3    2505.6

Distance                                              Total
     Miles               114.1      14.3       7.6    136.0
     Kilometers          183.6      23.0      12.2    218.9
     Percentage           83.9      10.5       5.6

Basis (people/sq. mi.)    <139  139-3326     >3326   Estimated 2020 population

Note: Due to rounding, the sum of the mileage in the individual population
      categories may not equal the total mileage shown on this report.
```

Route 4. From I-15 south of Las Vegas using bypass.

```
                                   HIGHWAY  3.4
**********************************************************************************************************

            CANVI15 NIPTSLOA            NV       to       MERCURY        S  U95  LOCL NV

**********************************************************************************************************
                     Leaving :  6/17/99 at 11:34 PDT Arriving:  6/17/99 at 13:23 PDT
                     Total Road Time:  1:49          Total Miles:  110.0

        Route Type: C with 2 Driver(s)   Time Bias:   .70  Mile Bias:   .30  Toll Bias:  1.00

        The following constraints are in effect:
           Route avoids links prohibiting truck use
           Route avoids ferry crossings

        Mileage by Highway Sign Type:
                Interstate:   61.0    U.S.:   49.0  State:     .0   Turnpike:     .0
                    County:     .0   Local:     .0  Other:     .0

        Mileage by Highway Lane Type:
              Limited Access Multilane:   61.0  Limited Access Single Lane:     .0
                     Multilane Divided:   49.0         Multilane Undivided:     .0
              Principal Highways:     .0   Through Highways:     .0   Other:     .0
```

Route 4. (*continued*).

State Mileage

State	Mileage
NV	110.0

.0		CANVI15 NIPTSLOA		NV	.0	0:00	6/17/99 at 11:34
34.0	I15	LAS VEGAS	S I15 I215	NV	34.0	0:31	6/17/99 at 12:05
27.0	I215	LAS VEGAS	NW I215 U95	NV	61.0	0:55	6/17/99 at 12:30
49.0	U95	MERCURY	S U95 LOCL	NV	110.0	1:49	6/17/99 at 13:23

MILEAGE WITHIN DENSITY LEVELS

State	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
NV	110.0	10.8	28.7	21.6	7.1	5.1	6.4	3.2	4.5	6.5	10.0	3.6	2.5
Route Total	110.0	10.8	28.7	21.6	7.1	5.1	6.4	3.2	4.5	6.5	10.0	3.6	2.5
Percentages		9.8	26.1	19.6	6.5	4.6	5.8	2.9	4.1	5.9	9.1	3.3	2.3

Basis: Estimated 2020 Population

RADTRAN Input Data	Rural	Suburban	Urban	
Weighted Population				
People/sq. mi.	16.0	1272.6	6469.6	
People/sq. km.	6.2	491.3	2498.0	
Distance				Total
Miles	73.3	20.6	16.1	110.0
Kilometers	118.0	33.2	25.9	177.0
Percentage	66.6	18.7	14.6	
Basis (people/sq. mi.)	<139	139-3326	>3326	Estimated 2020 Population

Note: Due to rounding, the sum of the mileage in the individual population categories may not equal the total mileage shown on this report.

APPENDIX 3

SELECTED PAGES FROM THE RADTRAN 4 COMPUTER CODE RUNS

ECHO CHECK

```
&& Edited Mon Jun 21 15:00:18 1999
&& _North_route_via_beltway_with_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID        GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 75278     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
```

