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Sent: Friday, July 11, 2008 8:31 AM
To: Neil Haggerty; Mallecia Hood
Subject: Letter No. 07 - Transportation
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Neil and Mallecia

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TVA

Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

July 2, 2008

10 CFR 52.80

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

In the Matter of)
Tennessee Valley Authority)

Docket Numbers 52-014 and 52-015

NUCLEAR REGULATORY COMMISSION (NRC) – BELLEFONTE NUCLEAR PLANT (BLN) – RESPONSE TO NRC INFORMATION NEED RELATED TO TRANSPORTATION

References:
1. Letter from Ashok Bhatnagar (TVA) to Mr. R. William Borchardt (NRC), "Application for Combined License for BLN Units 3 and 4," dated October 30, 2007.
2. Letter from Andrea L. Sterdis (TVA) to NRC Document Control Desk, "Response to Environmental Report (ER) Sufficiency Review Comments," dated May 2, 2008.

The purpose of this letter is to provide the response to a U.S. Nuclear Regulatory Commission (NRC) information need that was identified by the NRC reviewers during the Environmental Report (ER) site audit conducted at the Tennessee Valley Authority (TVA) Bellefonte Nuclear Plant Units 3 and 4 (BLN) site during the week of March 31 through April 4, 2008. The information need addressed in this letter is related to the environmental review of transportation of spent fuel.

By Reference 1, TVA submitted an application for a combined license for two AP1000 advanced passive pressurized-water reactors at the BLN site. In subsequent discussions with the NRC staff (staff) during the BLN COLA acceptance review, TVA compiled a list of staff comments regarding information in the ER. In Reference 2, TVA responded to an NRC comment (Comment ER20) regarding the environmental impacts associated with the transportation of spent nuclear fuel, as presented in ER Sections 3.8 and 7.4. In response to comment ER20, TVA stated that it had completed a detailed analysis of the radiological and nonradiological impacts of transporting unirradiated and spent nuclear fuel to and from the BLN site, as well as the four alternate site locations, has been performed to demonstrate compliance with 10 CFR 51.52(b). The results of this analysis are reflected in changes to ER Sections 3.8 and 7.4, which are provided as Attachments A and B, respectively, to Enclosure 1. To provide a consistent presentation of the different aspects of radioactive material transportation, these attachments also include updates to the discussions related to transportation of unirradiated fuel and radioactive waste. Therefore, the ER text in Sections 3.8 and 7.4 will be revised in its entirety, and new or deleted text is not specifically identified: This change will be incorporated in a future revision of BLNER. Hyperlinks to ER sections, figures, tables, and reference citations are not included in the changed ER sections enclosed with this letter, but will be provided when these sections are incorporated into the BLN ER revision.

If there are any questions regarding this application, please contact Phillip Ray at 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7030, or via email at pmray@tva.gov.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 2nd day of July, 2008.

Jack A. Bailey

Jack A. Bailey
Vice President, Nuclear Generation Development

Enclosure:
1. Response to NRC Information Needs Related to Transportation (T)

Attachments:
A. Changes to BLN ER Section 3.8 – Transportation of Radioactive Materials
B. Changes to BLN ER Section 7.4 – Transportation Accidents

cc: (Enclosures

E. Cummins, Westinghouse
S P. Frantz, Morgan Lewis
M.W Gettler, FP&L
R. C. Grumbir, NuStart
P. S. Hastings, NuStart
P. Hinnenkamp, Entergy
M. A. Hood, NRC/HQ
M. C. Kray, NuStart
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N. T. Simms, Westinghouse
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B.
M. M. Comar,NRC/HQ
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A. M. Monroe, SCE&G
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EDMS, WT CA-K

Response to NRC Information Needs
Related to
Transportation (T)

NRC Review of the BLN Environmental Report

NRC Information Needs - BLN ER Site Audit Exit Meeting

NRC Environmental Category: TRANSPORTATION

During the NRC's BLN Environmental Report site audit exit meeting on April 4, 2008, the staff identified the following information need:

> 10 CFR 51.52(b) states that license applications for reactors that do not meet the conditions specified in 10 CFR 51.52(a) must provide a "full description and detailed analysis of the environmental effects of transportation of fuel and waste to and from the reactor." The Applicant's Environmental Report (ER) indicates that the reactor does not meet the 10 CFR 51.52(a) conditions, that is, it exceeds the fuel enrichment and fuel exposure conditions. In the ER, the Applicant stated that, in NUREG-1555, the NRC generically considered higher fuel enrichment and exposure conditions than those specified in 10 CFR 51.52(a) and concluded that the environmental impacts of spent nuclear transport are bounded by the impacts in 10 CFR 51.52, Table S-4. However, as stated in the three previous Early Site Permit EISs, these statements apply to current generation LWRs and do not address advanced reactors. This position is made clear in the draft revisions to NUREG-1555 (see http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=072130133, which states that the analyses that support these conclusions (see NUREG-1437 and NUREG-1437 Addendum 1) cannot serve as the initial licensing basis for new reactors. Therefore, the Applicant must provide a full description and detailed analysis of the environmental effects of transportation of fuel and waste to and from the Bellefonte 3 and 4 reactor site.

BLN INFORMATION NEEDS: T-01

BLN RESPONSE:

A detailed analysis of the radiological and nonradiological impacts of transporting unirradiated and spent nuclear fuel to and from the BLN site, as well as the four alternate site locations, has been performed to demonstrate compliance with 10 CFR 51.52(b). For shipments from fuel fabrication facility sites to the plant sites and from the sites to the high-level waste repository at Yucca Mountain, Nevada, highway routes were analyzed using the routing computer code TRAGIS and 2000 Census data. The analysis demonstrates that the impact of accident-free transportation of unirradiated and spent fuel will be SMALL and will not warrant additional mitigation. Additionally, the analysis shows that the transportation accident risks associated with the spent fuel from the proposed new reactors at the BLN and alternative sites would also be SMALL. The results of this analysis are reflected in revisions to ER Sections 3.8 and 7.4, which are provided in Attachments A and B, respectively, to this enclosure.

ASSOCIATED BLN COL APPLICATION REVISIONS:

Revisions to ER Sections 3.8 and 7.4 are provided as Attachments A and B, respectively, to Enclosure 1. To provide a consistent presentation of the different aspects of radioactive material transportation, these enclosures also include updates to the discussions related to transportation of unirradiated fuel and radioactive waste. Therefore, the ER text in Sections 3.8 and 7.4 is replaced in its entirety, and new or deleted text is not specifically identified.

ATTACHMENTS:

A. Changes to BLN ER Section 3.8 – Transportation of Radioactive Materials

B. Changes to BLN ER Section 7.4 – Transportation Accidents

ATTACHMENT A
CHANGES TO ENVIRONMENTAL REPORT SECTION 3.8
TRANSPORTATION OF RADIOACTIVE MATERIALS
JULY 2, 2008

Changes to BLN ER Section 3.8

Transportation of Radioactive Materials

June 2008

BELLEFONTE NUCLEAR PLANT, UNITS 3 AND 4
COL APPLICATION
PART 3, ENVIRONMENTAL REPORT

CHAPTER 3
PLANT DESCRIPTION

TABLE OF CONTENTS

Section Page

LIST OF TABLES

Units of Measure Abbreviations and Acronyms

In addition to the units of measure abbreviations provided on pages ix through xii of the Bellefonte Nuclear Plant Units 3 and 4 (BLN) Environmental Report (ER), the following are used in this revised Section 3.8.

UNITS OF MEASURE ABBREVIATIONS

Abbreviation	Unit of Measurement
Ci	Curies
ft^2	square feet
ft^3	cubic feet
mrem/yr	millirem per year
MWd/MTU	megawatt days/metric tons of uranium
rem	roentgen equivalent man
rem/yr	rem per year

In addition to the acronyms provided on pages xiii through xxv of the BLN ER, the following are used in this revised Section 3.8.

