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Validation of the Transportation Computer Codes HIGHWAY, INTERLINE, RADTRAN 4, and RISKIND

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Idaho National Engineering Laboratory

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ABSTRACT

The computer codes HIGHWAY, INTERLINE, RADTRAN 4, and RISKIND were used to estimate radiation doses from the transportation of radioactive material in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement.* HIGHWAY and INTERLINE were used to estimate transportation routes for truck and rail shipments, respectively. RADTRAN 4 was used to estimate collective doses from incident-free transportation and the risk (probability × consequence) from transportation accidents. RISKIND was used to estimate incident-free radiation doses for maximally exposed individuals and the consequences from reasonably foreseeable transportation accidents. The purpose of this analysis is to validate the estimates made by these computer codes; critiques of the conceptual models used in RADTRAN 4 are also discussed. Validation is defined as "the test and evaluation of the completed software to ensure compliance with software requirements." In this analysis, validation means that the differences between the estimates generated by these codes and independent observations are small (i.e., within the acceptance criterion established for the validation analysis). In some cases, the independent observations used in the validation were measurements; in other cases, the independent observations used in the validation analysis were generated using hand calculations. The results of the validation analyses performed for HIGHWAY, INTERLINE, RADTRAN 4, and RISKIND show that the differences between the estimates generated using the computer codes and independent observations were small. Based on the acceptance criterion established for the validation analyses, the codes yielded acceptable results; in all cases the estimates met the requirements for successful validation.

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TABLES

Validation of the Transportation Computer Codes HIGHWAY, INTERLINE, RADTRAN 4, and RISKIND

1. INTRODUCTION

The computer codes HIGHWAY, INTERLINE, RADTRAN 4, and RISKIND were used to estimate radiation doses from the transportation of radioactive material in DOE (1995). HIGHWAY and INTERLINE were used to estimate transportation routes for truck and rail shipments, respectively. RADTRAN 4 was used to estimate collective doses from incident-free transportation and the risk (probability × consequence) from transportation accidents. RISKIND was used to estimate incident-free radiation doses for maximally exposed individuals and the consequences from reasonably foreseeable transportation accidents. The purpose of this analysis is to validate the estimates made by these computer codes. Validation was defined as "the test and evaluation of the completed software to ensure compliance with software requirements" (ASME 1989). In the context of this analysis, compliance with software requirements means that the differences between the estimates generated by these codes and independent observations are small (i.e., within the acceptance criterion established for the validation analysis). In some cases, the independent observations used in the validation were measurements; in other cases, the independent observations used in the validation analysis were generated using hand calculations.

Chapter 2 contains the validation analysis for the HIGHWAY and INTERLINE computer codes. Chapter 3 contains the validation analysis for the incident-free unit risk factors calculated using the RADTRAN 4 computer code. Chapter 4 contains the validation analysis for the accident risks calculated using the RADTRAN 4 computer code. Chapter 5 contains the validation analysis for the incident-free radiation doses calculated using the RISKIND computer code. Chapter 6 contains the validation analysis for the accident radiation doses calculated using the RISKIND computer code.

2. VALIDATION OF THE HIGHWAY AND INTERLINE RADIOACTIVE MATERIALS TRANSPORTATION ROUTING COMPUTER CODES

2.1 Introduction

The HIGHWAY and INTERLINE computer codes (Johnson et al. 1993a, 1993b) were used to determine the transportation routes for radioactive material shipments in DOE (1995). The purpose of this analysis is to validate the predictions made by HIGHWAY and INTERLINE. The definition of validation used in this analysis was "the test and evaluation of the completed software to ensure compliance with software requirements" (ASME 1989). In the context of this analysis, compliance with software requirements means that the origin to destination distances (predictions) generated by the HIGHWAY and INTERLINE computer codes were compared to origin to destination distances generated using independent data bases (observations); if the differences between the predictions and observations are small (i.e., within the acceptance criterion established for the validation analysis), then the predictions are valid.

