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Transportation Impacts of the Commercial Radioactive Waste Management Program

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Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
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TRANSPORTATION IMPACTS OF THE COMMERCIAL RADIOACTIVE WASTE MANAGEMENT PROGRAM

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ABSTRACT

This report discusses the relative costs and national environmental impacts resulting from the transportation of spent nuclear fuel and high level nuclear wastes to each of nine potential commercial repository sites. The analysis is an update of two previous studies performed for the Department of Energy and includes the Monitored Retrievable Storage (MRS) facility option as well as updated assumptions regarding high level waste flows and transportation cask capacities. Comparisons between the repository sites indicate that the eastern-most repository sites have the lowest relative transportation costs and risks with the highest values calculated for the most western sites. Incorporation of an MRS into the system reduces the disparity between the costs and risks projected for the candidate site locations with the use of the large-capacity dedicated rail cask from the MRS showing a benefit for that scenario.

* Prepared by Sandia National Laboratories' Transportation Technology Center for the United States Department of Energy under contract DE-AC04-76DP00789.

TABLE OF CONTENTS

LIST OF TABLES

TABLES IN APPENDICES

TABLES IN APPENDICES (cont'd)

TABLES IN APPENDICES (cont'd)

LIST OF FIGURES

EXECUTIVE SUMMARY

This report discusses the relative national environmental impacts of transporting nuclear wastes to each of nine candidate repository sites. Several of the potential sites are closely clustered and, for the purpose of distance and routing calculations, are treated as a single location. These are: Cypress Creek Dome and Richton Dome in Mississippi (Gulf Interior Region), Deaf Smith County and Swisher County sites in Texas (Permian Basin), and Davis Canyon and Lavender Canyon sites in Utah (Paradox Basin). The remaining sites are: Vacherie Dome, Louisiana; Yucca Mountain, Nevada; and Hanford Reservation, Washington.

For compatibility with both the repository system authorized by the 1982 Nuclear Waste Policy Act and the Monitored Retrievable Storage (MRS) option to be proposed to Congress, two separate scenarios are analyzed in this report. In brief, they are (1) shipment of spent fuel and high level waste (HLW) directly from waste generators to a repository (Reference Case) and (2) shipment of spent fuel to a Monitored Retrievable Storage (MRS) facility and then to a repository.

The results of this analysis are included in the Environmental Assessments for the first repository sites and the Monitored Retrievable Storage facility. Site specific analyses are being performed for each of the candidate repository and MRS sites by their responsible staffs and are not included in this document. Because of the relative complexity of the issues, these impacts should be considered to be relative indicators between the sites.

For the reference case (Scenario 1, above), the primary waste stream is spent nuclear fuel (SF) from reactors. Secondary waste streams considered for this case include defense high level wastes (DHLW) from the Savannah River Plant in South Carolina, the Hanford Reservation in Washington, and the Idaho National Engineering Laboratory in Idaho, and commercially-generated high level waste from West Valley, New York (WVHLW). Acceptance of DHLW in a commercial repository was endorsed by the President during 1985. In the case, all reactors will ship 5-year-old or older unconsolidated spent fuel directly to a candidate repository site. High level commercial and defense wastes will also be shipped directly to the repository. Two primary modal options are examined for the reference case: all truck and all rail from reactors and HLW generators. Detailed study parameters are discussed in Chapter II. The resultant costs and risks will bound the transportation impacts. No attempt has been made to forecast the actual fractions of truck and rail transport that might be used. The shipping system ultimately used for transportation of spent fuel and HLW will be a combination of modes determined by considerations such as the capabilities of handling facilities at the origins, freight rates, and operational constraints of the system.

MRS input data and scenarios in this document are compatible with those being used by the MRS program. Final MRS documentation to be presented to Congress will, however, include additional alternatives not discussed here.

For the MRS cases, as in the reference case, reactors will ship 5-year-old or older unconsolidated spent fuel, but to an MRS rather than a repository. All spent fuel leaving the MRS will be consolidated and at least 10 years old. Additional secondary wastes would be generated at an MRS by the proposed spent fuel consolidation and possible overpacking operations. These MRS-related secondary wastes would consist of assembly hardware, high activity waste (HAW), and transuranic waste (TRU), which would also be shipped to the repository. Transport from an MRS would be by one of two possible shipping options: (1) 100-ton (100T) dedicated rail shipments of overpacked consolidated spent fuel and waste byproducts generated in the consolidation process and (2) 150-ton (150T) dedicated rail shipments of nonoverpacked consolidated spent fuel and byproducts. As in the reference case, high level commercial and defense wastes are shipped directly to the repository. Bounding conditions considered for shipments out of the MRS include total cask weight and payload characteristics that minimize or maximize cask capacity and, hence, put upper and lower limits on the number of shipments from the MRS to the repository.

Results of the analysis performed for the reference case are summarized in Tables 1 through 3, below. It was the intention of this analysis to compare the repository options under the modal bounding cases outlined, differences in cost and impacts among the various repository sites are primarily to the total shipping distances (Table 1). As can be seen in the table, spent fuel shipments account for the largest fraction of the shipping distance for both modal options, comprising from 70-[illegible] [illegible] total truck travel and from approximately 60-75 percent of the total rail travel. In either case the largest percentages are associated with the westernmost site (Hanford, WA). The fraction of total travel attributable to spent fuel transport increases as the potential repository site is shifted to the west because most of the spent fuel inventory projected to require shipment to the first repository is from reactors in the East. The fraction of high level wastes requiring shipment to the repository is between 20 and 30 percent for truck and 25 and 35 percent for rail. Although the projected mileage increases as the more western repository options are analyzed, the relative influence of high level wastes on the results decreases. Data in Table 1 indicate that miles traveled to the westernmost sites (Yucca Mt, NV, and Hanford, WA) is almost double the total shipment miles required for transport to the easternmost sites (Gulf Interior Region).

Transportation costs for the repository location options are summarized in Table 2. These costs increase with the total number of shipment-miles; however, because of the tariff structures of the transport modes, they do not increase in a linear manner. Truck costs increase by approximately 75 percent between the most eastern site in the Gulf Interior Region and the Hanford site in the West. Consistent with the rail rate structure, total rail costs for these sites vary by only about 40 percent. Truck costs are lower than rail for the easternmost sites and higher than rail for the western sites. The contribution of spent fuel cost to the total is consistent with the fraction of shipment mileage attributable to spent fuel transport for truck; it is somewhat less than the fraction of total mileage for rail.

Because the points of origin of most shipments (i.e. reactors) are primarily in the eastern United States, the average fractions of total in rural, suburban, and urban population-density zones are about the spent fuel transport to each candidate repository site. Consequently,

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travel distance becomes the major discriminator of risk between sites for a given shipment scenario. Table 3 shows that the Gulf Interior Region ([illegible]) and Vacherie, LA, sites, which are closest to the origin points, have the lowest overall transportation risks associated with them; while those sites farthest from the majority of the country's reactors have the highest associated risks. However, the total transportation risks associated with the closest repository sites only differ from those for the most distant site by about a factor of two for truck and by about a factor of one and three-fourths for rail. These factors generally parallel increases in shipment-miles except for the radiological risk of rail transport. A component of radiological risk for rail transport, but not for truck transport, is associated with required endpoint classification and inspection stops. Because this component is distance-independent (i.e. the same for all trips, short or long), the influence of distance traveled on total radiological risk for rail is less pronounced than for truck

Insertion of an MRS into the system tends to reduce the variation between the potential repository sites because of the reduction in total shipment-miles, due to the consolidation of the spent fuel at the MRS and the use of the large dedicated rail casks between the MRS and the repository. A typical 100 ton (100T) cask and a large 150 ton (150T) cask were considered in this analysis. The 100T cask can carry between 18 and 45 consolidated, canistered spent fuel assemblies; the 150T cask capacity is between 48 and 171 assemblies. The actual payload depends on the fuel type (BWR or PWR) and the geologic medium of the repository because the consolidated fuel is packaged differently according to whether the repository is developed in salt, tuff, or basalt. Detailed operational parameters are contained in Chapter II. The total impacts of transport to the candidate repository sites are dominated by the costs and risks of shipments from the reactors to either the MRS or the repository and high level-waste directly to the repository. The large 150T dedicated rail cask in particular reduces the impacts of transportation from the MRS to the repository because of its large payload per shipment.

Use of repository-specific canisters and overpacks for the MRS cases influences the relative ranking of the Yucca Mountain (tuff) and the Hanford (basalt) repository sites because the tuff canister and overpack are capacity than the basalt canister and overpack (all of the other sites: salt canister and overpack). In addition, the projected rail routings the MRS locations and Yucca Mountain are more circuitous than the rail routings between the MRS locations and Hanford. The combination of in shipment-miles and reduced canister and overpack capacities causes Yucca Mountain to rank higher in cost and risk than the Hanford repository site. Tables 4 - 6 summarize the shipment-miles, costs, and risks for the MRS for an MRS located in Oak Ridge, TN, with 150T dedicated rail casks between the MRS and the repository.

To aid the reader to assess the significance of the risks of transport-related fatalities predicted in this report, the accident fatalities and radiological health effects predicted in this report may be compared with the following. In the United States, about 65,000 persons would die from truck accidents, and 32,000 would die from rail accidents during the 26-year repository operating period. During the same period an estimated 58,300 cancer fatalites are postulated to occur in the United States from exposure to natural background radiation alone (not including medical and other manmade sources) according to current models. The risks reported here are upper limit estimates and are small by comparison with the "natural background" of risks of the same type.

The appendices contain detailed packaging estimates, shipment-mile totals, fractions of travel through the various population-density zones, costs, unit-risk factors, and detailed risk estimates by waste type. These tables permit the interested reader to create or approximate additional scenarios not discussed specifically in the document.

TABLE 1. TOTAL SHIPMENT-MILES (millions of miles)
REFERENCE CASE-Direct to Repository

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
	Repository Location					
100% Truck						
SF	67.4	71.7	94.4	115.1	141.8	149.7
DHLW	28.0	28.0	26.0	28.0	33.0	35.0
WVHLW	1.0	1.0	1.0	2.0	2.0	2.0
TOTAL	96.4	100.7	121.4	145.1	176.8	186.7
100% Rail						
SF	11.0	11.7	15.4	18.8	23.2	24.6
DHLW	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW	0.2	0.2	0.2	0.2	0.3	0.3
TOTAL	17.7	21.2	21.7	25.5	31.1	33.3

TABLE 2. TOTAL TRANSPORTATION COSTS ($M)
REFERENCE CASE-Direct to Repository

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
	Repository Location					
100% Truck						
CAPITAL	227.2	234.2	261.2	290.1	325.1	337.2
OPERATING	708.9	730.0	866.0	1015.1	1213.6	1277.8
TOTAL	936.1	964.2	1127.2	1305.2	1538.7	1615.0
100% Rail						
CAPITAL	267.3	277.7	300.9	322.5	354.2	362.8
OPERATING	714.7	734.9	821.6	885.3	991.0	1013.8
TOTAL	982.0	1012.6	1122.5	1207.8	1345.2	1376.6

TABLE 3. SUMMARY OF THE TOTAL RISKS OF TRANSPORTATION
REFERENCE CASE - Direct to Repository

MODE	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
<u>100% Truck from origin</u>:						
SF to Repository						
Radiological[1]	4.6	5.0	6.2	7.7	9.2	10
Nonradiological[2]	13	14	18	24	29	31
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
<u>100% Rail from origin</u>:						
SF to Repository						
Radiological	.16	.17	.18	.21	.24	.25
Nonradiological	.81	.85	1.0	1.3	1.6	1.6
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
TOTALS						
Truck from origin:						
Radiological	6.4	6.7	7.9	9.5	11	12
Nonradiological	19	20	24	30	36	38
Rail from origin:						
Radiological	.22	.24	.24	.28	.32	.32
Nonradiological	1.4	1.5	1.6	2.0	2.4	2.4

[1] Radiological health effects include lethal cancer fatalities and genetic effects in all generations.

[2] Nonradiological fatalities

TABLE 4. TOTAL SHIPMENT-MILES (millions of miles)
MRS CASE - MRS at Oak Ridge

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Origin						
SF to MRS	48.8	48.8	48.8	48.8	48.8	48.8
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	35.0
WVHLW to Repos.	1.0	1.0	1.0	2.0	2.0	2.0
Rail from Origin						
SF to MRS	8.0	8.0	8.0	8.0	8.0	8.0
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	0.2	0.2	0.2	0.2	0.3	0.3
Rail from MRS to Repository (150T, nonoverpacked SF)	0.2	0.3	0.6	0.8	1.5	1.0
TOTALS						
Truck from Origin 150T from MRS	78.0	78.1	76.4	78.6	85.3	86.8
Rail from Origin 150T from MRS	14.9	15.0	14.9	15.5	17.4	17.7

TABLE 5. TOTAL TRANSPORTATION COSTS ($M)
MRS CASE – MRS at Oak Ridge

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites						
CAPITAL	201.0	202.1	204.3	209.8	214.2	217.5
OPERATING	613.7	608.1	601.1	615.8	639.0	652.9
Rail from Reactors, HLW Sites						
CAPITAL	232.3	237.7	235.9	239.5	246.7	250.3
OPERATING	643.7	646.1	647.5	644.2	667.9	664.4
Rail from MRS to Repository (150T, nonoverpacked SF)						
CAPITAL	78.6	78.6	78.6	78.6	100.6	84.1
OPERATING	172.7	199.0	265.3	306.8	468.7	346.8
TOTALS						
Truck from Origin 150T from MRS	1066.0	1087.8	1149.3	1211.0	1422.5	1301.3
Rail from Origin 150T from MRS	1127.3	1161.4	1227.3	1269.1	1483.9	1345.6

[1] The totals presented in this table are for the case in which all spent fuel and HLW wastes are shipped by the mode indicated; dedicated rail shipments from the MRS to the repository are added.

TABLE 6. SUMMARY OF THE RISKS OF TRANSPORTATION OF SPENT FUEL AND HIGH LEVEL WASTES: MRS AT OAK RIDGE (All SF to MRS, 150T cask)

MODE	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
<u>100% Truck from Origin</u>						
SF to MRS						
Radiological[1]	3.6	3.6	3.6	3.6	3.6	3.6
Nonradiological[2]	9.1	9.1	9.1	9.1	9.1	9.1
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
<u>100% Rail from Origin</u>						
SF to MRS						
Radiological	.14	.14	.14	.14	.14	.14
Nonradiological	.92	.92	.92	.92	.92	.92
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
<u>150T Rail from MRS to Repository</u>						
Radiological	.017	.035	.035	.038	.054	.042
Nonradiological	1.4	2.6	3.8	5.3	1.0	6.1
TOTALS						
Truck from Origin, 150T Rail from MRS						
Radiological	5.4	5.3	5.3	5.4	5.8	5.7
Nonradiological	17	18	19	20	26	22
Rail from Origin, 150T Rail from MRS						
Radiological	.22	.25	.24	.25	.27	.26
Nonradiological	2.9	4.2	5.3	6.9	12	7.7

[1] Radiological health effects include lethal cancer fatalities and genetic effects in all generations.

[2] Nonradiological fatalities

1. INTRODUCTION

This report discusses the relative national costs and risks of transporting nuclear wastes to each of nine candidate repository sites. The basic scenarios that are analyzed are (1) shipment of spent fuel and high level waste (HLW) directly from waste generators to a repository (Reference Case) and (2) shipment of spent fuel to a Monitored Retrievable Storage (MRS) facility and then to a repository. The reference case is the direct-to-repository shipment scenario, which is consistent with the Nuclear Waste Policy Act of 1982 (NWPA). If an MRS is to be included in the waste management system, the Act specifies that Congressional approval is necessary. The MRS cases included in this document are consistent with the analyses of that program.

This report is the third in a series of transportation cost and risk analyses used to support the siting processes for a first repository. The first of these reports (Reference 1) is a preliminary examination of potential transportation impacts of direct-to-repository shipments and an alternative reprocessing scenario. As in the present analysis, hypothetical future-generation cask designs were considered. The second report (Reference 2) documented the transportation-related impacts of using existing cask designs and considered only the direct-to-repository scenario. Because these casks were designed to carry spent fuel that is less than one year out of the reactor, they have more shielding and lower capacities than casks required for the commercial waste management system. The estimated impacts in that analysis are essentially those that would be associated with the use of "existing technology" in the absence of new cask-design initiatives. The latter report was used in the preparation of the draft Environmental Assessments (EAs) supporting the nomination of sites for characterization for the first repository. The present analysis incorporates recent changes in repository system parameters, includes future-generation cask designs, and encompasses a treatment of the MRS concept.

For all cases considered, the primary waste stream is spent nuclear fuel from reactors (SF). Secondary waste streams to be shipped directly to the repository include defense high level wastes (DHLW) from the Savannah River Plant in South Carolina, the Hanford Reservation in Washington, and the Idaho National Engineering Laboratory in Idaho, and commercially-generated high-level waste from West Valley, New York (WVHLW). Acceptance of DHLW in a commercial repository was endorsed by the President during 1985 (Reference 3). For the MRS case, the secondary waste stream also includes the additional wastes that would be generated at an MRS. These MRS-related secondary wastes would consist of assembly hardware (HDWR), high activity waste (HAW), and transuranic waste (TRU) generated during handling and repackaging of the spent fuel.

Two primary modal options are examined for the reference case: all truck and all rail from reactors and HLW generators. Because the resultant costs and risks will bound the transportation impacts, no attempt has been made to forecast the actual fractions of truck and rail transport that might be used. The shipping system ultimately used for transportation of spent fuel and HLW will be a combination of modes determined by considerations such as capabilities of handling facilities at the origins, freight rates, and operational constraints of the system. For the MRS case, all shipments between the MRS and the repository move by dedicated rail. Bounding conditions considered for this shipment mode are the two combinations of cask weight and payload characteristics that minimize and maximize, respectively, the number of shipments.

Actual reactor locations have been used in this analysis, which is a refinement not found in previous studies. Formerly, reactor centroids rather than actual locations were used to represent the origin points. Further, this analysis considers fewer spent fuel shipments because it is based on what is referred to as the "no-new-reactor" case. That is, only reactors that are either in operation or planned to be constructed are included in the analysis, and no long-term projections of future reactor construction are used.

II. STUDY SCENARIOS AND PARAMETERS

A. INTRODUCTION

The basic scenarios and parameters used in this analysis were defined by DOE/OCRWM. This chapter outlines these parameters and the published references used in this analysis, which supports the Final Environmental Assessments supporting the nomination of sites for characterization for the first repository. This analysis also is cited in the Needs and Feasibility Study and the Environmental Assessment for the Monitored Retrievable Storage Program. Parameters used in this analysis are, in general, consistent with those contained in these documents. The reader is encouraged to consult these documents for further detail.

B. STUDY ALTERNATIVES

This analysis addresses a total of nine waste flow alternatives: the reference case (direct to repository) and eight cases which include an MRS. Shipments from reactors and HLW generators could travel by one of two transport modes, truck or general commerce rail. All shipments from the MRS would be by dedicated rail transport with two cask size options. For the purpose of this analysis, a dedicated train is a train made up exclusively of railcars transporting consolidated spent fuel and other radioactive waste byproducts of the consolidation process between the MRS and potential repository locations. The operational characteristics, cask sizes, and payloads of the dedicated train discussed in this chapter bound the numbers of shipments and are consistent with the operational forecasts of the MRS program. The main text of this report discusses only the reference case (direct shipment to a repository) and two representative variations of the MRS case in detail. Several of the MRS alternatives are simple variations of the basic scenarios; the results of analysis of these variations are included in Appendix 2.

Consistent with the repository design criteria (Reference 4), the reference case is defined, for purposes of impact analysis, as [illegible] which all reactors will ship 5-year-old unconsolidated spent fuel to a candidate repository site. Although the actual ages of fuel to be [illegible] from the reactors usually would be much greater than 5 years, it is [illegible] that some 5-year old spent fuel could be shipped. Since radiological [illegible] decrease with the age of the fuel, an upper bound is established by [illegible] the impacts of shipping 5-year-old fuel. High level commercial and defense wastes will also be shipped directly to the repository. Shipments of the spent fuel from reactors and high level wastes will be made by either truck or general commerce rail.

For the MRS cases, reactors will ship 5-year-old unconsolidated spent fuel to an MRS. Consistent with the MRS Program scenarios, all spent fuel received at the MRS will be consolidated and placed into temporary storage for approximately 5 years. The consolidation process, mechanically separating the fuel pins and end fittings prior to placing them into canisters, reduces the number of shipments required between the MRS and the repository. A second possible function of the MRS facility is the incorporation of these canisters into emplacement-ready packages or "overpacks" (i.e. packages that could be emplaced directly into the geologic medium at a repository) prior to shipment to the repository. This could reduce the requirement for repackaging facilities at the repository.

Repackaging at an MRS is considered by including one ot the two possible shipping options: (1) 100 ton (100T) dedicated rail shipments of overpacked consolidated spent fuel and waste byproducts generated in the consolidation process and (2) 150 ton (150T) dedicated rail shipments of nonoverpacked consolidated spent fuel and byproducts. These options represent the largest and smallest numbers of shipments, respectively, from the MRS to the repository. High level commercial and defense wastes would be shipped directly to the repository as in the reference case. For illustration purposes, the analysis discussed in the text considers an MRS location at Oak Ridge, Tennessee.

Additional MRS alternatives are examined in Appendix 2. Two [illegible] alternatives not discussed in the text were analyzed in which [illegible] reactors (east of 100 degrees latitude) would ship directly to the MRS, while "western" reactors (west of 100 degrees latitude) would ship directlyto a repository. This is referred to as the "East-West split" scenario. Because either 100T or 150T cask options may be considered for this scenario, two alternatives are generated. The remaining four alternatives are analogous to those for the Oak Ridge MRS, but the MRS is located near Hartsville, Tennessee.

In summary, the alternatives considered in the main text of this report are:

Reference Case
- o unconsolidated 5 year-old spent fuel (SF) from reactors
  - all reactors ship directly to repository
  - HLW shipped directly to repository

MRS Case 1
- o Oak Ridge is the MRS location
- o unconsolidated 5-year-old SF from reactors
  - all reactors ship to MRS
  - 10-year-old overpacked, consolidated SF shipped from MRS
  - 100T dedicated rail cask used from MRS to repository
  - HLW shipped directly to repository

MRS Case 2
- o Oak Ridge is the MRS location
  - unconsolidated 5-year-old SF from reactors
- o all reactors to MRS
- o 10-year-old consolidated SF shipped from MRS
- o 150T dedicated rail cask used from MRS to repository
- o HLW directly to repository

Additional MRS cases treated in Appendix 2:

MRS Case 3
- o Oak Ridge is the MRS location
- o unconsolidated 5-year-old SF from reactors
- o eastern reactors ship to MRS
- o western reactors ship directly to repository
- o 10-year-old overpacked, consolidated SF from MRS
- o 100T dedicated rail cask used from MRS to repository
- o HLW shipped directly to repository

MRS Case 4
- o Oak Ridge is the MRS location
- o unconsolidated 5-year-old SF from reactors
- o eastern reactors ship to MRS
- o western reactors ship directly to repository
- o 10-year-old overpacked, consolidated SF from MRS
- o 150T dedicated rail cask used from MRS to repository
- o HLW shipped directly to repository

MRS Case 5

- o Hartsville is the MRS location
- o unconsolidated 5-year-old SF from reactors
  - .. all reactors ship to MRS
- o 10-year-old overpacked, consolidated SF from MRS
- o 100T dedicated rail cask used from MRS to repository
- o HLW shipped directly to repository

MRS Case 6

- o Hartsville is the MRS location
- o unconsolidated 5-year-old SF from reactors
- o all reactors ship to MRS
- o 10-year-old consolidated SF from MRS
- o 150T dedicated rail cask used from MRS to repository
- o HLW shipped directly to repository

MRS Case 7

- o Hartsville is the MRS location
- o unconsolidated 5-year-old SF from reactors
- o eastern reactors ship to MRS
- o western reactors ship directly to repository
- o 10-year-old overpacked, consolidated SF from MRS
- o 100T dedicated rail cask used from MRS to repository
- o HLW shipped directly to repository

MRS Case 8

- o Hartsville is the MRS location
- o unconsolidated 5-year-old SF from reactors
- o eastern reactors ship to MRS
- o western reactors ship directly to repository
- o 10-year-old overpacked, consolidated SF from MRS
- o 150T dedicated rail cask used from MRS to repository
- o HLW shipped directly to repository

C. FACILITY LOCATIONS

1. Generator Sites

Reactors

Actual locations of existing and planned reactors are used in this analysis. This analysis also differs from earlier reports in that no reactors that are projected but not planned or sited will ship spent fuel to the first repository. Figure 1 illustrates these locations. Appendix 1 contains a detailed listing of the reactors.

High-Level Waste Sites

According to the decision by the President in 1985, high level wastes generated by defense programs will be shipped to the first repository. Defense wastes are assumed to be shipped from the Savannah River Plant, South Carolina, the Hanford Reservation in Washington, and the Idaho National Engineering Laboratory, Idaho. Commercially-generated high level waste from West Valley, New York, will also be received at the first repository. Figure 2 illustrates the locations of these facilities.

2. Repository Locations

Nine candidate repository locations are considered in this analysis. Several of the potential sites are closely clustered and, for the purpose of distance and routing calculations, are treated as a single location. These are: Cypress Creek Dome and the Richton Dome in Mississippi, Deaf Smith County and Swisher County sites in Texas, and the Davis Canyon and Lavender Canyon sites in Utah. Thus, the following six destination points, illustrated in Figure 3, have been used in this analysis.

GIR	=	A point in the Gulf Interior Region (GIR) in Mississippi near the Cypress Creek and Richton sites.
VACHERIE	=	The Vacherie Dome site in Louisiana (also in the GIR but in a geographically distinct area).

PERMIAN = A point in the Permian Basin in Texas near [illegible] County and Swisher County Sites.

PARADOX = A point in the Paradox Basin in Utah near [illegible] Lavender Canyon sites

YUCCA MT = The Yucca Mountain site in Nevada.

HANFORD = The Hanford Reservation in Washington.

Spent fuel would be packaged differently at an MRS [illegible] geologic medium in which the first repository is developed. Two considerations are responsible for this. First, in the case of [illegible] ready packages shipped within a transport cask (i.e. overpacked shipments in 100T casks), the inner package must be suitable for the particular [illegible] medium for which it is intended. Second, for nonoverpacked shipments [illegible] MRS (i.e. nonoverpacked canistered shipments in 50T casks), which [illegible] transferred to emplacement containers at the repository, shipment and [illegible] sizes must be compatible with the design capacity of the repository's fuel-handling facility. In either case, the overpack or canister [illegible] and capacities (Reference 5) depend on whether the geologic medium is salt, tuff, or basalt. Sites in domed or bedded salt are GIR, Vacherie, Permian, and Paradox; Yucca Mt is a tuff site; and Hanford is a basalt site.

3. Storage/Repackaging Facilities

For the purposes of this analysis, two potential sites for a Monitored Retrievable Storage Facility are examined. They are located near Oak [illegible] Tennessee, and Hartsville, Tennessee, respectively (Figure 4). Since the MRS concept has not been presented to Congress for authorization, no specific [illegible] for the MRS has been designated.

D. WASTE FLOWS

Waste flows to the repository are obtained from the DOE/OCRWM [illegible] (Reference 6) and the Defense Programs Waste Management Plan (Reference [illegible] amended by guidance for the purpose of this analysis (Reference [illegible] these flows were defined to be as summarized in Table 1.

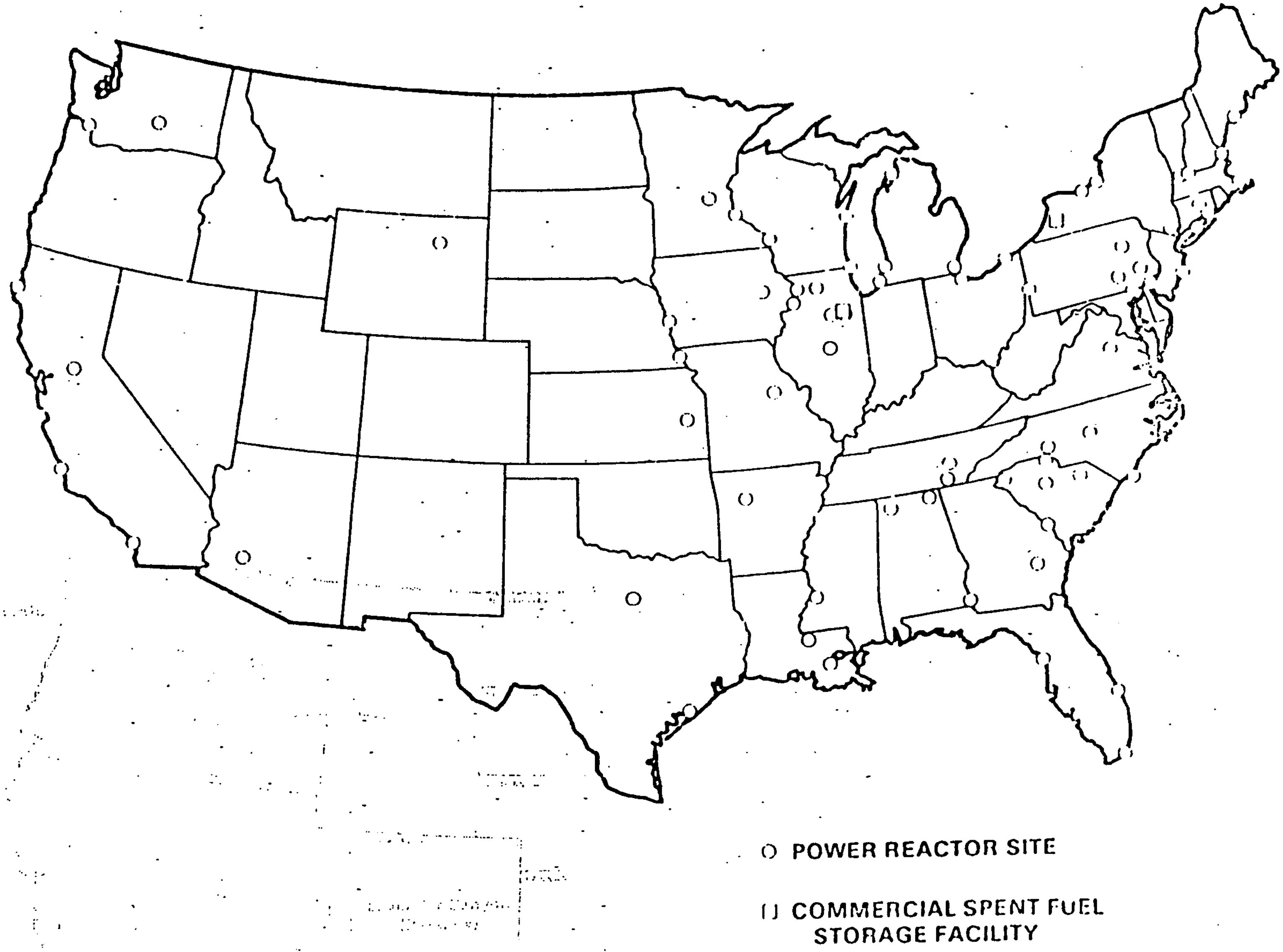

Figure 1. Location of Existing and Planned Commercial Reactors [illegible]