ACRONYMS

Acronym	Definition
DAW	Dry Active Waste
ESRP	environmental standard review plan
GEIS	Generic Environmental Impact Statement
HIC	High Integrity Container
HRCQ	Highway Route Controlled
ID	identification number
NANRC	National Academy National Research Council
NAS	National Academy of Sciences
PWR	pressurized water reactor
RADTRAN	Transportation Risk Assessment Computer Code
TRAGIS	Transportation Routing Analysis Geographic Information System

TRANSPORTATION OF RADIOACTIVE MATERIALS

This section addresses issues associated with the transportation of radioactive materials from the Tennessee Valley Authority (TVA) Bellefonte Nuclear Plant Units 3 and 4 (BLN) and alternative sites, i.e., Phipps Bend Nuclear (PBN), Yellow Creek Nuclear (YCN), Hartsville Nuclear (HVN), and Murphy Hill. Postulated accidents due to transportation of radioactive materials are discussed in Section 7.4.

3.8.1 Transportation Assessment

The NRC regulations in 10 CFR 51.52 state that:

> *"Every environmental report prepared for the construction permit stage or early site permit stage or combined license stage of a light-water-cooled nuclear power reactor, and submitted after February 4, 1975, shall contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor. That statement shall indicate that the reactor and this transportation either meet all of the conditions in paragraph (a) of this section or all of the conditions in paragraph (b) of this section."*

The NRC evaluated the environmental effects of transportation of fuel and waste for light-water reactors (LWRs) in the Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants in Reference 1 and Reference 2 and found the impacts to be SMALL. These NRC analyses provided the basis for Table S-4 in 10 CFR 51.52 (see Table 3.8-1), which summarizes the environmental impacts of transportation of fuel and radioactive wastes to and from a reference reactor. The table addresses two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport.

The advanced LWR technology being considered for the BLN site is the Westinghouse AP1000. The proposed configuration for this new plant is two units. The standard configuration (a single unit) for the AP1000 is used to evaluate transportation impacts relative to the reference reactor.

To compare the impacts of transporting AP1000 fuel to and from the BLN site to the Reference Reactor presented in Table S-4, the fuel and characteristics for the AP1000 were normalized to a reference reactor-year (See Tables 3.8-2 and 3.8-3). The reference reactor is an 1100 MWe reactor that has an 80 percent capacity factor, for an electrical output of 880 MWe per year. One AP1000 reactor is assumed to provide a net electric power to the grid of approximately 1115 MWe, with an annual capacity factor of 93 percent. One AP1000 reactor operating at 1115 MWe, with an annual capacity factor of 93 percent, yields an effective electric output of 1037 MWe.

Subparagraphs 10 CFR 51.52(a)(1) through (5) delineate specific conditions the reactor licensee must meet to use Table S-4 as part of its environmental report. For reactors not meeting all of the conditions in paragraph (a) of 10 CFR 51.52, paragraph (b) of 10 CFR 51.52 requires a further analysis of the transportation effects.

The conditions in paragraph (a) of 10 CFR 51.52 establishing the applicability of Table S-4 are reactor core thermal power, fuel form, fuel enrichment, fuel encapsulation, average fuel irradiation, time after discharge of irradiated fuel before shipment, mode of transport for unirradiated fuel, mode of transport for irradiated fuel, radioactive waste form and packaging, and mode of transport for radioactive waste other than irradiated fuel. The following sections describe the characteristics of the AP1000 relative to the conditions of 10 CFR 51.52 for use of Table S-4. Information for the AP1000 fuel is taken from the AP1000 Design Control Document and supporting documentation prepared by the Idaho National Engineering and Environmental Laboratory (Reference 3).

3.8.1.1 Reactor Core Thermal Power

Subparagraph 10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3800 MW.

> The 3400 MW_t rating of the AP1000 meets this requirement, as reported in the DCD.

The core power level was established as a condition because, for the LWRs being licensed when Table S-4 was promulgated, higher power levels typically indicated the need for more fuel and therefore more fuel shipments than was evaluated for Table S-4. This is not the case for the new LWR designs due to the higher unit capacity and higher burnup for these reactors. The annual fuel reloading for the reference reactor analyzed in WASH-1238 was 30 metric tons of uranium (MTU) while the average annual fuel loading for the AP1000 is approximately 24 MTU. When normalized to equivalent electric output, the annual fuel requirement for the AP1000 is approximately 20 MTU or two-thirds that of the reference LWR.

3.8.1.2 Fuel Form

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered UO2 pellets.

> As presented in the DCD, the AP1000 uses a sintered UO2 pellet fuel form.

3.8.1.3 Fuel Enrichment

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4 percent by weight.

For the AP1000, the enrichment of the initial core varies by region from 2.35 to 4.45 percent and the average for reloads is 4.51 percent. The AP1000 fuel exceeds the 4 percent U-235 condition.

3.8.1.4 Fuel Encapsulation

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. Regulation 10 CFR 50.46 also allows use of ZIRLO™.

The AP1000 uses ZIRLO™ clad fuel rods, which are equivalent to Zircaloy clad fuel rods evaluated in Table S-4 and, therefore, meets this subsequent evaluation condition.

3.8.1.5 Average Fuel Irradiation

Subparagraph 10 CFR 51.52(a)(3) requires that the average burnup not exceed 33,000 megawatt-days per MTU.

The AP1000 has an average maximum burnup of 60,000 MWd/MTU for the peak rod. The extended burnup is 62,000 MWd/MTU. Therefore, the AP1000 does not meet this subsequent evaluation condition.

3.8.1.6 Time after Discharge of Irradiated Fuel before Shipment

Subparagraph 10 CFR 51.52(a)(3) requires that no irradiated fuel assembly be shipped until at least 90 days after it is discharged from the reactor. The supporting basis (Reference 1) for Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies. NUREG/CR-6703, *Environmental Effects of Extending Fuel Burnup above 60 Gwd/MTU,* (Reference 4), which updated this analysis to extend Table S-4 to burnups of up to 62,000 megawatt-days per MTU, assumes a minimum of 5 years between removal from the reactor and shipment.

Five years is the minimum decay time before shipment of irradiated fuel assemblies. The 5-year minimum time is supported additionally by the following three conditions.

- Five years is the minimum cooling time specified in 10 CFR 961.11, within Appendix E of the standard U.S. Department of Energy (DOE) contract for spent fuel disposal with existing reactors.

- In NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (Reference 5), the NRC specifies 5 years as the minimum cooling period when it issues certificates of compliance for casks used for shipment of power reactor fuel.

- The NRC has generically considered the environmental effects of spent nuclear fuel with U-235 enrichment levels up to 5 percent and irradiation levels up to 62,000 megawatt-days per metric ton, and found that the environmental effects of spent nuclear fuel transport are bounded by the effects listed in Table S-4, provided that more than 5 years has elapsed between removal of the fuel from the reactor and shipment of the fuel off-site (Reference 6).

In addition to the minimum fuel storage time, NUREG-1555, *Environmental Standard Review Plan*, Section 3.8, identifies the reviewers' information need regarding the capacity of the on-site storage facilities to store irradiated fuel.

As discussed in the DCD:

The new spent fuel storage facilities (one for each unit) constructed to support the BLN units has enough storage capacity to store 889 total fuel assemblies per unit.

Based on this capacity, the BLN spent fuel storage facility provides more than enough capacity for 5 years of spent fuel storage.

3.8.1.7 Transportation of Unirradiated Fuel

Subparagraph 10 CFR 51.52(a)(5) requires that unirradiated fuel be shipped to the reactor site by truck. Fuel for the AP1000 will be shipped to the BLN site via truck shipments.

Table S-4 includes a condition that the truck shipments not exceed 73,000 lbs. as governed by federal or state gross vehicle weight restrictions. The fuel shipments to BLN and the alternative sites comply with Federal or state weight restrictions.

3.8.1.8 Transportation of Irradiated Fuel

Subparagraph 10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel.

For the impacts analysis described in Section 3.8.2, it was assumed that all spent fuel shipments are made using legal weight trucks. DOE is responsible for spent fuel transportation from reactor sites to the repository and makes the decision on transport mode (10 CFR 961.1).

3.8.1.9 Radioactive Waste Form and Packaging

Subparagraph 10 CFR 51.52(a)(4) requires that, with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form .

As reported in the DCD, waste is packaged in a solid form for shipment.

DAW is placed in an approved transport container, surveyed to ensure it meets all applicable DOT criteria, and shipped off-site for disposal.

3.8.1.10 Transportation of Radioactive Waste

Subparagraph 10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste be either truck or rail. Radioactive waste is shipped from BLN and the alternative sites by truck.