The HIGHWAY computer code was used to estimate truck routes and origin to destination distances. HIGHWAY contains a computerized road atlas of the United States that includes the interstate highway system, most U.S. highways, and many state, county and local highways. The HIGHWAY computer code selects transportation routes by minimizing the distance and driving time between an origin and destination. In addition, HIGHWAY can be used to select routes that comply with U.S. Department of Transportation regulations for the routing of radioactive material shipments. HIGHWAY also contains an option to calculate population densities along the route using block group-level data from the 1990 U.S. Census. In the validation analysis, the predictions consisted of origin to destination distances generated using HIGHWAY; the independent observations used for comparison were obtained from the Map-n-Go computer code (Delorme 1994).

The INTERLINE computer code was used to estimate rail routes and origin to destination distances. INTERLINE contains a computerized road atlas of the United States and includes all rail lines with the exception of industrial spurs. The INTERLINE computer code selects transportation routes by preferentially routing shipments along mainlines, while minimizing interchanges between railroads. As with HIGHWAY, INTERLINE also contains an option to calculate population densities along the route using block group-level data from the 1990 U.S. Census. In the validation analysis, the predictions consisted of origin to destination distances generated using INTERLINE; the independent observations used for comparison were obtained from the Railroad Information Service (Eggleston 1995).

2.2 Methods and Materials

In DOE (1995), approximately 300 truck routes (generated using HIGHWAY) and 300 rail routes (generated using INTERLINE) were evaluated. This large number of routes made it impractical to validate all the routes. In addition, the results presented in DOE (1995) indicate that the five Centralization Alternatives (Centralization at the Hanford Site, the Savannah River Site, the Idaho National Engineering Laboratory, the Oak Ridge Reservation, and the Nevada Test Site) yielded the largest transportation doses and risks for shipments of spent nuclear fuel. Based on these two considerations, a risk-based screening approach was used to select the routes evaluated in the validation analysis.

The risk-based screening approach was based on shipment-miles, the product of the number of shipments from a particular origin to a particular destination and the distance between the origin and destination. Shipment-miles provide an estimate of the total distance traveled by the shipments and are proportional to transportation dose and risk. For each of the five Centralization Alternatives, the shipment-miles were calculated for each origin and destination (see Tables 2-1 through 2-10). Within each Centralization Alternative, the cumulative fraction of the total shipment-miles was calculated for each origin and destination. Routes that contributed greater than 80 cumulative percent of the total shipment-miles for a Centralization Alternative were evaluated in the validation analysis.

For each of the truck routes selected for validation using the risk-based screening approach, the Map-n-Go computer code, an independent highway routing computer code from Delorme Mapping Company (Delorme 1994), was used to calculate the distance from the origin of the route to the destination of the route. For each route, origins and destinations were matched with those used by the HIGHWAY computer code and the routes were selected and distances were calculated independently using the Map-n-Go computer code. In some cases, the Map-n-Go computer code did not contain a node (i.e., an origin or destination) that matched the HIGHWAY node; for example, nodes on U.S. Department of Energy sites. In these cases, HIGHWAY was rerun using a nearby node that was also contained in Map-n-Go data base. Options in Map-n-Go were selected to match the route that would be required for a radioactive material shipment; for example, options were selected to favor travel on limited access roads, toll roads, and national highways, and to avoid travel on forest roads and ferries. The distances generated by the Map-n-Go computer code were compared to the distances generated using the HIGHWAY computer code (see Table 2-11).

An alternative computer code for generating rail routes was not available. Instead, the Railroad Information Service was used to generate independent estimates of the rail routes selected for validation using the risk-based screening approach. The Railroad Information Service, located in Georgetown, Texas, is a rail mapping company that owns proprietary rail line data bases and is currently developing rail routing and scheduling software (Eggleston 1995). The Railroad Information Service was provided with node descriptions generated by the INTERLINE computer code for each of the rail routes selected for evaluation in the validation analysis. As with the HIGHWAY computer code, sometimes the Railroad Information Service data base did not contain a node that matched the INTERLINE node (e.g., nodes on U.S. Department of Energy sites). In these cases, INTERLINE was rerun using a nearby node that was also contained in Railroad Information data base. The Railroad Information Service reported the distance results as generated from its independent databases; these distances were compared to the distances generated using the INTERLINE computer code (see Table 2-12).