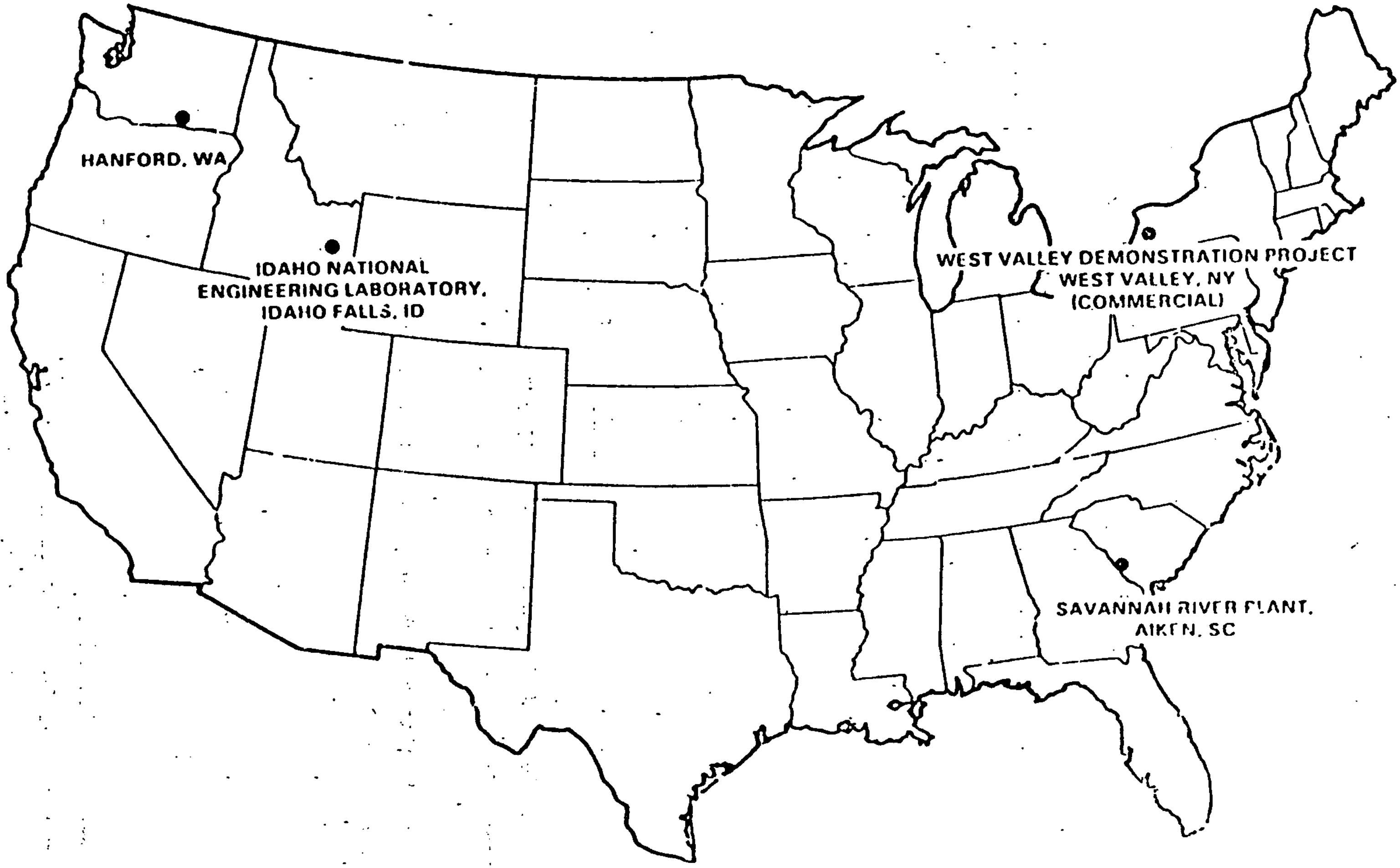

Figure 2. High Level Waste Generator Locations

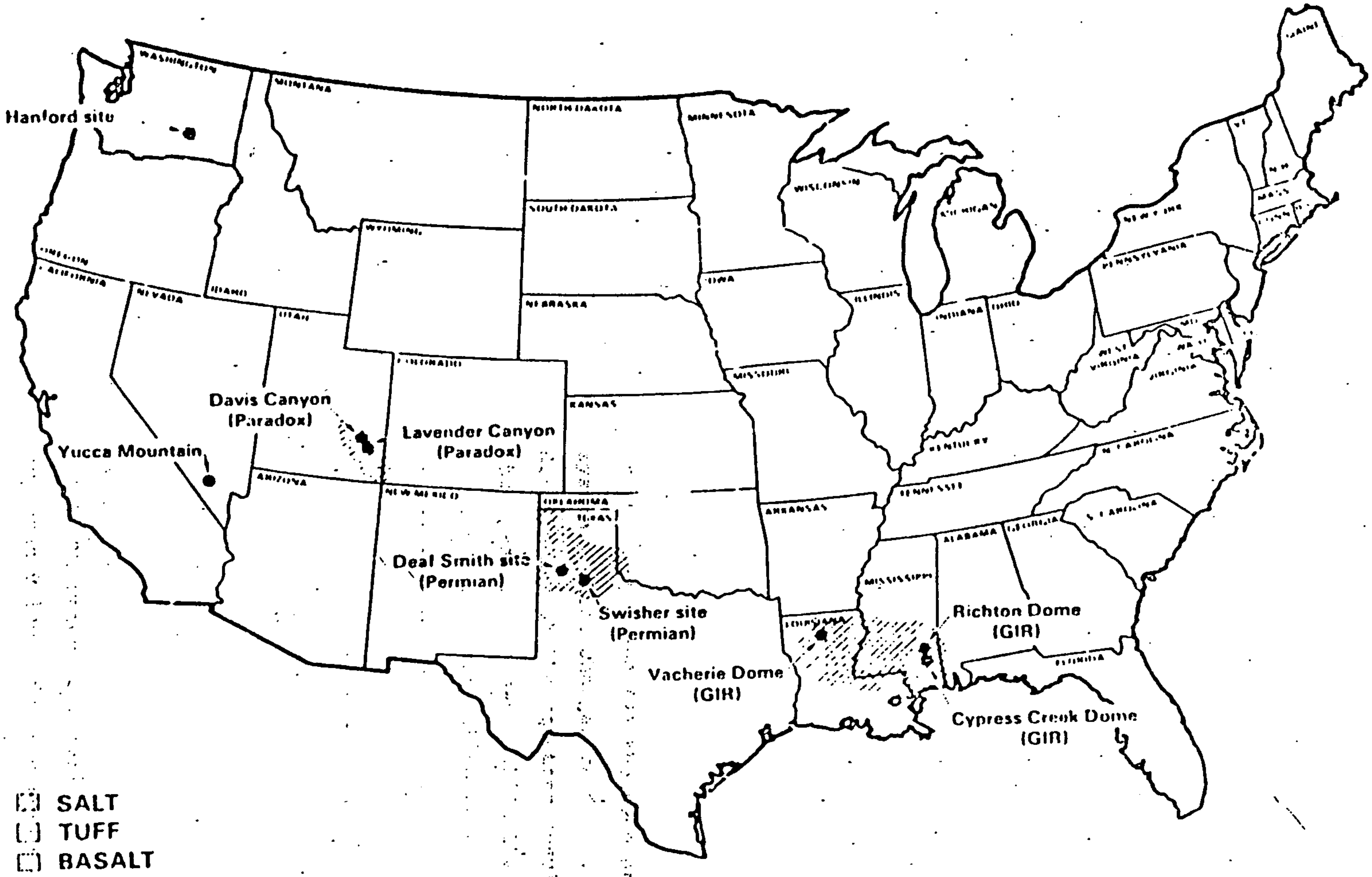

Figure 3. Potential Candidate First Repository Sites

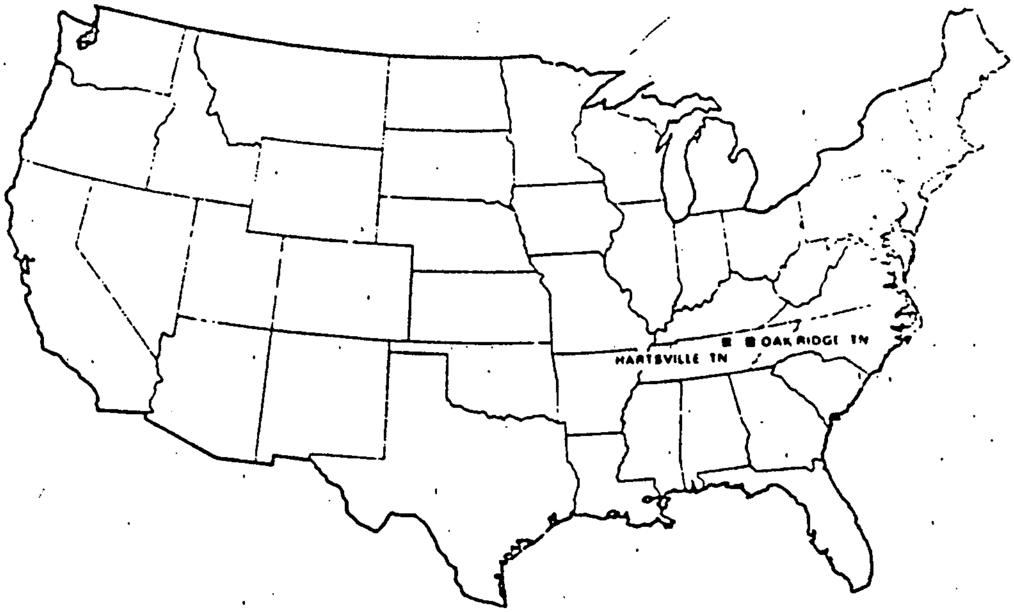

Figure 4. MRS Sites Used in this Analysis.

1. Spent Fuel

The first repository will receive 62,000 MTHM (metric tons of heavy metal) of spent fuel from reactors. In the reference case, spent fuel would be shipped unconsolidated from the reactors. In all MRS subcases, the MRS would consolidate any spent fuel received and, depending on the cask alternative, ship overpacked or nonoverpacked consolidated spent fuel along with the byproducts of the consolidation process (high activity wastes, hardware, and transuranic wastes) to the repository for disposal. The quantities of these byproducts generated at the MRS are discussed below.

The amount of spent nuclear fuel, in assemblies, to be removed from reactor storage pools were obtained from the 1985 Spent Fuel Data Base, which was compiled for the DOE by Battelle Pacific Northwest Laboratories from utility responses to a voluntary survey form (References 9 and 10). These responses were adjusted to be consistent with Energy Information Agency (EIA) projections of electrical generating rates, spent-fuel burnup, and discharge averages (Reference 11)

In order to assign priorities for the transportation of spent fuel from the reactors, the storage capacity at each reactor storage pool was used, along with the assumption that a full-core reserve was maintained at each pool. The spent fuel discharge data were derived from the current maximum licensed expansion of reactor storage pools and included any planned transhipments of spent fuel. In addition, the spent fuel flows were calculated under the assumptions that reactor assemblies were decommissioned at the end of their commercial life and that all remaining fuel assemblies were shipped within 5 years. Spent fuel assemblies stored at West Valley, NY, were shipped during the first five years of repository operation.

For the MRS alternatives in which an East-West split of reactors was analyzed, approximately 4500 MTHM from reactors west of 100 degrees latitude were shipped directly to the first repository.

Spent fuel flows from individual reactors vary slightly for the MRS alternatives. This variation is a result of the fact that (1) the beginning date for the receipt of wastes at a repository changes when an MRS is a part of the system and (2) the receipt rate of the MRS itself influences the system. These changes reflect an increased (or decreased) need for interim dry storage at the reactors resulting from new priorities being assigned to the spent fuel flows. While the resulting differences in total shipment-miles and characteristics were reflected in the analysis, the costs and risks of dry storage at the reactors were not included in this analysis. Appendix 1. details the waste flows from reactors in terms of shipments by truck and by rail for the reference and MRS cases.

2. High-Level Wastes

Vitrified HLW, in the form of glass "logs" encapsulated in stainless steel, are approximately 0.61 m (2 ft) in diameter and 3.05 m (10 ft) in length (Reference 12). As indicated in Table 1, each canister of HLW contains 0.5 MTHM, which is a maximum possible canister loading rather than the expected value. For the purposes of this analysis, HLW was always shipped directly to the repository regardless of the spent fuel shipment scenario.

TABLE 1. REPOSITORY ACCEPTANCE SCHEDULE (MTHM)[1]

Year	Spent Fuel	HLW[2,3]			
		Commercial	Defense		
		West Valley	SRP	INEL	[illegible]
1998	400				
1999	400				
2000	400				
2001	900				
2002	1800				
2003	3000	20	350		75
2004	3000	20	350		75
2005	3000	20	350		75
2006	3000	20	350		75
2007	3000	20	350		75
2008	3000	20	200	300	75
2009	3000	20	200	300	75
2010	3000	20	200	300	75
2011	3000	20	200	300	75
2012	3000	20	200	300	75
2013	3000	20	200	300	75
2014	3000	20	200	300	75
2015	3000	20	200	300	75
2016	3000	20	350	300	75
2017	3000	20	350	300	75
2018	3000	20	350	300	
2019	3000	20	350	300	
2020	3000	20	350	300	
2021	3000	20	350	300	
2022	1100	20	350	300	

[1] Reference 8.

[2] A canister of HLW contains 0.5 MTHM

[3] The values given for HLW were developed for use in the repository EAs. They are believed to be maximum values that would not be exceeded and do not reflect expected values.

3. Waste Flows from the MRS

Spent fuel from the reactors that is shipped to an MRS is consolidated at approximately a 2:1 volume ratio. Consolidation of the spent fuel at an MRS would generate assembly hardware, high activity wastes, and transuranic wastes as described in Table 2. For each of the MRS scenarios analyzed, these secondary wastes were shipped to the repository. This report does not consider the transportation-related impacts of decommissioning an MRS facility.

TABLE 2. SECONDARY WASTES GENERATION RATES[1]
(per 100 MTHM spent fuel consolidated)
(55 gallon drums)

Hardware	High Activity Wastes	Transuranic [illegible]
44.3 drums	41.4 drums	18.6 drums

1. Reference 13.

E. OPERATIONAL ASSUMPTIONS

1. Transport from Reactors and High Level Waste Sites

Two transport modes, truck and rail, were analyzed for shipments of unconsolidated spent fuel from reactors and canistered high level wastes from commercial and defense sites. In order to generate bounding estimates of impacts associated with transport by these modes, the following two scenarios were analyzed: 100% of the shipments of spent fuel and high level wastes by truck and 100% of the shipments of spent fuel and high level wastes by general commerce rail.

Packaging capacities for the reference case and shipments from reactors or HLW origins are for legal-weight truck and 100T rail casks. Cask capacities used in this analysis (Table 3) are for hypothetical future generation casks (Reference 14). Actual cask capacities will be determined by design initiatives sponsored by the OCRWM and may differ somewhat from those used here. Transportation cask capacities differ for the two rail HLW casks because of the characteristics of the various waste forms.

TABLE 3. TRANSPORTATION PACKAGE CAPACITIES:[1]
REACTOR TO REPOSITORY OR MRS

MODE	Unconsolidated Spent Fuel (PWR/BWR Ass'y)	Defense High Level Waste (Canisters)	Commercial High Level Waste (Canisters)
Truck	2/5	1	1
Rail	1[illegible]	5	7

1. Reference 14.

2. Transport from the MRS to the Repository

Two bounding cases for transportation from the MRS to the repository [illegible] analyzed: (1) the consolidated spent fuel was overpacked in applicable packages at the MRS and then shipped in 100T rail casks and (2) the consolidated spent fuel was shipped in canisters (nonoverpacked) in 150T rail casks. These options represent the greatest and least number of shipments, respectively, that would occur between the MRS and the repository. The cask capacities vary for both the 100T and 150T options for each geologic medium in which potential repository sites are located (Tables 4A and 4B).

All shipments travel from the MRS by dedicated rail. A dedicated rail shipment is defined to be a 10-car train made up of 5 railcar-casks containing consolidated spent fuel, 2 railcar-casks containing hardware, 2 railcar casks containing high activity wastes, and 1 railcar with two high volume Type B (HVTB) containers containing transuranic wastes.

TABLE 4A. TRANSPORTATION PACKAGE CAPACITIES:[1]
MRS TO REPOSITORY - DEDICATED RAIL
CONSOLIDATED SPENT FUEL (PWR/BWR Ass'y)

	100T Overpacked			150T Nonoverpacked		
Unit	Salt	Tuff	Basalt	Salt	Tuff	Basalt
Canisters	2/1	3/3	6/5	6/5	8/7	21/19
Assemblies	24/30	18/42	24/45	72/150	48/98	84/171

1. Reference 15.

TABLE 4B. TRANSPORTATION PACKAGE CAPACITIES:[1]
MRS TO REPOSITORY - DEDICATED RAIL
SECONDARY WASTE FORMS

Waste Form/Unit	100T Overpacked	150T Nonoverpacked
Hardware		
canisters/cask	4	7
drums/cask	20	35
High Activity Waste		
canisters/cask	4	7
drums/cask	20	35
Contact-Handled Waste		
HVTB/railcar	2	2
drums/railcar	72	72

1. Reference 15.

3. Other Operational Parameters

For the logistics analysis, average travel speeds, turnaround times (i.e. facility loading and unloading times), and the availability of transport packagings were estimated in order to calculate the total number of packagings required to serve the first repository. Average travel speeds for the modal options included in this analysis were based upon industry experience and include stops for fuel, driver breaks and crew changes, where applicable. Truck shipments traveled at an average speed of 56 km/h (35 mph). The average rail speed varied from 5 km/h (3 mph) for short distances to 19 km/h (12 mph) for cross-country shipments. These average speeds included vehicle stop time. Additional time was required for loading casks at the reactor or waste generator/storage site and for unloading at the repository or MRS site. A total loading/unloading time of 3 days per truck round trip and a total time of five days per rail package per round trip were used. The dedicated rail shipments from the MRS travelled approximately 1.5 times faster than general freight rail shipments (Reference 15). Dedicated train total turnaround time for loading and unloading was 9 days per shipment. In all cases transport packages were available 300 days/year. Table 5 lists additional transportation parameters used in the logistics analysis. Shipping rates used in the analysis are taken from published tariffs, where available (Reference 16). Talks with carrier organizations indicated that dedicated rail shipping rates could be 1.25 times the rates for general commerce rail.

TABLE 5. TRANSPORTATION PACKAGE PARAMETERS FOR THE LOGISTICS ANALYSIS[1]

	PACKAGE WEIGHTS				PACKAGE COSTS	
	Loaded		Empty		Capital	Maint. per [illegible]
MODE/payload	$(10^3$ kg)	$(10^3$ lb)	$(10^3$ kg)	$(10^3$ lb)	$ millions	$ millions
Truck						
SF	18.6	50.0	17.7	47.5	1.5	0.075
DHLW	22.7	50.0	20.6	45.5	1.1	0.06
WVHLW	22.7	50.0	20.6	45.5	1.1	0.06
Rail						
SF	90.7	200.0	67.1	180.0	2.5	0.125
DHLW	90.7	200.0	80.5	177.4	1.8	0.09
WVHLW	90.7	200.0	75.0	165.4	1.8	0.09
Dedicated Rail						
100 Ton						
SF-salt	90.7	200.0	50.7	136.0	2.5	0.125
SF-tuff	90.7	200.0	52.2	140.0	2.5	0.125
SF-basalt	90.7	200.0	44.8	120.0	2.5	0.125
HDWARE	56.0	150.0	48.5	130.0	2.5	0.125
HAW	56.0	150.0	48.5	130.0	2.5	0.125
150 Ton						
SF-salt	111.9	300.0	68.3	183.0	2.75	0.125
SF-tuff	111.9	300.0	73.8	198.0	2.75	0.125
SF-basalt	111.9	300.0	70.1	188.0	2.75	0.125
HDWARE	83.9	225.0	70.9	190.0	2.75	0.125
HAW	83.9	225.0	70.9	190.0	2.75	0.125
TRU[2]	37.3	100.0	26.1	70.0	1.6	0.150

1. References 2, 14, 15.
2. Two HVTBs are carried per railcar; values given are per railcar.

4. Other Operational Parameters Required for the Risk Analysis

The RADTRAN III risk analysis considers operational details in order to calculate the radiological risks of incident-free transport. For both truck and rail transport, the average travel speeds used in the logistics analysis are not sufficient because the radiological impacts of stops are evaluated separately from the impacts associated with actual transport. Further, three population density zones (rural, suburban, and urban) are considered separately. Therefore, travel speeds are identified for each population density zone. The number of stops along a route are a function of distance traveled for truck transport. For rail transport, however, two inspection stops must be made (at the beginning and end of each trip) regardless of the length of the trip; intermediate stops may also occur, and these are determined by the the length of the trip. Stop times are determined from operational experience (References 17, 18). Dedicated rail transport minimizes stop times en route, which results in a higher average trip speed. Table 6 summarizes these parameters.

TABLE 6. OPERATIONAL PARAMETERS USED IN THE RISK ANALYSIS

	Travel Speed (km/h)			
Mode	Rural	Suburban	Urban	Stop Times (h/km)
Truck	88	40	24	0.011
Rail	64	40	24	0.086 (+60h)[1]
Dedicated Rail	64	40	24	0.004 (+ 2h)[2]

[1] Stop times for general commerce rail shipments include (a) a total distance-independent time of 60 h at marshalling yards at each end of the route and (b) 0.086 h/km of stop time which is distance-dependent.

[2] Stop times for dedicated rail shipments include (a) a distance-independent time of 2 h at marshalling yards at each end of the route and (b) 0.004h/km of stop time which is distance-dependent.

An important operational parameter required by the risk assessment code for accident risk evaluation is accident rate data. Historical data for truck and rail transport were used in this analysis (Reference [illegible]).

F. SPECIAL PARAMETERS REQUIRED FOR RISK ANALYSIS

1. Radionuclide Inventory

In order to calculate accident risks, radiological characteristics of the payload are required. For the accident risk analysis, all spent fuel was treated as if it were pressurized water reactor (PWR) fuel because PWR spent fuel is generally higher in activity than boiling water reactor (BWR) fuel The accident-related radiological source term is thereby maximized. The radionuclide inventories of 5 and 10 year old PWR spent fuel were calculated by the ORIGEN2 computer code (Reference 20) at Oak Ridge National Laboratory. The radionuclide inventories of DHLW were specified by DOE/OCRWM and were derived from Reference 21; the inventory of WVHLW is given in Reference 22.

For each radiologically significant radionuclide in each waste form, a number of parameters must be evaluated for the risk assessment code. These include half-life and specific activity (Reference 23) and dose-effect factors for inhalation, ingestion, etc. (Reference 24).

2. Other Parameters

The regulatory maximum transportation index (TI) of 10 millirem/h at 2 meters from the packaging surface was used for all packaging types considered in this analysis. The axial dimension of each packaging type is used to calculate a shape factor in the risk assessment code. The axial dimension for hypothetical future design casks of each type was used in this analysis; the actual dimensions may differ from these values when current OCRWM design efforts are complete.

III. COMPUTATIONAL SYSTEM USED IN THE ANALYSIS

1. Introduction

In order to perform cost and risk analyses of the impacts of transportation for a future nuclear waste management system, values must be assigned to parameters describing the physical, operational, and geographical characteristics of the system over the time period assumed for operations. The analyses performed here contain data specific to the current transport system and networks in the US. It is expected, though unproven, that the same comparisons done for actual conditions during the time period in which the repository is built and operating would yield the same results, particularly since the purpose of the analyses is strictly for comparison among the sites and options. In addition, the comparative nature of these analyses permits application of consistent assumptions regarding waste flows and characteristics, operational characteristics, and modeling methods.

Figure 5 outlines the major components of the computational system used to perform the transportation cost and risk analysis. These components are discussed below.

2. Model Inputs

The computer programs used for the cost and risk analyses require large amounts of input data because the user must provide information on the transport link and the surrounding population, routing information (e.g. distances traveled), the packaging (e.g. cask capacity), transport-mode characteristics (e.g. train velocities), the source material (i.e. radionuclide inventory), and many pertinent operational characteristics of the transport system (e.g. accident rates). Many of the other parameters are discussed in Chapter II; where previously discussed, references for these components may be found in that chapter.

a. Electric Generating Capacity-The Energy Information Administration (EIA), a branch of the DOE, predicts anticipated industry [illegible] and capabilities by type of fuel source by year.

b. DOE/OCRWM Mission Plan-Overall receipt rates of spent fuel [illegible] the first repository are detailed in this document. These [illegible] used to assign scheduling priorities to projected waste flows.

c. Spent Fuel Data Base-This data base is a compilation of utility responses to a voluntary survey on rates of spent fuel discharges, capacities of storage pools, and anticipated future operational [illegible] it is compiled by Battelle Pacific Northwest Laboratories for the [illegible]

d. Spent Fuel Discharge Projections-These projections are derived from the the Spent Fuel Data Base, as adjusted to conform to the EIA Mid-Case; projections are used to calculate anticipated waste flows from reactors.

e. Shipping Tariffs-Published shipping tariffs are used to calculate the relative costs of transport.

f. Waste Form Definition: West Valley High Level Waste (WVHLW)-Documentation of the characteristics of WVHLW was based upon communications with the project office.

g. Waste Form Definition: Defense High Level Waste (DHLW)-Projections of characteristics of DHLW generated in support of US defense programs are discussed in Chapter II. This information is used to generate source term input for risk analysis.

h. Waste Form Definition: Spent Fuel-ORIGEN2 is a computer code developed by ORNL to describe the decay of radioisotopes in spent nuclear fuel assemblies over time. Output of this code is used to develop the radionuclide inventory for 5- and 10-year-old spent fuel. For the purpose of source term definition in the risk analysis only, all spent fuel shipments were treated as if they contained typical PWR fuel assemblies, which are 3.2% enriched with a burnup of 32,717 MWd/tHM at a power of 38.4 MW(t)/tHM. Each such assembly contains 0.46 tHM.

i. Route Simulation Model: Truck Transport - HIGHWAY is a computerized routing model developed by ORNL that includes a coded network of the nation's highways (Reference 25). It calculates travel path, distance, and travel time for any given origin-destination pair. All shipping (origin) and receiving (destination) facility locations considered in this analysis were input into the HIGHWAY code to generate the truck route distances used in the risk analysis.

j. Route Simulation Model: Rail Transport - The INTERLINE model developed at ORNL calculates a railroad route and travel distance between any given origin-destination pair (Reference 26). As in the HIGHWAY routing code, all shipping and receiving facility locations were input

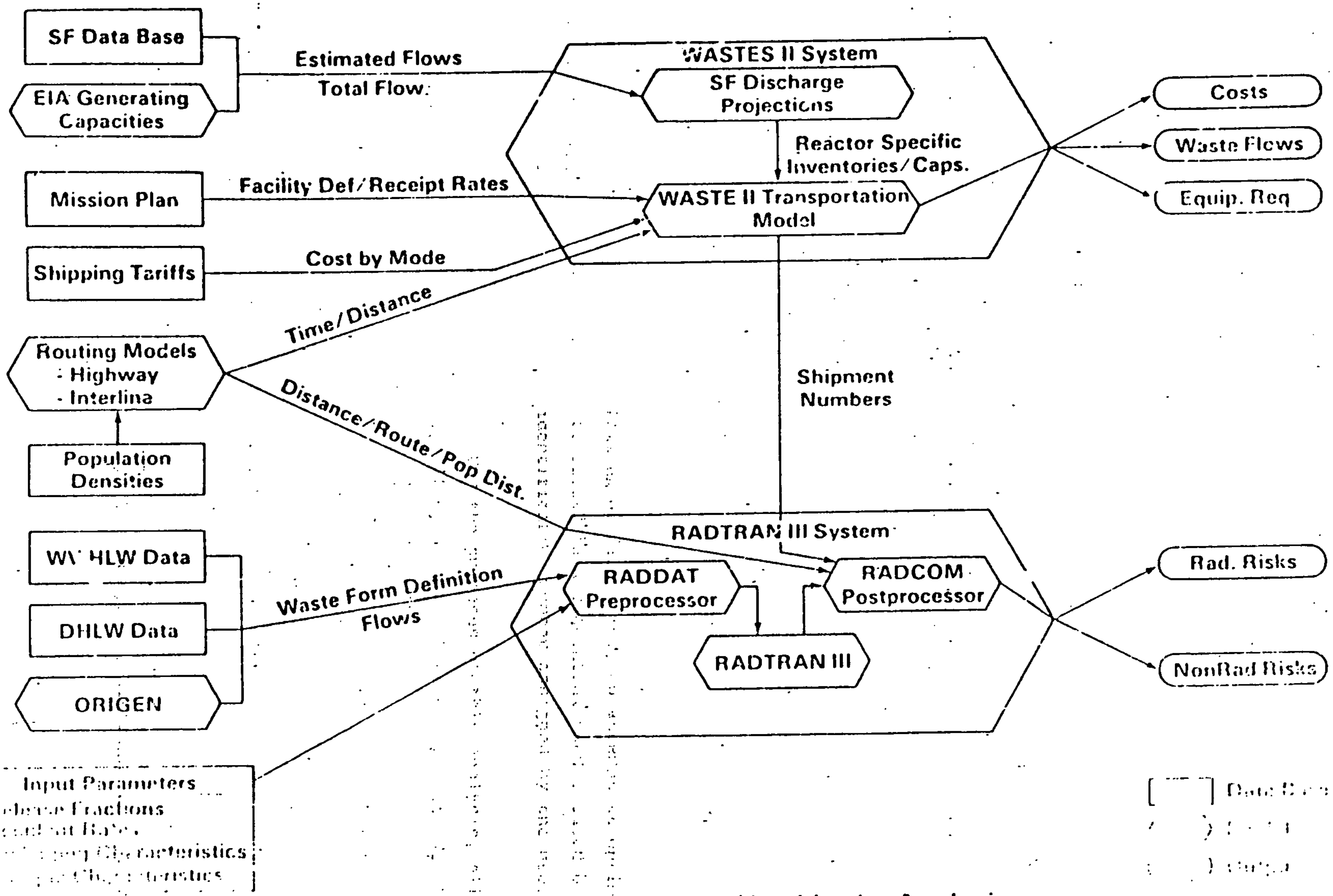

Figure 5. Computational System Used in the Analysis

into the INTERLINE code to generate the rail route distances used in the risk analysis.

k. Population Density Profiles-Based on the 1930 US Census, population density data are used together with the routes generated by the routing models to calculate the fractions of travel in each population density along each route. The population density zones used in the risk analysis correspond to mean densities of 3861 persons/km for urban, 719 persons/km for suburban, and 6 persons/km for rural.

3. Logistics Model (WASTES II)

The WASTES II model was developed at Battelle Pacific Northwest Laboratories under the joint sponsorship of the DOE/OCRWM MRS and Transportation programs. The WASTES II model is a tool for use in analyzing the effects of various policy decisions and/or facility operating schedules of the commercial waste management system. WASTES II uses discrete event simulation techniques to model the generation of spent nuclear fuel, the buildup of spent fuel inventories within the system and the transportation requirements for the movement of wastes throughout the system. The model is written in FORTRAN 77 as an extention to the SLAM commercial simulation language package (Reference 27).

The WASTES II model accepts up to a total of twelve facilities of four different types in addition to the pool and dry storage located at the reactors. The allowable types of facilities are federal interim storage (FIS), monitored retrievable storage (MRS), reprocessing plants, and repositories. The minimum time in which spent fuel must reside at each facility may be specified. In addition, the minimum age since discharge or the maximum heat generation rate allowed for receipt at each facility may be specified.

Reactor-specific data for the WASTES II model is received from two files in the spent fuel data base described above. The first file contains site-specific information such as reactor location, reactor type and transportation access while the second file contains historical and projected discharge data on the number of fuel assemblies, their metric tonnage, and the expected exposure for each discharge.

The simulation is driven by a combination of source and destination requested transfers. Source driven transfers would occur when a reactor pool violates its full core reserve storage margin or when a reactor is decommissioned. The material requiring transfer would be shipped to facilities with available capacity. Destination driven transfers occur when the annual capacity of a facility will not be met by full core reserve or decommissioning shipments and fuel must be scheduled from facilities with non-critical storage needs. The order in which facilities look to other facilities for storage capacity may be specified by the user of WASTES II.

Shipments within the system can be user specified to occur optimally, proximally or sequentially. Optimized shipping can be used when exactly two destination facilities exist. Optimized shipping selects source/destination pairs so that the total shipping distance in a given year is minimized. Proximity shipping fills the closest facility to the source according to the shipment priorities. This results in sub-optimal routing of waste material but can be used to approximate an optimal shipping strategy when more than two facilities of the same type are available to receive waste. In sequential filling of facilities, no attempt at optimization is made and the facilities are filled in a sequential manner based on an individual facility identification number assigned by the user.

For the purposes of this analysis, all spent fuel is shipped to either the repository or the MRS based upon area of the country, thus the features of the model just described are not used. Instead, this analysis concentrated upon the use of WASTES II to prioritize the shipments based upon shipping cask capacities, to estimate the number of trips from each shipment origin and, based upon travel and operational parameters to estimate the fleet size. Estimates of the total number of trips from each shipment origin were utilized in the risk calculations. Fleet size and total shipment mileage form the basis for projected operational and capital costs of the transportation system. These parameters were calculated for each component of the transportation system, although only the summary information is used in this report

4. Risk Model (RADTRAN III)

The RADTRAN III risk analysis model developed by Sandia National Laboratories calculates the radiological risks associated with the transport of radioactive materials (Reference 28). Although RADTRAN may be used for simple origin-destination calculations, it is used within the computational system described here solely to generate radiological unit-risk factors (risk per shipment-kilometer). The units of risk are radiological health effects, which include lethal cancer fatalities and genetic effects in all generations. The risks of nonradiological injuries and fatalities are calculated from published mode-specific death and injury unit-risk factors.

The RADTRAN III code consists of two major modules: the incident-free transport module in which doses resulting from normal transport are modeled, and the accident module in which consequences and probabilities of accidents are modeled. Included in the incident-free module are models describing:

- dose to persons within 800 meters of the highway or rail line (offlink dose);
- dose to persons sharing the transport link (onlink dose), which includes three submodels describing doses to persons in (a) vehicles traveling in the opposite direction, (b) vehicles traveling in the same direction, and (c) passing/adjacent vehicles, respectively;
- dose to members of the public at stops;
- dose to drivers, rail crews, etc. (occupational dose).

Each of these calculations is performed separately for each waste form and for each transport mode in each of the three population density zones.

In the accident module of the code, the range of possible accidents was divided into 6 accident severity categories for this study. The probability and the consequences of each accident severity category are specified for each important radionuclide in each waste form for each transport mode in each population density zone. The probabilities were derived from historical accident data for each mode (Reference 29). The consequences were calculated from the parameters describing the package, such as the radionuclide inventory of the contents (source term data) and the behavior of the contents under the specified accident conditions (fraction of material released, fraction of released material in aerosol form, etc.) (Reference 30), and by the meteorological and exposure models contained in the code.

The meteorological model allows the user to describe the plume of respirable aerosols that would be generated in very severe accidents. The user has the option of entering values for Pasquill stability categories, if known, or of using an average plume. The latter option was used in this analysis because the national character of the analysis precluded the use of local or regional data.

The exposure models describe the pathways by which the population may be exposed to radiation in the event of an accident severe enough to breach the cask and/or release some portion of its contents. These pathways include: penetrating radiation (e.g. gamma radiation) emanating from a breach in the cask (direct exposure dose); penetrating radiation from released material in the passing aerosol plume (cloudshine dose) and from material in the plume that is deposited on the ground (groundshine dose); inhalation of aerosols in the plume (inhalation dose) and aerosols of material that was deposited on the ground and then resuspended in the air (resuspension dose); and ingestion of material deposited on the ground that might enter the food chain (ingestion dose).

After the component risks, i.e. expected population doses per kilometer of transport, are generated as described above, they are summed and multiplied by a dose-conversion factor to generate unit-risk factors for incident-free transport and accidents in each population density zone. To obtain total risks, the unit-risk factors must be multiplied by the distances traveled in each population density zone and by the total number of shipments. This is accomplished by a simple combinatorial computer code in the postprocessor software.

RADTRAN III differs from its predecessors in several ways. Important changes include (a) improvements in the rail-stop model (Reference 17), (b) inclusion of an ingestion pathway model in the accident analysis module

(Reference 31), and (c) inclusion of a submodule in the calculation of dose that accounts more correctly for adjacent/passing vehicles.

The rail-stop model now considers separately a distance-independent component of dose that is associated with the classification and inspection stops at the beginning and end of a trip which are required regardless of the length of the trip. This component is accounted for by the Z factors, a separate set of unit-risk factors which are multiplied only by the number of shipments rather than by both the number of shipments and the number of kilometers traveled as are other unit risk factors, to give a radiological subcomponent of incident-free risk. The number of intermediate stops a railcar might experience, however, is a function of trip length; the dose associated with these stops is calculated by the model and is accounted for in the "regular" unit-risk factors for incident-free transport.

A complex input data set is required by RADTRAN III for each waste form/cask/mode combination that is to be analyzed for each scenario in each population density zone. These data sets were formatted by preprocessor software called RADDAT developed for this study. Application of the appropriate multipliers to the unit-risk factors was done by postprocessor software, also developed for this study and named RADCOM.