Radioactive waste shipments are subject to a weight limitation of 73,000 lbs. per truck and 100 tons per cask per rail car. Radioactive waste from the AP1000 is shipped in compliance with Federal or state weight restrictions.

3.8.1.11 Number of Truck Shipments

Table S-4 limits traffic density to less than one truck shipment per day or three rail cars per month. Assuming that all radioactive materials (fuel and waste) are received at the site or transported offsite via truck, the required number of truck shipments has been estimated and a discussion follows.

Table 3.8-2 summarizes the number of truck shipments of unirradiated fuel. The table also normalizes the number of shipments to the electrical output for the reference reactor analyzed in WASH-1238. When normalized for electrical output, the number of truck shipments of unirradiated fuel for the AP1000 is less than the number of truck shipments estimated for the reference LWR.

For the AP1000, the initial core load is estimated at 84.5 MTU per unit and the annual reload requirements are estimated at 24 MTU/yr per unit. This equates to about 157 fuel assemblies in the initial core (assuming 0.5383 MTU per fuel assembly) and 43 fuel assemblies per year for refueling. The vendor is designing a transportation container that to accommodate one 14-ft. fuel bundle. Due to weight limitations, the number of such containers is limited to 7 to 8 per truck shipment. For the initial core load, the trucks are assumed to carry 7 containers to allow for shipment of core components along with the fuel assemblies. Truck shipments are expected to accommodate 8 containers per shipment for refueling. The number of new fuel truck shipments equates to 23 for the initial core loading and 5.3 for annual reloads. After normalizing for electrical capacity the number of shipments to support annual reload is 4.9.

The numbers of spent fuel shipments were estimated as follows. For the reference LWR analyzed in WASH-1238, NRC assumed 60 shipments per year, each carrying 0.5 MTU of spent fuel. This amount is equivalent to the annual refueling requirement of 30 MTU per year for the reference LWR. For this transportation analysis, it was assumed that AP1000 spent fuel is also shipped at a rate equal to the annual refueling requirement. The shipping cask capacities used to calculate annual spent fuel shipments were assumed to be the same as those for the reference LWR (0.5 MTU per legal weight truck shipment). This results in 46 shipments per year for one AP1000. After normalizing for electrical output, the number of spent fuel shipments is 39 per year for the AP1000. The normalized spent fuel shipments for the AP1000 are less than the reference reactor that was the basis for Table S-4.

Table 3.8-3 presents estimates of annual waste volumes and numbers of truck shipments. The values are normalized to the reference LWR analyzed in WASH-1238. The normalized annual waste volumes and waste shipments for the AP1000 are less than the reference reactor that was the basis for Table S-4.

The total numbers of truck shipments of fuel and radioactive waste to and from the reactor are estimated at 65 per year for the AP1000. These radioactive material transportation estimates are well below the one truck shipment per day condition given in 10 CFR 51.52, Table S-4.

Doubling the estimated number of truck shipments to account for empty return shipments still results in number of shipments well below the one-shipment-per-day condition.

3.8.1.12 Summary

Table 3.8-4 summarizes the reference conditions in paragraph (a) of 10 CFR 51.52 for use of Table S-4, and the values for the AP1000. The AP1000 does not meet the conditions for average fuel enrichment or average fuel irradiation. Therefore, Sections 3.8.2 and 7.4 present additional analyses of fuel transportation effects for normal conditions and accidents, respectively. Transportation of radioactive waste meets the applicable conditions in 10 CFR 51.52 and no further analysis is required.

3.8.2 Incident-Free Transportation Impacts Analysis

Environmental impacts of incident-free transportation of fuel are discussed in this section. Transportation accidents are discussed in Section 7.4.

NRC analyzed the transportation of radioactive materials in its assessments of environmental impacts for the proposed Early Site Permit (ESP) sites at North Anna, Clinton, and Grand Gulf. The NRC analyses were reviewed for guidance in assessing transportation impacts for BLN and the alternative sites.

In many cases, the assumptions used by NRC are “generic” (i.e., independent of the reactor technology). For example, the radiation dose rate associated with fuel shipments is based on the regulatory limit rather than the fuel characteristics or packaging. The same generic assumptions were used in assessing transportation impacts for unirradiated fuel shipments to BLN and the alternative sites.

3.8.2.1 Transportation of Unirradiated Fuel

Table S-4 of 10 CFR 51.52 includes conditions related to radiological doses to transport workers and members of the public along transport routes. These doses, based on calculations in WASH-1238, are a function of the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time of transit (including travel and stop times), and the number of shipments to which the individuals are exposed.

The transportation risk assessment computer code, RADTRAN 5, calculations estimated worker and public doses associated with annual shipments of unirradiated fuel. One of the key assumptions in WASH-1238 for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 3.28 ft. from the transport vehicle is about 0.1 millirem/hr. This assumption was also used by NRC to analyze advanced LWR unirradiated fuel shipments for proposed ESP sites (References 7, 8, and 9). This assumption is reasonable for the other advanced LWR types because the fuel materials are expected to be low-dose rate uranium radionuclides and this fuel is expected to be packaged similarly (inside a metal container that provides little radiation shielding). The per-shipment dose estimates are “generic” (i.e., independent of reactor technology) because they were calculated based on an assumed external radiation dose rate rather than the specific characteristics of the fuel or packaging. Thus, the results can be used to evaluate the impacts for any of the advanced LWR designs.

For shipments from fuel fabrication facility sites, highway routes were analyzed using the Transportation Routing Analysis Geographic Information System (TRAGIS) routing computer code (Reference 10) and 2000 Census data.

Routes were estimated by minimizing the total impedance of a route, which is a function of distance and driving time between the origin and destination. TRAGIS also can estimate routes that maximize the use of interstate highways. For unirradiated fuel the commercial route setting was used to generate highway routes generally used by commercial trucks. However, the routes chosen may not be the actual routes used in the future. The population summary module of the TRAGIS computer code was used to determine the exposed populations within 0.5 mi. on either side of the route.

It is likely that unirradiated fuel for the AP1000 will initially be manufactured at the Westinghouse fuel fabrication facility in Columbia, South Carolina; however this fuel could also be manufactured at facilities located in Wilmington, North Carolina, Columbia, South Carolina, or Lynchburg, Virginia. Because it is currently unknown which of these facilities would be used, to bound the radiological impacts the Lynchburg facility was evaluated because the distances to that facility would be greater than the other facilities.

In addition to the proposed BLN site in Hollywood, Alabama, four alternate sites were evaluated. These sites and starting locations are provided in Table 3.8-5. Summary data produced by TRAGIS is provided in Table 3.8-6 for unirradiated fuel.

Other input parameters used in the radiation dose analysis for advanced LWR unirradiated fuel shipments are summarized in Table 3.8-6. The results for this “generic” fresh fuel shipment based on the RADTRAN 5 analyses are provided in Table 3.8-7.

These unit dose values were used to estimate the impacts of transporting unirradiated fuel to the BLN and alternative sites. Based on the parameters used in the analysis, these per-shipment doses are expected to conservatively estimate the impacts for fuel shipments. For example, the average shipping distance of 2000 mi. used in the NRC analyses exceeded the shipping distance for fuel deliveries to BLN and the alternative sites (221 mi. to 512 mi.)

The unit dose values were combined with the average number of annual shipments of unirradiated fuel to calculate annual doses to the public and workers that can be compared to Table S-4 conditions.

The number of unirradiated fuel shipments was normalized to the reference reactor analyzed in Reference 1. The number of shipments per year was obtained from Table 3.8-2. The results are presented in Table 3.8-8. As shown, the calculated radiation doses for transporting unirradiated fuel to BLN and the alternative sites are within the Table S-4 conditions.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposures to low doses and dose rates, below about 1E+02 mSv (1E+04 mrem). However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model may over-estimate those risks. A recent review by the National Academy of Sciences Committee to Assess Health Risks from Low Levels of Ionizing Radiation supports the linear no-threshold model.

Based on this model, the risk to the public from radiation exposure is estimated using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 1E+04 person-Sv (1 E+06 person-rem) from International Commission on Radiation Protection (ICRP) Publication 60. All the public doses presented in Table 3.8-8 are less than 1E-03 person-Sv (1E-01 person-rem per year); therefore, the total detriment estimates associated with these doses are all less than 1E-04 fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that the same population incurs annually from exposure to natural sources of radiation.