In order to evaluate the predictions made by HIGHWAY and INTERLINE, a quantitative metric that measures the difference between the predictions and observations was necessary. Many quantitative metrics currently exist, such as the maximum difference, the maximum relative difference, and the relative root mean square error (Baca and Magnuson 1990). In this validation analysis, three metrics were calculated: (1) the difference between the predictions and the observations, (2) the absolute value of the percent difference between the predictions and the observations, and (3) the relative root mean square error (RRMSE) of the predictions and the observations. The absolute difference and the absolute value of the percent difference were calculated in order to provide data on the differences for individual routes. The RRMSE was calculated in order to measure the overall difference between the predictions and observations and was the metric chosen for the acceptance criterion in the validation analysis. The metrics were calculated using the following equations:

$$\text{Absolute Difference} = \text{Predicted distance} - \text{Observed distance}$$

$$\text{Percent Difference} = \frac{\text{Predicted distance} - \text{Observed distance}}{\text{Predicted distance}} \times 100$$

$$\text{RRMSE} = \sqrt{\frac{\sum_{i=1}^{k} \left(\frac{P_i - O_i}{P_i}\right)^2}{k}}$$

where

P_i	=	the predicted distance for route i
O_i	=	the observed distance for route i
k	=	the number of routes evaluated in the validation analysis.

The acceptance criterion established for this validation analysis was based on values of the RRMSE (Baca and Magnuson 1990):

- Excellent - RRMSE ≤ 0.05
- Acceptable - 0.05 < RRMSE ≤ 0.10
- Unacceptable - RRMSE > 0.10

2.3 Results

Table 2-11 presents the results of the validation analysis for the HIGHWAY computer code. The average difference between the predictions and the observations was 21.8 kilometers (13.5 miles). Qualitatively, HIGHWAY did not consistently underestimate or overestimate. This suggests the absence of systematic bias in the predictions made by HIGHWAY. The absolute value of the percent difference between the predictions and the observations was 2.0 percent. A percent difference of 2 percent in the results is not considered to be significant relative to the overall uncertainty in dose assessments, which can have geometric standard deviations that approach 3 (Maheras et al. 1994). The value of the RRMSE was 0.025. Based on the acceptance criterion established for the validation analysis, HIGHWAY yields excellent results.

Table 2-12 presents the results of the validation analysis for the INTERLINE computer code. The average difference between the predictions and the observations was -13.9 kilometers (-8.6 miles). The absolute value of the percent difference between the predictions and the observations was 0.60 percent. A percent difference of 0.60 percent in the results is not considered to be significant relative to the overall uncertainty in dose assessments, which can have geometric standard deviations that approach 3 (Maheras et al. 1994). The value of the RRMSE was 0.0074. Based on the acceptance criterion established for the validation analysis, INTERLINE yields excellent results.

2.4 Conclusions

A validation analysis was conducted for transportation routes predicted by the HIGHWAY and INTERLINE computer codes. Using a risk-based screening approach based on shipment-miles, the distances predicted by HIGHWAY and INTERLINE were compared to independent observations from the Delorme Mapping Company and the Railroad Information Service. Using the acceptance criterion established for the validation analysis, both HIGHWAY and INTERLINE yielded excellent results. This demonstrates that HIGHWAY and INTERLINE, within their domain of applicability, adequately represent the systems that they were intended to describe; consequently, the predictions made by HIGHWAY and INTERLINE are considered validated.