RADTRAN determines population doses in terms of person-rem (a unit for measuring radiation dose) and uses a conversion factor adapted from a study by the International Council on Radiation Protection (Reference 32) to calculate the number of health effects that might be expected to occur in the exposed population. The population doses from RADTRAN are the sums of a large number of separate integrated-dose calculations for subgroups or subpopulations of the public (e.g. persons within 800 m of a transport link) and of occupationally exposed persons (e.g. truck drivers). For the accident related risk component, potential consequences (doses) are multiplied by the probabilities of their occurrence. Doses to individuals cannot be extracted from these sums. While the approach used in RADTRAN is quite adequate for the purpose for which it was intended, it could not be used to calculate, for example, dose to an individual located at some particular distance from a cask. Further, the actual shape of the cask radiation field becomes [illegible] in the immediate proximity of the cask, and this effect is not included in RADTRAN. Therefore, caution must be exercised when one compares a RADTRAN risk analysis with the results of what is often called a consequence analysis in which doses to individuals in special situations are calculated and in which the probability of occurrence of the situation is not considered.

5. Discussion

The models discussed above and the data sources cited allow national costs and risks of transport to the potential candidate repository sites to be calculated in a methodologically consistent manner with input data that are consistent for all parameters except those that depend directly on the locations of the repository sites and MRS sites (e.g. total shipment-miles). The result is a relative impact analysis that permits comparisons among the repository sites. The models generated the detailed and summary cost and risk tables found in this document.

The manner in which operational assumptions and parameters for the logistics model are treated is different from the manner in which they must be treated for the RADTRAN III risk analysis model because the sensitivity of the results to particular input parameters is not the same for the two codes. In the WASTES II logistics model, for example, average travel parameters may be used because the model outputs (packaging requirements, shipment-miles, and costs) are not sensitive to differential speeds through population zones, and stop time is accounted for in the average speed value. The risk analysis, however, must use generic characteristics of the routes, and specific stop times, speeds, and locations.

It should be noted that distances between shipment origin and destination points were estimated separately for the logistics and risk codes. The WASTES model uses an adjusted great circle distance for ease of calculation while the RADTRAN system utilizes distances and population densities generated by route simulation models (HIGHWAY and INTERLINE). A comparison of the two techniques indicates a difference of approximately 10% in the two methods--the dist [illegible]

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(and thus cask requirements and operational costs) generated by [illegible] greater than the aggregated distances used in the risk analysis. Since [illegible] is well within the expected accuracy of the route-simulation codes, the comparability of the results of the cost and risk analyses is not affected.

IV. STUDY CONSTRAINTS

A. INTRODUCTION

This report supports the Environmental Assessments (EAs) supporting nomination of candidate sites for characterization for the first repository. Therefore, the purpose of this study is to allow comparison of the national costs and environmental impacts of spent fuel and high-level waste transportation to the candidate repository sites. Because of the comparative purpose of this analysis, the transportation operational parameters for each case have been applied uniformly to each of the siting options.

It is not the intent of this document to support construction or site selection for the MRS. The MRS documentation submitted to Congress contains transportation analyses that will permit comparisons between repository siting options. The inclusion of the MRS scenarios in this report is to demonstrate how an MRS might impact repository site selection. Operational characteristics, particularly those concerning the dedicated rail shipments between the MRS and the repository, prevent a detailed comparison of the reference and MRS cases. The reasons for this are discussed below. Readers interested in the comparison of these alternatives should refer to MRS program documentation for a complete discussion of that concept.

The construction of a second repository, as defined in the NWPA, would affect the sources and characteristics of shipments both to the first repository and to a possible MRS facility. For the purposes of this analysis, the wastes to be shipped to the first repository would be the oldest 62,000 MTHM available for transport. If a second repository were included in the waste management system, younger spent fuel might be shipped to the first repository in order to optimize operations. The additional heat loading might reduce the capacities of future-generation casks or result in new special-use casks, which would require larger numbers of shipments to deliver the same number of MTHM to the first repository. However, the additional capacity available from a second repository could allow a reduced receipt rate for the first repository.

The Environmental Impact Statement (EIS) for the first repository satisfy the requirements of both the NWPA and the National Environmental Policy Act. The Draft EIS is scheduled for completion in early [illegible], [illegible] completion of the Final EIS is scheduled for late 1989. Future analyses [illegible] be more detailed as to anticipated waste flows, waste form characteristics, operational parameters, and routings.

B. DISCUSSION

The results presented in this document are highly dependent upon the study scenarios and parameters specified by the Office of Civilian Radioactive Waste Management (OCRWM). Interpretation of the results should only be made with an understanding of the limitations of the data and models used for this study. Specific parameters and modeling techniques are discussed below.

1. Case Structure

Waste ages, processing to be undertaken at a potential MRS facility, and repository-specific packages are currently being defined; thus the cases that have been used in this analysis are only bounding cases.

2. Spent Fuel and High Level Waste Flows and Descriptions

This analysis uses waste flows calculated with the use of the Spent Fuel Data Base and the flow assumptions outlined in the text. While these rates are representative of the required rates of receipt at the repository and MRS, actual flows from individual reactors or utilities may be negotiated under the Utility Contracts with the DOE. Such negotiations could cause minor fluctuations in the total shipment-miles from certain origin points, which would result in perturbations in the cost and risk calculations.

Waste flows from high level waste sites and the characteristics of these wastes were defined by the DOE and are known to overestimate the quantities and characteristics of these wastes. An overestimate of the impacts of this waste stream is thus reflected in the summary tables in this document.

3. Transportation Packaging Descriptions

This analysis uses engineering estimates of capacities for future generation packagings. However, these packaging designs are not fully defined. Design efforts for such future-generation casks are currently being undertaken under the sponsorship of the DOE Civilian Radioactive Waste Management Program. Should the actual capacities differ significantly from these predicted design capacities, the numbers of shipments and, consequently, total shipment-miles would change. Package requirements, costs, and most components of risk are highly mileage-dependent, thus predicted costs and risks would increase or decrease accordingly.

Packagings used for shipments out of the MRS, for the purposes of this analysis, consider only the 100T and 150T weight limits. Further refinement of the MRS concept and casks to be used between an MRS and a repository would be undertaken should this concept be authorized by Congress in 1986.

4. Distance Estimates and Repository Location Assumptions

Distances used in this analysis were obtained from two sources: a modified great circle distance was used in the WASTES logistics model for ease of calculation, while the RADTRAN III risk analysis used routes predicted by the HIGHWAY and INTERLINE routing models. These methods of predicting distances vary by about 10% on the average Although actual reactor locations were used in this analysis rather than centroids, as were used in previous analyses, the routing codes identify only one route for a given origin-destination pair. The routes are identified in accordance with Department of Transportation (DOT) rules, but other equally acceptable routes connecting the endpoints could be used. Actual routes may also reflect actions by the states to designate "preferred routes" under DOT quidelines. Should the actual routes differ significantly in length or in population-density zone distribution from those used in this analysis, the magnitudes of the mileage-dependent components of risk will increase or decrease accordingly.

Where a single destination has been used to represent more than one repository site, the actual distance to each of the sites will differ slightly from the estimate used here. In addition, the access route(s) in the immediate vicinity of site will be determined in the final design of the facilities- a process which has yet to be completed.

5. Shipping Costs

Transportation shipping costs are determined from published tariffs, as available. While this methodology permits comparison between repository [illegible] receiving the same waste flows, comparisons between the reference case and the MRS cases is more problematical because of the inconsistent basis for determination of shipping rates. For example, shipments from the MRS travel by "dedicated train" at a reference total speed of travel of approximately 1.25 times that for general-commerce rail. Determination of such a ratio without published tariffs is a "best guess" of experts contacted, however the actual rate to be paid for all routes and modes will be determined through negotiation between the DOE or its representative(s) and eligible carriers.

6. Operational Assumptions

Potential variations in the operational characteristics attributed to the transport modes considered in this analysis could alter the degree of difference between the options. For example, legal-weight truck and general commerce rail are the transport modes from the reactors and high level waste generating sites. The weights, payloads, and operational characteristics of these modes are determined routinely in the tariff guides. Deviation from these accepted standards could influence the shipping costs and travel speeds as well as impose additional institutional complexities not encountered by legal-weight truck and general commerce rail. Changes in travel speeds, the number and duration of stops, etc. would directly affect the magnitudes of the calculated risks.

When all spent fuel and HLW shipments are made by truck the total number of shipments is maximized because truck cask capacities are relatively small. When all shipments are by rail, the total number of shipments is minimized because of the increased payload size. In reality, a mixture of truck and rail shipments of spent fuel from reactors will most likely be [illegible] first repository or MRS. Because only a limited number of shipments [illegible] are to be made, however, it is entirely possible that all HLW ship[illegible] be made by a single mode. Since it is the intention of this analysis to [illegible] the total number of shipments of all spent fuel and HLW to the first repository or MRS, only the 100% truck or 100% rail options were summarized. For examination of modal combinations other than these bounding cases, detailed tables are provided in the Appendices.

Shipments from the MRS are made by dedicated rail in 100T or 150T casks. As mentioned above, assumptions were made in the analysis regarding the operations of the dedicated rail mode and the large casks. Because the results of this analysis for the MRS cases are highly dependent upon these assumptions, which include uncertainties not shared by the reference case, comparisons between the MRS cases and the reference case should not be considered as reliable as those between repository sites in the reference case.

7. Dose Estimates

Several simplifying assumptions have been made in the RADTRAN III model. These assumptions are responsible for a model bias that tends to overestimate dose and, hence, radiological risk. For example, groundshine is modeled by assuming that particulates released during an accident are deposited out of the plume onto an infinite plane surface. No credit is taken for radiation attenuation from surface roughness because, although attenuation would undoubtedly occur in an actual accident, the exact nature of the surrounding surface at an accident site cannot be predicted. Similarly, for incident-free exposure, no credit is taken for shielding of drivers and passengers by automobiles when the onlink dose (i.e. dose to persons sharing the transport link) is calculated, although estimates of the attenuation factor for automobiles are available (Reference 33) and could be included in a future refinement of the model. This model bias does not affect the meaningfulness of relative risk calculations, but the results do not represent absolute risks.

V. RESULTS

A. INTRODUCTION

The computational system discussed in Chapter III was used to [illegible] costs and risks of transport of spent fuel and HLW to the potential [illegible] repository sites. The results of the relative cost and risk analyses are presented here, and the differences among the repository sites are [illegible] in terms of the key input parameters for the reference direct to-repository case and two MRS cases in which all spent fuel is shipped to an MRS located at Oak Ridge, TN, and either a 100-ton or a 150-ton cask is used for shipment to the repository. Other MRS options investigated are presented in Appendix [illegible]

B. REFERENCE CASE

Tables 7 through 10 summarize the results of the analysis for the reference case: shipment of spent fuel and high level wastes directly to the candidate repository sites.

1. Results of the Logistics and Cost Analyses

Table 7 summarizes the total one-way shipment-miles for each of the sites. The total mileages vary between 96.4 and 186.7 million miles for truck from all generating sites and between 17.3 and 33.3 million miles for rail. As expected, the total mileage is lowest for the easternmost candidate site (GIR) and greatest for the westernmost site (Hanford). The differences between the various repository sites are related to the total shipping distances as summarized in Table 7. As can be noted from the table, spent fuel shipments dominate the total shipping distances for both modal options, comprising from 64-80 percent of the truck shipping distance and from [illegible] percent of the rail travel. This component becomes an increasingly larger fraction of the total as the potential repository site is shifted to the West since most of the spent fuel inventory projected to require shipment to the first repository is from reactors in the East.

The relative fraction of total shipment-miles for shipment of high level wastes to the repository is between 19 and 29 percent for truck and [illegible] percent for rail. In this case, although the actual mileage increases as more western repository options are analyzed, the fraction attributable to shipment of high level wastes drops. As can be noted from the totals in the Table, the more western sites require almost double the total shipment miles of the most eastern site.

Table 8 details total numbers of packagings required for the movement of spent fuel and high level wastes during the lifetime of the first repository. For the purposes of this calculation, all transport packagings were assumed to have an operational lifetime of 15 years. The cask requirement also reflects operational parameters for the modal options outlined above. Approximately 50% more truck casks would be required for the Hanford repository with respect to the most eastern location, the GIR. For rail, the variation in the number of casks needed between these two destinations is an increase of approximately 40%.

The total number of packagings required for the 26-year period of operation of the first repository is multiplied by the cost per cask to obtain the relative capital cost for each of the repository sites. It should be noted that this is the only capital cost considered in this analysis; costs of facility improvements, handling equipment and other equipment required to clean, load, or unload the casks will be included in the repository facility costs. The total relative transportation cost is detailed in Table 9. This cost is described as though all costs were assessed in 1985 and should be used only for relative comparisons between the candidate repository sites. As previously stated, these costs are taken from published tariffs, where available, and from estimated maintenance and capital purchase costs, which are applied uniformly to each of the sites. Actual costs at the time of repository operations will be determined by negotiated shipping tariffs and bids for maintenance and provision of the capital equipment, through either lease or purchase.

Transportation costs for the repository location options increase with the total number of shipment-miles; however, because of the tariff structure of the modes, they do not increase in a linear manner. Total costs for the transportation of spent fuel and high level wastes to a repository range between 936 million dollars and 1.6 billion dollars for truck, an increase of approximately 75 percent between the most eastern site in the Gulf Interior Region and the Hanford site in the west. Rail costs for the easternmost site are 980 million dollars and 1.4 billion dollars for the westernmost site. Consistent with the rate structure, total costs between these sites vary only about 40 percent for the rail option. Truck costs are lower than rail for the easternmost sites and higher than rail for the western sites. The contribution of spent fuel shipment cost to the total is consistent with the proportion of shipment mileage for truck and somewhat less than the fraction of total mileage for rail.

2. Results of the Risk Analysis

The relative risks of transport for the various repository sites are mainly a function of total distance traveled because the other major route-specific factors in the analysis, namely the average fractions of travel in the three population-density zones, are about the same for all sites. The points of origin of most shipments (i.e. the reactors) are primarily in the eastern United States. The GIR and Vacherie sites are closest to these origin points; the lowest total shipment-miles (Table 7) and consequently the lowest overall risks (Table 10) are associated with these repository sites. The highest total shipment-miles (Table 7) and risks (Table 10) are associated with those sites farthest from the majority of the country's reactors (Yucca Mt and Hanford). This relationship holds true for both modes of transport. However, the radiological risks associated with the closest repository sites (GIR) only differ from those for the most distant site by a factor of 1.9 for truck and by about a factor of 1.5 for rail. Similarly, the nonradiological risks associated with the Hanford site are a factor of 2.1 times greater than those associated with the easternmost site for truck transport, and are a factor of 1.8 times greater for rail transport.

The relationships outlined above roughly parallel the increases in total highway and rail shipment-miles as one goes from the easternmost to the westernmost repository sites, with the exception of the radiological risk for rail transport, which increases at a lower rate than does the distance traveled. The latter is a result of the fact that a significant part of the dose for incident-free rail transport is associated with the required inspection stops, which occur regardless of trip length. Since this distance-independent dose is constant for a given payload, it represents a larger fraction of the total dose for a short trip than it does for a long trip and thus dilutes the influence of distance travelled.

Risks associated with the shipment of DHLW and WVHLW directly to the repository are calculated separately because the routes traveled, the source terms, and the cask capacities are not the same as those for spent fuel (see Appendix 4 for details). These risks are included in the totals given in Table 10; they represent between 28 and 39 percent of the total risk for truck transport, and between 33 and 44 percent of the total risk for rail transport. Although the lowest risks are associated with the GIR and Vacherie sites, neither the shipment-miles (Table 7) nor the DHLW-associated component of risk differ by more than a factor of 1.3 when eastern and western sites are compared. This is because the DHLW sites are not concentrated in the eastern United States as are the commercial reactors, and the influence of the transport of these wastes is to reduce the relative differences in risk between eastern and western repository sites.

TABLE 7. TOTAL SHIPMENT-MILES (in millions)
REFERENCE CASE-Direct to Repository

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
100% Truck						
SF	67.4	71.7	94.4	115.1	141.8	149.7
DHLW	28.0	28.0	26.0	28.0	33.0	35.0
WVHLW	1.0	1.0	1.0	2.0	2.0	2.0
TOTAL	96.4	100.7	121.4	145.1	176.8	186.7
100% Rail						
SF	11.0	11.7	15.4	18.8	23.2	24.6
DHLW	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW	0.2	0.2	0.2	0.2	0.3	0.3
TOTAL	17.7	21.2	21.7	25.5	31.1	33.3

TABLE 8. TOTAL TRANSPORTATION PACKAGING REQUIREMENTS (number of casks) REFERENCE CASE-Direct to Repository

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
100% Truck						
SF	124	128	145	161	182	186
DHLW	40	41	43	48	50	53
WVHLW	2	2	2	2	4	4
100% Rail						
SF	81	83	93	100	110	112
DHLW	34	37	36	38	42	44
WVHLW	2	2	2	2	2	2

TABLE 9. TOTAL TRANSPORTATION COST ($M) REFERENCE CASE-Direct to Repository

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
100% Truck						
CAPITAL	227.2	234.2	261.2	290.1	325.1	337.2
OPERATING	708.9	730.0	866.0	1015.1	1213.6	1277.8
TOTAL	936.1	964.2	1127.2	1305.2	1538.7	1615.0
100% Rail						
CAPITAL	267.3	277.7	300.9	322.5	354.2	362.8
OPERATING	714.7	734.9	821.6	885.3	991.0	1013.8
TOTAL	982.0	1012.6	1122.5	1207.8	1345.2	1376.6

TABLE 10. SUMMARY OF THE TOTAL RISKS OF TRANSPORTATION REFERENCE CASE - Direct to Repository

	Repository Location					
MODE	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
100% Truck from origin						
SF to Repository						
Radiological[1]	4.6	5.0	6.2	7.7	9.2	10
Nonradiological[2]	13	14	18	24	29	31
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% Rail from origin						
SF to Repository						
Radiological	.16	.17	.18	.21	.24	.25
Nonradiological	.81	.85	1.0	1.3	1.6	1.6
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
TOTALS						
Truck from origin:						
Radiological	6.4	6.7	7.9	9.5	11	12
Nonradiological	19	20	24	30	36	38
Rail from origin:						
Radiological	.22	.24	.24	.28	.32	.32
Nonradiological	1.4	1.5	1.6	2.0	2.4	2.4

[1] Radiological health effects include lethal cancer fatalities and genetic effects in all generations.

[2] Nonradiological fatalities

C. MONITORED RETRIEVABLE STORAGE CASE

Tables 11 through 14 summarize the total shipment-miles, packaging requirements, costs, and risks for MRS Case 1. For this case, the MRS was located at Oak Ridge, Tennessee, all spent fuel was shipped directly to the MRS and 100T rail casks were used to transport overpacked, consolidated spent fuel to the repository. Tables 15 through 18 summarize the results for MRS Case 2 which used 150T rail casks to transport consolidated spent fuel canisters without overpacks. Analyses of the remaining MRS cases are presented in Appendix 2.

As with the reference case, the more eastern repository locations have the lowest economic and environmental impacts for both of these cases. Comparison of these two MRS cases shows an apparent reduction in impacts for the 150 ton cask, however the payloads of the two cask options are not the same; the 100T cask carries overpacked consolidated spent fuel, while the 150T cask carries nonoverpacked consolidated spent fuel canisters. Further, in these analyses the payloads of shipments from the MRS are repository-specific because the capacities of the canisters and overpacks are determined by the geologic medium (salt, tuff, or basalt). Careful evaluation of these results indicates that the degree of variation in the parameters is highly dependent on the repository-specific payloads assumed in the analysis.

1. Results of the Logistics and Cost Analyses

The total shipment-miles for truck or rail spent fuel shipments to the MRS, for HLW directly to the repository by the same mode, and for the 100T rail cask from the MRS to the repository, are summarized in Table 11. As previously noted, the 100T rail cask, which would be used to ship overpacked consolidated spent fuel, high activity wastes, and high level wastes, will result in the greatest number of shipment-miles of the two alternatives considered. It should be noted that the values in the table are for shipments. Each MRS-to-repository shipment is made up of five spent fuel casks, two high-activity-waste casks, two casks containing byproducts of consolidation, and one railcar with two transuranic waste packagings.

Accordingly, in order to calculate railcar-miles for the MRS-to-repository link, the figures given in the table must be multiplied by 10.

Total one-way shipment miles for truck vary from 78 million miles for the Permian repository (slightly greater for the two more eastern candidate sites) to 89 million miles for the Hanford alternative, a variation of less than 15 percent. Approximately 55 to 63 percent of this total is comprised of shipment-miles to the MRS. Shipment-miles for the rail mode vary from approximately 16 to 20 million miles between the GIR and the Hanford repository, the bounding cases. Variation between the bounding cases is approximately 30 percent. For rail, approximately 40 to 51 percent of the total mileage is for the shipments to the MRS. As with the truck case, above, spent fuel shipments to the MRS contribute a smaller percentage of the total travel as the candidate location moves to the west due to the increased contribution of the total mileage of high level waste shipments. The Yucca Mountain repository has the greatest number of shipment-miles for the shipments from the MRS, an effect of the cask capacity and the rail route chosen.

For the 150T dedicated rail shipments from the MRS summarized in Table 16, the MRS-to-repository leg comprises at most 2 to 9 percent of the total one-way shipment miles for truck and rail, respectively. Because of the reduced number of MRS-to-repository shipments, variation between the candidate repository locations is approximately the same for the truck-from-origin case but is reduced to approximately a 19% variation for the rail case. The absolute number of shipment-miles is approximately 10-15 percent less than the previous MRS case. As noted above, the Permian repository has the least number of total shipment-miles for the truck-from-origin option, an effect not reflected for the all-rail case. Also as previously noted, the Yucca Mountain repository has the greatest number of shipment-miles for the shipments from the MRS.

Total transportation packaging requirements for the two MRS cases are included in Tables 12 and 17 for the 100T and 150T dedicated rail cases, respectively. The reduced capacity of the rail casks for the Yucca Mountain canisters from the MRS is further reflected in the increased number of [illegible] required for the lifetime of the first repository. The total number of transportation casks required for the 26-year repository lifetime varies approximately 18 percent between the repository sites, with the lowest [illegible] of packagings required for the easternmost GIR site. Because of the constraints imposed in this analysis on the Yucca Mountain repository, [illegible] requires the greatest number of packagings in both cases. The increased capacity of the 150T cask is reflected in the 53-59 percent reduction in [illegible] number of casks required over the lifetime of the repository.

The total transportation cost for the 100T dedicated rail case is summarized in Table 13. The GIR repository option has the lowest total transportation-related costs, approximately 1.32 billion dollars for truck and 1.38 billion dollars for rail. The Yucca Mountain repository option has the greatest total cost of the repository options, approximately 1.83 billion dollars for truck and 1.9 billion dollars for rail. These values are about 35 percent greater than those for the GIR. For this MRS scenario, rail costs were 45-80 million dollars greater for rail for all repository options. MRS-to-repository shipments comprised approximately 38-53 percent of the total transportation costs, with the contribution highest for the Yucca Mountain repository. It should be noted that overpacking the spent fuel canisters at the MRS may offer a potential facility cost savings at the repository that is not reflected in this analysis.

The higher payloads achieved by dedicated rail transport of the 150T cask with no overpacks on the consolidated fuel canisters is reflected in the reduction of transportation costs for the MRS-to-repository shipments. Costs for this leg are reduced by approximately half for the larger cask, with the contribution varying between 22 to 40 percent of the total transportation cost. The Yucca Mountain repository again has the highest total cost, and the GIR locations have the lowest.

2. Results of the Risk Analysis

The interpolation of an MRS into the system has four major effects on risk. (1) The total shipment-miles from points of origin (i.e. re [illegible]

HLW generators) to an ultimate destination (i.e. a repository site) are less than they are for the reference case. This affects the transportation risk calculations because most components of radiological risk and all components of nonradiological risk are proportional to distance traveled. (2) The use of dedicated rail out of the MRS affects the risk calculation because the risks associated with transport by dedicated rail are different from and usually lower than those associated with transport by general commerce rail. Incident-free risks are reduced, but cask capacities, and hence accident-related radiological source terms, are increased. However, the accident rates for dedicated rail are lower than those for general commerce rail, which has the opposite effect of reducing the accident-related radiological risk values. (3) The radioactive decay of spent fuel radionuclides during the assumed five-year residence time of spent fuel at the MRS must be accounted for when the radiological source terms of fully loaded dedicated rail casks are calculated. Certain important gamma-emitting radionuclides in spent fuel undergo significant decay over this time period, which in part compensates for the otherwise large source term associated with the large dedicated rail casks. (4) The handling and repackaging operations at the MRS generate secondary wastes (assembly hardware, high activity waste, and transuranic waste) that must also be transported to a repository. Transport of these secondary wastes to the repository incurs risks that must be calculated and added to the other risks in order to generate total risk estimates for the MRS scenarios. Note that these byproducts are present in unconsolidated spent fuel assemblies, and the total radionuclide inventories of an unconsolidated spent fuel assemby and the equivalent amount of consolidated fuel rods, hardware, high-activity waste, and transuranic waste are the same. Therefore, no additional radioisotopes are transported. However, the byproducts are in altered forms which include nonradioactive components such as filters that increase their volume. They also may have dispersability properties during a severe accident that are different from those of the original fuel.

When one compares the risks of transport to the various repository sites for MRS Cases 1 and 2 (Tables 14 and 18), one must keep in mind that transport of consolidated spent fuel and secondary wastes from an MRS to a repository is always by dedicated rail. The "100% truck" option is defined to mean that spent fuel is transported to the MRS by truck but that transport out of MRS is by dedicated rail. Similarly, the 100% rail option is defined as that spent fuel is transported to the MRS by general commerce rail and that transport out of the MRS is by dedicated rail. Therefore, for any given repository site the differences in spent fuel-related risk between the two modal options are solely determined by the mode of transport to the MRS. risks of transport by truck to an MRS site are higher than the risks of transport by general commerce rail. This is consistent with the reference case analysis. The calculated risks for transport by truck and rail of DHLW and WVHLW directly to the repository are added to the totals.

The differences in total risk among the potential candidate repository sites are relatively small. This is a result of the facts that (a) travel to the MRS is responsible for between 40 and 63 percent of the total shipment-miles depending on the repository site and mode and (b) most of the remaining shipment-miles are accounted for by DHLW and WVHLW transport. For a given mode and a given MRS location, the risks associated with travel to the MRS are identical for every repository site. Further, because the four HLW origin points are not concentrated in the East as are the commercial reactors, the differences in risk are less pronounced from one repository site to another, although the lowest risks are still associated with the eastern sites. The contribution to risk of transport from the MRS to the repository is only a few percent of the total. Therefore, the influence on total risk of the location of the repository site with respect to most other components of the system is greatly reduced. The MRS-to-repository component of risk does increase, of course, as the distance between the MRS and the repository increases. This trend, in conjunction with the contribution from HLW transport, causes Tables 14 and 18 to show increases in risk associated with the westernmost repository sites regardless of mode. The nonradiological risks increase almost linearly with total shipment-miles; the complex influences discussed previously reduce but do not eliminate the distance-dependency of radiological risk.

TABLE 11. TOTAL SHIPMENT-MILES (in millions)
MRS CASE 1 - MRS at Oak Ridge

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	[illegible]
Truck from Origin						
SF to MRS	48.8	48.8	48.8	48.8	48.8	[illegible]
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	[illegible]
WVHLW to Repos.	1.0	1.0	1.0	2.0	2.0	[illegible]
Rail from Origin						
SF to MRS	8.0	8.0	8.0	8.0	8.0	8.0
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	0.2	0.2	0.2	0.2	0.3	0.3
Rail from MRS to Repository (100T, overpacked SF)						
Dedicated Rail	0.9	1.2	2.2	3.0	3.8	3.4
TOTALS						
Truck from Origin 100T from MRS	78.7	79.0	78.0	81.8	87.6	89.2
Rail from Origin 100T from MRS	15.6	15.9	16.5	17.7	19.7	20.1

TABLE 12. TOTAL TRANSPORTATION PACKAGING REQUIREMENTS
(number of casks)
MRS CASE 1 - MRS at Oak Ridge

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Origin						
SF to MRS	106	106	106	106	106	106
DHLW to Repos.	40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4
Rail from Origin						
SF to MRS	67	67	67	67	67	67
DHLW to Repos.	34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2
Rail from MRS to Repository (100T with Overpacks)						
SF	55	60	70	75	80	70
HAW/Hdw	4	4	4	4	4	4
CH-TRU	2	2	2	2	2	2

TABLE 13. TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 1 - MRS at Oak Ridge

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites						
CAPITAL	201.0	202.1	204.3	209.8	214.2	217.5
OPERATING	613.7	608.1	601.1	615.8	639.0	652.9
Rail from Reactors, HLW Sites						
CAPITAL	232.3	237.7	235.9	239.5	246.7	250.3
OPERATING	643.7	646.1	647.5	644.2	667.9	664.4
Rail from MRS to Repository (100T with Overpacks)						
CAPITAL	81.0	161.6	186.6	109.7	211.6	186.6
OPERATING	427.3	428.7	584.8	773.9	763.6	691.0
TOTALS						
Truck from Origin						
100T from MRS	1323.0	1400.5	1576.8	1709.2	1828.4	1748.0
Rail from Origin						
100T from MRS	1384.3	1474.1	1654.8	1767.3	1889.8	1792.3

TABLE 14. SUMMARY OF THE RISKS OF TRANSPORTATION OF SPENT FUEL AND HIGH LEVEL WASTES: MRS CASE 1 (All SF to MRS, 100T cask)

	Repository Location					
MODE	GIR	Vacherie	Permian	Paradox	Yucca Mt	[illegible]
<u>100% Truck from Origin</u>:						
SF to MRS						
Radiological[1]	3.6	3.6	3.6	3.6	3.6	3.6
Nonradiological[2]	9.1	9.1	9.1	9.1	9.1	9.1
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
<u>100% Rail from Origin</u>:						
SF to MRS						
Radiological	.14	.14	.14	.14	.14	.14
Nonradiological	.92	.92	.92	.92	.92	.92
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
150T Rail from MRS to Repository:						
Radiological	.034	.064	.062	.068	.082	.071
Nonradiological	5.4	10	15	20	25	21
TOTALS						
Truck from Origin, 150T Rail from MRS						
Radiological	5.4	5.4	5.4	5.5	5.8	5.8
Nonradiological	21	25	30	35	41	37
Rail from Origin, 150T Rail from MRS						
Radiological	.20	.22	.21	.22	.23	.22
Nonradiological	6.9	12	17	22	27	23

[1] Radiological health effects include lethal cancer fatalities and genetic effects in all generations.

[2] Nonradiological fatalities

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TABLE 15. TOTAL SHIPMENT-MILES (in millions)
MRS CASE 2 - MRS at Oak Ridge

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca	
			Repository Location			
Truck from Origin						
SF to MRS	48.8	48.8	48.8	48.8	48.8	[illegible]
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	[illegible]
WVHLW to Repos.	1.0	1.0	1.0	2.0	2.0	[illegible]
Rail from Origin						
SF to MRS	8.0	8.0	8.0	8.0	8.0	8.0
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	[illegible]
WVHLW to Repos.	0.2	0.2	0.2	0.2	0.3	0.3
Rail from MRS to Repository (150T, nonoverpacked SF)						
0.2	0 3	0.6	0.8	1.5	1.0	
TOTALS						
Truck from Origin 150T from MRS	78.0	78.1	76.4	78.6	85.3	86.8
Rail from Origin 150T from MRS	14.9	15.0	14.9	15.5	17.4	17.7

TABLE 16. TOTAL TRANSPORTATION PACKAGING REQUIREMENTS
(number of casks)
MRS CASE 2 - MRS at Oak Ridge

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
			Repository Location			
Truck from Origin						
SF to MRS	106	106	106	106	106	106
DHLW to Repos.	40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4
Rail from Origin						
SF to MRS	67	67	67	67	67	67
DHLW to Repos.	34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2
Rail from MRS to Repository (150T, nonoverpacked SF)						
SF	20	20	20	20	30	20
HAW/Hdw	8	8	[illegible]	8	6	10
CH-TRU	2	2	2	2	2	2

TABLE 17. TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 2 - MRS at Oak Ridge

Mode/Waste Type	Repository Location GIR	Vacherie	Permian	Paradox	Yucca Mt	[illegible]
Truck from Reactors, HLW Sites						
CAPITAL	201.0	202.1	204.3	209.8	214.2	217.5
OPERATING	613.7	608.1	601.1	615.8	639.0	652.9
Rail from Reactors, HLW Sites						
CAPITAL	232.3	237.7	235.9	239.5	246.7	250.2
OPERATING	643.7	646.1	647.5	644.2	667.9	664.4
Rail from MRS to Repository (150T, nonoverpacked)						
CAPITAL	78.6	78.6	78.6	78.6	100.6	84.1
OPERATING	172.7	199.0	265.3	306.8	468.7	346.8
TOTALS						
Truck from Origin 150T from MRS	1066.0	1087.8	1149.3	1211.0	1422.5	1301.3
Rail from Origin 150T from MRS	1127.3	1161.4	1227.3	1269.1	1483.9	1345.6

TABLE 18. SUMMARY OF THE RISKS OF TRANSPORTATION
OF SPENT FUEL AND HIGH LEVEL WASTES:
MRS CASE 2 (All SF to MRS, 150T cask)

MODE	Repository Location					
	GTR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
100% Truck from Origin:						
SF to MRS						
Radiological[1]	3.6	3.6	3.6	3.6	3.6	3.6
Nonradiological[2]	9.1	9.1	9.1	9.1	9.1	9.1
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% Rail from Origin						
SF to MRS						
Radiological	.14	.14	.14	.14	.14	.14
Nonradiological	.92	.92	.92	.92	.92	.92
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
150T Rail from MRS						
Radiological	.017	.035	.035	.038	.054	.042
Nonradiological	1.4	2.6	3.8	5.3	1.0	6.1
TOTALS						
Truck from Origin, 150T Rail from MRS						
Radiological	5.4	5.3	5.3	5.4	5.8	5.7
Nonradiological	17	18	19	20	26	22
Rail from Origin, 150T Rail from MRS						
Radiological	.22	.25	.24	.25	.27	.26
Nonradiological	2.9	4.2	5.3	6.9	12	7.7

[1] Radiological health effects include lethal cancer fatalities and genetic effects in all generations.

[2] Nonradiological fatalities

VI. CONCLUSIONS

For each of the scenarios analyzed, the easternmost repository locations had the lowest transportation-related impacts in terms of shipment-miles, costs, and risks for the bounding cases. Truck and rail totals for each of the sites reflect the routes chosen and operational characteristics of the modes. It should again be noted that these are relative impacts for operation of the transportation system between reactors and high level waste sites and the candidate repository locations and do not reflect activities within facilities at the sites or network changes or modifications necessary to operate the system. The costs and risks of handling, repackaging, and emplacing waste materials are not included in this analysis because these activities do not occur during transport but rather take place at fixed facilities, which are analyzed separately in the EAs.