3.8.2.2 Transportation of Spent Fuel

This section provides the environmental impacts of transporting spent fuel from BLN and the alternative sites to a spent fuel disposal facility using Yucca Mountain, Nevada, as a possible location for a geologic repository. The impacts of the transportation of spent fuel to a possible repository in Nevada provides a reasonable bounding estimate of the transportation impacts to a monitored retrievable storage facility because of the distances involved and the representative exposure of members of the public in urban, suburban, and rural areas.

Incident-free transportation refers to transportation activities in which the shipments reach their destination without releasing any radioactive cargo to the environment. Impacts from these shipments are from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Radiation doses would occur to (1) persons residing along the transportation corridors between BLN (or the alternative sites) and the proposed repository; (2) persons in vehicles passing a spent-fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers.

This analysis is based on shipment of spent fuel by legal-weight trucks in casks with characteristics similar to casks currently available (i.e., massive, heavily shielded, cylindrical metal pressure vessels). Each shipment is assumed to consist of a single shipping cask loaded on a modified trailer. These assumptions are consistent with assumptions made in evaluating environmental impacts of spent fuel transportation in Addendum 1 to NUREG-1437. As discussed in NUREG-1437, these assumptions are conservative, because the alternative assumptions involve rail transportation or heavy-haul trucks, which reduces the overall number of spent fuel shipments.

Routing and population data used in the RADTRAN 5 for truck shipments were obtained from the TRAGIS routing code (Reference 10). The population data in the TRAGIS code were based on the 2000 census.

For fresh fuel, the commercial routing option was used with the following constraints:

- Prohibit use of links prohibiting truck use
- Prohibit use of ferry crossing
- Prohibit low height clearance
- Prohibit narrow width clearance
- Prohibit use of roads with hazardous materials prohibition
- Prohibit use of roads with radioactive materials prohibition
- Prohibit use of roads with tunnels

For spent fuel, the Highway Route controlled option was selected with the following constraints:

- Prohibit use of links prohibiting truck use
- Prohibit use of ferry crossing
- Prohibit low height clearance
- Prohibit narrow width clearance
- Prohibit use of roads with Radioactive materials prohibition
- Prohibit use of roads with tunnels
- Las Vegas Beltway is considered a preferred route

Although shipping casks have not been designed for the advanced LWR fuels, the advanced LWR fuel designs are not significantly different from existing LWR designs. Current shipping cask designs were used for analysis.

Radiation doses are a function of many parameters, including vehicle speed, traffic count, dose rate at 3.3 ft from the vehicle, packaging dimensions, number in the truck crew, stop time, and population density at stops.

The transportation route selected for a shipment determines the total potentially exposed population and the expected frequency of transportation-related accidents. For truck transportation, the route characteristics most important to the risk assessment include the total shipping distance between each origin-destination pair of sites and the population density along the route.

Representative shipment routes for BLN and the alternative sites were identified using the TRAGIS routing model (Reference 10) for the truck shipments. The Highway data network in Web-TRAGIS is a computerized road atlas that includes a complete description of the interstate highway system and other U.S. highways. Input parameters used in the radiation dose analysis for advanced LWR spent nuclear fuel shipments are summarized in Table 3.8-9. The population densities along a route are derived from 2000 census data from the U.S. Bureau of the Census. This transportation route information is summarized in Table 3.8-10. The results for the incident free spent fuel shipments are presented in Table 3.8-11.

These per-shipment dose estimates were calculated based on an assumed external radiation dose rate emitted from the cask, which was fixed at the regulatory maximum of 10 millirem per hour at 6.6 ft. For purpose of this analysis, the transportation crew consists of two drivers. Stop times were assumed to accrue at the rate of 30 minutes per 4-hour driving time.

The number of spent fuel shipments for the transportation impacts analysis was derived as described in Section 3.8.1. The normalized annual shipment values and corresponding population dose estimates per reactor-year are presented in Table 3.8-12. The population doses were calculated by multiplying the number of spent fuel shipments per year for the AP1000 by the per-shipment doses. For comparison to Table S-4, the population doses were normalized to the reference LWR analyzed in WASH-1238.

As shown in Table 3.8-12, population doses to the transport crew and the onlookers for both the AP1000 and the reference LWR exceed Table S-4 values. Two key reasons for these higher population doses relative to Table S-4 are the number of spent fuel shipments and the shipping distances assumed for these analyses relative to the assumptions used in WASH-1238.

- The analyses in WASH-1238 used a "typical" distance for a spent fuel shipment of 1000 mi. The shipping distances used in this assessment were between 2486 mi. and 2610 mi., as presented in Table 3.8-10.

- The numbers of spent fuel shipments are based on shipping casks designed to transport shorter-cooled fuel (i.e., 150 days out of the reactor). This analysis assumed that the shipping cask capacities are 0.5 MTU per legal-weight truck shipment. Newer cask designs are based on longer-cooled spent fuel (i.e., 5 years out of reactor) and have larger capacities. For example, spent fuel shipping cask capacities used in the analysis were approximately 1.8 MTU per legal-weight truck shipment..

Use of the newer shipping cask designs reduces the number of spent fuel shipments and decreases the associated environmental impacts (because the dose rates used in the impacts analysis are fixed at the regulatory limit, rather than actual dose rates based on the cask design and contents).

If the population doses in S-4 were adjusted for the longer shipping distance and larger shipping cask capacity, the population doses from incident-free spent fuel transportation from BLN and the alternative sites would likely fall within Table S-4 requirements.

Other conservative assumptions in the spent fuel transportation impacts calculation include:

- The shipping casks discussed in the Yucca Mountain Environmental Impact Statement (Reference 12) transportation analyses were designed for spent fuel that has cooled for 5 years. In reality, most spent fuel will have cooled for much longer than 5 years before it is shipped to a possible geologic repository. NRC developed a probabilistic distribution of dose rates based on fuel cooling times that indicates that approximately three-fourths of the spent fuel to be transported to a possible geologic repository will have dose rates less than half of the regulatory limit (Reference 13). Consequently, the estimated doses in Table 3.8-

12 could be divided in half if more realistic dose rate projections are used for spent fuel shipments from BLN and the alternative sites.

- For these analyses, a 30-minute rest stop every 4 hours was used as the average stop time. Many stops made for actual spent fuel shipments are short duration stops (i.e., 10 minutes) for brief visual inspections of the cargo (checking the cask tie-downs). These stops typically occur in minimally populated areas, such as an overpass or freeway ramp in an unpopulated area. Based on data for actual truck stops, NRC concluded that the assumption of a 30-minute stop for every 4-hours of driving time used to evaluate other potential ESP sites overestimates public doses at stops by at least a factor of two (References 7, 8 and 9).

Consequently, the doses to onlookers given in Table 3.8-12 could be reduced by a factor of two to reflect more realistic truck shipping conditions.

The environmental impact of incident free transportation of unirradiated and spent fuel is considered to be SMALL and does not warrant additional mitigation.

3.8.3 References

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Table 3.8-1
SUMMARY TABLE S-4 – ENVIRONMENTAL IMPACT OF TRANSPORTATION OF FUEL AND WASTE TO AND FROM ONE LIGHT-WATER-COOLED NUCLEAR POWER REACTOR[A]

Normal Conditions of Transport			
		Environmental Impact	
Heat (per irradiated fuel cask in transport)		250,000 Btu/hr	
Weight (governed by federal or State restrictions)		73,000 lbs. per truck; 100 tons per cask per rail car	
Traffic density:			
Truck		Less than 1 per day	
Rail		Less than 3 per month	
Exposed Population	**Estimated Number of Persons Exposed**	**Range of Doses to Exposed Individuals (per reactor year)[b]**	**Cumulative Dose to Exposed Population (per reactor year)[c]**
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1100	0.003 to 1.3 millirem	3 man-rem.
Along route	600,000	0.0001 to 0.06 millirem	

Accidents in Transport	
Types of Effects	**Environmental Risk**
Radiological effects	Small[d]
Common (nonradiological) causes	1 fatal injury in 100 reactor years 1 nonfatal injury in 10 reactor years $475 property damage per reactor year

a. Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1 NUREG-75/038, April 1975.

b. The Federal Radiation Council has recommended that the radiation doses from the sources of radiation other than natural background and medical exposures should be limited to 5000 millirems per year for individuals as a result of occupational exposure and should be limited to 500 millirems per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

c. Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 millirem), or if two people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

d. Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

Table 3.8-2
Number of Truck Shipments of Unirradiated Fuel (One AP1000)