```
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.84E+02 8.80E+01 3.80E+00 4.70E+02 2.25E-07 R 1
LINK  1 2.30E+01 4.00E+01 4.53E+02 7.80E+02 2.25E-07 S 1
LINK  1 1.22E+01 2.40E+01 2.51E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.27E+03	0.00E+00	1.74E+00	1.13E+02	1.60E+03	0.00E+00	2.99E+03
LINK 2	0.00E+00	3.49E+02	0.00E+00	4.97E+01	1.19E+02	7.91E+02	0.00E+00	1.31E+03
LINK 3	0.00E+00	3.09E+02	0.00E+00	5.04E+00	6.68E+02	7.91E+02	0.00E+00	1.77E+03
RURAL	0.00E+00	1.27E+03	0.00E+00	1.74E+00	1.13E+02	1.60E+03	0.00E+00	2.99E+03
SUBURB	0.00E+00	3.49E+02	0.00E+00	4.97E+01	1.19E+02	7.91E+02	0.00E+00	1.31E+03
URBAN	0.00E+00	3.09E+02	0.00E+00	5.04E+00	6.68E+02	7.91E+02	0.00E+00	1.77E+03
TOTALS:	0.00E+00	1.93E+03	0.00E+00	5.65E+01	9.00E+02	3.18E+03	0.00E+00	6.07E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1	4.03E-02	REM
LINK 2	4.03E-02	REM
LINK 3	4.03E-02	REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.56E+01	2.37E-01	6.68E-01	7.41E-04	0.00E+00	1.65E+01
LINK 2	2.35E+02	3.46E+00	9.78E+00	1.12E-02	0.00E+00	2.49E+02
LINK 3	1.83E+02	2.35E+00	6.65E+00	7.46E-03	0.00E+00	1.92E+02
RURAL	1.56E+01	2.37E-01	6.68E-01	7.41E-04	0.00E+00	1.65E+01
SUBURB	2.35E+02	3.46E+00	9.78E+00	1.12E-02	0.00E+00	2.49E+02
URBAN	1.83E+02	2.35E+00	6.65E+00	7.46E-03	0.00E+00	1.92E+02
TOTALS:	4.34E+02	6.05E+00	1.71E+01	1.94E-02	0.00E+00	4.57E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

ECHO CHECK

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&& Edited Mon Jun 21 15:19:54 1999
&& _North_route_via_beltway_without_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID        GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 50185     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

```
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.84E+02 8.80E+01 3.80E+00 4.70E+02 2.25E-07 R 1
LINK  1 2.30E+01 4.00E+01 4.53E+02 7.80E+02 2.25E-07 S 1
LINK  1 1.22E+01 2.40E+01 2.51E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	8.46E+02	0.00E+00	1.16E+00	7.53E+01	1.07E+03	0.00E+00	1.99E+03
LINK 2	0.00E+00	2.33E+02	0.00E+00	3.32E+01	7.94E+01	5.28E+02	0.00E+00	8.73E+02
LINK 3	0.00E+00	2.06E+02	0.00E+00	3.36E+00	4.45E+02	5.28E+02	0.00E+00	1.18E+03
RURAL	0.00E+00	8.46E+02	0.00E+00	1.16E+00	7.53E+01	1.07E+03	0.00E+00	1.99E+03
SUBURB	0.00E+00	2.33E+02	0.00E+00	3.32E+01	7.94E+01	5.28E+02	0.00E+00	8.73E+02
URBAN	0.00E+00	2.06E+02	0.00E+00	3.36E+00	4.45E+02	5.28E+02	0.00E+00	1.18E+03
TOTALS:	0.00E+00	1.28E+03	0.00E+00	3.77E+01	6.00E+02	2.12E+03	0.00E+00	4.05E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 2.69E-02 REM
LINK 2 2.69E-02 REM
LINK 3 2.69E-02 REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.04E+01	1.58E-01	4.46E-01	4.94E-04	0.00E+00	1.10E+01
LINK 2	1.57E+02	2.31E+00	6.52E+00	7.46E-03	0.00E+00	1.66E+02
LINK 3	1.22E+02	1.57E+00	4.43E+00	4.97E-03	0.00E+00	1.28E+02
RURAL	1.04E+01	1.58E-01	4.46E-01	4.94E-04	0.00E+00	1.10E+01
SUBURB	1.57E+02	2.31E+00	6.52E+00	7.46E-03	0.00E+00	1.66E+02
URBAN	1.22E+02	1.57E+00	4.43E+00	4.97E-03	0.00E+00	1.28E+02
TOTALS:	2.90E+02	4.03E+00	1.14E+01	1.29E-02	0.00E+00	3.05E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

ECHO CHECK

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&& Edited Mon Jun 21 15:23:48 1999
&& _North_route_via_city_with_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID         GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 75278     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