Insertion of an MRS into the system tends to reduce the variation between the potential sites because of the reduction in shipment-miles possible with the large dedicated rail casks. Further, the MRS also reduces the difference previously noted between modal options from the reactors and high-level-waste sites, which dominate the total impacts. The large, 150T dedicated rail cask reduces the impacts of transportation out of the MRS because of its large payload in terms of MTU/shipment. Use of repository-specific canisters and overpacks for the MRS cases influences the relative ranking of the Yucca Mountain (tuff) and the Hanford (basalt) repository sites because the tuff canister and overpack are lower in capacity than the basalt canister and overpack (all of the other sites use the salt canister and overpack). In addition, the rail routings between the MRS locations and Yucca Mountain are more circuitous than the rail routings between the MRS locations and Hanford. The combination of increased shipment-miles and reduced canister and overpack capacity causes Yucca Mountain to rank higher in cost and risk than the Hanford repository site. The transport-related costs and risks of decommissioning an MRS facility are not considered here because they will be dealt with in a separate study.

To aid the reader to assess the significance of the risks of tr[illegible] related fatalities predicted in this report, the 17 to 38 truck accident fatalities, 1.4 to 7.7 rail accident fatalities, and the .22 to 1[illegible] radiological health effects predicted in this report may be compared with the following. In the United States, about 65,000 persons would die from truck accidents, and 32,000 would die from rail accidents during the 2[illegible]-year repository operating period. During the same period an estimated 5[illegible] cancer fatalites are postulated to occur in the United States from exposure to natural background radiation alone (not including medical and other manmade sources) according to current models (Reference 34). The risks reported here are upper limit estimates and are small by comparison with the "natural background" of risks of the same type.

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APPENDIX 1

WASTE SOURCES AND FLOWS

Table 1.1. Summary of Cask Shipments

REFERENCE CASE:

Reactors to Repository (Spent Fuel)

Mode	Reactor Type PWR	BWR	Total
100% Truck	43,611	26,942	70,553
100% Rail	6,190	3,737	9,927

Defense High-Level Waste to Repository

	Truck	Rail
Hanford	2,250	450
Idaho Eng. Lab	9,000	1,800
Savannah River Plant	11,600	2,320
West Valley	800	115

ALTERNATIVE CASES:

Reactors to MRS (Spent Fuel)

Mode	Reactor Type PWR	BWR	Total
100% Truck	44,222	26,346	70,568
100% Rail	6,267	3,667	9,934

Reactors to MRS (Eastern Spent Fuel Only)

Mode	Reactor Type PWR	BWR	Total
100% Truck	40,915	24,382	65,297
100% Rail	5,793	3,390	9,183

MRS to Repository (Consolidated Spent Fuel)

Repository	Cask	Scenario All fuel	Eastern fuel only[A]
Richton, Deaf Smith, Davis Canyon, Yucca Mt	100 T	8,074	7,500
	150 T	2,103	1,900
	100 T	8,050	7,500
	150 T	3,186	3,000
Hanford	100 T	6,610	6,100
	150 T	1,823	1,700

MRS to Repository (Secondary Waste)

Mode	Cask	Hardware	High Activity Waste	Transuranic
Rail	100 T	1364	1270	159 (2 per railcar)
Rail	150 T	780	726	159 (2 per railcar)

MRS to Repository (Secondary waste from eastern spent fuel)[A]

Mode	Cask	Hardware	High Activity Waste	Transuranic
Rail	100 T	1300	1200	150 (2 per railcar)
Rail	150 T	700	700	150 (2 per railcar)

[A] Estimates of shipment numbers

Table 1.2. Number of Shipments to a Repository from Each Reactor Site
Reference Case

Reactor Name	100% Truck	100% Rail	Reactor Name	100% Truck	100% Rail
Farley-1	120	18	Millstone-1	804	111
Farley-2	46	7	Millstone-2	805	106
Palo Verde-1	511	72	Millstone-3	36	6
Palo Verde-2	484	70	Monticello	693	96
Palo Verde-3	448	63	Prairie Island-1	650	92
Arkansas Nucl One-1	762	108	Prairie Island-2	631	90
Arkansas Nucl One-2	187	27	Fort Calhoun-1	534	76
Calvert Cliffs-1	893	127	Humboldt Bay	65	12
Calvert Cliffs-2	853	122	Diablo Canyon-2	236	34
Pilgrim-1	761	105	Diablo Canyon-1	279	40
Robinson-2	581	83	Susquehanna-1	652	90
Brunswick-2	799	111	Susquehanna-2	614	85
Brunswick-1	751	109	Peach Bottom-2	1126	156
Perry-1	806	110	Peach Bottom-3	1126	156
Perry-2	747	104	Limerick-1	679	95
Dresden-1	136	18	Limerick-2	421	59
Dresden-2	909	126	Trojan	330	18
Dresden-3	825	116	Fitzpatrick	614	107
Quad-Cities-1	862	119	Indian Point-3	714	102
Quad-Cities-2	815	113	Seabrook-1	486	69
Zion-1	858	122	Seabrook-2	320	46
Zion-2	824	117	Salem-1	791	113
La Salle-1	572	79	Salem-2	764	109
La Salle-2	572	79	Hope Creek-1	509	71
Byron-1	638	88	Ginna	503	71
Byron-2	631	86	Rancho Seco-1	721	103
Braidwood-1	568	83	Summer	12	2
Connecticut Yankee	702	100	San Onofre-1	203	29
Indian Point-1	80	11	San Onofre-2	306	44
Indian Point-2	762	108	San Onofre-3	347	50
Big Rock Point	104	14	South Texas Proj-1	594	82
Palisades	796	113	South Texas Proj-2	592	82
Midland-2	373	49	Browns Ferry-1	699	135
Midland-1	334	46	Browns Ferry-2	695	140
La Crosse	143	19	Browns Ferry-3	986	137
Fermi-2	609	85	Sequoyah-1	444	60
Oconee-1	759	108	Sequoyah-2	425	62
Oconee-2	612	87	Watts Bar-1	518	76
Oconee-3	779	111	Watts Bar-2	524	74
McGuire-1	115	17	Bellefonte-1	444	64
McGuire-2	73	11	Bellefonte-2	327	47
Beaver Valley-1	735	104	Hartsville-A1	463	65
Beavery Valley-2	272	39	Hartsville-A2	328	45
Crystal River-3	676	96	Yellow Creek-1	90	13
Turkey Point-3	695	99	Yellow Creek-2	50	8
Turkey Point-4	694	99	Comanche Peak-1	412	58
St. Lucie-1	894	123	Comanche Peak-2	368	53
St. Lucie-2	486	70	Davis Besse-1	248	31
Hatch-1	312	43	Callaway-1	360	51
Hatch-2	289	40	Vermont Yankee	675	93
Vogtle-1	547	78	Surry-1	748	102
Vogtle-2	416	60	Surry-2	623	77
River Bend-1	455	65	North Anna-1	365	47
Clinton-1	528	74	North Anna-2	295	38
D C Cook-1	948	135	WNP-2	550	90
D C Cook-2	933	133	WNP-1	394	56
Duane Arnold	562	79	WNP-3	617	89
Oyster Creek	777	108	Point Beach-1	620	88
Wolf Creek	191	27	Point Beach-2	591	84
Shoreham	270	38	Kewaunee	634	90
Waterford-3	421	61	Yankee	340	48
Maine Yankee	980	140	Brunswick-2 PWR Pool	72	10
Three Mile Island-1	723	103	Brunswick-1 PWR POOL	80	11
Grand Gulf-1	247	35	Morris-BWR	150	20
Grand Gulf-2	340	48	Morris-PWR	175	25
Cooper	771	107	West Valley-BWR	17	2
Nine Mile Point-1	700	97	West Valley-PWR	60	8
Nine Mile Point-2	243	33		70,553	9,927

Table 1.3. Number of Shipments to an MRS from Eastern and Western Reactor Sites

Reactor Name	100% by Truck	100% by Rail	Reactor Name	100% by Truck	100% by Rail
Farley-1	387	56	Millstone-1	804	111
Farley-2	513	45	Millstone-2	949	135
*Palo Verde-1	366	52	Millstone-3	227	33
*Palo Verde-2	339	49	Monticello	693	96
*Palo Verde-3	332	47	Prairie Island-1	650	92
Arkansas Nucl One-1	762	108	Prairie Island-2	631	90
Arkansas Nucl One-2	495	43	Fort Calhoun-1	534	76
Calvert Cliffs-1	893	127	*Humboldt Bay	86	12
Calvert Cliffs-2	853	121	*Diablo Canyon-2	209	30
Pilgrim-1	761	105	*Diablo Canyon-1	252	36
Robinson -2	581	83	Susquehanna-1	516	71
Brunswick-2	799	111	Susquehanna-2	483	67
Brunswick-1	791	109	Peach Bottom-2	1,126	156
Harris-1	160	23	Peach Bottom-3	1,126	156
Perry-1	722	100	Limerick-1	500	70
Perry-2	579	80	Limerick-2	287	40
Dresden-1	136	18	*Trojan	805	117
Dresden-2	909	126	Fitzpatrick	864	127
Dresden-3	825	114	Indian Point-3	714	102
Quad Cities-1	862	119	Seabrook-1	343	49
Quad Cities-2	815	113	Seabrook-2	177	26
Zion-1	858	122	Salem-1	791	113
Zion-2	824	117	Salem-2	764	109
LaSalle-1	669	93	Hope-Creek-1	365	51
LaSalle-2	632	87	Ginna	503	71
Byron-1	593	85	*Rancho Seco-1	721	103
Byron-2	552	78	Summer	215	31
Braidwood-1	570	81	*San Onofre-1	203	29
Braidwood-2	484	69	*San Onofre-2	306	44
Connecticut Yankee	702	100	*San Onofre-3	348	49
Indian Point-1	80	11	South Texas Proj-1	539	77
Indian Point-2	762	108	South Texas Proj-2	453	64
Big Rock Point	104	14	Browns Ferry-1	944	135
Palisades	796	113	Browns Ferry-2	821	140
Midland-2	304	43	Browns Ferry-3	986	137
Midland-1	261	37	Sequoyah-1	588	113
LaCrosse	143	19	Sequoyah-2	571	108
Fermi-2	609	85	Watts Bar-1	465	66
Oconee-1	759	108	Watts Bar-2	424	61
Oconee-2	612	87	Bellefonte-1	315	45
Oconee-3	779	111	Bellefonte-2	199	29
McGuire-1	334	44	Hartsville-A1	284	40
McGuire-2	268	39	Hartsville-A2	194	26
Catawba-1	241	31	Comanche Peak-1	294	42
Catawba-2	198	25	Comanche Peak-2	257	33
Beaver Valley-1	735	105	Davis-Besse-1	321	43
Beaver Valley-2	154	22	Callaway-1	260	38
Crystal River-3	676	96	Vermont Yankee	675	93
Turkey Point-3	695	99	Surry-1	748	106
Turkey Point-4	694	99	Surry-2	620	88
St. Lucie-1	914	130	North Anna-1	469	58
St. Lucie-2	375	54	North Anna-2	420	50
Hatch-1	512	61	*WNP-2	605	84
Hatch-2	482	57	*WNP-1	251	36
Vogtle-1	415	59	*WNP-3	448	63
Vogtle-2	290	41	Point Beach-1	620	88
River Bend-1	329	45	Point Beach-2	591	84
Clinton-1	407	57	Kewaunee	634	90
D C Cook-1	948	135	Yankee	340	48
D C Cook-2	933	133	Brunswick-2 PWR Pool	72	10
Duane Arnold	572	79	Brunswick-1 PWR Pool	80	11
Oyster Creek	777	108	Morris-BWR	150	20
Wood Creek	184	27	Morris-PWR	175	25
Shoreham	201	28	West Valley-BWR	17	2
Waterford-3	291	42	West Valley-PWR	60	8
Maine Yankee	980	140			
Three Mile Island	723	103	TOTALS	70,568	9,934
Grand Gulf-1	318	45			
Grand Gulf-2	210	30			
Cooper	771	107			
Nine Mile Point-1	700	97			
Nine Mile Point-2	185	26			

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*Considered a western reactor for this analysis

Table 1.4. Facility Receipt Rates for Scenario Involving All Reactors Shipping to an MRS Facility

	Spent Fuel		Secondary Waste Products MRS to Repository		
Year	All Reactors to MRS (MTU)	MRS to Repository (MTU)	Hardware (canisters)	High Activity Waste (canisters)	CH-TRU (drums)
1996	400				
1997	1,800				
1998	3,000	400	35	33	74
1999	3,000	400	35	33	74
2000	3,000	400	35	33	74
2001	3,000	900	79	74	165
2002	3,000	1,800	158	147	331
2003	3,000	3,000	264	246	552
2004	3,000	3,000	264	246	552
2005	3,000	3,000	264	246	552
2006	3,000	3,000	264	246	552
2007	3,000	3,000	264	246	552
2008	3,000	3,000	264	246	552
2009	3,000	3,000	264	246	552
2010	3,000	3,000	264	246	552
2011	3,000	3,000	264	246	552
2012	3,000	3,000	264	246	552
2013	3,000	3,000	264	246	552
2014	3,000	3,000	264	246	552
2015	3,000	3,000	264	246	552
2016	3,000	3,000	264	246	552
2017	2,800	3,000	264	246	552
2018		3,000	264	246	552
2019		3,000	264	246	552
2020		3,000	264	246	552
2021		3,000	264	246	552
2022		1,100	97	90	202

Table 1.5. Facility Receipt Rates for Scenario Involving Eastern Reactors Shipping to an MRS Facility

Year	Spent Fuel Eastern Reactors to MRS (MTU)	Western Reactors to Repository (MTU)	MRS to Repository (MTU)	Secondary Waste Products MRS to Repository Hardware (canisters)	High Activity Waste (canisters)	[illegible]
1996	370					
1997	1,665					
1998	2,775	30	370	32	31	68
1999	2,775	30	370	32	31	68
2000	2,775	30	370	32	31	68
2001	2,775	67.5	832.5	73	68	154
2002	2,775	135	1,665	146	228	306
2003	2,775	225	2,775	244	228	511
2004	2,775	225	2,775	244	228	511
2005	2,775	225	2,775	244	228	511
2006	2,775	225	2,775	244	228	511
2007	2,775	225	2,775	244	228	511
2008	2,775	225	2,775	244	228	511
2009	2,775	225	2,775	244	228	511
2010	2,775	225	2,775	244	228	511
2011	2,775	225	2,775	244	228	511
2012	2,775	225	2,775	244	228	511
2013	2,775	225	2,775	244	228	511
2014	2,775	225	2,775	244	228	511
2015	2,775	225	2,775	244	228	511
2016	2,590	225	2,775	244	228	511
2017	2,800	225	2,775	244	228	511
2018		225	2,775	244	228	511
2019		225	2,775	244	228	511
2020		225	2,775	244	228	511
2021		225	2,775	244	228	511
2022		82.5	1,017.5	90	83	187

Table 1.6. One-Way Truck Miles to Richton Repository

Site Name	Population Category Rural Miles	 Suburban Miles	 [illegible]
Reactors			
Bellefonte NP, AL	273	78	[illegible]
Browns Ferry NP, AL	259	70	[illegible]
Farley NP, AL	241	69	[illegible]
Arkansas NP, AR	457	123	[illegible]
Palo Verde NP, AZ	1,608	286	15
Diablo Canyon NP, CA	2,037	369	26
Humboldt Bay NP, CA	2,418	432	33
Rancho Seco NP, CA	2,159	377	26
San Onofre NP, CA	1,846	347	21
Connecticut Yankee NP, CT	820	517	4
Millstone NP, CT	823	549	13
Crystal River NP, FL	468	110	0
St. Lucie NP, FL	601	130	0
Turkey Point NP, FL	632	205	37
Hatch NP, GA	425	152	4
Vogtle NP, GA	408	169	4
Arnold NP, IA	827	220	0
Braidwood NP, IL	720	158	0
Byron NP, IL	733	256	6
Clinton NP, IL	651	148	0
Dresden NP, IL	729	173	0
G.E. Repro Plant, IL	731	173	0
La Salle NP, IL	731	167	0
Quad Cities NP, IL	776	182	0
Zion NP, IL	703	246	8
Wolf Creek NP, KS	757	232	0
River Bend NP, LA	156	55	4
Waterford NP, LA	99	60	10
Pilgrim NP, MA	853	598	10
Yankee-Rowe NP, MA	867	563	15
Calvert Cliffs NP, MD	697	311	14
Maine Yankee NP, ME	889	666	14
Big Rock Point NP, MI	783	440	[illegible]
Cook NP, MI	624	265	[illegible]
Fermi NP, MI	606	321	[illegible]
Midland NP, MI	639	422	[illegible]
Palisades NP, MI	634	285	[illegible]
Monticello NP, MN	998	341	[illegible]

Table 1.6. One-Way Truck Miles to Richton Repository (Continued)

Site Name	Population Category		
	Rural Miles	Suburban Miles	[illegible]
Prairie Island NP, MN	996	303	
Callaway NP, MO	570	177	
Grand Gulf NP, MS	193	46	
Brunswick NP, NC	592	223	[illegible]
Harris NP, NC	450	349	[illegible]
McGuire NP, NC	395	227	[illegible]
Cooper NP, NE	792	231	0
Fort Calhoun NP, NE	854	251	0
Seabrook NP, NH	846	604	14
Hope Creek NP, NJ	685	403	15
Oyster Creek NP, NJ	785	415	[illegible]
Salem NP, NJ	685	403	15
Fitzpatrick NP, NY	861	450	9
Ginna NP, NY	808	415	14
Indian Point NP, NY	815	437	4
Nine Mile Point NP, NY	862	450	[illegible]
Shoreham NP, NY	827	513	33
West Valley RP, NY	777	371	7
Davis-Besse NP, OH	615	311	15
Perry NP, OH	678	308	[illegible]
Trojan NP, OR	2,346	442	2
Beaver Valley NP, PA	695	313	8
Limerick NP, PA	735	373	4
Peach Bottom NP, PA	714	357	5
Susquehanna NP, PA	754	377	4
Three Mile Island NP, PA	697	341	4
Catawba NP, SC	394	223	3
Oconee NP, SC	357	157	3
Robinson NP, SC	463	205	4
Summer NP, SC	427	177	[illegible]
Sequoyah NP, TN	283	108	[illegible]
Watts Bar NP, TN	337	115	[illegible]
Comanche Peak NP, TX	674	246	[illegible]
South Texas NP, TX	850	287	[illegible]
North Anna NP, VA	654	262	[illegible]
Surry NP, VA	569	369	[illegible]
Vermont Yankee NP, VT	834	559	[illegible]
WNP 1;2;4 NP, WA	2,218	404	
Kewaunee NP, WI	765	305	
La Crosse BWR NP, WI	870	295	
Point Beach NP, WI	761	305	

Table 1.6. One-Way Truck Miles to Richton Repository (Continued)

Site Name	Population Category Rural Miles	 Suburban Miles
High-Level Waste Sites		
Hanford	2,201	407
Idaho	1,829	328
Savannah River	394	170
West Valley	778	371

Table 1.7. One-Way Rail Miles to Richton Dome Repository

	Population Category		
Site Name	Rural Miles	Suburban Miles	[illegible]
Reactors			
Bellefonte NP, AL	342	117	3
Browns Ferry NP, AL	327	95	6
Farley NP, AL	437	154	1
Arkansas NP, AR	410	99	0
Palo Verde NP, AZ	1,514	374	56
Diablo Canyon NP, CA	1,935	482	106
Humboldt Bay NP, CA	2,320	627	57
Rancho Seco NP, CA	2,074	532	59
San Onofre NP, CA	1.818	414	67
Connecticut Yankee NP, CT	1.074	601	58
Millstone NP, CT	1,078	618	58
Crystal River NP, FL	462	104	3
St. Lucie NP, FL	530	233	8
Turkey Point NP, FL	537	354	38
Hatch NP, GA	447	184	9
Vogtle NP, GA	485	181	[illegible]
Arnold NP, IA	877	251	49
Braidwood NP, IL	694	153	5
Byron NP, IL	709	217	22
Clinton NP, IL	636	133	5
Dresden NP, IL	676	198	[illegible]
G.E. Pepro Plant, IL	674	198	[illegible]
La Salle NP, IL	696	215	[illegible]
Quad Cities NP, IL	797	260	[illegible]
Zion NP, IL	658	206	[illegible]
Wolf Creek NP, KS	685	150	
River Bend NP, LA	172	94	[illegible]
Waterford NP, LA	180	83	[illegible]
Pilgrim NP, MA	1,107	668	
Yankee Rowe NP, MA	851	747	[illegible]
Calvert Cliffs NP, MD	612	502	[illegible]
Maine Yankee NP, ME	950	922	[illegible]
Big Rock Point NP, MI	916	309	[illegible]
Cook NP, MI	714	332	
Fermi NP, MI	833	325	
Midland NP, MI	712	454	
Palisades NP, MI	727	[illegible]	
Monticello NP, MN	905		

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Table 1.7. One-Way Rail Miles to Richton Dome Repository (Continued)

Site Name	Population Category		
	Rural Miles	Suburban Miles	Urban Miles
Prairie Island NP, MN	889	327	31
Callaway NP, MO	592	161	11
Grand Gulf NP, MS	123	35	0
Brunswick NP, NC	657	241	14
Harris NP, NC	607	220	15
McGuire NP, NC	529	216	17
Cooper NP, NE	948	178	7
Fort Calhoun NP, NE	995	240	5
Seabrock NP, NH	901	874	46
Hope Creek NP, NJ	951	560	46
Oyster Creek NP, NJ	956	657	52
Salem NP, NJ	955	563	46
Fitzpatrick NP, NY	953	438	44
Ginna NP, NY	925	413	43
Indian Point NP, NY	1,043	559	48
Nine Mile Point NP, NY	952	438	44
Shoreham NP, NY	1,053	629	87
West Valley RP, NY	926	483	43
Davis-Besse NP, OH	747	336	25
Perry NP, OH	755	373	42
Trojan NP, OR	2,581	322	13
Beaver Valley NP, PA	870	306	20
Limerick NP, PA	944	538	28
Peach Bottom NP, PA	779	467	45
Susquehanna NP, PA	977	504	28
Three Mile Island NP, PA	943	473	28
Catawba NP, SC	393	337	10
Oconee NP, SC	349	208	9
Robinson NP, SC	527	201	[illegible]
Summer NP, SC	416	295	[illegible]
Sequoyah NP, TN	310	136	[illegible]
Watts Bar NP, TN	338	144	[illegible]
Comanche Peak NP, TX	533	171	[illegible]
South Texas NP, TX	444	163	[illegible]
North Anna NP, VA	752	335	[illegible]
Surry NP, VA	728	301	[illegible]
Vermont Yankee NP, VT	1,106	565	[illegible]
WNP 1,2,4 NP, WA	2,370	[illegible]	[illegible]
Kewaunee NP, WI	763	[illegible]	[illegible]
La Crosse BWR NP, WI	860	[illegible]	[illegible]
Point Beach NP, WI	[illegible]	[illegible]	[illegible]

Table 1.7. One-Way Rail Miles to Richton Dome Repository

Site Name	Population Class Rural Miles	Suburban Miles
High-Level Waste Sites		
Hanford	2,363	299
Idaho	1,894	205
Savannah River	460	166
West Valley	926	484

Table 1.8. One-Way Truck Miles to Vacherie Dome Repository

	Population C[illegible]		
Site Name	Rural Miles	Suburban Miles	[illegible]
Reactors			
Bellefonte NP, AL	420	128	[illegible]
Browns Ferry NP, AL	406	120	[illegible]
Farley NP, AL	478	157	[illegible]
Arkansas NP, AR	265	106	1
Palo Verde NP, AZ	1,115	236	[illegible]
Diablo Canyon NP, CA	1,523	373	[illegible]
Humboldt Bay NP, CA	1,902	437	[illegible]
Rancho Seco NP, CA	1,645	381	37
San Onofre NP, CA	1,364	261	27
Connecticut Yankee NP, CT	968	566	4
Millstone NP, CT	971	598	13
Crystal River NP, FL	739	259	4
St. Lucie NP, FL	873	278	[illegible]
Turkey Point NP, FL	904	353	40
Hatch NP, GA	573	201	3
Vogtle NP, GA	556	218	4
Arnold NP, IA	840	234	0
Braidwood NP, IL	729	186	0
Byron NP, IL	742	273	[illegible]
Clinton NP, IL	[illegible]	166	0
Dresden NP, IL	738	191	0
G.E. Repro Plant, IL	740	191	[illegible]
La Salle NP, IL	739	184	0
Quad Cities NP, IL	784	200	0
Zion NP, IL	712	264	[illegible]
Wolf Creek NP, KS	551	156	[illegible]
River Bend NP, LA	228	78	[illegible]
Waterford NP, LA	256	125	[illegible]
Pilgrim NP, MA	[illegible]	647	[illegible]
Yankee Rowe NP, MA	1,015	612	[illegible]
Calvert Cliffs NP, MD	844	361	[illegible]
Maine Yankee NP, ME	1.037	715	[illegible]
Big Rock Point NP, MI	941	426	
Cook NP, MI	712	[illegible]	
Fermi NP, MI	763	354	
Midland NP, MI	799	[illegible]	
Palisades NP, M[illegible]	722	[illegible]	
Monticello NP, [illegible]	954	[illegible]	

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Table 1.8. One-Way Truck Miles to Vacherie Dome Repository (Continued)

	Population Category		
Site Name	Rural Miles	Suburban Miles	[illegible]
Prairie Island NP, MN	947	265	1
Callaway NP, MO	579	195	0
Grand Gulf NP, MS	148	30	0
Brunswick NP, NC	739	272	3
Harris NP, NC	598	398	4
McGuire NP, NC	542	276	3
Cooper NP, NE	694	205	1
Fort Calhoun NP, NE	756	225	1
Seabrook NP, NH	994	652	14
Hope Creek NP, NJ	833	452	15
Oyster Creek NP, NJ	933	464	5
Salem NP, NJ	833	453	16
Fitzpatrick NP, NY	1,034	474	4
Ginna NP, NY	964	448	9
Indian Point NP, NY	963	406	4
Nine Mile Point NP, NY	1,035	474	4
Shoreham NP, NY	976	562	32
West Valley RP, NY	934	404	2
Davis-Besse NP, OH	772	344	11
Perry NP, OH	834	342	2
Trojan NP, OR	2,034	364	6
Beaver Valley NP, PA	851	347	3
Limerick NP, PA	883	422	4
Peach Bottom NP, PA	837	415	16
Susquehanna NP, PA	902	426	3
Three Mile Island NP, PA	845	390	3
Catawba NP, SC	541	273	4
Oconee NP, SC	504	207	4
Robinson NP, SC	611	255	4
Summer NP, SC	574	227	4
Sequoyah NP, TN	430	158	2
Watts Bar NP, TN	485	154	[illegible]
Comanche Peak NP, TX	214	107	1
South Texas NP, TX	390	148	[illegible]
North Anna NP, VA	801	312	
Surry NP, VA	717	418	
Vermont Yankee NP, VT	982	[illegible]	
WNP 1;2;4 NP, WA	1,906	326	
Kewaunee NP, WI	773	322	
La Crosse BWR NP, WI	879	312	
Point Beach NP, WI	769		

Table 1.8. One-Way Truck Miles to Vacherie [illegible]

Site Name	Population [illegible]	
	Rural Miles	Suburban Miles
High-Level Waste Sites		
Hanford	1,885	523
Idaho	1,513	450
Savannah River	541	220
West Valley	933	405

Table 1.9. One-Way Rail Miles to Vacherie Dome Repository

Site Name	Population Category Rural Miles	 Suburban Miles	
Reactors			
Bellefonte NP, AL	657	229	
Browns Ferry NP, AL	575	247	[illegible]
Farley NP, AL	753	266	[illegible]
Arkansas NP, AR	220	61	[illegible]
Palo Verde NP, AZ	1,325	234	[illegible]
Diablo Canyon NP, CA	1,747	343	[illegible]
Humboldt Bay NP, CA	2,132	487	[illegible]
Rancho Seco NP, CA	1,885	392	[illegible]
San Onofre NP, CA	1,616	286	[illegible]
Connecticut Yankee NP, CT	1,020	617	[illegible]
Millstone NP, CT	1,024	634	53
Crystal River NP, FL	733	255	20
St Lucie NP, FL	798	385	25
Turkey Point NP, FL	804	507	55
Hatch NP, GA	763	296	26
Vogtle NP, GA	801	293	26
Arnold NP, IA	793	136	9
Braidwood NP, IL	744	181	[illegible]
Byron NP, IL	834	168	10
Clinton NP, IL	686	161	[illegible]
Dresden NP, IL	622	218	12
G.E. Repro Plant, IL	620	218	12
La Salle NP, IL	830	122	9
Quad Cities NP, IL	769	148	[illegible]
Zion NP, IL	910	242	[illegible]
Wolf Creek NP, KS	437	86	[illegible]
River Bend NP, LA	242	57	
Waterford NP, LA	267	60	
Pilgrim NP, MA	1,053	684	
Yankee Rowe NP, MA	988	522	
Calvert Cliffs NP, MD	935	[illegible]	
Maine Yankee NP, ME	1,094	[illegible]	
Big Rock Point NP, MI	862	[illegible]	
Cook NP, MI	618	[illegible]	
Fermi NP, MI	778	[illegible]	
Midland NP, MI	739	[illegible]	
Palisades NP, MI	633	[illegible]	
Monticello NP, MN	1,041	[illegible]	

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Table 1.9. One-Way Rail Miles to Vacherie Dome Repository (Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Prairie Island NP, MN	996	201	9
Callaway NP, MO	589	101	0
Grand Gulf NP, MS	115	29	0
Brunswick NP, NC	924	394	32
Harris NP, NC	874	373	32
McGuire NP, NC	795	369	34
Cooper NP, NE	760	162	5
Fort Calhoun NP, NE	824	146	9
Seabrook NP, NH	1,042	644	45
Hope Creek NP, NJ	896	577	40
Oyster Creek NP, NJ	901	693	47
Salem NP, NJ	901	579	41
Fitzpatrick NP, NY	898	454	38
Ginna NP, NY	870	429	38
Indian Point NP, NY	989	576	43
Nine Mile Point NP, NY	898	454	38
Shoreham NP, NY	999	645	81
West Valley RP, NY	953	451	47
Davis-Besse NP, OH	1,048	240	14
Perry NP, OH	1,056	277	31
Trojan NP, OR	2,395	304	10
Beaver Valley NP, PA	1,144	307	22
Limerick NP, PA	890	554	25
Peach Bottom NP, PA	906	515	24
Susquehanna NP, PA	922	521	23
Three Mile Island NP, PA	888	490	23
Catawba NP, SC	709	449	27
Oconee NP, SC	665	319	26
Robinson NP, SC	794	354	34
Summer NP, SC	733	404	27
Sequoyah NP, TN	626	248	[illegible]
Watts Bar NP, TN	654	256	[illegible]
Comanche Peak NP, TX	272	81	14
South Texas NP, TX	311	118	17
North Anna NP, VA	1,020	483	33
Surry NP, VA	1,044	417	[illegible]
Vermont Yankee NP, VT	1,051	577	[illegible]
WNP 1;2;4 NP, WA	2,126	218	[illegible]
Kewaunee NP, WI	972	298	[illegible]
La Crosse [illegible] NP, WI	952	191	[illegible]
Point Beach NP, WI	941	[illegible]	[illegible]

Table 1.9. One-Way Rail Miles to Vacherie Dome Repository [illegible]

	Population C[illegible]		
Site Name	Rural Miles	Suburban Miles	
High-Level Waste Sites			
Hanford	2,120	219	[illegible]
Idaho	1,659	187	[illegible]
Savannah River	727	319	[illegible]
West Valley	955	452	4[illegible]

Table 1.10. One-Way Truck Miles to Leaf Smith County Repository

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Reactors			
Bellefonte NP, AL	925	195	[illegible]
Browns Ferry NP, AL	912	184	11
Farley NP, AL	1,111	270	17
Arkansas NP, AR	485	87	0
Palo Verde NP, AZ	699	73	16
Diablo Canyon NP, CA	1,128	157	26
Humboldt Bay NP, CA	1,509	219	33
Rancho Seco NP, CA	1,250	165	26
San Onofre NP, CA	937	134	21
Connecticut Yankee NP, CT	1,310	600	8
Millstone NP, CT	1,313	633	17
Crystal River NP, FL	1,284	377	10
St. Lucie NP, FL	1,418	396	10
Turkey Point NP, FL	1,448	471	48
Hatch NP, GA	1,118	318	10
Vogtle NP, GA	1,099	324	10
Arnold NP, IA	818	173	0
Braidwood NP, IL	803	244	3
Byron NP, IL	903	204	0
Clinton NP, IL	760	219	3
Dresden NP, IL	812	249	3
G.E. Repro Plant, IL	814	249	3
La Salle NP, IL	814	242	3
Quad Cities NP, IL	852	187	0
Zion NP, IL	828	320	[illegible]
Wolf Creek NP, KS	506	83	[illegible]
River Bend NP, LA	731	315	13
Waterford NP, LA	760	361	20
Pilgrim NP, MA	1,343	683	[illegible]
Yankee-Rowe NP, MA	1,273	634	
Calvert Cliffs NP, MD	1,303	388	[illegible]
Maine Yankee NP, ME	1,379	350	[illegible]
Big Rock Point NP, MI	1,053	504	[illegible]
Cook NP, MI	824	332	[illegible]
Fermi NP, MI	967	375	[illegible]
Midland NP, MI	910	496	[illegible]
Palisades NP, MI	834	352	[illegible]
Monticello NP, MN	909	223	[illegible]

Table 1.10. One-Way Truck Miles to Deaf Smith County Repository
(Continued)