Reactor Type	Number of Shipments/Unit: Initial Core[a]	Annual reload	Total[b]	Unit Electric Generation MWe[c]	Capacity Factor[c]	Normalized Shipments Total[d]	Normalized Shipments Annual[e]
Reference LWR	18[f]	6.0	252	1100	0.8	252	6.3
AP1000	23[h]	5.3[h]	230	1115	0.93[g]	196	4.9

a. Shipments of the initial core have been rounded up to the next highest whole number.

b. Total shipments of fresh fuel over 40-year plant lifetime (i.e., initial core load plus 39 years of average annual reload quantities).

c. Unit generating capacities from the AP1000 DCD and an assumed capacity factor.

d. Normalized to electric output for WASH-1238 reference plant (i.e., 1100 MWe) plant at 80 percent or an electrical output of 880 MWe).

e. Annual average for 40-year plant lifetime.

f. The initial core load for the reference BWR in WASH-1238 was 150 MTU. The initial core load for the reference PWR was 100 MTU. Both types result in 18 truck shipments of fresh fuel per reactor.

g. Capacity factor was assumed.

h. Initial core load of 157 assemblies required and 43 per year for refueling. Assume 7 assemblies/shipment for initial loading and 8 assemblies/shipment for annual reload.

Table 3.8-3
Number of Radioactive Waste Shipments (One AP1000)

Reactor Type	Waste Generation, ft^3/yr, per unit	Annual Waste Volume, ft^3/yr, per site	Electrical Output, MWe, per site	Capacit y Factor	Normalized Waste Generation Rate, ft^3/ reactor-year[a]	Normalize d Shipments / reactor-year[b]
Reference LWR	3800	3800	1100	0.80	3800	46
AP1000	1964	3928	2230[c]	0.93	1667	21

a. Annual waste generation rates normalized to equivalent electrical output of 880 MWe for reference LWR (1100-MWe plant with an 80 percent capacity factor) analyzed in WASH-1238.

b. The number of shipments was calculated assuming the average waste shipment capacity of 83 ft^3 per shipment (3800 ft^3/yr divided by 46 shipments/yr) used in WASH-1238.

c. The AP1000 site includes two reactor units at net 1115 MWe per unit.

Table 3.8-4
AP1000 Comparisons to Table S-4 Reference Conditions

Characteristic	Table S-4 Condition	AP1000 Single Unit 1115 MWe
Reactor Power Level (MWt)	Not exceeding 3800 per reactor	3400
Fuel Form	Sintered UO_2 pellets	Sintered UO2 pellets
U235 Enrichment (%)	Not exceeding 4	Initial Core Region 1: 2.35 Region 2: 3.40; Region 3: 4.45 Reload Average 4.51
Fuel Rod Cladding	Zircaloy rods; NRC has also accepted ZIRLO™ per 10 CFR 50.46	Zircaloy or ZIRLO™
Average burnup (MWd/MTU)	Not exceeding 33,000	Peak-62,000
Unirradiated Fuel		
Transport Mode	Truck	Truck
No. of shipments for initial core loading[a]		23
No. of reload shipments per year[a]		5.3
Irradiated Fuel		
Transport mode	Truck, rail, or barge	Truck, rail
Decay time prior to shipment	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE	Minimum of 5 years
No. of spent fuel shipments by truck[a]		39 per year
No. of spent fuel shipments by rail		Not analyzed
Radioactive Waste		
Transport mode	Truck or rail	Truck
Waste form	Solid	Solid
Packaged	Yes	Yes
No. of waste shipments by truck[a]		21 per year
Traffic Density		
Trucks per day[b]	Less than 1	<1
(normalized total)		(65 per year)
Rail cars per month	Less than 3	Not analyzed

a. The table provides the total numbers of normalized truck shipments of fuel and waste for the AP1000, based on electric output. These values are then summed for comparison to the traffic density condition in Table S-4.

b. Total truck shipments per year calculated after normalization of estimated fuel and waste shipments for equivalent electrical output to the reference reactor analyzed in WASH-1238.

Table 3.8-5
Primary and Alternative Sites for the BLN COL Application

Site	Location	TRAGIS Origin Location
Bellefonte Units 3 and 4 (BLN)	Hollywood, AL	BLN
Phipps Bend (PBN)	Surgoinsville, TN	Kingsport, TN
Yellow Creek (YCN)	Iuka, MS	Muscle Shoals, AL
Hartsville (HVN)	Hartsville, TN	Lebanon, TN
Murphy Hill	Guntersville Reservoir, Langston, AL	Guntersville, AL

Table 3.8-6 (Sheet 1 of 2)
RADTRAN 5 Input Parameters for the Analysis of Unirradiated Fuel Shipments for BLN and Alternative Sites

Parameter	Parameter Value	Comments and Reference
Package		
Package dimension	38.58 ft.	Approximate length of two LWR Traveller XLs at 226 inches each.
Dose rate at 1 meter from vehicle	0.1 mrem/hr	Reference 1
Fraction of emitted radiation that is gamma	0.5	Assumed the same as for spent nuclear fuel Reference 14
Fraction of emitted radiation that is neutrons	0.5	Assumed the same as for spent nuclear fuel Reference 14
Crew		
Number of crew	2	Reference 1 and 16
Distance from source to crew	10.2 ft.	Reference 16
Crew shielding factor	1.0	No shielding - Analytical assumption
Route-specific parameters		
Rural Suburban Urban	55 mph	Average speed in rural areas given in Reference 15. Conservative in-transit speed of 55 mph assumed: predominately interstate highways used.
Number of people per vehicle sharing route	1.5	Reference 16
One-way traffic volumes		

Rural	Varies by state	Reference 11[a]
Suburban	Varies by state	Reference 11[a]
Urban	Varies by state	Reference 11[a]
Minimum and maximum distances to exposed resident off-link population	33 to 2625 ft.	Reference 13

a. Appendix D, Table D-3 and D-7

Table 3.8-6 (Sheet 2 of 2)
RADTRAN 5 Input Parameters for the Analysis of Unirradiated Fuel Shipments for BLN and the Alternative Sites

Parameter	Parameter Value	Comments and Reference
Distances (mi.)/Population densities (persons per square mi.)		
BLN		
Rural	282.5/48.8	Reference 10
Suburban	225.5/809.7	Reference 10
Urban	10.9/4988.8	Reference 10
PBN		
Rural	143.4/45.2	Reference 10
Suburban	108.1/811.5	Reference 10
Urban	3.6/5282.3	Reference 10
YCN		
Rural	360.0/47.3	Reference 10
Suburban	256.0/828.1	Reference 10
Urban	13.8/5107.7	Reference 10
HVN		
Rural	289.8/49.5	Reference 10
Suburban	202.6/776.3	Reference 10
Urban	7.7/5031.8	Reference 10
Murphy Hill		
Rural	300.6/49.2	Reference 10
Suburban	237.3/801.2	Reference 10
Urban	11.6/4963.3	Reference 10
Truck Stop Parameters		
Min/Max radii of annular area around vehicle at stops	3.3 to 33 ft.	Reference 13
Population density at stops	77,700 persons/mi^2	Reference 13
Shielding factor applied to annular area around vehicle at stops	1.0	Reference 13
Min/Max radii of annular area around truck stop	33 to 2625 ft.	Reference 13
Population density surrounding truck stops	881 persons/mi^2	Reference 13
Shielding factor applied to	0.2	Reference 13

area around truck stop		
Stop time	30 minutes per 4 hour driving time	Reference 13
Shipments per year	4.9 Normalized	Table 3.8-2

Table 3.8-7
Radiological Impacts of Transporting Unirradiated Fuel by Truck to BLN and the Alternative Sites

Population Component	Dose person-rem/shipment				
	BLN	PBN	YCN	HVN	Murphy Hill
Transport workers	4.54E-04	2.23E-04	5.51E-04	4.38E-04	4.81E-04
General public (Onlookers – persons at stops and sharing the highway)	1.49E-03	7.27E-04	1.56E-03	1.47E-03	1.51E-03
General public (Along Route – persons living near a highway)	4.94E-05	2.37E-05	5.77E-05	4.33E-05	5.16E-05

Table 3.8-8
Radiological Impacts of Transporting Unirradiated Fuel by Truck to BLN and the Alternative Sites (One AP1000)

Reactor Type	Normalized Average Annual Shipments	Cumulative Annual Dose, person-rem per reference reactor year		
		Transport Workers	General Public-Onlookers	General Public-Along Route
Reference LWR	6.3	1.10E-02	4.20E-02	1.00E-03
AP1000 - BLN	4.9	2.20E-03	7.30E-03	2.42E-04
AP1000 - PBN	4.9	1.09E-03	3.56E-03	1.16E-04
AP1000 - YCN	4.9	2.70E-03	7.63E-03	2.83E-04
AP1000 - HVN	4.9	2.15E-03	7.21E-03	2.12E-04
AP1000 – Murphy Hill	4.9	2.36E-03	7.40E-03	2.53E-04
10 CFR 51.52	365	4	3	3
Table S-4 Condition	< 1 per day			

a. AP1000 values calculated by multiplying Table 3.8-7 values by the total normalized amount of shipments.