Table 2-1. Centralization at the Hanford Site cumulative shipment-miles for truck shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Hanford Site	Savannah River Site	2727.0	864	2.36E+06	26.965
Hanford Site	Hampton Roads, VA	2903.0	541	1.57E+06	44.939
Hanford Site	Idaho National Engineering Laboratory	599.0	1918	1.15E+06	58.088
Hanford Site	Alexandria Bay, NY	2768.0	236	6.53E+05	65.564
Hanford Site	Gaithersburg, MD	2732.0	188	5.14E+05	71.442
Hanford Site	Oak Ridge Reservation	2464.0	120	2.96E+05	74.826
Hanford Site	Fort St. Vrain Nuclear Generating Station	1108.0	247	2.74E+05	77.958
Hanford Site	University of Missouri - Columbia	1870.0	145	2.71E+05	81.061
Hanford Site	West Valley Demonstration Project	2556.0	83	2.12E+05	83.489
Hanford Site	Massachusetts Institute of Technology	2986.0	69	2.06E+05	85.847
Hanford Site	Brookhaven National Laboratory	2853.0	71	2.03E+05	88.165
Hanford Site	Oakland, CA	875.0	231	2.02E+05	90.479
Hanford Site	University of Michigan	2227.0	72	1.60E+05	92.314
Hanford Site	Rhode Island Nuclear Science Center	2965.0	32	9.49E+04	93.400
Hanford Site	Georgia Institute of Technology	2550.0	19	4.85E+04	93.954
Hanford Site	Rensselaer Polytechnic Institute	2819.0	16	4.51E+04	94.470
Hanford Site	Sandia National Laboratories-Albuquerque	1584.0	27	4.28E+04	94.960
Hanford Site	Texas A&M University	2212.0	15	3.32E+04	95.340
Hanford Site	University of Virginia	2757.0	12	3.31E+04	95.718
Hanford Site	Cornell University	2730.0	12	3.28E+04	96.093
Hanford Site	State University of New York - Buffalo	2534.0	12	3.04E+04	96.441
Hanford Site	Los Alamos National Laboratory	1560.0	17	2.65E+04	96.745
Hanford Site	University of Illinois	2033.0	13	2.64E+04	97.047
Hanford Site	North Carolina State University	2862.0	8	2.29E+04	97.309
Hanford Site	Argonne National Laboratory - East	1998.0	11	2.20E+04	97.561
Hanford Site	University of Florida	2894.0	7	2.03E+04	97.793
Hanford Site	University of Wisconsin	1943.0	9	1.75E+04	97.993
Hanford Site	Pennsylvania State University	2578.0	6	1.55E+04	98.170
Hanford Site	University of Missouri - Rolla	2082.0	7	1.46E+04	98.336
Hanford Site	University of Maryland	2753.0	5	1.38E+04	98.494
Hanford Site	University of Lowell	2991.0	4	1.20E+04	98.631
Hanford Site	Worcester Polytechnic Institute	2948.0	4	1.18E+04	98.766
Hanford Site	Kansas State University	1624.0	7	1.14E+04	98.896
Hanford Site	San Diego, CA	1352.0	8	1.08E+04	99.020
Hanford Site	University of Texas	2216.0	4	8.86E+03	99.121
Hanford Site	Purdue University	2111.0	4	8.44E+03	99.218
Hanford Site	Manhattan College	2786.0	3	8.36E+03	99.314
Hanford Site	Ohio State University	2342.0	3	7.03E+03	99.394
Hanford Site	Midland, MI	2318.0	3	6.95E+03	99.474
Hanford Site	Iowa State University	1703.0	4	6.81E+03	99.551
Hanford Site	Denver, CO	1133.0	6	6.80E+03	99.629
Hanford Site	Babcock & Wilcox	2738.0	2	5.48E+03	99.692
Hanford Site	University of Arizona	1699.0	3	5.10E+03	99.750
Hanford Site	University of California - Irvine	1270.0	3	3.81E+03	99.794
Hanford Site	Pleasanton, CA	881.0	4	3.52E+03	99.834
Hanford Site	Washington State University	361.0	8	2.89E+03	99.867