```
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.84E+02 8.80E+01 3.90E+00 4.70E+02 2.25E-07 R 1
LINK  1 3.14E+01 4.00E+01 4.64E+02 7.80E+02 2.25E-07 S 1
LINK  1 1.50E+01 2.40E+01 2.53E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.27E+03	0.00E+00	1.79E+00	1.13E+02	1.60E+03	0.00E+00	2.99E+03
LINK 2	0.00E+00	4.77E+02	0.00E+00	6.95E+01	1.63E+02	7.91E+02	0.00E+00	1.50E+03
LINK 3	0.00E+00	3.79E+02	0.00E+00	6.25E+00	8.21E+02	7.91E+02	0.00E+00	2.00E+03
RURAL	0.00E+00	1.27E+03	0.00E+00	1.79E+00	1.13E+02	1.60E+03	0.00E+00	2.99E+03
SUBURB	0.00E+00	4.77E+02	0.00E+00	6.95E+01	1.63E+02	7.91E+02	0.00E+00	1.50E+03
URBAN	0.00E+00	3.79E+02	0.00E+00	6.25E+00	8.21E+02	7.91E+02	0.00E+00	2.00E+03
TOTALS:	0.00E+00	2.13E+03	0.00E+00	7.76E+01	1.10E+03	3.18E+03	0.00E+00	6.48E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1	4.03E-02 REM
LINK 2	4.03E-02 REM
LINK 3	4.03E-02 REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.60E+01	2.43E-01	6.86E-01	7.60E-04	0.00E+00	1.69E+01
LINK 2	3.29E+02	4.84E+00	1.37E+01	1.56E-02	0.00E+00	3.48E+02
LINK 3	2.27E+02	2.91E+00	8.24E+00	9.24E-03	0.00E+00	2.38E+02
RURAL	1.60E+01	2.43E-01	6.86E-01	7.60E-04	0.00E+00	1.69E+01
SUBURB	3.29E+02	4.84E+00	1.37E+01	1.56E-02	0.00E+00	3.48E+02
URBAN	2.27E+02	2.91E+00	8.24E+00	9.24E-03	0.00E+00	2.38E+02
TOTALS:	5.72E+02	7.99E+00	2.26E+01	2.56E-02	0.00E+00	6.03E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

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                              ECHO CHECK


&& Edited Mon Jun 21 15:25:58 1999
&& _North_route_via_city_without_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID        GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 50185     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

```
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.84E+02 8.80E+01 3.90E+00 4.70E+02 2.25E-07 R 1
LINK  1 3.14E+01 4.00E+01 4.64E+02 7.80E+02 2.25E-07 S 1
LINK  1 1.50E+01 2.40E+01 2.53E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	8.46E+02	0.00E+00	1.19E+00	7.53E+01	1.07E+03	0.00E+00	1.99E+03
LINK 2	0.00E+00	3.18E+02	0.00E+00	4.64E+01	1.08E+02	5.28E+02	0.00E+00	1.00E+03
LINK 3	0.00E+00	2.53E+02	0.00E+00	4.16E+00	5.47E+02	5.28E+02	0.00E+00	1.33E+03
RURAL	0.00E+00	8.46E+02	0.00E+00	1.19E+00	7.53E+01	1.07E+03	0.00E+00	1.99E+03
SUBURB	0.00E+00	3.18E+02	0.00E+00	4.64E+01	1.08E+02	5.28E+02	0.00E+00	1.00E+03
URBAN	0.00E+00	2.53E+02	0.00E+00	4.16E+00	5.47E+02	5.28E+02	0.00E+00	1.33E+03
TOTALS:	0.00E+00	1.42E+03	0.00E+00	5.17E+01	7.31E+02	2.12E+03	0.00E+00	4.32E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 2.69E-02 REM
LINK 2 2.69E-02 REM
LINK 3 2.69E-02 REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.07E+01	1.62E-01	4.57E-01	5.07E-04	0.00E+00	1.13E+01
LINK 2	2.19E+02	3.22E+00	9.11E+00	1.04E-02	0.00E+00	2.32E+02
LINK 3	1.51E+02	1.94E+00	5.49E+00	6.16E-03	0.00E+00	1.59E+02
RURAL	1.07E+01	1.62E-01	4.57E-01	5.07E-04	0.00E+00	1.13E+01
SUBURB	2.19E+02	3.22E+00	9.11E+00	1.04E-02	0.00E+00	2.32E+02
URBAN	1.51E+02	1.94E+00	5.49E+00	6.16E-03	0.00E+00	1.59E+02
TOTALS:	3.82E+02	5.33E+00	1.51E+01	1.71E-02	0.00E+00	4.02E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

ECHO CHECK