Table 3.8-9
RADTRAN 5 Input Parameters for the BLN Analysis of Spent Nuclear Fuel Shipments

Parameter	Parameter Value	Comments and Reference
Package		
Package dimension	19.0 ft.	The AP1000 spent nuclear fuel is shipped in a Traveller XL that is 226.0 in. (approximately 19 ft)
Dose rate at 1 meter from vehicle	14 mrem/hr	Approximate dose at 1 meter that is equal to the legal limit of 10 mrem/hr at 2 meters (Reference 1)
Fraction of emitted radiation that is gamma	0.5	Reference 14
Fraction of emitted radiation that is neutrons	0.5	Reference 14
Crew		
Number of crew	2	References 1 and 15
Distance from source to crew	10.2 ft.	Reference 16
Crew shielding factor	1.0	Analytical assumption. Results in dose rate to crew greater than legal limit. Crew dose rate reset by RADTRAN to 2 mrem/hr
Route-specific parameters		
Rural Suburban Urban	55 mi. per hour	Average speed in rural areas given in Reference 15. Conservative in-transit speed of 55 mph assumed: predominately interstate highways used.
Number of people per vehicle sharing route	1.5	Reference 15
One-way traffic volumes		
Rural	Varies by state	Reference 11[a]
Suburban	Varies by state	Reference 11[a]
Urban	Varies by state	Reference 11[a]
Minimum and	33 to 2,625 feet	Reference 13

maximum distances to exposed resident off-link population		
Shipments per year per reactor	46 Average 39 normalized	Table 3.8-2

a. Appendix D, Table D-3 and D-7

Table 3.8-10
Transportation Route Information for Spent Fuel Shipments from BLN and the Alternative Sites to the Potential Yucca Mountain Disposal Facility

Reactor Site	One-way Shipping Distance, mi.				Population Density, persons per square mi.			Stop Time per trip, hr
	Total	Rural	Suburban	Urban	Rural	Suburban	Urban	
BLN	2249.1	1878.8	326.7	43.7	22.4	821.7	5893.3	4.5
PBN	2399.0	1950.6	401.4	47.2	24.2	815.1	5743.5	4.5
YCN	2271.8	1901.6	328.4	42.0	22.7	816.1	5773.1	4.5
HVN	2146.1	1800.7	302.6	43.0	21.7	836.3	5829.0	4.0
Murphy Hill	2343.6	1939.6	358.7	45.4	23.3	817.1	5849.7	4.5

Table 3.8-11
Radiological Impacts of Transporting Spent Fuel from BLN and the Alternative Sites by Truck to the Potential Yucca Mountain Disposal Facility (One AP1000)

Population Component	Dose person-rem/shipment				
	BLN	PBN	YCN	HVN	Murphy Hill
Transport workers	1.65E-01	1.76E-01	1.67E-01	1.57E-01	1.72E-01
General public (Onlookers – persons at stops and sharing the highway)	3.93E-01	4.04E-01	3.96E-01	3.55E-01	4.00E-01
General public (Along Route – persons living near a highway)	5.10E-03	6.12E-03	5.10E-03	4.79E-03	5.54E-03

Table 3.8-12
Population Doses from Spent Fuel Transportation, Normalized to Reference LWR

Reactor Site	Exposed Population	Cumulative Dose Limit Specified in Table S-4 Person-rem/RRY	Reactor Type: Reference LWR	Reactor Type: One AP1000
			Number of Spent Fuel Shipments/year	
			60	39[a]
			Environmental Effects Person-rem/RRY[b]	
BLN	Crew	4	5.9	6.4
	Onlookers	3	21	15.3
	Along Route	3	0.60	0.20
PBN	Crew	4	5.9	6.9
	Onlookers	3	21	15.8
	Along Route	3	0.60	0.24
YCN	Crew	4	5.9	6.5
	Onlookers	3	21	15.4
	Along Route	3	0.60	0.20
HVN	Crew	4	5.9	6.1
	Onlookers	3	21	13.9
	Along Route	3	0.60	0.19
Murphy Hill	Crew	4	5.9	6.7
	Onlookers	3	21	15.6
	Along Route	3	0.60	0.22

a. Normalized

b. For the AP1000 values, the number of shipments were multiplied times Table 3.8-11 values

Changes to BLN ER Section 7.4

Transportation Accidents

June 2008

BELLEFONTE NUCLEAR PLANT, UNITS 3 AND 4
COL APPLICATION
PART 3, ENVIRONMENTAL REPORT

CHAPTER 7
ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

TABLE OF CONTENTS

LIST OF TABLES

Units of Measure Abbreviations and Acronyms

In addition to the units of measure abbreviations provided on pages ix through xii of the Bellefonte Nuclear Plant Units 3 and 4 (BLN) Environmental Report (ER), the following are used in this revised Section 7.4.

UNITS OF MEASURE ABBREVIATIONS	
Abbreviation	Unit of Measurement
Ci	curies
ft^2	square feet
ft^3	cubic feet
mrem/yr	millirem per year
MWd/MTU	megawatt days/metric tons of uranium
rem	roentgen equivalent man
rem/yr	rem per year

In addition to the acronyms provided on pages xiii through xxv of the BLN ER, the following are used in this revised Section 7.4.

ACRONYMS

Acronym	Definition
DAW	Dry Active Waste
ESRP	environmental standard review plan
ft^2	square feet
ft^3	cubic feet
HIC	High Integrity Container
HRCQ	Highway Route Controlled
INEEL	Idaho National Engineering and Environmental Laboratory
NANRC	National Academy National Research Council
NAS	National Academy of Sciences
PWR	pressurized water reactor
RADTRAN	Transportation Risk Assessment Computer Code
TRAGIS	Transportation Routing Analysis Geographic Information System

7.4 TRANSPORTATION ACCIDENTS

7.4.1 Transportation of Unirradiated Fuel

Accidents involving unirradiated fuel shipments are addressed in Table S-4 of 10 CFR 51.52. Accident risks are calculated as frequency times consequence. Accident frequencies for transportation of fuel to future reactors are expected to be lower than those used in the analysis in Reference 1, which forms the basis for Table S-4 of 10 CFR 51.52, because of improvements in highway safety and security. Traffic accident, injury, and fatality rates have fallen over the past 30 years. The consequences of accidents that are severe enough to result in a release of unirradiated particles to the environment from fuel for advanced LWRs fuels are not significantly different from those for current generation LWRs. The fuel form, cladding, and packaging are similar to those LWRs analyzed in WASH-1238. Consequently, as described in References 2, 3, and 4, the overall transportation accident risks associated with advanced reactor spent fuel shipments are likely to be SMALL and are consistent with the risks associated with transportation of spent fuel from current-generation reactors.

7.4.2 Transportation of Spent Fuel

In its assessments of proposed ESP sites, NRC used the RADTRAN 5 computer code to estimate impacts of transportation accidents involving spent fuel shipments. RADTRAN 5 considers a spectrum of potential transportation accidents, ranging from those with high frequencies and low consequences (i.e., “fender benders”) to those with low frequencies and high consequences (i.e., accidents in which the shipping container is exposed to severe mechanical and thermal conditions).

A screening analysis was conducted on the inventories reported in Reference 5 by the NRC to select the dominant contributors to accident risks to simplify the RADTRAN 5 calculations. The screening identified the radionuclides that would contribute more than 99.999 percent of the dose from inhalation and the results are reported in the References 2, 3, and 4.