Hanford Site	San Ramon,CA	874.0	3	2.62E+03	99.897
Hanford Site	McClellan AFB, CA	830.0	3	2.49E+03	99.926
Hanford Site	Oregon State University	324.0	6	1.94E+03	99.948
Hanford Site	University of Utah	643.0	3	1.93E+03	99.970
Hanford Site	University of New Mexico	1593.0	1	1.59E+03	99.988
Hanford Site	Idaho State University	546.0	1	5.46E+02	99.995
Hanford Site	Reed College	236.0	2	4.72E+02	100.000
Total			**5102**	**8.74E+06**	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-2. Centralization at the Savannah River Site cumulative shipment-miles for truck shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Savannah River Site	Hanford Site	2727.0	1716	4.68E+06	40.219
Savannah River Site	Idaho National Engineering Laboratory	2311.0	1918	4.43E+06	78.314
Savannah River Site	Seattle, WA	2900.0	231	6.70E+05	84.072
Savannah River Site	Fort St. Vrain Nuclear Generating Station	1636.0	247	4.04E+05	87.545
Savannah River Site	Hampton Roads, VA	505.0	541	2.73E+05	89.893
Savannah River Site	Alexandria Bay, NY	1012.0	236	2.39E+05	91.946
Savannah River Site	University of Missouri - Columbia	858.0	145	1.24E+05	93.015
Savannah River Site	Gaithersburg, MD	597.0	188	1.12E+05	93.979
Savannah River Site	West Valley Demonstration Project	883.0	83	7.33E+04	94.609
Savannah River Site	Massachusetts Institute of Technology	1040.0	69	7.18E+04	95.226
Savannah River Site	University of Michigan	903.0	72	6.50E+04	95.785
Savannah River Site	Brookhaven National Laboratory	897.0	71	6.37E+04	96.332
Savannah River Site	Oak Ridge Reservation	379.0	120	4.55E+04	96.723
Savannah River Site	Sandia National Laboratories-Albuquerque	1644.0	27	4.44E+04	97.105
Savannah River Site	Rhode Island Nuclear Science Center	1009.0	32	3.23E+04	97.382
Savannah River Site	Los Alamos National Laboratory	1742.0	17	2.96E+04	97.637
Savannah River Site	Washington State University	2699.0	8	2.16E+04	97.822
Savannah River Site	San Diego, CA	2345.0	8	1.88E+04	97.983
Savannah River Site	Oregon State University	2937.0	6	1.76E+04	98.135
Savannah River Site	Texas A&M University	1099.0	15	1.65E+04	98.277
Savannah River Site	Rensselaer Polytechnic Institute	955.0	16	1.53E+04	98.408
Savannah River Site	State University of New York - Buffalo	1001.0	12	1.20E+04	98.511
Savannah River Site	Pleasanton, CA	2768.0	4	1.11E+04	98.606
Savannah River Site	Cornell University	896.0	12	1.08E+04	98.699
Savannah River Site	University of Illinois	803.0	13	1.04E+04	98.788
Savannah River Site	Argonne National Laboratory - East	892.0	11	9.81E+03	98.873
Savannah River Site	Denver, CO	1613.0	6	9.68E+03	98.956
Savannah River Site	University of Wisconsin	1038.0	9	9.34E+03	99.036
Savannah River Site	McClellan AFB, CA	2780.0	3	8.34E+03	99.108
Savannah River Site	San Ramon, CA	2775.0	3	8.33E+03	99.179
Savannah River Site	Kansas State University	1121.0	7	7.85E+03	99.247
Savannah River Site	University of California - Irvine	2406.0	3	7.22E+03	99.309
Savannah River Site	University of Utah	2127.0	3	6.38E+03	99.364
Savannah River Site	University of Missouri - Rolla	835.0	7	5.85E+03	99.414