```
&& Edited Mon Jun 21 15:43:05 1999
&& _South_route_via_city_with_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID         GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 75278     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

```
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.18E+02 8.80E+01 6.20E+00 4.70E+02 2.25E-07 R 1
LINK  1 2.51E+01 4.00E+01 3.71E+02 7.80E+02 2.25E-07 S 1
LINK  1 2.27E+01 2.40E+01 3.21E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	8.14E+02	0.00E+00	1.82E+00	7.24E+01	1.03E+03	0.00E+00	1.92E+03
LINK 2	0.00E+00	3.81E+02	0.00E+00	4.44E+01	1.30E+02	7.91E+02	0.00E+00	1.35E+03
LINK 3	0.00E+00	5.74E+02	0.00E+00	1.20E+01	1.24E+03	7.91E+02	0.00E+00	2.62E+03
RURAL	0.00E+00	8.14E+02	0.00E+00	1.82E+00	7.24E+01	1.03E+03	0.00E+00	1.92E+03
SUBURB	0.00E+00	3.81E+02	0.00E+00	4.44E+01	1.30E+02	7.91E+02	0.00E+00	1.35E+03
URBAN	0.00E+00	5.74E+02	0.00E+00	1.20E+01	1.24E+03	7.91E+02	0.00E+00	2.62E+03
TOTALS:	0.00E+00	1.77E+03	0.00E+00	5.83E+01	1.44E+03	2.61E+03	0.00E+00	5.88E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1	4.03E-02 REM
LINK 2	4.03E-02 REM
LINK 3	4.03E-02 REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.63E+01	2.47E-01	6.99E-01	7.75E-04	0.00E+00	1.73E+01
LINK 2	2.10E+02	3.09E+00	8.74E+00	1.00E-02	0.00E+00	2.22E+02
LINK 3	4.36E+02	5.60E+00	1.58E+01	1.78E-02	0.00E+00	4.58E+02
RURAL	1.63E+01	2.47E-01	6.99E-01	7.75E-04	0.00E+00	1.73E+01
SUBURB	2.10E+02	3.09E+00	8.74E+00	1.00E-02	0.00E+00	2.22E+02
URBAN	4.36E+02	5.60E+00	1.58E+01	1.78E-02	0.00E+00	4.58E+02
TOTALS:	6.63E+02	8.94E+00	2.53E+01	2.85E-02	0.00E+00	6.97E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

ECHO CHECK

```
&& Edited Mon Jun 21 15:45:28 1999
&& _South_route_via_city_without_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID        GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 50185     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

```
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.18E+02 8.80E+01 6.20E+00 4.70E+02 2.25E-07 R 1
LINK  1 2.51E+01 4.00E+01 3.71E+02 7.80E+02 2.25E-07 S 1
LINK  1 2.27E+01 2.40E+01 3.21E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	5.43E+02	0.00E+00	1.22E+00	4.83E+01	6.85E+02	0.00E+00	1.28E+03
LINK 2	0.00E+00	2.54E+02	0.00E+00	2.96E+01	8.67E+01	5.28E+02	0.00E+00	8.98E+02
LINK 3	0.00E+00	3.83E+02	0.00E+00	8.00E+00	8.28E+02	5.28E+02	0.00E+00	1.75E+03
RURAL	0.00E+00	5.43E+02	0.00E+00	1.22E+00	4.83E+01	6.85E+02	0.00E+00	1.28E+03
SUBURB	0.00E+00	2.54E+02	0.00E+00	2.96E+01	8.67E+01	5.28E+02	0.00E+00	8.98E+02
URBAN	0.00E+00	3.83E+02	0.00E+00	8.00E+00	8.28E+02	5.28E+02	0.00E+00	1.75E+03
TOTALS:	0.00E+00	1.18E+03	0.00E+00	3.88E+01	9.63E+02	1.74E+03	0.00E+00	3.92E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1	2.69E-02	REM
LINK 2	2.69E-02	REM
LINK 3	2.69E-02	REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.09E+01	1.65E-01	4.66E-01	5.17E-04	0.00E+00	1.15E+01
LINK 2	1.40E+02	2.06E+00	5.83E+00	6.67E-03	0.00E+00	1.48E+02
LINK 3	2.91E+02	3.73E+00	1.05E+01	1.18E-02	0.00E+00	3.05E+02
RURAL	1.09E+01	1.65E-01	4.66E-01	5.17E-04	0.00E+00	1.15E+01
SUBURB	1.40E+02	2.06E+00	5.83E+00	6.67E-03	0.00E+00	1.48E+02
URBAN	2.91E+02	3.73E+00	1.05E+01	1.18E-02	0.00E+00	3.05E+02
TOTALS:	4.42E+02	5.96E+00	1.68E+01	1.90E-02	0.00E+00	4.65E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

ECHO CHECK