Radionuclide inventories are important parameters in the calculation of accident risks. The radionuclide inventories used in this analysis were taken directly from References 2, 3, 4, and 5, with the exception of Co-60.

Co-60 inventories for this analysis were taken directly from Reference 6. The following discussion is from Section 7.2.3.5 of Reference 6 and provides a discussion regarding the importance of including Co-60 in the overall source term.

> “During reactor operation, corrosion products formed in the reactor’s primary cooling system deposit on fuel assembly surfaces where elements in these deposits are activated by neutron bombardment. The resulting radioactive deposits are called CRUD. Due to vibratory loads during incident free transportation, impact loads during collision accidents, and thermal loads during accidents that lead to fires, portions of these radioactive deposits may spall from the rods. Then, if some of these spalled materials become airborne during an accident, their release to the atmosphere could contribute to the radiation exposures caused by the accident. Although

CRUD contains a number of radionuclides, only Co-60 would contribute significantly to these radiation exposures. Since the CRUD deposits on typical PWR spent fuel rods typically contain 0.2 Ci of Co-60 per rod and the generic PWR assemblies for which ORIGEN inventories were calculated contain respectively 289 spent fuel rods, the amounts of Co-60 produced by activation of deposits on assembly surfaces is 57.8 Ci for the generic PWR assembly (115.6 Ci/MTU based on 0.5 MTU/assembly)."

The spent fuel inventory used in this analysis for the AP1000 is presented in Table 7.4-1.

Massive shipping casks are used to transport spent fuel because of the radiation shielding and accident resistance required by 10 CFR Part 71. Spent fuel shipping casks must be certified Type B packaging systems, meaning they must withstand a series of severe hypothetical accident conditions with essentially no loss of containment or shielding capability. According to Reference 7, the probability of encountering accident conditions that would lead to shipping cask failure is less than 0.01 percent (i.e., more than 99.99 percent of all accidents would result in no release of radioactive material from the shipping cask). The NRC analysis assumed that shipping casks for advanced LWR spent fuels would provide equivalent mechanical and thermal protection of the spent fuel cargo.

The NRC performed the RADTRAN 5 accident risk calculations using unit radionuclide inventories (curies/metric ton uranium [Ci/MTU]) for the spent fuel shipments from the advanced LWRs. The resulting risk estimates were multiplied by the expected annual spent fuel shipments (MTU/yr) to derive estimates of the annual accident risks associated with spent fuel shipments from each potential advanced LWR. The amount of spent fuel shipped per year was assumed to be equivalent to the annual discharge quantities: 24 MTU/yr for the AP1000. This discharge quantity has not been normalized to the reference LWR. The normalized value is presented in Table 7.4-2.

NRC used the release fractions for current generation LWR fuels to approximate the impacts from the advanced LWR spent fuel shipments. This assumes that the fuel materials and containment systems (i.e., cladding, fuel coatings) behave similarly to current LWR fuel under applied mechanical and thermal conditions. The same assumptions regarding release fractions were used in this analysis.

The shipping distances and population distribution information for the routes from BLN and the alternative sites were the same as those used for the "incident-free" transportation impacts analysis (described in Section 3.8.2).

Table 7.4-2 presents unit (per MTU) accident risks associated with transportation of spent fuel from the proposed advanced reactor sites to the proposed Yucca Mountain repository. The accident risks are provided in the form of a unit collective population dose (i.e., person-rem per MTU). The table also presents estimates of accident risk per reactor year normalized to the reference reactor analyzed in Reference 1.

7.4.3 Nonradiological Impacts

Nonradiological impacts are calculated using accident, injury, and fatality rates from published sources. The rates (i.e., impacts per vehicle-mi. traveled) are then multiplied by estimated travel distances for workers and materials. The general formula for calculating nonradiological impacts is:

Impacts = (unit rate) x (round-trip shipping distance) x (annual number of shipments)

In this formula, impacts are presented in units of the number of accidents, number of injuries, and number of fatalities per year. Corresponding unit rates (i.e., impacts per vehicle-mi traveled) are used in the calculations.

The general approach used, in this document, to calculate nonradiological impacts of unirradiated and spent fuel shipments is based on the approach used in the Yucca Mountain SEIS which used adjusted state-level accident, injury, and fatality statistics from References 8 and 9 (Table 7.4-3). The round trip distances between the proposed advanced reactor sites and the fuel fabrication facility (assumed to be located in Lynchburg, Virginia) and Yucca Mountain, Nevada (Table 7.4-4) provided the data for the last part of the equation. State-by-state shipping distances were obtained from the Web-TRAGIS output file and combined with the annual number of shipments and accident, injury, and fatality rates by state from References 8 and 9, to calculate nonradiological impacts. The results are shown in Table 7.4-4 and are compared to those reported in Table S-4. It should be noted that because of the larger round trip distances and greater number of shipments, 95 percent of the total nonradiological impacts (fresh fuel and spent nuclear fuel), are from the shipment of spent nuclear fuel. It should also be noted that the fatalities/RRY calculated for the shipment of fresh and spent nuclear fuel are slightly larger than those reported in Table S-4. This is primarily due to the longer shipping distances and adjusted accident, injury, and fatality rate data that were used for the shipment of fresh fuel to and spent fuel from Bellefonte and the alternative sites versus what was used for the basis to support Table S-4.

7.4.4 Conclusion

Considering the uncertainties in the data and computational methods, NRC concluded that the overall transportation accident risks associated with advanced LWR unirradiated and spent fuel shipments are considered to be SMALL and are consistent with the transportation risks from current generation reactors presented in Table S-4 of 10 CFR 51.52. The same conclusion is true of the Transportation accident risks associated with the spent fuel from proposed new reactors at BLN and the alternative sites and are considered to be SMALL.

7.4.5 References

1. U.S. Atomic Energy Commission (AEC), *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plant*, WASH-1238, Washington, D.C., December 1972.

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3. U.S. Nuclear Regulatory Commission, *Draft Environmental Impact Statement for an Early Site Permit (ESP) at the Exelon ESP Site*, NUREG-1815, Office or Nuclear Reactor Regulation, Washington, D.C., July 2006.

4. U.S. Nuclear Regulatory Commission, *Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site*, NUREG-1817, Office or Nuclear Reactor Regulation, Washington, D.C., April 2006.

5. Idaho National Engineering and Environmental Laboratory (INEEL), *Early Site Permit Environmental Report Sections and Supporting Documentation*, Design File Number 3747, Idaho Falls, Idaho, July 2003.

6. U.S. Nuclear Regulatory Commission. *Reexamination of Spent Fuel Shipment Risk Estimates*. NUREG/CR-6672. Office or Nuclear Reactor Regulation. Washington, D.C. March 2000.

7. Sprung, J. L., D. J. Ammerman, N. L. Breivik, R. J. Dukart, F. L. Kanipe, J. A. Koski, G. S. Mills, K. S. Neuhauser, H. D. Radloff, R. F. Weiner, and H. R. Yoshimura, *Reexamination of Spent Fuel Shipment Risk Estimates*, NUREG/CR-6672, Volume 1, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C., March 2000.

8. Saricks, C.L., and M.M. Tompkins**,** *State-Level Accident Rates of Surface Freight Transportation: A Re-examination*, Argonne National Laboratory, Energy Systems Division, Center for Transportation Research, April 1999.

9. Blower, D and A. Matteson, Center for National Truck Statistics, *Evaluation of the Motor Carrier Management Information System Crash File, Phase 1*. University of Michigan. March 2003.

Table 7.4-1
Radionuclide Inventory Used in Transportation Accident Risk Calculations for the AP1000

Radionuclide	AP1000 Inventory Ci/MTU[a]
Am-241	7.27E+02
Am-242m	1.31E+01
Am-243	3.34E+01
Ce-144	8.87E+03
Cm-242	2.83E+01
Cm-243	3.07E+01
Cm-244	7.75E+03
Cm-245	1.21E+00
Cs-134	4.80E+04
Cs-137	9.31E+04
Co-60[b]	1.20E+02
Eu-154	9.13E+03
Eu-155	4.62E+03
Pm-147	1.76E+04
Pu-238	6.07E+03
Pu-239	2.55E+02
Pu-240	5.43E+02
Pu-241	6.96E+04
Pu-242	1.82E+00
Ru-106	1.55E+04
Sb-125	3.83E+03
Sr-90	6.19E+04
Y-90	6.19E+04

Source: References 2, 3, 4, and 5
a. Ci/MTU = curies per metric ton uranium
b. Cobalt-60 is the key radionuclide constituent of fuel assembly Crud (rounded up). Source: Reference 6.