Site Name	Population Category Rural Miles	Suburban Miles	[illegible]
Prairie Island NP, MN	902	193	
Callaway NP, MO	678	245	
Grand Gulf NP, MS	849	209	
Brunswick NP, NC	1,287	356	
Harris NP, NC	1,135	412	[illegible]
McGuire NP, NC	1,073	340	10
Cooper NP, NE	650	132	[illegible]
Fort Calhoun NP, NE	712	152	[illegible]
Seabrook NP, NH	1,335	688	[illegible]
Hope Creek NP, NJ	1,208	554	[illegible]
Oyster Creek NP, NJ	1,289	563	[illegible]
Salem NP, NJ	1,208	554	[illegible]
Fitzpatrick NP, NY	1,205	539	[illegible]
Ginna NP, NY	1,135	514	[illegible]
Indian Point NP, NY	1,305	520	[illegible]
Nine Mile Point NP, NY	1,706	539	[illegible]
Shoreham NP, NY	1,318	596	[illegible]
West Valley RP, NY	1,105	469	
Davis-Besse NP, OH	976	365	
Perry NP, OH	1,005	407	
Trojan NP, OR	1,590	240	
Beaver Valley NP, PA	1,024	428	
Limerick NP, PA	1,239	521	
Peach Bottom NP, PA	1,219	545	
Susquehanna NP, PA	1,222	435	
Three Mile Island NP, PA	1,201	489	
Catawba NP, SC	1,061	349	
Oconee NP, SC	1,048	306	
Robinson NP, SC	1,158	339	
Summer NP, SC	1,107	308	
Sequoyah NP, TN	918	219	
Watts Bar NP, TN	944	195	
Comanche Peak NP, TX	459	115	
South Texas NP, TX	616	231	
North Anna NP, VA	1,261	388	
Surry NP, VA	1,291	[illegible]	
Vermont Yankee NP, VT	2,312	[illegible]	
WNP 1;2;4 NP, WA	1,463	201	
Kewaunee NP, WI	888	379	
La Crosse BWR NP, WI	946	195	
Point Beach NP, WI	885	379	

Table 1.10. One-Way Truck Miles to Deaf Smith County Repository (Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
High-Level Waste Sites			
Hanford	1,447	203	13
Idaho	1,074	125	15
Savannah River	1,083	327	11
West Valley	1,105	471	3

Table 1.11. One-Way Rail Miles to Deaf Smith County Repository

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Reactors			
Bellefonte NP, AL	1,229	274	25
Browns Ferry NP, AL	1,013	255	21
Farley NP, AL	1,441	409	33
Arkansas NP, AR	681	88	0
Palo Verde NP, AZ	836	87	9
Diablo Canyon NP, CA	1,173	225	60
Humboldt Bay NP, CA	1,507	305	2
Rancho Seco NP, CA	1,243	232	[illegible]
San Onofre NP, CA	1,057	156	20
Connecticut Yankee NP, CT	1,324	659	62
Millstone NP, CT	1,296	690	73
Crystal River NP, FL	1,260	409	28
St. Lucie NP, FL	1,327	539	33
Turkey Point NP, FL	1,334	660	64
Hatch NP, GA	1,407	385	33
Vogtle NP, GA	1,445	382	[illegible]
Arnold NP, IA	832	112	[illegible]
Braidwood NP, IL	857	121	[illegible]
Byron NP, IL	874	143	[illegible]
Clinton NP, IL	811	95	[illegible]
Dresden NP, IL	[illegible]	127	[illegible]
G.E. Repro Plant, IL	[illegible]	[illegible]	[illegible]
La Salle NP, IL	868	[illegible]	[illegible]
Quad Cities NP, IL	[illegible]	[illegible]	[illegible]
Zion NP, IL	951	[illegible]	[illegible]
Wolf Creek NP, KS	468	[illegible]	[illegible]
River Bend NP, LA	731	[illegible]	[illegible]
Waterford NP, LA	765	[illegible]	[illegible]
Pilgrim NP, MA	[illegible]	[illegible]	[illegible]
Yankee-Rowe NP, MA	[illegible]	[illegible]	[illegible]
Calvert Cliffs NP, MD	1,315	[illegible]	[illegible]
Maine Yankee NP, ME	1,356	[illegible]	[illegible]
Big Rock Point NP, MI	[illegible]	[illegible]	[illegible]
Cook NP, MI	[illegible]	193	[illegible]
Fermi NP, MI	[illegible]	[illegible]	[illegible]
Midland NP, MI	[illegible]	[illegible]	[illegible]
Palisades NP, MI	[illegible]	[illegible]	[illegible]
Monticello NP, MN	[illegible]	[illegible]	[illegible]

Table 1.11. One-Way Rail Miles to Deaf Smith County Repository (Continued)

Site Name	Population Category		
	Rural Miles	Suburban Miles	Urban Miles
Prairie Island NP, MN	1,036	177	2
Callaway NP, MO	700	62	0
Grand Gulf NP, MS	654	179	12
Brunswick NP, NC	1,377	389	23
Harris NP, NC	1,391	464	31
McGuire NP, NC	1,474	396	37
Cooper NP, NE	777	113	4
Fort Calhoun NP, NE	863	122	2
Seabrook NP, NH	1,315	700	66
Hope Creek NP, NJ	1,275	558	45
Oyster Creek NP, NJ	1,281	654	52
Salem NP, NJ	1,280	560	45
Fitzpatrick NP, NY	1,203	496	48
Ginna NP, NY	1,143	486	58
Indian Point NP, NY	1,293	618	52
Nine Mile Point NP, NY	1,202	496	48
Shoreham NP, NY	1,271	701	102
West Valley RP, NY	1,311	350	24
Davis-Besse NP, OH	1,088	216	7
Perry NP, OH	1,097	252	23
Trojan NP, OR	1,984	203	22
Beaver Valley NP, PA	1,184	281	15
Limarick NP, PA	1,269	535	27
Peach Bottom NP, PA	1,254	504	46
Susquehanna NP, PA	1,302	501	27
Three Mile Island NP, PA	1,268	470	27
Catawba NP, SC	1,318	399	28
Oconee NP, SC	1,279	388	27
Robinson NP, SC	1,310	445	33
Summer NP, SC	1,346	351	28
Sequoyah NP, TN	1,194	244	25
Watts Bar NP, TN	1,173	231	25
Comanche Peak NP, TX	414	47	0
South Texas NP, TX	666	167	22
North Anna NP, VA	1,421	382	35
Surry NP, VA	,421	382	9
Vermont Yankee NP, VT	1,324	633	67
WNP 1;2;4 NP, WA	1,538	179	15
Kewaunee NP, WI	992	238	24
La Crosse BWR NP, WI	969	142	2
Point Beach NP, WI	985	288	24

Table 1.11. One-Way Rail Miles to Deaf Smith County [illegible] (Continued)

Site Name	Population [illegible]		
	Rural Miles	Suburban Miles	[illegible]
High-Level Waste Sites			
Hanford	1,531	179	1[illegible]
Idaho	1,060	126	[illegible]
Savannah River	1,180	315	26
West Valley	1,311	351	25

Table 1.12. One-Way Truck Miles to Davis Repository

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
Reactors			
Bellefonte NP, AL	1,432	326	9
Browns Ferry NP, AL	1,479	315	11
Farley NP, AL	1,617	402	18
Arkansas NP, AR	1,058	119	5
Palo Verde NP, AZ	457	51	10
Diablo Canyon NP, CA	893	126	27
Humboldt Bay NP, CA	1,555	184	12
Rancho Seco NP, CA	915	129	23
San Onofre NP, CA	702	104	22
Connecticut Yankee NP, CT	1,744	573	19
Millstone NP, CT	1,745	605	28
Crystal River NP, FL	1,789	510	9
St. Lucie NP, FL	1,924	528	9
Turkey Point NP, FL	1,952	604	47
Hatch NP, GA	1,624	451	9
Vogtle NP, GA	1,604	457	9
Arnold NP, IA	1,106	132	9
Braidwood NP, IL	1,244	176	9
Byron NP, IL	1,190	165	9
Clinton NP, IL	1,259	183	9
Dresden NP, IL	1,229	171	9
G.E. Repro Plant, IL	1,231	171	9
La Salle NP, IL	1,230	163	9
Quad Cities NP, IL	1,139	147	9
Zion NP, IL	1,242	241	17
Wolf Creek NP, KS	970	95	7
River Bend NP, LA	1,302	349	18
Waterford NP, LA	1,331	395	26
Pilgrim NP, MA	1,775	656	25
Yankee-Rowe NP, MA	1,697	612	23
Calvert Cliffs NP, MD	1,672	517	20
Maine Yankee NP, ME	1,811	724	30
Big Rock Point NP, MI	1,465	428	23
Cook NP, MI	1,239	254	19
Fermi NP, MI	1,302	384	19
Midland NP, MI	1,327	410	23
Palisades NP, MI	1,248	274	19
Monticello NP, MN	1,195	194	10

Table 1.12. One-Way Truck Miles to Davis Repository (Continued)

Site Name	Population Zone		
	Rural Miles	Suburban Miles	
Prairie Island NP, MN	1,190	153	9
Callaway NP, MO	1,048	157	7
Grand Gulf NP, MS	1,421	242	6
Brunswick NP, NC	1,793	489	9
Harris NP, NC	1,640	545	9
McGuire NP, NC	1,578	472	9
Cooper NP, NE	944	904	9
Fort Calhoun NP, NE	890	93	7
Seabrook NP, NH	1,768	661	30
Hope Creek NP, NJ	1,655	579	15
Oyster Creek NP, NJ	1,744	535	21
Salem NP, NJ	1,655	580	15
Fitzpatrick NP, NY	1,629	517	20
Ginna NP, NY	1,559	491	26
Indian Point NP, NY	1,739	492	19
Nine Mile Point NP, NY	1,630	517	20
Shoreham NP, NY	1,751	568	49
West Valley RP, NY	1,530	447	19
Davis-Besse NP, OH	1,379	305	19
Perry NP, OH	1,431	384	19
Trojan NP, OR	957	226	4
Beaver Valley NP, PA	1,466	389	19
Limerick NP, PA	1,695	493	19
Peach Bottom NP, PA	1,674	484	22
Susquehanna NP, PA	1,656	416	19
Three Mile Island NP, PA	1,656	458	19
Catawba NP, SC	1,566	483	9
Oconee NP, SC	1,553	438	9
Robinson NP, SC	1,663	471	9
Summer NP, SC	1,613	441	9
Sequoyah NP, TN	1,424	350	9
Watts Bar NP, TN	1,451	328	9
Comanche Peak NP, TX	1,033	147	5
South Texas NP, TX	1,267	124	11
North Anna NP, VA	1,743	444	12
Surry NP, VA	1,772	478	17
Vermont Yankee NP, VT	1,735	634	22
WNP 1;2;4 NP, WA	830	188	4
Kewaunee NP, WI	1,302	301	30
La Crosse BWR NP, WI	1,233	153	9
Point Beach NP, WI	1,298	301	30

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Table 1.12. One-Way Truck Miles to Davis Repository (Continued)

Site Name	Rural Miles	Suburban Miles	Urban Miles
High-Level Waste Sites			
Hanford	817	190	5
Idaho	469	130	5
Savannah River	1,594	460	8
West Valley	1,533	448	20

Table 1.13. One-Way Rail Miles to Davis Repository

Site Name	[illegible]		
	Rural Miles	Suburban Miles	Urban Miles
Reactors			
Bellefonte NP, AL	1,761	275	[illegible]
Browns Ferry NP, AL	1,520	261	22
Farley NP, AL	1,969	412	39
Arkansas NP, AR	1,330	101	0
Palo Verde NP, AZ	1,397	359	31
Diablo Canyon NP, CA	1,007	284	34
Humboldt Bay NP, CA	1,127	287	27
Rancho Seco NP, CA	863	151	23
San Onofre NP, CA	863	130	27
Connecticut Yankee NP, CT	1,657	710	60
Millstone NP, CT	1,661	728	80
Crystal River NP, FL	2,008	413	30
St. Lucie NP, FL	1,982	531	35
Turkey Point NP, FL	1,985	656	67
Hatch NP, GA	1,936	389	39
Vogtle NP, GA	1,975	385	19
Arnold NP, IA	1,369	110	6
Braidwood NP, IL	1,391	120	11
Byron NP, IL	1,410	141	6
Clinton NP, IL	1,347	92	11
Dresden NP, IL	1,280	145	6
G.E. Repro Plant, IL	1,267	155	6
La Salle NP, IL	1,366	166	22
Quad Cities NP, IL	1,345	122	6
Zion NP, IL	1,481	219	13
Wolf Creek NP, KS	1,082	47	0
River Bend NP, LA	1,830	320	17
Waterford NP, LA	1,781	193	0
Pilgrim NP, MA	1,690	778	78
Yankee-Rowe NP, MA	1,974	459	37
Calvert Cliffs NP, MD	1,651	610	59
Maine Yankee NP, ME	2,078	629	39
Big Rock Point NP, MI	1,518	298	30
Cook NP, MI	1,276	221	23
Fermi NP, MI	1,435	320	50
Midland NP, MI	1,389	413	32
Palisades NP, MI	1,288	257	23
Monticello NP, MN	1,242	129	17

Table 1.13. One-Way Rail Miles to Davis Repository (Continued)

Site Name	Population Category		
	Rural Miles	Suburban Miles	Urban Miles
Prairie Island NP, MN	1,571	176	6
Callaway NP, MO	1,400	117	8
Grand Gulf NP, MS	1,747	237	16
Brunswick NP, NC	1,946	495	32
Harris NP, NC	1,896	473	32
McGuire NP, NC	1,844	369	23
Cooper NP, NE	937	56	9
Fort Calhoun NP, NE	886	85	7
Seabrook NP, NH	2,025	585	39
Hope Creek NP, NJ	2,611	604	66
Oyster Creek NP, NJ	1,614	702	72
Salem NP, NJ	1,615	606	66
Fitzpatrick NP, NY	1,538	545	65
Ginna NP, NY	1,509	521	64
Indian Point NP, NY	1,627	668	69
Nine Mile Point NP, NY	1,537	545	65
Shoreham NP, NY	1,634	738	109
West Valley RP, NY	1,684	380	30
Davis-Besse NP, OH	1,619	218	11
Perry NP, OH	1,626	256	28
Trojan NP, OR	1,062	172	13
Beaver Valley NP, PA	1,714	286	20
Limerick NP, PA	1,605	581	48
Peach Bottom NP, PA	1,623	537	52
Susquehanna NP, PA	1,640	545	48
Three Mile Island NP, PA	1,606	514	48
Catawba NP, SC	1,847	403	34
Oconee NP, SC	1,808	393	33
Robinson NP, SC	1,815	455	34
Summer NP, SC	1,878	353	33
Sequoyah NP, TN	1,727	244	31
Watts Bar NP, TN	1,706	230	31
Comanche Peak NP, TX	1,190	224	29
South Texas NP, TX	1,701	254	22
North Anna NP, VA	1,794	412	37
Surry NP, VA	1,950	387	13
Vermont Yankee NP, VT	1,690	669	73
WNP 1;2;4 NP, WA	911	165	4
Kewaunee NP, WI	1,520	170	20
La Crosse BWR NP, WI	1,378	129	7
Point Beach NP, WI	1,511	205	29

Table 1.13. One-Way Rail Miles to Davis Repository (Continued)

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
High-Level Waste Sites			
Hanford	904	165	4
Idaho	426	123	6
Savannah River	1,750	419	35
West Valley	1,682	381	31

Table 1.14. One-Way Truck Miles to Yucca Mountain Repository

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
Reactors			
Bellefonte NP, AL	1,762	270	23
Browns Ferry NP, AL	1,750	259	24
Farley NP, AL	1,948	345	30
Arkansas NP, AR	1,322	263	13
Palo Verde NP, AZ	512	83	10
Diablo Canyon NP, CA	490	108	28
Humboldt Bay NP, CA	870	171	36
Rancho Seco NP, CA	613	116	28
San Onofre NP, CA	299	86	24
Connecticut Yankee NP, CT	2,170	626	17
Millstone NP, CT	2,173	659	26
Crystal River NP, FL	2,121	452	23
St. Lucie NP, FL	2,255	472	23
Turkey Point NP, FL	2,284	548	61
Hatch NP, GA	1,955	394	23
Vogtle NP, GA	1,937	400	23
Arnold NP, IA	1,529	189	7
Braidwood NP, IL	1,668	232	7
Byron NP, IL	1,613	221	7
Clinton NP, IL	1,683	240	7
Dresden NP, IL	1,652	227	7
G.E. Repro Plant, IL	1,655	227	7
La Salle NP, IL	1,653	220	7
Quad Cities NP, IL	1,563	204	7
Zion NP, IL	1,667	296	15
Wolf Creek NP, KS	1,372	116	7
River Bend NP, LA	1,567	391	26
Waterford NP, LA	1,596	438	33
Pilgrim NP, MA	2,203	708	23
Yankee-Rowe NP, MA	2,124	665	21
Calvert Cliffs NP, MD	2,076	538	20
Maine Yankee NP, ME	2,238	776	28
Big Rock Point NP, MI	1,891	482	20
Cook NP, MI	1,664	309	17
Fermi NP, MI	1,729	438	17
Midland NP, MI	1,748	464	20
Palisades NP, MI	1,673	329	17
Monticello NP, MN	1,619	240	8

Table 1.14. One-Way Truck Miles to Yucca Mountain Repository (Continued)

Site Name	Population Category		
	Rural Miles	Suburban Miles	Urban Miles
Prairie Island NP, MN	1,613	210	7
Callaway NP, MO	1,451	188	7
Grand Gulf NP, MS	1,686	285	13
Brunswick NP, NC	2,125	431	24
Harris NP, NC	1,974	486	23
McGuire NP, NC	1,911	414	23
Cooper NP, NE	1,367	151	7
Fort Calhoun NP, NE	1,313	150	5
Seabrook NP, NH	2,195	713	28
Hope Creek NP, NJ	2,059	599	15
Oyster Creek NP, NJ	2,170	589	18
Salem NP, NJ	2,059	600	15
Fitzpatrick NP, NY	2,055	571	18
Ginna NP, NY	1,986	545	24
Indian Point NP, NY	2,165	546	17
Nine Mile Point NP, NY	2,056	571	18
Shoreham NP, NY	2,178	621	46
West Valley RP, NY	1,956	500	17
Davis-Besse NP, OH	1,805	360	17
Perry NP, OH	1,857	438	17
Trojan NP, OR	1,084	239	4
Beaver Valley NP, PA	1,892	443	17
Limerick NP, PA	2,121	546	17
Peach Bottom NP, PA	2,101	538	20
Susquehanna NP, PA	2,081	471	17
Three Mile Island NP, PA	2,083	512	17
Catawba NP, SC	1,899	424	23
Oconee NP, SC	1,885	381	23
Robinson NP, SC	1,996	413	23
Summer NP, SC	1,945	383	24
Sequoyah NP, TN	1,755	293	23
Watts Bar NP, TN	1,782	272	23
Comanche Peak NP, TX	1,297	190	13
South Texas NP, TX	1,511	149	35
North Anna NP, VA	2,099	414	23
Surry NP, VA	2,128	447	28
Vermont Yankee NP, VT	2,162	687	20
WNP 1;2;4 NP, WA	957	200	4
Kewaunee NP, WI	1,728	356	27
La Crosse BWR NP, WI	1,656	209	7
Point Beach NP, WI	1,724	356	27

Table 1.14. One-Way Truck Miles to Yucca Mountain Repository (Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
High-Level Waste Sites			
Hanford	940	203	5
Idaho	594	142	4
Savannah River	1,922	415	23
West Valley	2,171	554	19

Table 1.15. One-Way Rail Miles to Yucca Mountain Repository

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Reactors			
Bellefonte NP, AL	2,211	240	39
Browns Ferry NP, AL	1,992	323	35
Farley NP, AL	2,422	475	47
Arkansas NP, AR	1,830	200	21
Palo Verde NP, AZ	585	58	8
Diablo Canyon NP, CA	402	167	66
Humboldt Bay NP, CA	788	314	14
Rancho Seco NP, CA	545	214	16
San Onofre NP, CA	289	96	25
Connecticut Yankee NP, CT	2,288	713	89
Millstone NP, CT	2,291	730	88
Crystal River NP, FL	2,482	472	43
St. Lucie NP, FL	2,458	588	48
Turkey Point NP, FL	2,463	711	78
Hatch NP, GA	2,388	451	47
Vogtle NP, GA	2,426	448	47
Arnold NP, IA	1,608	157	12
Braidwood NP, IL	1,798	258	38
Byron NP, IL	1,856	209	15
Clinton NP, IL	1,793	161	20
Dresden NP, IL	1,923	275	37
G.E. Repro Plant, IL	1,921	275	37
La Salle NP, IL	2,078	176	7
Quad Cities NP, IL	1,791	190	15
Zion NP, IL	1,725	263	19
Wolf Creek NP, KS	1,580	149	21
River Bend NP, LA	2,280	384	26
Waterford NP, LA	2,283	291	21
Pilgrim NP, MA	2,321	780	87
Yankee-Rowe NP, MA	2,427	521	45
Calvert Cliffs NP, MD	2,206	675	69
Maine Yankee NP, ME	2,534	688	47
Big Rock Point NP, MI	2,161	389	49
Cook NP, MI	1,918	313	42
Fermi NP, MI	2,081	393	68
Midland NP, MI	2,034	503	51
Palisades NP, MI	1,932	349	42
Monticello NP, MN	1,712	183	23

Table 1.15. One-Way Rail Miles to Yucca Mountain Repository (Continued)

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
Prairie Island NP, MN	2,018	243	15
Callaway NP, MO	1,660	163	21
Grand Gulf NP, MS	2,196	303	24
Brunswick NP, NC	2,422	551	44
Harris NP, NC	2,372	531	45
McGuire NP, NC	2,318	428	36
Cooper NP, NE	1,428	124	15
Fort Calhoun NP, NE	1,379	123	13
Seabrook NP, NH	2,480	645	47
Hope Creek NP, NJ	2,166	670	76
Oyster Creek NP, NJ	2,172	766	83
Salem NP, NJ	2,171	672	76
Fitzpatrick NP, NY	2,165	550	74
Ginna NP, NY	2,136	527	73
Indian Point NP, NY	2,256	672	78
Nine Mile Point NP, NY	2,164	550	74
Shoreham NP, NY	2,266	740	118
West Valley RP, NY	2,280	524	59
Davis-Besse NP, OH	2,067	284	20
Perry NP. OH	2,076	321	37
Trojan NP, OR	1,295	143	22
Beaver Valley NP, PA	2,164	351	28
Limerick NP, PA	2,161	646	58
Peach Bottom NP, PA	2,179	605	59
Susquehanna NP, PA	2,195	611	58
Three Mile Island NP, PA	2,161	580	58
Catawba NP, SC	2,[illegible]00	464	42
Oconee NP, SC	2,261	454	41
Robinson NP, SC	2,291	512	46
Summer NP, SC	2,329	416	41
Sequoyah NP, TN	2,176	310	39
Watts Bar NP, TN	2,155	296	39
Comanche Peak NP, TX	1,520	124	5
South Texas NP, TX	2,205	350	43
North Anna NP, VA	2,322	408	44
Surry NP, VA	2,401	450	22
Vermont Yankee NP, VT	2,319	672	83
WNP 1;2;4 NP, WA	1,145	136	13
Kewaunee NP, WI	1,821	340	35
La Crosse BWR NP, WI	1,870	106	13
Point Beach NP, WI	1,758	336	34

Table 1.15. One-Way Rail Miles to Yucca Mountain Repository (Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 [illegible]
High-Level Waste Sites			
Hanford	1,142	134	12
Idaho	674	80	9
Savannah River	2,133	569	47
West Valley	2,225	596	43

Table 1.16. One-Way Truck Miles to Hanford Repository

Site Name	Population Category		
	Rural Miles	Suburban Miles	Urban Miles
Reactors			
Bellefonte NP, AL	2,057	391	4
Browns Ferry NP, AL	2,045	380	6
Farley NP, AL	2,242	466	13
Arkansas NP, AR	1,824	241	4
Palo Verde NP, AZ	1,148	353	32
Diablo Canyon NP, CA	778	333	10
Humboldt Bay NP, CA	504	165	5
Rancho Seco NP, CA	629	233	13
San Onofre NP, CA	940	303	56
Connecticut Yankee NP, CT	2,196	669	18
Millstone NP, CT	2,198	702	27
Crystal River NP, FL	2,415	573	4
St. Lucie NP, FL	2,550	592	4
Turkey Point NP, FL	2,579	668	41
Hatch NP, GA	2,250	514	4
Vogtle NP, GA	2,231	521	4
Arnold NP, IA	1,689	171	1
Braidwood NP, IL	1,697	309	9
Byron NP, IL	1,662	248	3
Clinton NP, IL	1,842	222	1
Dresden NP, IL	1,700	304	9
G.E. Repro Plant, IL	1,702	304	9
La Salle NP, IL	1,812	202	2
Quad Cities NP, IL	1,722	186	1
Zion NP, IL	1,677	252	8
Wolf Creek NP, KS	1,583	191	0
River Bend NP, LA	2,069	476	17
Waterford NP, LA	2,098	522	25
Pilgrim NP, MA	2,228	752	24
Yankee-Rowe NP, MA	2,150	708	22
Calvert Cliffs NP, MD	2,218	631	28
Maine Yankee NP, ME	2,264	820	29
Big Rock Point NP, MI	1,918	525	21
Cook NP, MI	1,689	352	18
Fermi NP, MI	1,755	481	18
Midland NP, MI	1,774	507	21
Palisades NP, MI	1,699	372	18
Monticello NP, MN	1,382	142	1

Table 1.16. One-Way Truck Miles to Hanford Repository (Continued)

Site Area	Population Category Rural Miles	Suburban Miles	Urban Miles
Prairie Island NP, MN	1,417	194	3
Callaway NP, MO	1,673	233	2
Grand Gulf NP, MS	2,138	402	2
Brunswick NP, NC	2,356	614	18
Harris NP, NC	2,206	670	18
McGuire NP, NC	2,142	598	18
Cooper NP, NE	1,455	171	2
Fort Calhoun NP, NE	1,467	141	1
Seabrook NP, NH	2,221	757	29
Hope Creek NP, NJ	2,112	692	23
Oyster Creek NP, NJ	2,196	632	19
Salem NP, NJ	2,112	692	23
Fitzpatrick NP, NY	1,081	614	19
Ginna NP, NY	2,012	588	25
Indian Point NP, NY	2,191	590	18
Nine Mile Point NP, NY	2,082	614	19
Shoreham NP, NY	2,204	665	47
West Valley RP, NY	1,982	544	18
Davis-Besse NP, OH	1,830	403	18
Perry NP, OH	1,882	481	18
Trojan NP, OR	194	106	1
Beaver Valley NP, PA	1,917	486	18
Limerick NP, PA	2,146	590	18
Peach Bottom NP, PA	2,126	582	21
Susquehanna NP, PA	2,108	514	18
Three Mile Island NP, PA	2,108	555	18
Catawba NP, SC	2,131	608	18
Oconee NP, SC	2,180	502	4
Robinson NP, SC	2,227	597	18
Summer NP, SC	2,176	567	18
Sequoyah NP, TN	2,050	414	4
Watts Bar NP, TN	2,077	392	4
Comanche Peak NP, TX	1,798	275	4
South Texas NP, TX	1,955	392	23
North Anna NP, VA	2,136	655	23
Surry NP, VA	2,180	691	27
Vermont Y[illegible]kee NP, VT	2,188	731	21
WNP 1;2;4 NP, WA	29	0	0
Kewaunee NP, WI	1,672	243	3
La Crosse BWR NP, WI	1,601	146	1
Point Beach NP, WI	1,668	243	3

Table 1.16. One-Way Truck Miles to Hanford Repository (Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
High-Level Waste Sites			
Hanford	25	1	0
Idaho	517	93	0
Savannah River	2,214	524	5
West Valley	1,983	545	18

Table 1.17. One-Way Rail Miles to Hanford Repository

	Population Category		
Site Name	Rural Miles	Suburban Miles	[illegible]
Reactors			
Bellefonte NP, AL	2,295	303	9
Browns Ferry NP, AL	2,124	417	22
Farley NP, AL	2,533	405	13
Arkansas NP, AR	1,984	205	8
Palo Verde NP, AZ	1,228	421	41
Diablo Canyon NP, CA	837	347	41
Humboldt Bay NP, CA	955	352	34
Rancho Seco NP, CA	693	213	30
San Onofre NP, CA	894	445	91
Connecticut Yankee NP, CT	2,152	777	82
Millstone NP, CT	2,156	794	82
Crystal River NP, FL	2,615	566	30
St. Lucie NP, FL	2,608	597	35
Turkey Point NP, FL	2,612	720	66
Hatch NP, GA	2,543	435	21
Vogtle NP, GA	2,581	432	21
Arnold NP, IA	1,709	221	11
Braidwood NP, IL	1,755	269	33
Byron NP, IL	1,738	210	11
Clinton NP, IL	1,834	270	55
Dresden NP, IL	1,763	233	11
G.E. Repro Plant, IL	1,761	233	11
La Salle NP, IL	1,786	266	12
Quad Cities NP, IL	1,731	238	11
Zion NP, IL	1,723	232	24
Wolf Creek NP, KS	1,734	154	8
River Bend NP, LA	2,432	391	13
Waterford NP, LA	2,437	296	8
Pilgrim NP, MA	2,185	844	81
Yankee-Rowe NP, MA	2,119	683	73
Calvert Cliffs NP, MD	2,144	678	62
Maine Yankee NP, ME	2,227	849	75
Big Rock Point NP, MI	2,005	372	33
Cook NP, MI	1,762	296	27
Fermi NP, MI	1,923	394	53
Midland NP, MI	1,879	484	35
Palisades NP, MI	1,775	331	27
Monticello NP, MN	1,476	150	15

Table 1.17. One-Way Rail Miles to Hanford Repository
(Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Prairie Island NP, MN	1,470	153	11
Callaway NP, MO	1,814	168	7
Grand Gulf NP, MS	2,349	308	11
Brunswick NP, NC	2,470	583	43
Harris NP, NC	2,420	563	43
McGuire NP, NC	2,338	496	41
Cooper NP, NE	1,585	142	2
Fort Calhoun NP, NE	1,534	127	0
Seabrook NP, NH	2,173	805	74
Hope Creek NP, NJ	2,104	672	68
Oyster Creek NP, NJ	2,110	767	75
Salem NP, NJ	2,108	674	69
Fitzpatrick NP, NY	2,030	615	68
Ginna NP, NY	2,000	532	67
Indian Point NP, NY	2,121	736	72
Nine Mile Point NP, NY	2,029	615	68
Shoreham NP, NY	2,130	804	111
West Valley RP, NY	2,172	453	33
Davis-Besse NP, OH	1,975	310	35
Perry NP, OH	1,984	346	52
Trojan NP, OR	235	58	7
Beaver Valley NP, PA	2,014	420	33
Limerick NP, PA	2,098	649	50
Peach Bottom NP, PA	2,115	606	55
Susquehanna NP, PA	2,132	614	51
Three Mile Island NP, PA	2,098	583	51
Catawba NP, SC	2,452	472	29
Oconee NP, SC	2,413	461	28
Robinson NP, SC	2,425	605	33
Summer NP, SC	2,482	423	28
Sequoyah NP, TN	2,319	315	26
Watts Bar NP, TN	2,308	301	26
Comanche Peak NP, TX	1,943	316	25
South Texas NP, TX	2,358	356	30
North Anna NP, VA	2,282	485	40
Surry NP, VA	2,397	499	47
Vermont Yankee NP, VT	2,183	737	76
WNP 1;2;4 NP, WA	10	0	0
Kewaunee NP, WI	1,758	191	11
La Crosse BWR NP, WI	1,557	176	10
Point Beach NP, WI	1,762	239	27

Table 1.17. One-Way Rail Miles to Hanford [illegible] (Continued)

Site Name	Population [illegible]		
	Rural Miles	Suburban Miles	[illegible]
High-Level Waste Sites			
Hanford	18	0	0
Idaho	613	63	0
Savannah River	2,374	486	35
West Valley	2,172	452	35

Table 1.18. One-Way Truck Distances to the Oak Ridge MRS Site

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Reactors			
Bellefonte	111	54	0
Browns Ferry	206	57	2
Farley	279	135	0
Arkansas	456	113	10
Palo Verde	1,608	275	26
Diablo Canyon	2,037	359	37
Humboldt Bay	2,389	424	21
Rancho Seco	2,150	369	31
San Onofre	1,846	337	32
Connecticut Yankee	500	393	32
Millstone	503	426	8
Crystal River	436	203	0
St. Lucie	569	222	0
Turkey Point	601	296	37
Hatch	269	145	0
Vogtle	250	152	0
Arnold	533	270	0
Braidwood	366	231	10
Byron	392	271	15
Carroll County	504	238	0
Clinton	357	198	0
Dresden	370	225	10
La Salle	381	233	10
Quad Cities	481	232	0
Zion	362	262	16
Marble Hill	191	122	2
Wolf Creek	598	227	2
River Bend	488	178	8
Waterford	431	182	15
Pilgrim	534	474	6
Yankee-Rowe	546	440	11
Calvert Cliffs	378	186	11
Maine Yankee	569	542	10
Big Rock Point	439	390	4
Cook	363	229	0
Fermi	261	272	12
Midland	295	374	4
Palisades	372	249	0

Table 1.18. One-Way Truck Distances to the Oak Ridge MRS Site
(Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Monticello	657	356	17
Prairie Island	654	318	15
Callaway	410	173	2
Grand Gulf	401	156	4
Brunswick	361	155	0
Harris	206	214	0
McGuire	144	141	0
Cooper	632	226	2
Fort Calhoun	695	245	2
Seabrook	526	480	10
Hope Creek	366	278	12
Oyster Creek	466	290	18
Salem	386	278	12
Fitzpatrick	542	325	5
Ginna	465	364	6
Indian Point	495	313	0
Nine Mile Point	543	325	5
Shoreham	507	388	29
West Valley	435	320	0
Davis Besse	270	262	8
Perry	336	257	0
Zimmer	190	116	0
Trojan	2,189	435	4
Beaver Valley	352	263	0
Limerick	416	248	0
Peach Bottom	395	232	1
Susquehanna	435	252	0
Three Mile Island	378	216	0
Catawba	133	150	0
Oconee	132	148	0
Robinson	231	136	0
Summer	180	109	0
Sequoyah	71	49	0
Watts Bar	46	10	0
Comanche Peak	672	238	10
South Texas	848	278	29
North Anna	335	137	0
Surry	365	171	4
Vermont Yankee	513	435	11
WNP 1, 2, 4	2,061	397	4

Table 1.18. One-Way Truck Distances to the Oak Ridge MRS Site
(Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Kewaunee	423	321	28
La Crosse	527	312	15
Point Beach	419	320	28