```
&& Edited Mon Jun 21 15:48:15 1999
&& _South_route_via_beltway_with_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID        GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 75278     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

```
        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.18E+02 8.80E+01 6.20E+00 4.70E+02 2.25E-07 R 1
LINK  1 3.32E+01 4.00E+01 4.91E+02 7.80E+02 2.25E-07 S 1
LINK  1 2.59E+01 2.40E+01 2.50E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	8.14E+02	0.00E+00	1.82E+00	7.24E+01	1.03E+03	0.00E+00	1.92E+03
LINK 2	0.00E+00	5.04E+02	0.00E+00	7.78E+01	1.72E+02	7.91E+02	0.00E+00	1.55E+03
LINK 3	0.00E+00	6.55E+02	0.00E+00	1.07E+01	1.42E+03	7.91E+02	0.00E+00	2.87E+03
RURAL	0.00E+00	8.14E+02	0.00E+00	1.82E+00	7.24E+01	1.03E+03	0.00E+00	1.92E+03
SUBURB	0.00E+00	5.04E+02	0.00E+00	7.78E+01	1.72E+02	7.91E+02	0.00E+00	1.55E+03
URBAN	0.00E+00	6.55E+02	0.00E+00	1.07E+01	1.42E+03	7.91E+02	0.00E+00	2.87E+03
TOTALS:	0.00E+00	1.97E+03	0.00E+00	9.03E+01	1.66E+03	2.61E+03	0.00E+00	6.34E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1	4.03E-02 REM
LINK 2	4.03E-02 REM
LINK 3	4.03E-02 REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.63E+01	2.47E-01	6.99E-01	7.75E-04	0.00E+00	1.73E+01
LINK 2	3.68E+02	5.41E+00	1.53E+01	1.75E-02	0.00E+00	3.89E+02
LINK 3	3.88E+02	4.97E+00	1.41E+01	1.58E-02	0.00E+00	4.07E+02
RURAL	1.63E+01	2.47E-01	6.99E-01	7.75E-04	0.00E+00	1.73E+01
SUBURB	3.68E+02	5.41E+00	1.53E+01	1.75E-02	0.00E+00	3.89E+02
URBAN	3.88E+02	4.97E+00	1.41E+01	1.58E-02	0.00E+00	4.07E+02
TOTALS:	7.72E+02	1.06E+01	3.00E+01	3.41E-02	0.00E+00	8.13E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.

ECHO CHECK