Table 7.4-2
Spent Fuel Transportation Accident Risks for the AP1000

Site	Unit Population Dose (Person-rem/MTU)	MTU/RRY[a]	Population Dose (person-rem/RRY)[b]
Bellafonte	1.68E-06	19.5	3.27E-05
PBN	1.78E-06	19.5	3.47E-05
YCN	1.67E-06	19.5	3.25E-05
HVN	1.64E-06	19.5	3.19E-05
Murphy Hill	1.83E-06	19.5	3.57E-05
Table S-4			SMALL

a. Based on 39 normalized shipments/yr and 0.5 MTU/shipment

b. Value presented is the product of unit population dose times the product of MTU/shipment and normalized shipments/year.

Table 7.4-3
Adjusted Accident, Injury and Fatality Rates for the United States

	Accidents/Trucks-mi.		Fatalities/Trucks-mi.		Injuries/Trucks-mi.	
State/Parameter	**Interstate**	**Total**	**Interstate**	**Total**	**Interstate**	**Total**
Alabama	7.45E-07	9.96E-07	2.17E-08	5.55E-08	2.86E-07	4.12E-07
Arizona	3.49E-07	2.83E-07	2.38E-08	2.38E-08	2.25E-07	1.77E-07
Arkansas	3.54E-07	3.91E-07	1.57E-08	5.63E-08	1.90E-07	2.40E-07
California	4.23E-07	2.19E-07	1.77E-08	9.12E-09	2.40E-07	1.24E-07
Colorado	1.18E-06	1.15E-06	2.90E-08	4.44E-08	6.08E-07	5.86E-07
Connecticut	2.38E-06	2.33E-06	3.67E-08	4.84E-08	1.18E-06	1.19E-06
Delaware	1.37E-06	1.92E-06	1.42E-08	5.95E-08	6.60E-07	9.87E-07
Florida	1.82E-07	2.35E-07	1.95E-08	2.72E-08	1.06E-07	1.37E-07
Georgia	*	1.77E-06	*	4.94E-08	*	8.87E-07
Idaho	7.79E-07	1.04E-06	9.62E-09	6.31E-08	5.92E-07	7.61E-07
Illinois	5.86E-07	7.82E-07	2.11E-08	2.78E-08	2.90E-07	3.17E-07
Indiana	5.94E-07	4.46E-07	1.71E-08	2.17E-08	2.70E-07	2.22E-07
Iowa	2.96E-07	3.91E-07	2.38E-08	3.40E-08	1.66E-07	2.19E-07
Kansas	7.50E-07	1.01E-06	1.32E-08	5.81E-08	4.91E-07	6.66E-07
Kentucky	8.19E-07	1.37E-06	3.25E-08	5.81E-08	4.26E-07	6.97E-07
Louisiana	*	5.84E-07	*	2.33E-08	*	3.56E-07
Maine	1.16E-06	1.09E-06	2.30E-08	1.98E-08	6.02E-07	6.44E-07
Maryland	1.43E-06	1.96E-06	1.64E-08	5.04E-08	8.87E-07	1.17E-06
Massachusetts	2.27E-07	4.09E-07	2.03E-09	9.62E-09	9.85E-08	2.01E-07
Michigan	7.47E-07	5.68E-07	2.72E-08	2.72E-08	5.04E-07	4.25E-07
Minnesota	4.52E-07	4.65E-07	7.60E-09	3.04E-08	1.63E-07	2.33E-07
Mississippi	1.27E-07	1.66E-07	6.34E-09	8.61E-09	7.53E-08	1.10E-07
Missouri	1.23E-06	1.42E-06	3.14E-08	4.99E-08	6.07E-07	7.05E-07
Montana	1.64E-06	1.54E-06	3.44E-08	5.15E-08	4.94E-07	4.99E-07
Nebraska	8.43E-07	1.15E-06	3.48E-08	4.75E-08	3.80E-07	5.01E-07
Nevada	5.94E-07	6.47E-07	1.67E-08	2.25E-08	2.86E-07	3.12E-07
New Hampshire	6.95E-07	1.01E-06	0.00E+00	2.99E-08	3.15E-07	4.52E-07
New Jersey	1.49E-06	1.30E-06	3.07E-08	1.80E-08	7.55E-07	7.32E-07
New Mexico	2.98E-07	2.85E-07	2.99E-08	2.78E-08	2.22E-07	2.09E-07
New York	*	9.11E-07	*	3.14E-08	*	3.57E-07
North Carolina	9.14E-07	8.82E-07	3.78E-08	4.10E-08	6.12E-07	6.10E-07
North Dakota	7.98E-07	9.03E-07	2.59E-08	2.82E-08	3.65E-07	4.89E-07
Ohio	4.33E-07	3.06E-07	9.88E-09	9.88E-09	2.70E-07	2.06E-07
Oklahoma	7.08E-07	7.29E-07	3.36E-08	3.73E-08	5.58E-07	5.50E-07
Oregon	*	5.70E-07	*	5.17E-08	*	2.62E-07
Pennsylvania	1.36E-06	1.79E-06	3.43E-08	6.16E-08	7.40E-07	1.03E-06
Rhode Island	*	*	*	*	*	*
South Carolina	*	1.24E-06	*	6.58E-08	*	6.37E-07
South Dakota	6.15E-07	6.05E-07	1.55E-08	3.22E-08	3.32E-07	3.07E-07
Tennessee	3.25E-07	4.20E-07	2.53E-08	3.30E-08	1.77E-07	2.45E-07

a. Values from Table 4 presented in Reference 8 were adjusted by the values obtained in Tables 1 and 2 of Reference 9 to form the basis for this table

Table 7.4-3
Adjusted Accident, Injury and Fatality Rates for the United States (cont.)

	Accidents/Trucks-mi.		Fatalities/Trucks-mi.		Injuries/Trucks-mi.	
State/Parameter	**Interstate**	**Total**	**Interstate**	**Total**	**Interstate**	**Total**
Texas	1.59E-06	1.74E-06	3.30E-08	6.84E-08	1.06E-06	1.04E-06
Utah	7.66E-07	8.98E-07	3.01E-08	3.52E-08	4.89E-07	5.49E-07
Vermont	4.97E-07	7.87E-07	*	2.46E-08	2.93E-07	4.25E-07
Virginia	1.04E-06	7.00E-07	4.09E-08	2.95E-08	5.99E-07	4.17E-07
Washington	7.00E-07	5.41E-07	4.55E-09	1.34E-08	3.48E-07	2.70E-07
West Virginia	4.54E-07	5.68E-07	4.26E-08	7.05E-08	2.16E-07	2.70E-07
Wisconsin	1.19E-06	1.45E-06	2.30E-08	5.63E-08	6.44E-07	7.92E-07
Wyoming	1.79E-06	1.79E-06	2.74E-08	3.14E-08	6.24E-07	6.24E-07

Table 7.4-4
Nonradiological Impacts Resulting from the Shipment of Unirradiated and Spent Nuclear Fuel, Normalized to Reference LWR

Site	Round Trip Distance One Shipment Unirradiated Fuel - mi	Round Trip Distance One Shipment Spent Fuel – mi	Round-trip Distance, mi/RRY[a]	Accidents/ RRY	Injuries/ RRY	Fatalities/ RRY
BLN	1,038	4,499	180,547	9.32E-02	6.04E-02	4.57E-03
PBN	511	4,798	189,626	9.49E-02	6.15E-02	4.82E-03
YCN	1,260	4,544	183,390	9.60E-02	6.11E-02	4.63E-03
HVN	1,001	4,293	172,332	8.95E-02	5.84E-02	4.37E-03
Murphy Hill	1,099	4,688	188,217	1.00E-01	6.33E-02	4.77E-03
Table S-4	----	----	144,357	NC[b]	1.00E-01	1.00E-03

a. Based on 4.9 shipments/yr of unirradiated waste, 39 shipments/yr of spent fuel, and round trip shipping distances for both Unirradiated and spent fuel.

b. Not calculated.