Table 1.19. One-Way Railroad Distances to the Oak Ridge MRS Site

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Reactors			
Bellefonte	89	59	0
Browns Ferry	134	78	0
Farley	302	191	8
Arkansas	442	178	6
Palo Verde	1,917	341	27
Diablo Canyon	2,340	450	77
Humboldt Bay	2,725	593	27
Rancho Seco	2,478	499	30
San Onofre	2,057	452	31
Connecticut Yankee	572	560	79
Millstone	464	661	103
Crystal River	509	181	7
St. Lucie	486	319	12
Turkey Point	493	440	42
Hatch	268	168	7
Vogtle	305	166	8
Arnold	700	201	7
Braidwood	552	121	8
Byron	531	164	34
Carroll County	655	116	7
Clinton	495	100	8
Dresden	419	239	18
La Salle	440	226	41
Quad Cities	618	208	34
Zion	400	225	50
Marble Hill	252	59	9
Wolf Creek	717	228	6
River Bend	460	254	5
Waterford	431	201	16
Pilgrim	490	714	101
Yankee-Rowe	611	555	37
Calvert Cliffs	372	309	21
Maine Yankee	710	730	39
Big Rock Point	508	335	26
Cook	371	166	11
Fermi	366	210	18
Midland	221	307	27
Palisades	385	201	11

Table 1.19. One-Way Railroad Distances the Oak Ridge MRS Site (Continued)

Site Name	Population Category		
	Rural Miles	Suburban Miles	Urban Miles
Monticello	896	190	25
Prairie Island	707	277	45
Callaway	505	153	14
Grand Gulf	376	172	3
Brunswick	303	221	3
Harris	256	199	4
McGuire	172	134	2
Cooper	946	242	11
Fort Calhoun	910	230	7
Seabrook	661	682	39
Hope Creek	373	397	51
Oyster Creek	378	497	58
Salem	382	399	51
Fitzpatrick	455	393	64
Ginna	429	367	63
Indian Point	542	518	69
Nine Mile Point	455	393	64
Shoreham	434	673	134
West Valley	534	338	23
Davis Besse	405	192	21
Perry	413	228	38
Zimmer	226	98	10
Trojan	2,534	335	26
Beaver Valley	501	258	30
Limerick	442	443	48
Peach Bottom	387	360	32
Susquehanna	476	408	49
Three Mile Island	442	377	49
Catawba	172	170	3
Oconee	132	161	2
Robinson	249	152	3
Summer	195	128	2
Sequoyah	54	28	0
Watts Bar	32	15	0
Comanche Peak	716	243	11
South Texas	795	312	22
North Anna	356	232	2
Surry	395	158	2
Vermont Yankee	495	599	96
WNP 1, 2, 4	2,322	311	18

Table 1.19. One-Way Railroad Distances to the Oak Ridge MRS Site (Continued)

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
Kewaunee	581	239	47
La Crosse	773	136	0
Point Beach	433	297	65

Table 1.20. One-Way Truck Distances to the Hartsville MRS Site

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
Reactors			
Bellefonte	152	43	0
Browns Ferry	140	36	2
Farley	339	122	8
Arkansas	390	93	11
Palo Verde	1,542	255	26
Diablo Canyon	1,971	338	38
Humboldt Bay	2,322	404	22
Rancho Seco	2,082	350	32
San Onofre	1,779	317	32
Connecticut Yankee	587	415	2
Millstone	591	448	8
Crystal River	512	225	0
St. Lucie	646	243	0
Turkey Point	677	318	37
Hatch	346	166	0
Vogtle	326	173	0
Arnold	550	174	2
Braidwood	309	187	15
Byron	335	227	20
Carroll County	521	141	2
Clinton	374	102	2
Dresden	313	182	15
La Salle	324	189	16
Quad Cities	498	136	2
Zion	305	218	22
Marble Hill	161	51	6
Wolf Creek	531	205	2
River Bend	513	148	11
Waterford	456	153	17
Pilgrim	621	197	7
Yankee-Rowe	635	462	11
Calvert Cliffs	466	209	11
Maine Yankee	656	566	11
Big Rock Point	463	361	5
Cook	306	186	5
Fermi	285	244	13
Midland	318	345	5
Palisades	315	205	6

Table 1.20. One-Way Truck Distances to the Hartsville MRS Site
(Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Monticello	600	312	22
Prairie Island	597	274	21
Callaway	344	152	2
Grand Gulf	436	111	4
Brunswick	450	177	0
Harris	295	236	0
McGuire	233	163	0
Cooper	567	204	2
Fort Calhoun	628	224	3
Seabrook	613	503	11
Hope Creek	454	301	13
Oyster Creek	554	312	2
Salem	454	302	12
Fitzpatrick	559	360	2
Ginna	489	336	7
Indian Point	584	335	0
Nine Mile Point	560	360	2
Shoreham	596	411	29
West Valley	458	292	0
Davis Besse	294	233	9
Perry	359	229	0
Zimmer	213	87	0
Trojan	2,122	414	5
Beaver Valley	375	235	0
Limerick	504	271	0
Peach Bottom	484	255	148
Susquehanna	524	275	0
Three Mile Island	466	239	0
Catawba	221	173	0
Oconee	220	171	0
Robinson	320	160	0
Summer	268	131	0
Sequoyah	145	66	0
Watts Bar	108	16	0
Comanche Peak	61	217	11
South Texas	782	257	30
North Anna	424	159	0
Surry	454	193	5
Vermont Yankee	602	458	11
WNP 1, 2, 4	1,995	375	5

Table 1.20. One-Way Truck Distances to the Hartsville MRS Site
(Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Kewaunee	366	277	35
La Crosse	470	268	21
Point Beach	362	277	34
GE	314	182	16

Table 1.21. One-Way Railroad Distances to the Hartsville [illegible]

	Population [illegible]		
Site Name	Rural Miles	Suburban Miles	[illegible]
Reactors			
Bellefonte	109	58	0
Browns Ferry	86	59	0
Farley	323	146	4
Arkansas	343	137	11
Palo Verde	1,712	297	37
Diablo Canyon	2,137	404	84
Humboldt Bay	2,522	547	37
Rancho Seco	2,274	454	39
San Onofre	2,016	338	46
Connecticut Yankee	553	557	93
Millstone	558	575	91
Crystal River	573	211	8
St. Lucie	550	326	12
Turkey Point	555	450	43
Hatch	332	199	8
Vogtle	369	196	9
Arnold	491	197	1
Braidwood	425	114	0
Byron	363	185	25
Carroll County	451	119	1
Clinton	367	94	0
Dresden	312	178	3
La Salle	332	188	12
Quad Cities	449	229	25
Zion	295	180	34
Marble Hill	141	60	9
Wolf Creek	497	186	26
River Bend	483	200	14
Waterford	438	238	20
Pilgrim	584	626	91
Yankee-Rowe	526	458	82
Calvert Cliffs	468	470	73
Maine Yankee	626	630	84
Big Rock Point	490	332	39
Cook	351	164	24
Fermi	346	208	32
Midland	303	304	39
Palisades	365	199	24

Table 1.21. One-Way Railroad Distances to the Hartsville MRS Site (Continued)

	Population Category		
Site Name	Rural Miles	Suburban Miles	Urban Miles
Monticello	694	191	18
Prairie Island	542	295	36
Callaway	296	150	6
Grand Gulf	398	118	12
Brunswick	505	298	10
Harris	455	278	10
McGuire	374	275	12
Cooper	770	169	2
Fort Calhoun	699	227	1
Seabrook	577	583	83
Hope Creek	430	463	80
Oyster Creek	431	562	86
Salem	434	465	79
Fitzpatrick	438	391	76
Ginna	411	364	75
Indian Point	524	514	82
Nine Mile Point	437	390	76
Shoreham	529	586	121
West Valley	514	336	36
Davis Besse	385	190	34
Perry	394	226	51
Zimmer	205	96	24
Trojan	2,327	341	19
Beaver Valley	356	304	37
Limerick	424	440	61
Peach Bottom	581	234	30
Susquehanna	456	406	62
Three Mile Island	423	375	62
Catawba	318	276	3
Oconee	233	224	9
Robinson	374	259	12
Summer	340	234	2
Sequoyah	121	98	0
Watts Bar	149	105	0
Comanche Peak	616	202	16
South Texas	69[illegible]	271	27
North Anna	[illegible]4	223	15
Surry	539	266	2
Vermont Yankee	586	515	85
WNP 1, 2, 4	2,057	305	21

Table 1.21. One-Way Railroad Distances to the Hartsville MRS Site
(Continued)

Site Name	Population Category Rural Miles	 Suburban Miles	 Urban Miles
Kewaunee	399	263	32
La Crosse	569	139	1
Point Beach	330	251	48

Table 1.22. One-Way Railroad Distances from MRS to a Repository

	Population Category		
MRS/ Repository Location	Rural Miles	Suburban Miles	Urban Miles
Oak Ridge			
Richton	360	130	5
Vacherie	675	270	21
Deaf Smith	1,160	230	26
Davis	1,690	230	31
Yucca Mountain	2,140	290	39
BWIP	2,290	200	26
Hartsville			
Richton	413	155	7
Vacherie	439	125	10
Deaf Smith	936	229	21
Davis	1,445	237	22
Yucca Mountain	1,915	297	36
BWIP	2,048	392	22

[illegible] western reactors ship directly [illegible]
[illegible] 10-year-old [illegible], [illegible]
[illegible]
[illegible] MRS [illegible] directly to repository

APPENDIX 2

MRS ALTERNATIVES OUTPUT SUMMARY

This appendix contains summary logistics, cost, and risk tables for MRS Cases 3 through 8. MRS Cases 1 and 2 are considered in the main text. Brief descriptions of all cases are listed below.

Reference Case (Main Text)
o unconsolidated 5-year-old spent fuel (SF) from reactors
    - all reactors ship directly to repository
    - HLW shipped directly to repository

MRS Case #1 (Main Text)
o Oak Ridge is MRS location
o unconsolidated 5-year-old SF from reactors
    - all reactors ship to MRS
    - 10-year-old overpacked, consolidated SF shipped from MRS
    - 100T dedicated rail cask used from MRS to repository
    - HLW shipped directly to repository

MRS Case #2 (Main Text)
o Oak Ridge is MRS location
y unconsolidated 5-year-old SF from reactors
o all reactors to MRS
o 10-year-old consolidated SF shipped from MRS
o 150T dedicated rail cask used from MRS to repository
o HLW directly to repository

MRS Case #3 (Appendix 3.A)
o Oak Ridge is MRS location
o unconsolidated 5-year-old SF from reactors
o eastern reactors ship to MRS
o western reactors ship directly to repository
o 10-year-old overpacked, consolidated SF from MRS
o 100T dedicated rail cask used from MRS to repository
o HLW shipped directly to repository

MRS Case #4 (Appendix 3.B)
o Oak Ridge is MRS location
o unconsolidated 5-year-old SF from reactors.
o eastern reactors ship to MRS
o western reactors ship directly to repository
o 10-year-old overpacked, consolidated SF from MRS
o 150T dedicated rail cask used from MRS to repository
o HLW shipped directly to repository

MRS Case #5 (Appendix 3.C)

- Hartsville is MRS location
- unconsolidated 5-year-old SF from reactors
    - all reactors ship to MRS
- 10-year-old overpacked, consolidated SF from MRS
- 100T dedicated rail cask used from MRS to repository
- HLW shipped directly to repository

MRS Case #6 (Appendix 3.D)

- Hartsville is MRS location
- unconsolidated 5-year-old SF from reactors
- all reactors ship to MRS
- 10-year-old consolidated SF from MRS
- 150T dedicated rail cask used from MRS to repository
- HLW shipped directly to repository

MRS Case #7 (Appendix 3.E)

- Hartsville is MRS location
- unconsolidated 5-year-old SF from reactors
- eastern reactors ship to MRS
- western reactors ship directly to repository
- 10-year-old overpacked, consolidated SF from MRS
- 100T dedicated rail cask used from MRS to repository
- HLW shipped directly to repository

MRS Case #8 (Appendix 3.F)

- Hartsville is MRS location
- unconsolidated 5-year-old SF from reactors
- eastern reactors ship to MRS
- western reactors ship directly to repository
- 10-year-old overpacked, consolidated SF from MRS
- 150T dedicated rail cask used from MRS to repository
- HLW shipped directly to repository

TABLE 2.1 TOTAL SHIPMENT-MILES (million miles)
MRS CASE 3 - MRS at Oak Ridge; [illegible]

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Origin						
SF to MRS	38.0	33.0	38.0	38.0	38.0	38.0
SF to Repos.	10.9	9.4	6.0	3.9	2.8	3.5
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	35.0
WVHLW to Repos.	1.0	1.0	1.0	1.5	2.0	2.0
Rail from Origin						
SF to MRS	6.2	6.2	6.2	6.2	6.2	6.2
SF to Repos.	1.8	1.5	1.0	0.6	0.5	0.6
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	2.0	2.0	2.0	2.0	3.0	3.0
Rail from MRS to Repository (100T, overpacked SF)						
Dedicated Rail	0.8	1.1	2.1	2.8	3.5	3.2
TOTALS						
Truck from Origin						
100T from MRS	78.7	77.5	73.1	74.2	79.3	81.7
Rail from Origin						
100T from MRS	17.3	17.3	17.4	18.1	20.8	21.4

TABLE 2.2 TOTAL TRANSPORTATION PACKAGING REQUIREMENTS
(number of casks) MRS CASE 3 - MRS at Oak Ridge;
East-West split]

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Origin						
SF to MRS	97	97	97	97	97	97
SF to Repos.	14	13	11	9	8	9
DHLW to Repos.	40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4
Rail from Origin						
SF to MRS	61	61	61	61	61	61
SF to Repos.	9	8	8	6	6	6
DHLW to Repos.	34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2
Rail from MRS to Repository (100T with overpacks)						
SF	50	50	60	70	70	60
HAW/Hdw	4	4	4	4	4	4
CH-TRU	2	2	2	2	2	2

TABLE 2.3 TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 3 - MRS at Oak Ridge; East-West Split

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Truck from Reactors, HLW Sites						
CAPITAL	208.2	209.3	211.5	217.0	221.4	224.7
OPERATING	599.3	593.7	586.7	601.4	624.6	638.5
Rail from Reactors, HLW Sites						
CAPITAL	239.8	245.2	243.4	247.0	254.2	257.8
OPERATING	630.9	633.3	634.7	631.4	655.1	651.6
Rail from MRS to Repository (100T with Overpacks)						
CAPITAL	136.6	136.6	161.6	186.6	186.6	161.6
OPERATING	320.9	371.5	515.5	607.6	702.2	592.3
TOTALS						
Truck from Origin						
100T from MRS	1265.0	1299.9	1439.4	1560.7	1674.9	1562.8
Rail from Origin						
100T from MRS	1328.2	1378.5	1537.4	1640.3	1760.9	1628.3

SUMMARY OF THE RISKS OF TRANSPORTATION OF SPENT FUEL AND HIGH LEVEL WASTES MRS CASE 3 - Oak Ridge MRS; East-West Split

Mode/Waste	Repository Location					
	GIR	Vacherie	Permian	Paradox	[illegible]	[illegible]
100% TRUCK FROM ORIGIN						
SF to Repository						
Radiological	.75	.61	.42	.29	.27	[illegible]
Nonradiological	2.5	2.0	1.5	.97	.87	[illegible]
SF to MRS						
Radiological	2.8	2.8	2.8	2.8	2.8	[illegible]
Nonradiological	6.7	6.7	6.7	6.7	6.7	6.7
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% RAIL FROM ORIGIN						
SF to Repository						
Radiological	.018	.016	.011	.011	.0016	.0097
Nonradiological	.18	.16	.11	.092	.096	.070
SF to MRS						
Radiological	.12	.12	.12	.12	.12	.12
Nonradiological	.73	.73	.73	.73	.73	.73
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
MRS TO REPOSITORY; 100T Cask[1]						
Radiological	.032	.048	.055	.059	.075	.069
Nonradiological	5.0	9.2	14	19	24	20
TOTALS						
Truck to Repository/MRS; Dedicated Rail from MRS; 100T Cask						
Radiological	5.4	5.2	5.0	5.0	5.2	5.2
Nonradiological	20	24	28	33	39	35
Rail to Repository/MRS; Dedicated Rail from MRS; 100T Cask						
Radiological	.23	.25	.25	.26	.28	.27
Nonradiological	6.5	11	16	21	26	22

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[1] Includes risk values for SF and secondary wastes.

TABLE 2.5 TOTAL SHIPMENT-MILES (million miles)
MRS CASE 4 - MRS at Oak Ridge; East-West split

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Origin						
SF to MRS	38.0	38.0	38.0	38.0	38.0	38.0
SF to Repos.	10.9	9.4	6.0	3.9	2.8	3.5
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	35.0
WVHLW to Repos.	1.0	1.0	1.0	1.5	2.0	2.0
Rail from Origin						
SF to MRS	6.2	6.2	6.2	6.2	6.2	6.2
SF to Repos.	1.8	1.5	1.0	0.6	0.5	0.6
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	2.0	2.0	2.0	2.0	3.0	3.0
Rail from MRS to Repository (150T, nonoverpacked)						
Dedicated Rail	0.2	0.3	0.5	0.5	1.4	0.9
TOTALS						
Truck from Origin 150T from MRS	78.1	76.7	71.5	71.9	77.2	79.4
Rail from Origin 150T from MRS	16.7	16.5	15.8	15.8	18.7	19.1

TABLE 2.6 TOTAL TRANSPORTATION PACKAGING REQUIREMENTS
(number of packagings) MRS CASE 4 - MRS at Oak Ridge;
East-West split

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Origin						
SF to MRS	97	97	97	97	97	97
SF to Repos.	14	13	11	9	8	9
DHLW to Repos.	40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4
Rail from Origin						
SF to MRS	61	61	61	61	61	61
SF to Repos.	9	8	8	6	6	6
DHLW to Repos.	34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2
Rail from MRS to Repository (150T, nonoverpacked)						
SF	20	20	20	20	30	20
HAW/Hdw	8	8	8	8	6	8
CH-TRU	2	2	2	2	2	2

TABLE 2.7 TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 4 - MRS at Oak Ridge; [illegible]

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
	Repository Location					
Truck from Reactors, HLW Sites						
CAPITAL	208.2	209.3	211.5	217.0	221.4	224.7
OPERATING	599.3	593.7	586.7	601.4	624.6	630.5
Rail from Reactors, HLW Sites						
CAPITAL	239.8	245.2	243.4	247.0	254.2	257.8
OPERATING	630.9	633.3	634.7	631.4	655.1	651.6
Rail from MRS to Repository (150T, nonoverpacked)						
CAPITAL	78.6	78.6	78.6	78.6	100.6	78.6
OPERATING	159.8	189.6	243.4	264.8	422.0	318.0
TOTALS						
Truck from Origin						
150T from MRS	1046.0	1053.9	1084.5	1126.5	1308.9	1205.7
Rail from Origin						
150T from MRS	1109.2	1132.5	1182.5	1206.1	1394.9	1271.2

TABLE 2.8 SUMMARY OF THE RISKS OF TRANSPORTATION OF SPENT FUEL AND HIGH LEVEL WASTES
MRS CASE 4 - Oak Ridge MRS; East-West split; 150T cask

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
100% TRUCK FROM ORIGIN						
SF to Repository						
Radiological	.75	.61	.42	.29	.27	.27
Nonradiological	2.5	2.0	1.5	.97	.87	.76
SF to MRS						
Radiological	2.8	2.8	2.8	2.8	2.8	2.8
Nonradiological	6.7	6.7	6.7	6.7	6.7	6.7
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% RAIL FROM ORIGIN						
SF to Repository						
Radiological	.018	.016	.011	.011	.0016	.0097
Nonradiological	.18	.16	.11	.092	.096	.070
SF to MRS						
Radiological	.12	.12	.12	.12	.12	.12
Nonradiological	.73	.73	.73	.73	.73	.73
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
MRS TO REPOSITORY; 150T Cask[1]						
Radiological	.016	.033	.032	.036	.049	.039
Nonradiological	1.3	2.4	3.5	4.9	9.3	5.7
TOTALS						
Truck from Origin; Dedicated Rail from MRS; 150T Cask						
Radiological	5.4	5.1	5.0	4.9	5.2	5.2
Nonradiological	17	17	18	19	24	21
Rail from Origin; Dedicated Rail from MRS; 150T Cask						
Radiological	.22	.24	.23	.23	.25	.24
Nonradiological	2.8	4.0	5.0	6.4	11	7.3

[1] Includes risk values for SF and secondary wastes.

TABLE 2.9 TOTAL SHIPMENT-MILES (million miles)
MRS CASE 5 - MRS at Hartsville; all SF [illegible]

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites						
SF to MRS	49.2	49.2	49.2	49.2	49.2	49.2
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	[illegible]
WVHLW to Repos. 1.0	1.0	1.0	1.5	2.0	2.0	
Rail from Reactors, HLW Sites						
SF to MRS	8.1	8.1	8.1	8.1	8.1	8.1
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	2.0	2.0	2.0	2.0	3.0	3.0
Rail from MRS to Repository (100T with overpacks)						
Dedicated Rail	0.8	1.0	2.0	2.8	3.6	3.2
TOTALS						
Truck from Origin						
100T from MRS	79.0	79.2	78.2	81.5	87.8	89.4
Rail from Origin						
100T from MRS	17.4	17.6	18.2	19.4	22.3	22.7

TABLE 2.10 TOTAL TRANSPORTATION PACKAGING REQUIREMENTS
(number of casks) MRS CASE 5 - MRS at Hartsville;
all SF shipped to MRS

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites						
SF to MRS	106	106	106	106	106	106
DHLW to Repos.	40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4
Rail from Reactors, HLW Sites						
SF to MRS	67	67	67	67	67	67
DHLW to Repos.	34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2
Rail from MRS to Repository (100T with overpacks)						
SF	50	55	65	65	80	70
HAW/Hdw	4	4	4	4	4	4
CH-TRU	2	2	2	2	2	2

TABLE 2.11 TOTAL TRANSPORTATION COST ($M)
MRS CASE 5 - MRS at Hartsville;
all SF shipped to MRS

Mode/Waste Type	Repository Location GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites						
CAPITAL	201.0	202.1	204.3	209.8	214.2	217.5
OPERATING	615.7	610.1	603.1	617.8	641.0	654.9
Rail from Reactors, HLW Sites						
CAPITAL	232.3	237.7	235.9	239.5	246.7	250.3
OPERATING	648.2	650.6	652.0	648.7	672.4	668.9
Rail from MRS to Repository (100T with overpacks)						
CAPITAL	136.6	149.1	174.1	186.6	211.6	186.6
OPERATING	342.3	385.2	545.1	652.4	739.6	666.5
TOTALS						
Truck from Origin 100T from MRS	1295.6	1346.5	1526.6	1666.6	1806.4	1725.5
Rail from Origin 100T from MRS	1359.4	1422.6	1607.1	1727.2	1870.3	1772.3

TABLE 2.12 SUMMARY OF THE RISKS OF THE [illegible]
OF SPENT FUEL AND HIGH LEVEL [illegible]
MRS CASE 5 - Hartsville MRS; All SF to MRS; [illegible]

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	[illegible]	[illegible]	[illegible]
100% TRUCK FROM ORIGIN						
SF						
Radiological	3.6	3.6	3.6	3.6	3.6	[illegible]
Nonradiological	9.4	9.4	9.4	9.4	9.4	9.4
HLW						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% RAIL FROM ORIGIN						
SF						
Radiological	.14	.14	.14	.14	.14	.14
Nonradiological	.92	.92	.92	.92	.92	.92
HLW						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
MRS TO REPOSITORY; 100T Cask[1]						
Radiological	.035	.032	.059	.063	.080	.082
Nonradiological	5.9	5.9	12	18	23	21
TOTALS						
Truck from Origin; Dedicated Rail to Repository; 100T Cask						
Radiological	5.4	5.3	5.4	5.5	5.8	5.8
Nonradiological	22	21	28	34	40	38
Rail from Origin; Dedicated Rail from MRS; 100T Cask						
Radiological	.24	.24	.26	.27	.30	.30
Nonradiological	7.5	7.5	14	20	25	23

[1] Includes risk values for SF and secondary wastes.

TABLE 2.13 TOTAL SHIPMENT-MILES (million miles)
MRS CASE 6 - MRS at Hartsville; all SF shipped to MRS

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
	Repository Location					
Truck from Reactors, HLW Sites						
SF to MRS	49.2	49.2	49.2	49.2	49.2	49.2
DHLW to Repos.	28.0	28.0	26.0	28.0	33.0	35.0
WVHLW to Repos.	1.0	1.0	1.0	1.5	2.0	2.0
Rail from Reactors, HLW Sites						
SF to MRS	8.1	8.1	8.1	8.1	8.1	8.1
DHLW to Repos.	6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	2.0	2.0	2.0	2.0	3.0	3.0
Rail from MRS (150T, nonoverpacked)						
Dedicated Rail	0.2	0.3	0.5	0.7	1.4	0.9
TOTALS						
Truck from Origin						
150T from MRS	78.4	78.5	76.7	79.4	85.6	87.1
Rail from Origin						
150T from MRS	16.8	16.9	16.7	17.3	20.1	20.4

TABLE 2.14 TOTAL TRANSPORTATION PACKAGING REQUIREMENTS (number of casks) MRS CASE 6 - MRS at Hartsville; all SF shipped to MRS

Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
	Repository Location					
Truck from Reactors, HLW Sites						
SF to MRS	106	106	106	106	106	106
DHLW to Repos.	40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4
Rail from Reactors, HLW Sites						
SF to MRS	67	67	67	67	67	67
DHLW to Repos.	34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2
Rail from MRS to Repository (150T, nonoverpacked)						
SF	20	20	20	20	30	20
HAW/Hdw	8	8	8	8	6	10
CH-TRU	2	2	2	2	2	2

TABLE 2.15 TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 6 - MRS at Hartsville;
all SF shipped to MRS

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	[illegible]
Truck from Reactors, HLW Sites						
CAPITAL	201.0	202.1	204.3	209.8	214.2	217.5
OPERATING	615.7	610.1	603.1	617.8	641.0	654.9
Rail from Reactors, HLW Sites						
CAPITAL	232.3	237.7	235.9	239.5	246.7	250.3
OPERATING	648.2	650.6	652.0	648.7	672.4	668.9
Rail from MRS to Repository (150T, nonoverpacked)						
CAPITAL	78.6	78.6	78.6	78.6	100.6	84.1
OPERATING	166.1	184.1	252.1	293.6	453.7	334.7
TOTALS						
Truck from Origin 150T from MRS	1061.4	1074.9	1138.1	1199.8	1409.5	1291.2
Rail from Origin 150T from MRS	1125.2	1151.0	1218.6	1260.4	1473.4	1338.0

TABLE 2.16 SUMMARY OF THE RISKS OF TRANSPORTATION OF SPENT FUEL AND HIGH LEVEL WASTES
MRS CASE 6 - Hartsville MRS; all SF to MRS; 150T [illegible]

Mode/Waste Type	Repository Location GIR	Vacherie	Permian	Paradox	Yucca Mt	[illegible]
100% TRUCK FROM ORIGIN						
SF						
Radiological	3.6	3.6	3.6	3.6	3.6	3.6
Nonradiological	9.4	9.4	9.4	9.4	9.4	9.4
HLW						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% RAIL FROM ORIGIN						
SF						
Radiological	.14	.14	.14	.14	.14	.14
Nonradiological	.92	.92	.92	.92	.92	.92
HLW						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
MRS TO REPOSITORY; 150T Cask[1]						
Radiological	.018	.017	.032	.034	.052	.048
Nonradiological	1.5	1.5	3.2	4.6	9.2	5.7
TOTALS						
Truck from Origin; Dedicated Rail to Repository; 150T Cask						
Radiological	5.4	5.3	5.3	5.4	5.8	5.8
Nonradiological	17	17	19	20	26	23
Rail from Origin; Dedicated Rail from MRS; 150T Cask						
Radiological	.22	.22	.24	.24	.27	.26
Nonradiological	3.1	3.1	4.8	6.2	11	7.4

[1] Includes risk values for SF and secondary wastes.

TABLE 2.17 TOTAL SHIPMENT-MILES (million miles)
MRS CASE 7 - MRS at Hartsville; East-West split

		Repository Location					
Mode/Waste Type		GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites							
SF to MRS		38.9	38.9	38.9	38.9	38.9	38.9
SF to Repos.		10.9	9.4	6.0	3.9	2.8	[illegible]
DHLW to Repos.		28.0	28.0	26.0	28.0	33.0	35.0
WVHLW to Repos.	1.0		1.0	1.0	1.5	2.0	2.0
Rail from Reactors, HLW Sites							
SF to MRS		6.4	6.4	6.4	6.4	6.4	6.4
SF to Repos.		1.8	1.5	1.0	0.6	0.5	0.6
DHLW to Repos.		6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	2.0		2.0	2.0	2.0	3.0	3.0
Rail from MRS to Repository (100T with overpacks)							
Dedicated Rail	0.8		1.0	1.9	2.6	3.4	3.0
TOTALS							
Truck from Origin 100T from MRS	79.6		78.3	73.8	74.9	80.1	82.4
Rail from Origin 100T from MRS		17.5	17.4	17.4	18.1	20.9	21.4

TABLE 2.18 TOTAL TRANSPORTATION PACKAGING REQUIREMENTS (number of packagings) MRS CASE 7 - MRS at Hartsville; East-West split

		Repository Location					
Mode/Waste Type		GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW Sites							
SF to MRS		97	97	97	97	97	97
SF to Repos.		14	13	11	9	8	9
DHLW to Repos.		40	41	44	48	51	56
WVHLW to Repos.		2	2	2	2	4	4
Rail from Reactors, HLW Sites							
SF to MRS		61	61	61	61	61	61
SF to Repos.		9	8	8	6	6	6
DHLW to Repos.		34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2	
Rail from MRS to Repository (100T with overpacks)							
SF	50	50	60	70	750	60	
HAW/Hdw		4	4	4	4	4	4
CH-TRU		2	2	2	2	2	2

TABLE 2.19 TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 7 - MRS at Hartsville; East-West split

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
Truck from Reactors, HLW sites						
CAPITAL	208.2	207.9	207.2	209.7	212.7	217.4
OPERATING	603.8	588.4	559.6	561.3	577.9	596.0
Rail from Reactors, HLW sites						
CAPITAL	239.8	242.7	240.9	239.5	246.7	250.3
OPERATING	636.2	633.0	624.7	611.9	630.7	629.4
Rail from MRS to Repository (100T with overpacks)						
CAPITAL	136.6	136.6	161.6	186.6	186.6	161.6
OPERATING	308.4	342.9	488.7	583.1	680.2	572.4
TOTALS						
Truck from Origin 100T from MRS	1257.0	1275.8	1417.1	1540.5	1657.4	1547.2
Rail from Origin 100T from MRS	1321.0	1355.2	1515.9	1620.9	1744.2	1613.5

TABLE 2.20 SUMMARY OF THE RISKS OF THE TRANSPORT OF SPENT FUEL AND HIGH LEVEL WASTES
MRS CASE 7 - Hartsville MRS; East-West split; [illegible]

Mode/Waste Type	Repository Location					
	GIR	Vacherie	Richton	[illegible]	[illegible]	[illegible]
100% TRUCK FROM ORIGIN						
SF to Repository						
Radiological	.75	.61	.42	.29	.27	.27
Nonradiological	2.5	2.0	1.5	.97	.87	.76
SF to MRS						
Radiological	2.9	2.9	2.9	2.9	2.9	2.9
Nonradiological	7.1	7.1	7.1	7.1	7.1	7.1
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% RAIL FROM ORIGIN						
SF to Repository						
Radiological	.018	.016	.011	.011	.0086	.0097
Nonradiological	.18	.16	.11	.092	.069	.070
SF to MRS						
Radiological	.12	.12	.12	.12	.12	.12
Nonradiological	.74	.74	.74	.74	.74	.74
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
MRS TO REPOSITORY; 100T Cask[1]						
Radiological	.032	.029	.054	.058	.074	.076
Nonradiological	5.5	5.5	11	16	21	19
TOTALS						
Truck from Origin; Dedicated Rail from MRS; 100T Cask						
Radiological	5.5	5.2	5.1	5.1	5.3	5.4
Nonradiological	21	20	26	30	36	34
Rail from Origin; Dedicated Rail from MRS; 100T Cask						
Radiological	.23	.23	.25	.26	.28	.28
Nonradiological	7.1	7.0	13	18	22	20

[1] Includes risk values for SF and secondary wastes.