Savannah River Site	University of Arizona	1926.0	3	5.78E+03	99.464
Savannah River Site	University of Virginia	478.0	12	5.74E+03	99.513
Savannah River Site	Reed College	2849.0	2	5.70E+03	99.562
Savannah River Site	Pennsylvania State University	849.0	6	5.09E+03	99.606
Savannah River Site	Iowa State University	1175.0	4	4.70E+03	99.646
Savannah River Site	University of Texas	1169.0	4	4.68E+03	99.686
Savannah River Site	University of Lowell	1045.0	4	4.18E+03	99.722
Savannah River Site	Worcester Polytechnic Institute	1002.0	4	4.01E+03	99.757
Savannah River Site	Georgia Institute of Technology	197.0	19	3.74E+03	99.789
Savannah River Site	University of Florida	496.0	7	3.47E+03	99.819
Savannah River Site	Midland, MI	1036.0	3	3.11E+03	99.845
Savannah River Site	Purdue University	768.0	4	3.07E+03	99.872
Savannah River Site	University of Maryland	589.0	5	2.95E+03	99.897
Savannah River Site	North Carolina State University	318.0	8	2.54E+03	99.919
Savannah River Site	Manhattan College	830.0	3	2.49E+03	99.940
Savannah River Site	Idaho State University	2248.0	1	2.25E+03	99.960
Savannah River Site	Ohio State University	708.0	3	2.12E+03	99.978
Savannah River Site	University of New Mexico	1653.0	1	1.65E+03	99.992
Savannah River Site	Babcock & Wilcox	455.0	2	9.10E+02	100.000
Total			5954	1.16E+07	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-3. Centralization at the Idaho National Engineering Laboratory cumulative shipment-miles for truck shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
INEL	Savannah River Site	2311.0	864	2.00E+06	26.882
INEL	Hampton Roads, VA	2487.0	541	1.35E+06	44.996
INEL	Hanford Site	599.0	1716	1.03E+06	58.835
INEL	Alexandria Bay, NY	2352.0	236	5.55E+05	66.307
INEL	Gaithersburg, MD	2316.0	188	4.35E+05	72.169
INEL	Oak Ridge Reservation	2048.0	120	2.46E+05	75.478
INEL	Oakland, CA	963.0	231	2.22E+05	78.473
INEL	University of Missouri - Columbia	1454.0	145	2.11E+05	81.311
INEL	West Valley Demonstration Project	2140.0	83	1.78E+05	83.703
INEL	Massachusetts Institute of Technology	2570.0	69	1.77E+05	86.090
INEL	Brookhaven National Laboratory	2437.0	71	1.73E+05	88.420
INEL	Fort St. Vrain Nuclear Generating Station	692.0	247	1.71E+05	90.721
INEL	University of Michigan	1811.0	72	1.30E+05	92.476
INEL	Rhode Island Nuclear Science Center	2549.0	32	8.16E+04	93.574
INEL	Georgia Institute of Technology	2134.0	19	4.05E+04	94.120
INEL	Rensselaer Polytechnic Institute	2403.0	16	3.84E+04	94.638
INEL	Sandia National Laboratories-Albuquerque	1168.0	27	3.15E+04	95.063
INEL	University of Virginia	2341.0	12	2.81E+04	95.441
INEL	Cornell University	2314.0	12	2.78E+04	95.815
INEL	Texas A&M University	1796.0	15	2.69E+04	96.177
INEL	State University of New York - Buffalo	2118.0	12	2.54E+04	96.519
INEL	University of Illinois	1617.0	13	2.10E+04	96.802
INEL	North Carolina State University	2446.0	8	1.96E+04	97.066
INEL	Los Alamos National Laboratory	1144.0	17	1.94E+04	97.328
INEL	Argonne National Laboratory - East	1582.0	11	1.74E+04	97.562
INEL	University of Florida	2478.0	7	1.73E+04	97.796
INEL	University of Wisconsin	1612.0	9	1.45E+04	97.991