```
&& Edited Mon Jun 21 15:51:08 1999
&& _South_route_via_beltway_without_rx_life_extension_
TITLE RADTRAN 4.0 INPUT
FORM UNIT
DIMEN 31 8 3 10 18
PARM 1 3 2 1 0
PACKAGE
   LABGRP
      SOLID        GAS    VOLATIL
SHIPMENT
   LABISO
       CR51       MN54       FE55       FE59       CO58       CO60
       KR85       SR89       SR90        Y91       ZR95       NB95
      RU103      RU106      SB125     TE125M      TE127     TE127M
      CS134      CS137      CE141      CE144      PM147      EU154
      PU238      PU239      PU240      PU241      AM241      CM242
      CM244
NORMAL
   NMODE=1
       9.000E-01  5.000E-02  5.000E-02  8.849E+01  4.025E+01  2.416E+01
       4.000E+00  3.100E+00  0.000E+00  1.100E-02  1.000E+00  0.000E+00
       0.000E+00  3.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  8.000E-02  5.000E-02  8.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   SEVFRC
     NPOP=1
       NMODE=1
       4.62E-01  3.02E-01  1.76E-01  4.03E-02  1.18E-02  6.47E-03
       5.71E-04  1.13E-04
     NPOP=2
       NMODE=1
       4.35E-01  2.85E-01  2.21E-01  5.06E-02  6.64E-03  1.74E-03
       6.72E-05  5.93E-06
     NPOP=3
       NMODE=1
       5.83E-01  3.82E-01  2.78E-02  6.36E-03  7.42E-04  1.46E-04
       1.13E-05  9.94E-07
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  6.00E-08  2.00E-07  2.00E-06  2.00E-06  2.00E-06
       2.00E-05  2.00E-05
     GROUP=2
       0.00E+00  9.90E-03  3.30E-02  3.90E-01  3.30E-01  3.30E-01
       6.30E-01  6.30E-01
     GROUP=3
       0.00E+00  6.00E-06  2.00E-05  2.00E-04  2.00E-04  2.00E-04
       2.00E-03  2.00E-03
EOF
ISOTOPES  -1 50185     1.00   13.000   1.00   0.00  VEGAS1
         CR51  7.40E-16     SOLID   2
         MN54  4.80E+01     SOLID   2
         FE55  3.82E+03     SOLID   2
         FE59  3.84E-10     SOLID   2
         CO58  3.67E-04     SOLID   2
         CO60  1.20E+04     SOLID   2
         KR85  1.96E+04       GAS  10
         SR89  1.42E-05     SOLID   2
         SR90  2.20E+05     SOLID   2
          Y91  5.81E-04     SOLID   2
         ZR95  1.78E-04     SOLID   2
         NB95  1.24E-02     SOLID   2
        RU103  2.40E-08   VOLATIL   7
        RU106  4.04E+04   VOLATIL   7
        SB125  5.80E+03     SOLID   2
       TE125M  1.63E+02     SOLID   2
        TE127  2.09E-01     SOLID   2
       TE127M  2.12E-01     SOLID   2
        CS134  1.09E+05   VOLATIL   7
        CS137  3.21E+05   VOLATIL   7
```

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        CE141  2.71E-11     SOLID   2
        CE144  2.21E+04     SOLID   2
        PM147  9.17E+04     SOLID   2
        EU154  1.77E+04     SOLID   2
        PU238  1.72E+04     SOLID   2
        PU239  7.09E+02     SOLID   2
        PU240  1.32E+03     SOLID   2
        PU241  2.88E+05     SOLID   2
        AM241  3.17E+03     SOLID   2
        CM242  1.14E+02     SOLID   2
        CM244  2.18E+04     SOLID   2
LINK  1 1.18E+02 8.80E+01 6.20E+00 4.70E+02 2.25E-07 R 1
LINK  1 3.32E+01 4.00E+01 4.91E+02 7.80E+02 2.25E-07 S 1
LINK  1 2.59E+01 2.40E+01 2.50E+03 2.80E+03 3.60E-07 U 1
PKGSIZ
         VEGAS1     5.00
EOF
```

INCIDENT-FREE SUMMARY
******** **** *******

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	5.43E+02	0.00E+00	1.22E+00	4.83E+01	6.85E+02	0.00E+00	1.28E+03
LINK 2	0.00E+00	3.36E+02	0.00E+00	5.19E+01	1.15E+02	5.28E+02	0.00E+00	1.03E+03
LINK 3	0.00E+00	4.37E+02	0.00E+00	7.10E+00	9.45E+02	5.28E+02	0.00E+00	1.92E+03
RURAL	0.00E+00	5.43E+02	0.00E+00	1.22E+00	4.83E+01	6.85E+02	0.00E+00	1.28E+03
SUBURB	0.00E+00	3.36E+02	0.00E+00	5.19E+01	1.15E+02	5.28E+02	0.00E+00	1.03E+03
URBAN	0.00E+00	4.37E+02	0.00E+00	7.10E+00	9.45E+02	5.28E+02	0.00E+00	1.92E+03
TOTALS:	0.00E+00	1.32E+03	0.00E+00	6.02E+01	1.11E+03	1.74E+03	0.00E+00	4.22E+03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1	2.69E-02	REM
LINK 2	2.69E-02	REM
LINK 3	2.69E-02	REM

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
LINK 1	1.09E+01	1.65E-01	4.66E-01	5.17E-04	0.00E+00	1.15E+01
LINK 2	2.45E+02	3.61E+00	1.02E+01	1.17E-02	0.00E+00	2.59E+02
LINK 3	2.58E+02	3.32E+00	9.37E+00	1.05E-02	0.00E+00	2.71E+02
RURAL	1.09E+01	1.65E-01	4.66E-01	5.17E-04	0.00E+00	1.15E+01
SUBURB	2.45E+02	3.61E+00	1.02E+01	1.17E-02	0.00E+00	2.59E+02
URBAN	2.58E+02	3.32E+00	9.37E+00	1.05E-02	0.00E+00	2.71E+02
TOTALS:	5.15E+02	7.09E+00	2.00E+01	2.27E-02	0.00E+00	5.42E+02

* NOTE THAT INGESTION RISK IS A SOCIETAL RISK;
THE USER MAY WISH TO TREAT THIS VALUE SEPARATELY.