TABLE 2.21 TOTAL SHIPMENT-MILES (million miles)
MRS CASE 8-MRS at Hartsville; East-West split

Mode/Waste Type		GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
		Repository Location					
Truck from Reactors, HLW Sites							
SF to MRS		38.9	38.9	38.9	38.9	38.9	[illegible]
SF to Repos.		10.9	9.4	6.0	3.9	2.0	[illegible]
DHLW to Repos.		28.0	28.0	26.0	28.0	33.0	35.0
WVHLW to Repos.	1.0		1.0	1.0	1.5	2.0	2.0
Rail from Reactors, HLW Sites							
SF to MRS		6.4	6.4	6.4	6.4	6.4	6.4
SF to Repos.		1.8	1.5	1.0	0.6	0.5	0.6
DHLW to Repos.		6.5	6.5	6.1	6.5	7.6	8.4
WVHLW to Repos.	2.0		2.0	2.0	2.0	3.0	3.0
Rail from MRS to Repository (150T, nonoverpacked)							
Dedicated Rail	0.2		0.2	0.5	0.7	1.3	0.8
TOTALS							
Truck from Origin 150T from MRS	79.0		77.5	72.4	73.0	78.0	80.2
Rail from Origin 150T from MRS		16.9	16.6	16.0	16.2	18.8	19.2

TABLE 2.22 TOTAL TRANSPORTATION PACKAGING REQUIREMENTS
(number of packagings) MRS CASE 8 - MRS at Hartsville;
East-West split

Mode/Waste Type		GIR	Vacherie	Permian	Paradox	Yucca Mt	Hanford
		Repository Location					
Truck from Reactors, HLW Sites							
SF to MRS	97	97	97	97	97	97	-
SF to Repos.		14	13	11	9	8	9
DHLW to Repos.		40	41	44	48	51	56
WVHLW to Repos.	2	2	2	2	4	4	
Rail from Reactors, HLW Sites							
SF to MRS		61	61	61	61	61	61
SF to Repos.		9	8	8	6	6	6
DHLW to Repos.		34	37	37	38	42	47
WVHLW to Repos.	2	2	2	2	2	2	
Rail from MRS to Repository (150T, nonoverpacked)							
SF		20	20	20	20	30	20
HAW/Hdw		8	8	8	8	6	8
CH-TRU		2	2	2	2	2	2

TABLE 2.23 TOTAL TRANSPORTATION COSTS ($M)
MRS CASE 8 - MRS at Hartsville; East-West split

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt	[illegible]
Truck from Reactors, HLW sites						
CAPITAL	208.2	207.9	207.2	209.7	212.7	217.4
OPERATING	603.8	588.4	559.6	561.3	577.9	596.0
Rail from Reactors, HLW sites						
CAPITAL	239.8	242.7	240.9	239.5	246.7	250.3
OPERATING	636.2	633.0	624.7	611.9	630.7	629.4
Rail from MRS to Repository (150T, nonoverpacked)						
CAPITAL	78.6	78.6	78.6	78.6	106.1	78.6
OPERATING	148.4	170.2	231.8	269.7	409.2	307.2
TOTALS						
Truck from Origin 150T from MRS	1044.7	1045.1	1077.2	1119.3	1300.4	1199.2
Rail from Origin 150T from MRS	1108.7	1124.5	1176.0	1199.7	1387.2	1265.5

TABLE 2.24 SUMMARY OF THE RISKS OF TRANSPORTATION
OF SPENT FUEL AND HIGH LEVEL WASTES
MRS CASE 8 - Hartsville MRS; East-West split, 150T cask

	Repository Location					
Mode/Waste Type	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
100% TRUCK FROM ORIGIN						
SF to Repository						
Radiological	.75	.61	.42	.29	.27	.27
Nonradiological	2.5	2.0	1.5	.97	.87	.76
SF to MRS						
Radiological	2.9	2.9	2.9	2.9	2.9	2.9
Nonradiological	7.1	7.1	7.1	7.1	7.1	7.1
HLW to Repository						
Radiological	1.8	1.7	1.7	1.8	2.1	2.1
Nonradiological	6.2	5.8	6.2	6.1	7.4	7.4
100% RAIL FROM ORIGIN						
SF to Repository						
Radiological	.018	.016	.011	.011	.0086	.0097
Nonradiological	.18	.16	.11	.092	.069	.070
SF to MRS						
Radiological	.12	.12	.12	.12	.12	912
Nonradiological	.74	.74	.74	.74	.74	.74
HLW to Repository						
Radiological	.062	.067	.063	.066	.079	.074
Nonradiological	.63	.69	.64	.66	.84	.79
MRS TO REPOSITORY; 150T Cask[1]						
Radiological	.017	.017	.029	.031	.048	.043
Nonradiological	1.4	1.4	3.0	4.2	8.5	5.3
TOTALS						
Truck from Origin; Dedicated Rail from MRS; 150T Cask						
Radiological	5.5	5.2	5.1	5.0	5.3	5.3
Nonradiological	17	16	18	18	24	21
Rail from Origin; Dedicated Rail from MRS; 150T Cask						
Radiological	.22	.22	.22	.23	.26	.25
Nonradiological	3.0	3.0	4.5	5.7	10	6.9

[1] Includes risk values for SF and secondary wastes.

APPENDIX 3

DETAILED WASTES II OUTPUT

TABLE 3.1A

SUMMARY OF SPENT FUEL SHIPMENTS DIRECT TO REPOSITORY

100% TRUCK-(CASK CAPACITY OF 2/5)

	COST ($M)				MILES	CASKS
REPOS LOCATION	SHIPPING	CAPITAL	MAINT	TOTAL	(Millions)	(Number)
RICHTON	442.4	181.0	98.8	722.2	67.4	124
VACHERIE	466.3	186.9	101.6	754.8	71.7	128
DEAF SMITH	595.4	211.7	115.5	922.6	94.4	145
DAVIS	717.2	235.1	128.1	1080.3	115.1	161
NNWSI	875.6	265.7	145.0	1286.2	141.8	182
BWIP	921.7	274.5	149.2	1345.4	149.7	188

TABLE 3.1B

SUMMARY OF SPENT FUEL SHIPMENTS DIRECT TO REPOSITORY

100% RAIL-(CASK CAPACITY OF 14/36)

	COST ($M)				MILES	CASKS
REPOS LOCATION	SHIPPING	CAPITAL	MAINT	TOTAL	(Millions)	(Number)
RICHTON	389.7	202.5	107.6	699.8	11.0	81
VACHERIE	404.7	207.5	110.4	722.6	11.7	83
DEAF SMITH	477.0	232.5	123.4	832.9	15.4	93
DAVIS	533.9	250.5	133.5	917.9	18.8	100
NNWSI	603.5	275.0	145.9	1024.4	23.2	110
BWIP	625.8	280.0	149.9	1055.7	24.6	112

TABLE 3.2

SUMMARY OF DEFENSE AND COMMERCIAL HIGH-LEVEL WASTE SHIPMENTS DIRECT TO REPOSITORY- 100% TRUCK SHIPMENTS

	COST ($M)				CASKS
REPOS LOCATION	SHIPPING	CAPITAL	MAINT	TOTAL	(Number)
RICHTON	33.6	22.0	12.0	67.6	20
VACHERIE	39.0	24.2	13.2	76.4	22
DEAF SMITH	63.4	30.8	16.8	111.0	28
DAVIS	97.1	39.6	21.6	158.3	36
NNWSI	110.0	41.8	22.8	174.6	38
BWIP	135.2	48.4	26.4	210.0	44
FROM HANFORD TO					
RICHTON	24.5	5.5	4.5	34.5	5
VACHERIE	21.6	5.5	4.5	31.6	5
DEAF SMITH	15.1	4.4	3.6	23.1	4
DAVIS	9.4	3.3	2.7	15.4	3
NNWSI	9.8	3.3	2.7	15.8	3
BWIP	NA	NA	NA	NA	NA
FROM INEL TO					
RICHTON	74.5	16.5	13.5	104.5	15
VACHERIE	65.9	15.4	12.6	93.9	14
DEAF SMITH	39.8	12.1	9.9	61.8	11
DAVIS	23.0	9.9	8.1	41.0	9
NNWSI	29.0	9.9	8.1	47.0	9
BWIP	26.1	9.9	8.1	44.1	9
FROM WEST VALLEY TO					
RICHTON	3.9	2.2	1.2	7.3	2
VACHERIE	4.1	3.2	1.2	7.5	2
DEAF SMITH	5.3	2.2	1.2	8.7	2
DAVIS	6.7	2.2	1.2	10.1	2
NNWSI	8.2	4.4	2.4	15.0	4
BWIP	8.7	4.4	2.4	15.5	4

TABLE 3.3

SUMMARY OF DEFENSE AND COMMERCIAL HIGH LEVEL WASTE SHIPMENT IF DIRECT TO REPOSITORY-100% RAIL SHIPMENTS

	COST ($M)				CASKS
FROM SRP TO	SHIPPING	CAPITAL	MAINT.	TOTAL	([illegible])
RICHTON	56.5	32.4	16.2	105.1	18
VACHERIE	64.1	39.6	19.8	123.5	22
DEAF SMITH	92.5	43.2	21.6	157.3	24
DAVIS	117.7	50.4	25.2	193.3	28
NNWSI	126.5	54.0	27.0	207.5	30
BWIP	142.4	64.8	32.4	239.6	36
FROM HANFORD TO					
RICHTON	26.1	7.2	5.4	38.7	4
VACHERIE	24.7	7.2	5.4	37.3	4
DEAF SMITH	20.1	5.4	4.1	29.6	3
DAVIS	14.4	5.4	4.1	23.9	3
NNWSI	15.3	5.4	4.1	24.8	3
BWIP	NA	NA	NA	NA	NA
FROM INEL TO					
RICHTON	90.8	21.6	16.2	128.6	12
VACHERIE	84.7	[illegible]	14.9	119.4	11
DEAF SMITH	63.8	16.2	12.2	92.2	9
DAVIS	39.3	12.6	9.5	61.4	7
NNWSI	48.1	16.2	12.2	76.5	9
BWIP	43.9	14.4	10.8	69.1	8
FROM WEST VALLEY TO					
RICHTON	4.4	3.6	1.8	9.8	2
VACHERIE	4.4	3.6	[illegible]	9.8	2
DEAF SMITH	5.1	3.6	1.8	10.5	2
DAVIS	5.9	3.6	1.8	11.3	2
NNSWI	6.6	3.6	1.8	12.0	2
BWIP	6.8	3.6	1.8	12.2	2

TABLE 3.4

SUMMARY FOR SHIPMENTS FROM ALL REACTORS TO AN MRS

(SPENT FUEL)

	COST ($M)				CASKS	CASK MILES
SHIPPING MODE	SHIPPING	CAPITAL	MAINT.	TOTAL	(Number)	(Millions)
100% Truck						
To Oak Ridge	343.1	154.8	102.9	600.8	106	48.8
To Hartsville	345.1	154.8	102.9	602.8	106	49.2
100% Rail						
To Oak Ridge	318.4	167.5	107.9	593.8	67	8.0
To Hartsville	322.9	167.5	107.9	598.3	67	8.1

TABLE 3.5

SUMMARY FOR CONSOLIDATED SPENT FUEL SHIPMENTS FROM AN MRS TO A REPOSITORY IN FIVE CAR DEDICATED TRAINS

(FUEL FROM ALL REACTORS)

MRS CASK SIZE	COST (M)				CASKS (Number)	CASK MILES (Millions)	TRIP MILES (Millions)
	SHIPPING	CAPITAL	MAINT.	TOTAL			
Oak Ridge							
(100T Cask)							
RICHTON	213.9	137.5	69.4	420.8	55	4.6	0.9
VACHERIE	261.0	150.0	79.4	490.4	60	6.1	1.2
DEAF SMITH	369.3	175.0	93.9	638.1	70	11.2	2.2
DAVIS	443.3	187.5	98.1	728.9	75	15.1	3.0
NNWSI	491.8	200.0	108.8	800.6	80	19.2	3.8
BWIP	425.0	175.0	93.1	693.1	70	17.3	3.5
(150T Cask)							
RICHTON	74.0	55.0	28.1	157.1	20	1.2	0.2
VACHERIE	90.0	55.0	28.1	173.1	20	1.6	0.3
DEAF SMITH	128.8	55.0	28.1	211.9	20	2.9	0.6
DAVIS	152.6	55.0	28.1	235.7	20	3.9	0.8
NNSWI	287.9	82.5	41.3	411.7	30	7.6	1.5
BWIP	164.8	55.0	28.1	247.9	20	4.8	1.0
Hartsville							
(100T Cask)							
RICHTON	202.1	125.0	67.5	394.6	50	4.2	0.8
VACHERIE	233.8	137.5	70.0	441.3	55	5.2	1.0
DEAF SMITH	346.8	162.5	83.6	592.9	65	10.1	2.0
DAVIS	420.1	175.0	95.8	690.9	70	13.9	2.8
NNSWI	473.5	200.0	108.1	781.6	80	18.1	3.6
BWIP	407.4	175.0	92.9	675.3	70	16.3	3.3
(150T Cask)							
RICHTON	70.0	55.0	28.1	153.1	20	1.1	0.2
VACHERIE	80.8	55.0	28.1	163.9	20	1.4	0.3
DEAF SMITH	121.3	55.0	28.1	204.4	20	2.6	0.5
DAVIS	144.9	55.0	28.1	228.0	20	3.6	0.7
NNSWI	276.9	82.5	41.3	400.7	30	7.2	1.4
BWIP	158.3	55.0	28.1	241.4	20	4.5	0.9

TABLE 5.6

SUMMARY FOR SHIPPING WASTE PRODUCTS FROM MRS FACILITY TO REPOSITORY

(HARDWARE AND HIGH ACTIVITY WASTES)

(ALL REACTORS THROUGH MRS)

MRS CASK SIZE	COST ($M)				CASKS (Number)	CASK-MILES (Millions)
	SHIPPING	CAPITAL	MAINT.	TOTAL		
Oak Ridge						
(100T Cask)						
RICHTON	63.6	10.0	6.3	79.9	4	1.5
VACHERIE	75.6	10.0	6.3	91.9	4	2.0
DEAF SMITH	107.8	10.0	6.3	124.1	4	3.7
DAVIS	128.6	10.0	6.3	144.9	4	4.9
NNWSI	147.8	10.0	6.3	164.1	4	6.3
BWIP	157.4	10.0	6.3	173.7	4.	6.9
(150T Cask)						
RICHTON	52.1	22.0	12.5	86.6	8	0.8
VACHERIE	62.0	22.0	12.5	96.5	8	1.1
DEAF SMITH	88.4	22.0	12.5	122.9	8	2.1
DAVIS	105.4	22.0	12.5	139.9	8	2.8
NNWSI	121.2	16.5	9.4	147.1	6	3.[illegible]
BWIP	129.1	27.5	15.6	172.2	10	3.9
Hartsville						
(100T Cask)						
RICHTON	60.5	10.0	6.3	76.8	4	1.4
VACHERIE	68.9	10.0	6.3	85.2	4	1.7
DEAF SMITH	101.1	10.0	6.3	117.4	4	3.3
DAVIS	122.2	10.0	6.3	138.5	4	4.5
NNWSI	143.0	10.0	6.3	159.3	4	5.9
BWIP	150.9	10.0	6.3	167.2	4	6.5
RICHTON	49.6	2.0	12.5	84.1	8	0.8
VACHERIE	56.5	22.0	12.5	91.0	8	1.0
DEAF SMITH	82.9	22.0	12.5	117.4	3	1.9
DAVIS	100.1	22.0	12.5	134.6	8	2.6
NNWSI	117.4	16.5	9.4	143.3	6	3.4
BWIP	123.7	27.5	15.6	166.8	10.0	3.7

TABLE 3.7

SUMMARY FOR SHIPPING WASTE PRODUCTS FROM MRS FACILITY TO REPOSITORY
(CONTACT HANDLED TRU WASTE, ALL REACTORS THROUGH MRS)

REPOSITORY	(COST ($M)) SHIPPING	CAPITAL	MAINT.	TOTAL	CASKS (Number)	CASK-MILES (Millions)
Oak Ridge (TRU)						
RICHTON	2.2	1.6	3.8	7.6	2	0.2
VACHERIE	2.6	1.6	3.8	8.0	2	0.2
DEAF SMITH	3.7	1.6	3.8	9.1	2	0.4
DAVIS	4.4	1.6	3.8	9.8	2	0.6
NNWSI	5.1	1.6	3.8	10.5	2	0.8
BWIP	5.4	1.6	3.8	10.8	2	0.8
Hartsville (TRU)						
RICHTON	2.1	1.6	3.8	7.5	2	0.2
VACHERIE	2.4	1.6	3.8	7.8	2	0.2
DEAF SMITH	3.5	1.6	3.8	8.9	2	0.4
DAVIS	4.2	1.6	3.8	9.6	2	0.5
NNWSI	4.9	1.6	3.8	10.3	2	0.7
BWIP	5.2	1.6	3.8	10.6	2	0.7

TABLE 3.8

SUMMARY OF SPENT FUEL SHIPMENTS,

DIRECT TO MRS

EASTERN REACTORS ONLY

MODE/LOC. MRS	COST ($)				MILES (Millions)	CASKS (Number)
	SHIPPING	CAPITAL	MAINT.	TOTAL		
Truck						
Oak Ridge	276.4	141.6	76.6	494.6	38.1	97
Hartsville	280.9	141.6	76.6	499.1	38.9	97
Rail						
Oak Ridge	273.4	152.5	81.0	506.9	6.2	61
Hartsville	278.4	152.5	81.3	512.2	6.4	61

TABLE 3.9

SUMMARY OF SPENT FUEL SHIPMENTS

DIRECT TO REPOSITORY

WESTERN REACTORS ONLY

MODE/ REPOS. LOC.	COST ($M)				MILES	CASK
	SHIPPING	CAPITAL	MAINT.	TOTAL	(Millions)	(Number)
Truck						
RICHTON	67.1	20.4	11.5	99.0	10.9	14
VACHERIE	58.1	19.0	10.7	87.8	9.4	13
DEAF SMITH	38.3	16.1	8.7	63.1	6.0	11
DAVIS	26.7	13.1	7.3	47.1	3.9	9
NNWSI	20.8	11.7	6.6	39.1	2.8	8
BWIP	24.6	13.1	7.0	44.7	3.5	9
Rail						
RICHTON	46.8	22.5	12.3	81.6	1.8	9
VACHERIE	42.6	20.0	10.9	73.5	1.5	8
DEAF SMITH	33.0	20.0	10.8	63.8	1.0	8
DAVIS	25.9	15.0	8.4	49.3	0.6	6
NNWSI	21.1	15.0	8.3	44.4	0.5	6
BWIP	23.5	15.0	8.1	46.6	0.6	6

TABLE 3.10

SUMMARY FOR CONSOLIDATED SPENT FUEL SHIPMENTS FROM AN MRS TO A REPOSITORY IN FIVE CAR DEDICATED TRAINS

(FUEL FROM EASTERN REACTORS ONLY)

MRS/CASK SIZE	COST ($M)				CASKS (Number)	MILES (Millions)	
	SHIPPING	CAPITAL	MAINT.	TOTAL		CASK	TRIP
Oak Ridge							
(100T)							
RICHTON	182.5	125.0	67.5	375.0	50	4.3	0.9
VACHERIE	221.6	125.0	67.5	414.1	50	5.7	1.1
DEAF SMITH	319.8	150.0	82.5	552.3	60	10.4	2.1
DAVIS	380.4	175.0	94.0	649.4	70	14.1	2.8
NNWSI	454.4	175.0	96.3	725.7	70	17.7	3.5
BWIP	351.0	150.0	80.6	581.6	60	16.0	3.2
(150T)							
RICHTON	65.3	55.0	28.1	148.4	20	1.1	0.2
VACHERIE	79.3	55.0	28.1	162.4	20	1.5	0.3
DEAF SMITH	114.0	55.0	28.1	197.1	20	2.7	0.5
DAVIS	135.4	55.0	28.1	218.5	20	2.7	0.5
NNSWI	250.9	82.5	41.3	374.7	30	7.0	1.4
BWIP	149.4	55.0	28.1	232.5	20	4.4	0.9
Hartsville							
(100T)							
RICHTON	172.9	125.0	67.5	365.4	50	3.9	0.8
VACHERIE	199.4	125.0	67.5	391.9	50	4.9	1.0
DEAF SMITH	301.3	150.0	80.6	531.9	60	9.3	1.9
DAVIS	361.5	175.0	94.4	630.9	70	12.9	2.6
NNSWI	437.5	175.0	95.8	708.3	70	16.7	3.4
BWIP	337.1	150.0	80.6	567.7	60	15.1	3.0
(150T)							
RICHTON	61.9	55.0	28.1	145.0	20	1.0	0.2
VACHERIE	71.3	55.0	28.1	154.4	20	1.3	0.3
DEAF SMITH	107.5	55.0	28.1	190.6	20	2.4	0.5
DAVIS	128.8	55.0	28.1	211.9	20	3.4	0.7
NNSWI	241.6	82.5	41.3	365.4	30	6.6	1.3
BWIP	143.6	55.0	28.1	226.7	20	4.1	0.8

TABLE 3.11

SHIPMENT SUMMARY FROM MRS FACILITY TO REPOSITORY
(HARDWARE AND HIGH ACTIVITY WASTES)
(EASTERN REACTORS ONLY THROUGH MRS)

MRS/REPOS	COST ($M)				CASKS	CASK-MILES
LOCATION	SHIPPING	CAPITAL	MAINT.	TOTAL	(Number)	(Millions)
Hartsville						
(100T)						
RICHTON	56.0	10	6.3	72.3	4	1.30
VACHERIE	63.7	10	6.3	80.0	4	1.57
DEAF SMITH	93.5	10	6.3	109.8	4	3.05
DAVIS	113.0	10	6.3	129.3	4	4.16
NNWSI	132.3	10	6.3	148.6	4	5.46
BWIP	139.6	10	6.3	155.9	4	6.01
(150T)						
RICHTON	45.9	22	12.5	80.4	8	0.72
VACHERIE	52.3	22	12.5	86.8	8	0.91
DEAF SMITH	76.7	22	12.5	111.2	8	1.76
DAVIS	92.6	22	12.5	127.1	8	2.41
NNSWI	108.6	16.5	9.4	134.5	6	3.15
BWIP	114.4	22	12.5	148.9	8	3.42

TABLE 3.12

SPREADSHEET RESULTS FOR SHIPPING WASTE PRODUCTS FROM MRS FACILITY TO REPOSITORY

(CONTACT HANDLED TRU WASTE)

(EASTERN REACTORS ONLY THROUGH MRS)

MRS/REPOS LOCATION	COST ($M) SHIPPING	CAPITAL	MAINT.	TOTAL	CASKS (Number)	CASK-MILES (Millions)
Oak Ridge						
(TRUPAC)						
RICHTON	2.04	1.6	3.8	7.4	2	0.17
VACHERIE	2.41	1.6	3.8	7.8	2	0.22
DEAF SMITH	3.42	1.6	3.8	8.8	2	0.41
DAVIS	4.07	1.6	3.8	9.5	2	0.56
NNWSI	4.72	1.6	3.8	10.1	2	0.70
BWIP	5.00	1.6	3.8	10.4	2	0.78
Hartsville						
(TRUPAC)						
RICHTON	1.94	1.6	3.8	7.3	2	0.15
VACHERIE	2.22	1.6	3.8	7.6	2	0.19
DEAF SMITH	3.24	1.6	3.8	8.6	2	0.37
DAVIS	3.89	1.6	3.8	9.3	2	0.50
NNWSI	4.53	1.6	3.8	9.9	2	0.67
BWIP	4.81	1.6	3.8	10.2	2	0.72

APPENDIX A

DETAILED RADTRAN III OUTPUT

Included in this appendix are tables of all components of transportation risk for the cases analyzed in this report. For each case, there are two sets of units-risk factors: radiological and nonradiological. The radiological unit-risk factors (Tables 5-1 to 5-3) were generated by RADTRAN III; each factor represents the risk associated with 1 kilometer of travel of a truck or railcar for the specified payload/population density zone/etc. combination.

For each logical combination of mode, payload, population density zone, etc., three radiological unit-risk factors are given: normal nonoccupational risk, normal occupational risk, and accident nonoccupational risk. Normal nonoccupational risk is the risk to members of the general public during normal (i.e. incident-free) transport; normal occupational risk is the risk to occupationally exposed persons such as truck drivers and rail crew members during incident-free transport; and accident nonoccupational is the risk to members of the public from accidents of all severities. A fourth set of radiological unit-risk factors, the Z factors, apply only to rail transport. They represent the risks associated with the two endpoint stops that occur for each trip and are thus distance-independent. These unit-risk factors are multiplied only by the number of shipments, not also by the trip distance as are other unit-risk factors, to generate total risks. Note that for dedicated rail transport the number of shipments is not equivalent to the number of railcars because each dedicated rail shipment consists of 10 railcars. Only nonoccupational risk is calculated for accidents. One reason is the fact that the total population dose to members of the public in severe accidents in which a release occurred would dominate the total risk estimate. In addition, the chance of fatality from nonradiological causes (e.g. mechanical impact) for persons such as drivers, who otherwise might receive an occupational dose during an accident, is relatively high and makes radiological accident risk for this group difficult to estimate.

Nonradiological unit-risk factors are given in Tables 5-4A and 5-4B. For rail transport, nonradiological nonoccupational accident unit-risk factors give the risk of fatality or injury for 1 kilometer of travel per shipment rather than per railcar. This is because the fatalities and injuries that commonly associated with rail transport, i.e. grade-crossing collisions and accidents involving trespassers, are independent of train length. With general commerce rail transport, any given shipment (i.e. train) is likely to include only one railcar carrying spent fuel or high level waste, and, therefore, a per shipment basis is equivalent to a per railcar basis for this mode. The two are not equivalent for dedicated rail transport, however, because a dedicated rail shipment. as already noted, consists of 10 railcars, all of which carry radioactive materials.

The detailed risk tables (Tables 5-5 to 5-19) give the RADCOM-generated risks for each logical grouping of waste forms and origin points (e.g. spent fuel from reactors by truck, spent fuel from an MRS in 100T casks by dedicated rail). For each potential destination, the tables give the occupational, nonoccupational, and accident-related radiological risks and the nonradiological risks for transport of the specified waste form by the specified mode from the specified origin point(s).

Note that all unit-risk factors give risk per kilometer of travel. In order to apply these unit factors to a route or scenario not covered in this study, the user must be careful to convert distance from shipment-miles, railcar-miles, or highway-miles, as appropriate, to their kilometer equivalents before multiplying the distance by the unit-risk factors.

Table 4.17 Transport Risks: Secondary Waste from MRS to Repository (100T Cask - MRS Cases 3 and 7)

Table 4.18 Transport Risks: Spent Fuel from MRS to Repository (150T Cask - MRS Cases 4 and 8)

Table 4.19 Transport Risks: Secondary Wastes from MRS to Repository (150T Cask - MRS Cases 4 and 8)

Table 4-1. Radiological Unit-Risk Factors (per km)--Truck and Commercial Rail

Mode	Zone	Hazard Group	SFUEL	DHLW	WVHLW
Truck	Rural	Normal Occupational Fatalities	4.70E-09	4.14E-09	4.14E-09
Truck	Rural	Normal Non-Occupational Fatalities	2.84E-08	2.54E-08	2.54E-08
Truck	Rural	Accident Non-Occupational Fatalities	3.10E-13	2.56E-13	1.[illegible]E-13
Truck	Suburban	Normal Occupational Fatalities	1.03E-08	9.10E-09	9.10E-09
Truck	Suburban	Normal Non-Occupational Fatalities	4.36E-08	3.92E-08	3.92E-08
Truck	Suburban	Accident Non-Occupational Fatalities	7.46E-10	1.08E-10	7.60E-11
Truck	Urban	Normal Occupational Fatalities	1.72E-08	1.52E-08	1.52E-08
Truck	Urban	Normal Non-Occupational Fatalities	5.96E-08	5.36E-08	5.36E-08
Truck	Urban	Accident Non-Occupational Fatalities	1.22E-09	2.16E-10	1.52E-10
Rail	Rural	Normal Occupational Fatalities	2.14E-09	2.04E-09	1.03E-09
Rail	Rural	Normal Non-Occupational Fatalities	1.15E-09	1.03E-09	1.03E-09
Rail	Rural	Accident Non-Occupational Fatalities	1.34E-12	5.56E-13	5.40E-13
Rail	Suburban	Normal Occupational Fatalities	2.14E-09	2.04E-09	2.04E-09
Rail	Suburban	Normal Non-Occupational Fatalities	7.70E-09	6.90E-09	6.90E-09
Rail	Suburban	Accident Non-Occupational Fatalities	2.78E-09	2.72E-10	2.64E-10
Rail	Urban	Normal Occupational Fatalities	2.14E-09	2.04E-09	2.04E-09
Rail	Urban	Normal Non-Occupational Fatalities	2.58E-09	2.32E-09	2.32E-09
Rail	Urban	Accident Non-Occupational Fatalities	6.72E-09	5.08E-09	4.92E-09

Table 4-2. Radiological Unit-Risk Factors (per km)--MRS Cases
Dedicated Rail--100T Cask

		Spent Fuel			Secondary Wastes		
Zone	Hazard Group	SALT	TUFF	BSLT	MRS-[illegible]	MRS-HAW	MRS-TRU
Rural	Normal Occupational Fatalities	6.68E-10	6.68E-10	6.68E-10	2.68E-10	2.68E-10	1.56E-10
Rural	Normal Non-Occupational Fatalities	8.32E-10	8.32E-10	8.32E-10	3.34E-10	3.34E-10	2.40E-10
Rural	Accident Non-Occupational Fatalities	6.58E-12	4.88E-12	6.56E-12	3.46E-16	2.34E-11	3.28E-17
Suburban	Normal Occupational Fatalities	6.68E-10	6.68E-10	6.68E-10	2.68E-10	2.68E-10	1.56E-10
Suburban	Normal Non-Occupational Fatalities	3.36E-08	3.36E-08	3.36E-08	1.34E-08	1.34E-08	9.66E-09
Suburban	Accident Non-Occupational Fatalities	1.29E-08	9.88E-09	1.29E-08	3.58E-14	2.12E-08	2.28E-14
Urban	Normal Occupational Fatalities	6.68E-10	6.68E-10	6.68E-10	2.68E-10	2.68E-10	1.56E-10
Urban	Normal Non-Occupational Fatalities	7.98E-09	7.98E-09	7.98E-09	3.20E-09	3.20E-09	3.20E-09
Urban	Accident Non-Occupational Fatalities	3.10E-08	2.38E-08	3.10E-08	1.80E-13	3.86E-07	4.18E-13

Table 4-3. Radiological Unit-Risk Factors (per km)--MRS Cases
Dedicated Rail--150T Cask

		Spent Fuel			Secondary Wastes		
Zone	Hazard Group	SALT	TUFF	BSLT	HDW	HAW	TRU
Rural	Normal Occupational Fatalities	6.68E-10	6.68E-10	6.68E-10	2.68E-10	2.68E-10	1.56E-10
Rural	Normal Non-Occupational Fatalities	8.32E-10	8.32E-10	8.32E-10	3.34E-10	3.34E-10	2.40E-10
Rural	Accident Non-Occupational Fatalities	1.76E-11	1.22E-11	2.02E-11	8.80E-16	3.98E-11	3.28E-17
Suburban	Normal Occupational Fatalities	6.68E-10	6.68E-10	6.68E-10	2.68E-10	2.68E-10	1.56E-10
Suburban	Normal Non-Occupational Fatalities	3.36E-08	3.36E-08	3.36E-08	1.34E-08	1.34E-08	9.65E-09
Suburban	Accident Non-Occupational Fatalities	3.46E-08	2.38E-08	3.94E-08	9.80E-14	3.62E-08	2.26E-14
Urban	Normal Occupational Fatalities	6.68E-10	6.68E-10	6.68E-10	2.68E-10	2.68E-10	1.56E-10
Urban	Normal Non-Occupational Fatalities	7.98E-09	7.98E-09	7.98E-09	3.20E-09	3.20E-09	3.20E-09
Urban	Accident Non-Occupational Fatalities	8.30E-08	5.76E-08	9.50E-08	2.74E-13	6.64E-07	4.18E-13

Table 4-4A. Nonradiological Unit-Risk Factors (per km) for Truck - All Cases

Mode	Zone	Hazard Group	SFUEL	DHLW	WVHLW
Truck	Rural	Normal Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Truck	Rural	Accident Occupational Fatalities	1.50E-08	1.50E-08	1.50E-08
Truck	Rural	Accident Non-Occupational Fatalities	5.30E-08	5.30E-08	5.30E-08
Truck	Rural	Accident Occupational Injuries	2.80E-08	2.80E-08	2.80E-08
Truck	Rural	Accident Non-Occupational Injuries	8.00E-07	8.00E-07	8.00E-07
Truck	Suburban	Normal Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Truck	Suburban	Accident Occupational Fatalities	3.70E-09	3.70E-09	3.70E-09
Truck	Suburban	Accident Non-Occupational Fatalities	1.30E-08	1.30E-08	1.30E-08
Truck	Suburban	Accident Occupational Injuries	1.30E-08	1.30E-08	1.30E-08
Truck	Suburban	Accident Non-Occupational Injuries	3.80E-07	3.80E-07	3.80E-07
Truck	Urban	Normal Non-Occupational Fatalities	1.00E-07	1.00E-07	1.00E-07
Truck	Urban	Accident Occupational Fatalities	2.10E-09	2.10E-09	2.10E-09
Truck	Urban	Accident Non-Occupational Fatalities	7.50E-09	7.50E-09	7.50E-09
Truck	Urban	Accident Occupational Injuries	1.30E-08	1.30E-08	1.30E-08
Truck	Urban	Accident Non-Occupational Injuries	3.70E-07	3.70E-07	3.70E-07

Table 4-4B. Nonradiological Unit-Risk Factors (per km) for Rail - All [illegible]

Zone	Hazard Group	[illegible]			[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Rural	Normal Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00	.00E+00	[illegible]	[illegible]
Rural	Accident Occupational Fatalities	1.91E-09	1.91E-09	1.91E-09	1.27E-07	[illegible]	[illegible]
Rural	Accident Non-Occupational Fatalities	2.64E-08	2.64E-08	2.64E-08	1.85E-06	[illegible]	[illegible]
Rural	Accident Occupational Injuries	2.46E-07	2.46E-07	2.46E-07	1.74E-05	1.74E-05	[illegible]
Rural	Accident Non-Occupational Injuries	5.12E-08	5.12E-08	5.12E-08	3.60E-06	3.60E-06	3.60E-06
Suburban	Normal Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
Suburban	Accident Occupational Fatalities	1.91E-09	1.91E-09	1.91E-09	1.27E-07	1.27E-07	1.27E-07
Suburban	Accident Non-Occupational Fatalities	2.64E-08	2.64E-08	2.64E-08	1.85E-06	1.85E-06	1.85E-06
Suburban	Accident Occupational Injuries	2.46E-07	2.46E-07	2.46E-07	1.74E-05	1.74E-05	1.74E-05
Suburban	Accident Non-Occupational Injuries	5.12E-08	5.12E-08	5.12E-08	3.60E-06	3.60E-06	3.60E-06
Urban	Normal Non-Occupational Fatalities	1.30E-07	1.30E-07	1.30E-07	6.50E-07	6.50E-07	6.50E-07
Urban	Accident Occupational Fatalities	1.91E-09	1.91E-09	1.91E-09	1.27E-07	1.27E-07	1.27E-07
Urban	Accident Non-Occupational Fatalities	2.64E-08	2.64E-08	2.64E-08	1.85E-06	1.85E-06	1.85E-06
Urban	Accident Occupational Injuries	2.46E-07	2.46E-07	2.46E-07	1.74E-05	1.74E-05	1.74E-05
Urban	Accident Non-Occupational Injuries	5.12E-08	5.12E-08	5.12E-08	3.60E-06	3.60E-06	3.60E-06

Zone	Hazard Group	Dedicated Rail		
		HDWR*	HAW*	TRU*
Rural	Normal Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Rural	Accident Occupational Fatalities	.00E+00	.00E+00	.00E+00
Rural	Accident Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Rural	Accident Occupational Injuries	.00E+00	.00E+00	.00E+00
Rural	Accident Non-Occupational Injuries	.00E+00	.00E+00	.00E+00
Suburban	Normal Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Suburban	Accident Occupational Fatalities	.00E+00	.00E+00	.00E+00
Suburban	Accident Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Suburban	Accident Occupational Injuries	.00E+00	.00E+00	.00E+00
Suburban	Accident Non-Occupational Injuries	.00E+00	.00E+00	.00E+00
Urban	Normal Non-Occupational Fatalities	2.60E-07	2.60E-07	1.30E-07
Urban	Accident Occupational Fatalities	.00E+00	.00E+00	.00E+00
Urban	Accident Non-Occupational Fatalities	.00E+00	.00E+00	.00E+00
Urban	Accident Occupational Injuries	.00E+00	.00E+00	.00E+00
Urban	Accident Non-Occupational Injuries	.00E+00	.00E+00	.00E+00

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*Nonradiological risks, except for normal non-occupational fatalities in urban areas, are independent of train length. Therefore, this nonradiological risk is assigned to the spent fuel in the generic 10-car dedicated train (5 SFUEL cars, 2 HDWR cars, 2 HAW cars, and 1 TRU car), and zero risk is assigned to all other waste types carried in the same train.

Table 4-5. Transport Risks: Spent Fuel Direct to Repositories - Reference Case

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	[illegible]
Normal Occupational Fatalities	7.3E-01	8.1E-01	9.9E-01	1.2E+00	1.4E+00	[illegible]
Normal Non-Occupational Fatalities	3.6E+00	4.2E+00	5.2E+00	6.5E+00	7.7E+00	[illegible]
Accident Non-Occupational Fatalities	2.5E-02	2.8E-02	3.1E-02	3.3E-02	3.5E-02	[illegible]
Total Fatalities	4.6E+00	5.0E+00	6.2E+00	7.7E+00	9.2E+00	1.0E+01

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	6.4E-02	6.7E-02	7.5E-02	9.1E-02	1.1E-01	1.1E-01
Normal Non-Occupational Fatalities	7.8E-02	8.0E-02	8.4E-02	9.6E-02	1.1E-01	1.1E-01
Accident Non-Occupational Fatalities	1.8E-02	1.8E-02	1.8E-02	2.0E-02	2.3E-02	2.4E-02
Total Fatalities	1.6E-01	1.7E-01	1.8E-01	2.1E-01	2.4E-01	2.5E-01

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.8E-01	2.0E-01	2.5E-01	3.8E-01	4.4E-01	3.5E-01
Accident Occupational Fatalities	2.7E+00	3.0E+00	3.9E+00	5.2E+00	6.4E+00	6.5E+00
Accident Non-Occupational Fatalities	9.6E+00	1.1E+00	1.4E+01	1.8E+01	2.3E+01	2.4E+01
Accident Occupational Injuries	5.5E+00	6.1E+00	7.7E+00	1.0E+01	1.2E+01	1.3E+01
Accident Non-Occupational Injuries	1.6E+02	1.7E+02	2.2E+02	2.9E+02	3.6E+02	3.8E+02
Total Fatalities	1.3E+01	1.4E+01	1.8E+01	2.4E+01	2.9E+01	3.1E+01

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.2E-01	1.1E-01	1.2E-01	1.4E-01	1.8E-01	1.6E-01
Accident Occupational Fatalities	5.3E-02	5.6E-02	6.7E-02	8.8E-02	1.1E-01	1.1E-01
Accident Non-Occupational Fatalities	6.4E-01	6.9E-01	8.2E-01	1.1E+00	1.3E+00	1.3E+00
Accident Occupational Injuries	7.2E+00	7.7E+00	9.1E+00	1.2E+01	1.5E+01	1.5E+01
Accident Non-Occupational Injuries	1.2E+00	1.3E+00	1.6E+00	2.1E+00	2.6E+00	2.6E+00
Total Fatalities	8.1E-01	8.5E-01	1.0E+00	1.3E+00	1.6E+00	1.6E+00

Table 4-6. Transport Risks: Spent Fuel Direct to Repositories - MRS Cases 3, 4, 7, and 8

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	1.2E-01	9.5E-02	6.4E-02	4.5E-02	4.2E-02	4.0E-02
Normal Non-Occupational Fatalities	6.4E-01	5.2E-01	3.6E-01	2.5E-01	2.3E-01	2.2E-01
Accident Non-Occupational Fatalities	2.3E-03	2.2E-03	1.2E-03	1.0E-03	1.1E-03	1.5E-03
Total Fatalities	7.5E-01	6.1E-01	4.2E-01	2.9E-01	2.7E-01	2.7E-01

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	8.2E-03	7.4E-03	5.7E-03	5.0E-03	4.2E-03	4.0E-03
Normal Non-Occupational Fatalities	8.1E-03	6.8E-03	5.0E-03	4.9E-03	3.9E-03	4.6E-03
Accident Non-Occupational Fatalities	1.7E-03	1.2E-03	7.3E-04	8.7E-04	6.1E-04	1.0E-03
Total Fatalities	1.8E-02	1.6E-02	1.1E-02	1.1E-02	8.6E-03	9.7E-03

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.4E-02	3.2E-02	3.2E-02	2.3E-02	2.5E-02	3.2E-02
Accident Occupational Fatalities	5.4E-01	4.3E-01	3.1E-01	2.1E-01	1.9E-01	1.6E-01
Accident Non-Occupational Fatalities	1.9E+00	1.5E+00	1.1E+00	7.4E-01	6.6E-01	5.7E-01
Accident Occupational Injuries	1.1E+00	8.4E-01	6.0E-01	4.0E-01	3.6E-01	3.2E-01
Accident Non-Occupational Injuries	3.0E+01	2.4E+01	1.7E+01	1.2E+01	1.0E+01	9.3E+00
Total Fatalities	2.5E+00	2.0E+00	1.5E+00	9.7E-01	8.7E-01	7.6E-01

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.4E-02	1.1E-02	5.6E-03	6.4E-03	6.5E-03	1.0E-02
Accident Occupational Fatalities	1.1E-02	9.5E-03	6.6E-03	5.5E-03	4.0E-03	3.8E-03
Accident Non-Occupational Fatalities	1.6E-01	1.4E-01	9.6E-02	8.0E-02	5.9E-02	5.6E-02
Accident Occupational Injuries	1.5E+00	1.3E+00	9.0E-01	7.5E-01	5.5E-01	5.2E-01
Accident Non-Occupational Injuries	3.1F-01	2.7E-01	1.9E-01	1.6E-01	1.1E-01	1.1E-01
Total Fatalities	1.8E-01	1.6E-01	1.1E-01	9.2E-02	6.9E-02	7.0E-02

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Table 4-7. Transport Risks: High-Level Waste Direct to Repository - All Cases

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	[illegible]
Normal Occupational Fatalities	2.7E-01	2.5E-01	2.7E-01	2.3E-01	3.2E-01	[illegible]
Normal Non-Occupational Fatalities	1.5E+00	1.4E+00	1.5E+00	1.5E+00	[illegible]	[illegible]
Accident Non-Occupational Fatalities	1.1E-03	1.1E-03	1.1E-03	1.3E-03	[illegible]	[illegible]
Total Fatalities	1.8E+00	1.7E+03	1.7E+00	1.8E+00	2.1E+00	[illegible]

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	3.2E-02	3.4E-02	3.2E-02	3.3E-02	3.9E-02	3.7E-02
Normal Non-Occupational Fatalities	2.8E-02	3.2E-02	3.0E-02	3.2E-02	3.8E-02	3.5E-02
Accident Non-Occupational Fatalities	9.6E-04	1.4E-03	1.3E-03	1.4E-03	1.6E-03	1.3E-03
Total Fatalities	6.2E-02	6.7E-02	6.3E-02	6.6E-02	7.9E-02	7.4E-02

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.5E-02	4.0E-02	9.5E-02	5.4E-02	1.1E-01	2.5E-02
Accident Occupational Fatalities	1.4E+00	1.3E+00	1.3E+00	1.3E+00	1.6E+00	1.6E+00
Accident Non-Occupational Fatalities	4.8E+00	4.5E+00	4.7E+00	4.7E+00	5.7E+00	5.8E+00
Accident Occupational Injuries	2.7E+00	2.5E 00	2.6E+00	2.6E+00	3.1E+00	3.2E+00
Accident Non-Occupational Injuries	7.6E+01	7.1E+01	7.5E+01	7.5E+01	9.0E+01	9.1E+01
Total Fatalities	6.2E+00	5.8E+00	6.2E+00	6.1E+00	7.4E+00	7.4E+00

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.8E-02	4.5E-02	4.0E-02	4.1E-02	5.7E-02	3.5E-02
Accident Occupational Fatalities	3.9E-02	4.1E-02	3.9E-02	4.0E-02	5.0E-02	4.5E-02
Accident Non-Occupational Fatalities	5.7E-01	6.0E-01	5.7E-01	5.8E-01	7.4E-01	7.0E-01
Accident Occupational Injuries	5.3E+00	5.6E+00	5.3E+00	5.4E+00	6.9E+00	6.6E+00
Accident Non-Occupational Injuries	1.1E+00	1.2E+00	1.1E+00	1.1E+00	1.4E+00	1.4E+00
Total Fatalities	6.3E-01	6.9E-01	6.4E-01	6.6E-01	8.4E-01	7.9E-01

Table 4-8. Transport Risks: Spent Fuel Direct to Oak Ridge MRS - MRS Cases 1 and 2

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.8E-01	5.6E-01	5.6E-01	5.8E-01	5.8E-01	5.8E-01
Normal Non-Occupational Fatalities	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00
Accident Non-Occupational Fatalities	2.2E-02	2.2E-02	2.2E-02	2.2E-02	2.2E-02	2.2E-02
Total Fatalities	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.4E-02	5.4E-02	5.4E-02	5.4E-02	5.4E-02	5.4E-02
Normal Non-Occupational Fatalities	6.7E-02	6.7E-02	6.7E-02	6.7E-02	6.7E-02	6.7E-02
Accident Non-Occupational Fatalities	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.6E-02
Total Fatalities	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Accident Occupational Fatalities	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Accident Non-Occupational Fatalities	7.0E+00	7.0E+00	7.0E+00	7.0E+00	7.0E+00	7.0E+00
Accident Occupational Injuries	4.1E+00	4.1E+00	4.1E+00	4.1E+00	4.1E+00	4.1E+00
Accident Non-Occupational Injuries	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02
Total Fatalities	9.1E+00	9.1E+00	9.1E+00	9.1E+00	9.1E+00	9.1E+00

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01
Accident Occupational Fatalities	5.1E-02	5.1E-02	5.1E-02	5.1E-02	5.1E-02	5.1E-02
Accident Non-Occupational Fatalities	7.5E-01	7.5E-01	7.5E-01	7.5E-01	7.5E-01	7.5E-01
Accident Occupational Injuries	7.0E+00	7.0E+00	7.0E+00	7.0E+00	7.0E+00	7.0E+00
Accident Non-Occupational Injuries	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00
Total Fatalities	9.2E-01	9.2E-01	9.2E-01	9.2E-01	9.2E-01	9.2E-01

Table 4-9. Transport Risks: Spent Fuel Direct to Oak Ridge MRS - MRS Cases 3 and 4

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	[illegible]
Normal Non-Occupational Fatalities	2.3E+00	2.3E+00	2.3E+00	2.3E+00	2.3E+00	[illegible]
Accident Non-Occupational Fatalities	2.0E-02	2.0E-02	2.0E-02	2.0E-02	2.0E-02	[illegible]
Total Fatalities	2.8E+00	2.8E+00	2.8E+00	2.8E+00	2.8E+00	2.8E+00

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02
Normal Non-Occupational Fatalities	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02
Accident Non-Occupational Fatalities	1.5E-02	1.5E-02	1.5E-02	1.5E-02	1.5E-02	1.5E-02
Total Fatalities	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01
Accident Occupational Fatalities	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00
Accident Non-Occupational Fatalities	5.1E+00	5.1E+00	5.1E+00	5.1E+00	5.1E+00	5.1E+00
Accident Occupational Injuries	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00
Accident Non-Occupational Injuries	8.7E+01	8.7E+01	8.7E+01	8.7E+01	8.7E+01	8.7E+01
Total Fatalities	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
Accident Occupational Fatalities	3.9E-02	3.9E-02	3.9E-02	3.9E-02	3.9E-02	3.9E-02
Accident Non-Occupational Fatalities	5.8E-01	5.8E-01	5.8E-01	5.8E-01	5.8E-01	5.8E-01
Accident Occupational Injuries	5.4E+00	5.4E+00	5.4E+00	5.4E+00	5.4E+00	5.4E+00
Accident Non-Occupational Injuries	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Total Fatalities	7.3E-01	7.3E-01	7.3E-01	7.3E-01	7.3E-01	7.3E-01

Table 4-10. Transport Risks: Spent Fuel Direct to Hartsville MRS - MRS Cases 5 and 6

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.8E-01	5.8E-01	5.8E-01	5.8E-01	5.8E-01	5.8E-01
Normal Non-Occupational Fatalities	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00
Accident Non-Occupational Fatalities	2.2E-02	2.2E-02	2.2E-02	2.2E-02	2.2E-02	2.2E-02
Total Fatalities	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00	3.6E+00

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.3E-02	5.3E-02	5.3E-02	5.3E-02	5.3E-02	5.3E-02
Normal Non-Occupational Fatalities	6.7E-02	6.7E-02	6.7E-02	6.7E-02	6.7E-02	6.7E-02
Accident Non-Occupational Fatalities	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.6E-02
Total Fatalities	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.0E-01	2.0E-01	2.0E-01	2.0E-01	2.0E-01	2.0E-01
Accident Occupational Fatalities	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00
Accident Non-Occupational Fatalities	7.2E+00	7.2E+00	7.2E+00	7.2E+00	7.2E+00	7.2E+00
Accident Occupational Injuries	4.2E+00	4.2E+00	4.2E+00	4.2E+00	4.2E+00	4.2E+00
Accident Non-Occupational Injuries	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02	1.2E+02
Total Fatalities	9.4E+00	9.4E+00	9.4E+00	9.4E+00	9.4E+00	9.4E+00

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01
Accident Occupational Fatalities	5.0E-02	5.0E-02	5.0E-02	5.0E-02	5.0E-02	5.0E-02
Accident Non-Occupational Fatalities	7.3E-01	7.3E-01	7.3E-01	7.3E-01	7.3E-01	7.3E-01
Accident Occupational Injuries	6.8E+00	6.8E+00	6.8E+00	6.8E+00	6.8E+00	6.8E+00
Accident Non-Occupational Injuries	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00
Total Fatalities	9.2E-01	9.2E-01	9.2E-01	9.2E-01	9.2E-01	9.2E-01

Table 4-11. Transportation Risks: Spent Fuel Direct to Hartsville MRS - [illegible]

	Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.8E-01	4.8E-01	4.8E-01	4.8E-01	4.8E-01	[illegible]
Normal Non-Occupational Fatalities	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	[illegible]
Accident Non-Occupational Fatalities	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	[illegible]
Total Fatalities	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00	2.9E+00

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02	4.5E-02
Normal Non-Occupational Fatalities	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02	5.9E-02
Accident Non-Occupational Fatalities	1.5E-02	1.5E-02	1.5E-02	1.5E-02	1.5E-02	1.5E-02
Total Fatalities	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01

	Non-Radiological - Truck					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01	1.7E-01
Accident Occupational Fatalities	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00	1.5E+00
Accident Non-Occupational Fatalities	5.4E+00	5.4E+00	5.4E+00	5.4E+00	5.4E+00	5.4E+00
Accident Occupational Injuries	3.2E+00	3.2E+00	3.2E+00	3.2E+00	3.2E+00	3.2E+00
Accident Non-Occupational Injuries	9.1E+01	9.1E+01	9.1E+01	9.1E+01	9.1E+01	9.1E+01
Total Fatalities	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01
Accident Occupational Fatalities	3.9E-02	3.9E-02	3.9E-02	3.9E-02	3.9E-02	3.9E-02
Accident Non-Occupational Fatalities	5.7E-01	5.7E-01	5.7E-01	5.7E-01	5.7E-01	5.7E-01
Accident Occupational Injuries	5.3E+00	5.3E+00	5.3E+00	5.3E+00	5.3E+00	5.3E+00
Accident Non-Occupational Injuries	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
Total Fatalities	7.4E-01	7.4E-01	7.4E-01	7.4E-01	7.4E-01	7.4E-01

Table 4-12. Transport Risks: Spent Fuel - MRS to Repository (100T Cask - MRS Cases 1 and 2)

OAK RIDGE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	2.1E-03	2.9E-03	3.7E-03	4.6E-03	5.5E-03	4.7E-03
Normal Non-Occupational Fatalities	1.5E-02	2.6E-02	2.4E-02	2.5E-02	3.2E-02	[illegible]
Accident Non-Occupational Fatalities	5.6E-03	1.1E-02	9.7E-03	1.0E-02	1.0E-02	[illegible]
Total Fatalities	2.3E-02	4.0E-02	3.7E-02	4.0E-02	4.7E-02	4.1E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.2E-02	7.2E-02	8.6E-02	1.1E-01	1.3E-01	7.2E-02
Accident Occupational Fatalities	3.4E-01	6.4E-01	9.3E-01	1.3E+00	1.6E+00	1.4E+00
Accident Non-Occupational Fatalities	5.0E+00	9.3E+00	1.4E+01	1.9E+01	2.4E+01	2.1E+01
Accident Occupational Injuries	4.7E+01	8.7E+01	1.3E+02	1.8E+02	2.2E+02	1.9E+02
Accident Non-Occupational Injuries	9.7E+00	1.8E+01	2.6E+01	3.6E+01	4.6E+01	[illegible]
Total Fatalities	5.4E+00	1.0E+01	1.5E+01	2.0E+01	2.5E+01	2.2E+01

HARTSVILLE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	2.2E-03	2.2E-03	3.3E-03	4.2E-03	5.1E-03	4.5E-03
Normal Non-Occupational Fatalities	1.5E-02	1.3E-02	2.3E-02	2.5E-02	3.1E-02	3.2E-02
Accident Non-Occupational Fatalities	5.7E-03	5.0E-03	9.4E-03	9.7E-03	9.8E-03	1.2E-02
Total Fatalities	2.3E-02	2.0E-02	3.6E-02	3.09-02	4.6E-02	4.9E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.3E-02	3.5E-02	7.2E-02	7.5E-02	1.2E-01	6.1E-02
Accident Occupational Fatalities	3.8E-01	3.8E-01	7.8E-01	1.1E+00	1.5E+00	1.3E+00
Accident Non-Occupational Fatalities	5.5E+00	5.5E+00	1.1E+01	1.6E+01	2.2E+01	1.9E+01
Accident Occupational Injuries	5.2E+01	5.2E+01	1.1E+02	1.5E+02	2.0E+02	1.3E+02
Accident Non-Occupational Injuries	1.1E+01	1.1E+01	2.2E+01	3.2E+01	4.2E+01	[illegible]
Total Fatalities	5.9E+00	5.9E+00	1.2E+01	1.8E+01	2.3E+01	2.1E+01

Table 4-13. Transportation Risks: Secondary Wastes - MRS to Repository [illegible]

OAK RIDGE MRS

	Radiological [illegible]					
	GIR	Vacherie	Permian	[illegible]	[illegible]	[illegible]
Normal Occupational Fatalities	7.4E-04	1.0E-03	1.3E-03	[illegible]	[illegible]	[illegible]
Normal Non-Occupational Fatalities	5.4E-03	9.2E-03	8.3E-03	[illegible]	[illegible]	[illegible]
Accident Non-Occupational Fatalities	4.9E-03	1.4E-02	1.5E-02	1.7E-02	[illegible]	[illegible]
Total Fatalities	1.1E-02	2.4E-02	2.5E-02	[illegible]	[illegible]	[illegible]

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	4.3E-03	2.5E-02	3.0E-02	3.6E-02	4.6E-02	3.1E-02
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Total Fatalities	4.3E-03	2.5E-02	3.0E-02	3.6E-02	4.6E-02	3.1E-02

HARTSVILLE MRS

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	8.1E-03	1.2E-02	2.5E-02	2.6E-02	4.2E-02	2.6E-02
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Total Fatalities	8.1E-03	1.2E-02	2.5E-02	2.6E-02	4.2E-02	2.6E-02

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	7.7E-04	7.7E-04	1.1E-03	1.5E-03	1.8E-03	1.9E-03
Normal Non-Occupational Fatalities	5.3E-03	4.5E-03	8.1E-03	8.5E-03	1.1E-02	1.4E-02
Accident Non-Occupational Fatalities	6.1E-03	6.8E-03	1.3E-02	1.4E-02	2.1E-02	1.7E-02
Total Fatalities	1.2E-02	1.2E-02	2.3E-02	2.4E-02	3.4E-02	[illegible]

Table 4-14. Transportation Risks: Spent Fuel - MRS to Repository (150T Cask - [illegible]

OAK RIDGE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.5E-04	7.5E-04	9.5E-04	1.2E-03	2.2E-03	[illegible]
Normal Non-Occupational Fatalities	3.9E-03	6.8E-03	6.1E-03	6.5E-03	1.3E-02	[illegible]
Accident Non-Occupational Fatalities	3.9E-03	7.5E-03	6.8E-03	7.1E-03	9.6E-03	[illegible]
Total Fatalities	8.4E-03	1.5E-02	1.4E-02	1.5E-02	2.4E-02	1.7E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	3.2E-03	1.9E-02	2.2E-02	2.7E-02	5.3E-02	2.0E-02
Accident Occupational Fatalities	8.9E-02	1.7E-01	2.4E-01	3.4E-01	6.4E-01	3.9E-01
Accident Non-Occupational Fatalities	1.3E+00	2.4E+00	3.5E+00	4.9E+00	9.4E+00	5.7E+00
Accident Occupational Injuries	1.2E+01	2.3E+01	3.3E+01	4.6E+01	8.8E+01	5.4E+01
Accident Non-Occupational Injuries	2.5E+00	4.7E+00	6.9E+00	9.5E+00	1.6E+01	1.1E+01
Total Fatalities	1.4E+00	2.6E+00	3.8E+00	5.3E+00	1.0E+01	6.1E+00

HARTSVILLE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.7E-04	5.7E-04	8.5E-04	1.1E-03	2.0E-03	1.2E-03
Normal Non-Occupational Fatalities	3.9E-03	3.3E-03	6.0E-03	6.5E-03	1.2E-02	9.0E-03
Accident Non-Occupational Fatalities	4.0E-03	3.5E-03	6.6E-03	6.8E-03	9.4E-03	1.0E-02
Total Fatalities	8.5E-03	7.4E-03	1.3E-02	1.4E-02	2.4E-02	2.1E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	5.1E-03	9.1E-03	1.9E-02	2.0E-02	4.6E-02	1.7E-02
Accident Occupational Fatalities	9.9E-02	9.9E-02	2.0E-01	2.9E-01	5.9E-01	3.7E-01
Accident Non-Occupational Fatalities	1.4E+00	1.4E+00	3.0E+00	4.3E+00	8.5E+00	[illegible]
Accident Occupational Injuries	1.4E+01	1.4E+01	2.8E+01	4.0E+01	5.0E+01	[illegible]
Accident Non-Occupational Injuries	2.8E+00	2.8E+00	5.8E+00	8.3E+00	1.7E+01	[illegible]
Total Fatalities	1.5E+00	1.5E+00	3.2E+00	4.6E+00	9.2E+00	[illegible]

Table 4-15. Transport Risks: Secondary Wastes - MRS to Repository (15 [illegible]

OAK RIDGE MRS

	Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.4E-04	6.0E-04	7.7E-04	9.[illegible]	1.2E-03	1.2E-03
Normal Non-Occupational Fatalities	3.3E-03	5.6E-03	5.1E-03	5.3E-03	6.[illegible]	[illegible]
Accident Non-Occupational Fatalities	4.6E-03	1.4E-02	1.5E-02	1.7E-02	2.2E-02	1.7E-02
Total Fatalities	8.4E-03	2.0E-02	2.1E-02	2.3E-02	3.0E-02	2.5E-02

	Non-Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.5E-03	1.5E-02	1.8E-02	2.2E-02	2.8E-02	1.8E-02
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Total Fatalities	2.5E-03	1.5E-02	1.8E-02	2.2E-02	2.8E-02	1.8E-02

HARTSVILLE MRS

	Radiological - Risk					
	CIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.6E-04	4.6E-04	6.5E-04	8.7E-04	1.1E-03	1.1E-03
Normal Non-Occupational Fatalities	3.2E-03	2.7E-03	4.9E-03	5.3E-03	6.2E-03	6.5E-03
Accident Non-Occupational Fatalities	6.0E-03	6.7E-03	1.3E-02	1.4E-02	2.0E-02	1.7E-02
Total Fatalities	9.7E-03	9.8E-03	1.9E-02	2.0E-02	2.8E-02	2.7E-02

	Non-Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	[illegible]	[illegible]
Normal Non-Occupational Fatalities	4.8E-03	7.2E-03	1.5E-02	[illegible]	[illegible]	[illegible]
Accident Occupational Fatalities	.0E+00	[illegible]	.0E+00	[illegible]	[illegible]	[illegible]
Accident Non-Occupational Fatalities	.0E+00	[illegible]	.0E+00	[illegible]	[illegible]	[illegible]
Accident Occupational Injuries	.0E+00	.0E+00	[illegible]	[illegible]	[illegible]	[illegible]
Accident Non-Occupational Injuries	.0E+00	.0E+00	[illegible]	[illegible]	[illegible]	[illegible]
Total Fatalities	4.8E-03	7.2E-03	1.5E-02	[illegible]	[illegible]	[illegible]

Table 4-16. Transport Risks: Spent Fuel - MRS to Repository ([illegible]

OAK RIDGE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	1.9E-03	2.7E-03	3.4E-03	4.2E-03	5.1E-03	[illegible]
Normal Non-Occupational Fatalities	1.4E-02	2.4E-02	2.2E-02	2.3E-02	[illegible]	[illegible]
Accident Non-Occupational Fatalities	5.2E-03	9.9E-03	[illegible]	[illegible]	[illegible]	[illegible]
Total Fatalities	2.1E-02	2.7E-02	3.4E-02	3.7E-02	4.4E-02	3.6E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	1.1E-02	6.6E-02	7.9E-02	9.7E-02	1.2E-01	[illegible]
Accident Occupational Fatalities	3.2E-01	5.9E-01	8.6E-01	1.2E+00	1.5E+00	1.3E+00
Accident Non-Occupational Fatalities	4.6E+00	8.6E+00	1.3E+01	1.7E+01	2.2E+01	1.9E+01
Accident Occupational Injuries	4.3E+01	6.1E+01	1.2E+02	1.6E+02	2.1E+02	[illegible]
Accident Non-Occupational Injuries	9.0E+00	1.7E+01	2.4E+01	3.4E+01	4.3E+01	3.7E+01
Total Fatalities	5.0E+00	9.2E+00	1.4E+01	1.9E+01	2.4E+01	2.0E+01

HARTSVILLE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	2.0E-03	2.0E-03	3.0E-03	3.8E-03	4.7E-03	4.1E-03
Normal Non-Occupational Fatalities	1.4E-02	1.2E-02	2.1E-02	2.3E-02	2.9E-02	3.0E-02
Accident Non-Occupational Fatalities	5.3E-03	4.6E-03	8.7E-03	9.0E-03	9.1E-03	1.1E-02
Total Fatalities	2.1E-02	1.8E-02	3.3E-02	3.6E-02	4.3E-02	4.5E-02

	diological - Rail					
	GIR	Vacherie	an	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	3.2E-02	3.2E-02	[illegible]	6.9E-02	1.1E-01	5.7E-02
Accident Occupational Fatalities	3.5E-01	3.5E-01	7.2E-01	1.0E+00	1.4E+00	1.2E+00
Accident Non-Occupational Fatalities	5.1E+00	5.1E+00	1.1E+01	1.5E+01	2.0E+01	[illegible]
Accident Occupational Injuries	4.8E+01	4.8E+01	9.9E+01	1.4E+02	1.9E+02	[illegible]
Accident Non-Occupational Injuries	1.0E+01	9.9E+00	2.1E+01	2.9E+01	3.9E+01	[illegible]
Total Fatalities	5.5E+00	5.5E+00	1.1E+01	1.6E+01	2.1E+01	1.9E+01

Table 4-17. Transport Risks: Secondary Wastes - MRS to Repositor[illegible]

OAK RIDGE MRS

	Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	7.1E-04	7.1E-04	1.1E-03	1.3E-03	1.7E-03	[illegible]
Normal Non-Occupational Fatalities	4.9E-03	4.1E-03	7.5E-03	6.1E-03	1.0E-02	[illegible]
Accident Non-Occupational Fatalities	5.6E-03	6.3E-03	1.2E-02	1.3E-02	[illegible]	[illegible]
Total Fatalities	1.1E-02	1.1E-02	2.1E-02	2.2E-02	3.[illegible]E-02	3.1E-02

	Non-Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	7.5E-03	1.1E-02	2.3E-02	2.4E-02	3.9E-02	2.4E-02
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Total Fatalities	7.5E-03	1.1E-02	2.3E-02	2.4E-02	3.9E-02	2.4[illegible]-02

HARTSVILLE MRS

	Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	6.8E-04	9.3E-04	1.2E-03	1.[illegible]E-03	1.6E-03	1.4E-03
Normal Non-Occupational Fatalities	5.0E-03	8.5E-03	7.7E-03	8.1E-03	1.0E-02	1.1E-02
Accident Non-Occupational Fatalities	4.5E-03	1.3E-02	1.4E-02	1.6E-02	2.0E-02	1.5E-02
Total Fatalities	1.0E-02	2.3E-02	2.3E-02	2.6E-02	3.3E-02	2.[illegible]E-02

	Non-Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	3.9E-03	2.3E-02	2.7E-02	3.4E-02	4.3E-02	2.[illegible]
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Total Fatalities	3.9E-03	2.3E-02	2.7E-02	3.4E-02	4.3E-02	[illegible]

Table 4-18. Transport Risks: Spent Fuel - MRS to Repository ([illegible] - MRS Cases [illegible])

OAK RIDGE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.1E-04	6.9E-04	8.8E-04	1.1E-03	2.0E-03	1.2E-03
Normal Non-Occupational Fatalities	3.6E-03	6.2E-03	5.7E-03	6.0E-03	1.2E-02	6.7E-03
Accident Non-Occupational Fatalities	3.6E-03	6.9E-03	6.1E-03	6.5E-03	6.8E-03	7.3E-03
Total Fatalities	7.2E-03	1.4E-02	1.3E-02	1.4E-02	2.2E-02	1.6E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	3.0E-03	1.7E-02	2.1E-02	2.5E-02	4.9E-02	1.9E-02
Accident Occupational Fatalities	8.3E-02	1.5E-01	2.2E-01	3.1E-01	6.0E-01	3.6E-01
Accident Non-Occupational Fatalities	1.2E+00	2.2E+00	3.1E+00	4.5E+00	8.7E+00	5.3E+00
Accident Occupational Injuries	1.1E+01	2.1E+01	3.1E+01	4.2E+01	8.2E+01	5.0E+01
Accident Non-Occupational Injuries	2.3E+00	4.3E+00	[illegible]	[illegible]	1.7E+01	1.0E+01
Total Fatalities	1.3E+00	2.4E+00	3.5E+00	4.9E+00	9.3E+00	5.7E+00

HARTSVILLE MRS

	Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	5.3E-04	5.3E-04	7.9E-04	1.0E-03	1.9E-03	1.1E-03
Normal Non-Occupational Fatalities	3.6E-03	3.0E-03	[illegible]	6.0E-03	1.1E-02	8.3E-03
Accident Non-Occupational Fatalities	3.7E-03	3.2E-03	6.3E-03	6.3E-03	8.7E-03	9.6E-03
Total Fatalities	7.9E-03	6.8E-03	1.2E-02	1.3E-02	2.2E-02	1.9E-02

	Non-Radiological - Rail					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	5.6E-03	8.4E-03	1.2E-02	1.6E-02	4.4E-02	1.6E-02
Accident Occupational Fatalities	9.1E-02	9.1E-02	1.4E-01	2.7E-01	5.4E-01	3.4E-01
Accident Non-Occupational Fatalities	1.3E+00	1.3E+00	2.2E+00	3.9E+00	7.9E+00	5.0E+00
Accident Occupational Injuries	1.3E+01	1.3E+01	[illegible]	2.7E+01	7.4E+01	4.7E+01
Accident Non-Occupational Injuries	2.6E+00	2.6E+00	[illegible]	7.7E+00	1.5E+01	9.5E+00
Total Fatalities	1.4E+00	1.4E+00	[illegible]	4.2E+00	8.5E+00	5.3E+00

Table 5-19. Transport Risks: Secondary Wastes - MRS to Repository ([illegible] - MRS Cases [illegible]

OAK RIDGE MRS

	Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.1E-04	5.6E-04	7.1E-04	5.9E-04	1.1E-03	[illegible]
Normal Non-Occupational Fatalities	3.0E-03	5.2E-03	4.7E-03	4.9E-03	6.3E-03	[illegible]
Accident Non-Occupational Fatalities	4.4E-03	1.3E-02	1.4E-02	1.6E-02	2.0E-02	[illegible]
Total Fatalities	7.8E-03	1.9E-02	1.9E-02	2.2E-02	2.7E-02	2.3E-02

	Non-Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	2.3E-03	1.4E-02	1.6E-02	2.0E-02	2.6E-02	1.7E-02
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Total Fatalities	2.3E-03	1.4E-02	1.6E-02	2.0E-02	2.6E-02	1.7E-02

HARTSVILLE MRS

	Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Occupational Fatalities	4.3E-04	4.3E-04	6.3E-04	8.1E-04	9.9E-04	1.1E-03
Normal Non-Occupational Fatalities	3.0E-03	2.5E-03	4.6E-03	4.9E-03	6.2E-03	7.7E-03
Accident Non-Occupational Fatalities	5.5E-03	6.2E-03	1.2E-02	1.3E-02	1.9E-02	1.5E-02
Total Fatalities	8.9E-03	9.1E-03	1.7E-02	1.8E-02	2.6E-02	2.4E-02

	Non-Radiological - Risk					
	GIR	Vacherie	Permian	Paradox	Yucca Mt.	Hanford
Normal Non-Occupational Fatalities	4.4E-03	6.7E-03	1.4E-02	1.4E-02	2.3E-02	1.4E-02
Accident Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00
Accident Non-Occupational Fatalities	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Accident Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Accident Non-Occupational Injuries	.0E+00	.0E+00	.0E+00	.0E+00	.0E+00	[illegible]
Total Fatalities	4.4E-03	6.7E-03	1.4E-02	1.4E-02	2.3E-02	[illegible]

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