INEL	Pennsylvania State University	2162.0	6	1.30E+04	98.166
INEL	University of Maryland	2337.0	5	1.17E+04	98.323
INEL	University of Missouri - Rolla	1666.0	7	1.17E+04	98.480
INEL	University of Lowell	2575.0	4	1.03E+04	98.619
INEL	Worcester Polytechnic Institute	2532.0	4	1.01E+04	98.755
INEL	Kansas State University	1208.0	7	8.46E+03	98.869
INEL	San Diego, CA	976.0	8	7.81E+03	98.974
INEL	University of Texas	1800.0	4	7.20E+03	99.071
INEL	Manhattan College	2370.0	3	7.11E+03	99.167
INEL	Purdue University	1695.0	4	6.78E+03	99.258
INEL	Ohio State University	1926.0	3	5.78E+03	99.336
INEL	Midland, MI	1902.0	3	5.71E+03	99.412
INEL	Washington State University	652.0	8	5.22E+03	99.483
INEL	Iowa State University	1287.0	4	5.15E+03	99.552
INEL	Oregon State University	809.0	6	4.85E+03	99.617
INEL	Babcock & Wilcox	2322.0	2	4.64E+03	99.680
INEL	Denver, CO	717.0	6	4.30E+03	99.738
INEL	University of Arizona	1301.0	3	3.90E+03	99.790
INEL	Pleasanton, CA	969.0	4	3.88E+03	99.842
INEL	San Ramon, CA	962.0	3	2.89E+03	99.881
INEL	University of California - Irvine	942.0	3	2.83E+03	99.919
INFL	McClellan AFB, CA	875.0	3	2.63E+03	99.955
INEL	Reed College	721.0	2	1.44E+03	99.974
INEL	University of New Mexico	1177.0	1	1.18E+03	99.990
INEL	University of Utah	227.0	3	6.81E+02	99.999
INEL	Idaho State University	65.0	1	6.50E+01	100.000
Total			4900	7.43E+06	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-4. Centralization at the Oak Ridge Reservation cumulative shipment-miles for truck shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Oak Ridge Reservation	Hanford Site	2464.0	1716	4.23E+06	39.538
Oak Ridge Reservation	Idaho National Engineering Laboratory	2048.0	1918	3.93E+06	76.270
Oak Ridge Reservation	Seattle, WA	2636.0	231	6.09E+05	81.964
Oak Ridge Reservation	Fort St. Vrain Nuclear Generating Station	1372.0	247	3.39E+05	85.133
Oak Ridge Reservation	Savannah River Site	379.0	864	3.27E+05	88.195
Oak Ridge Reservation	Hampton Roads, VA	548.0	541	2.96E+05	90.967
Oak Ridge Reservation	Alexandria Bay, NY	927.0	236	2.19E+05	93.013
Oak Ridge Reservation	Gaithersburg, MD	536.0	188	1.01E+05	93.955
Oak Ridge Reservation	University of Missouri - Columbia	594.0	145	8.61E+04	94.761
Oak Ridge Reservation	Massachusetts Institute of Technology	965.0	69	6.66E+04	95.384
Oak Ridge Reservation	West Valley Demonstration Project	766.0	83	6.36E+04	95.978
Oak Ridge Reservation	Brookhaven National Laboratory	821.0	71	5.83E+04	96.523
Oak Ridge Reservation	University of Michigan	595.0	72	4.28E+04	96.924
Oak Ridge Reservation	Sandia National Laboratories-Albuquerque	1382.0	27	3.73E+04	97.273
Oak Ridge Reservation	Rhode Island Nuclear Science Center	933.0	32	2.99E+04	97.552
Oak Ridge Reservation	Los Alamos National Laboratory	1480.0	17	2.52E+04	97.787
Oak Ridge Reservation	Washington State University	2435.0	8	1.95E+04	97.969
Oak Ridge Reservation	San Diego, CA	2193.0	8	1.75E+04	98.133
Oak Ridge Reservation	Oregon State University	2674.0	6	1.60E+04	98.283
Oak Ridge Reservation	Texas A&M University	1004.0	15	1.51E+04	98.424
Oak Ridge Reservation	Rensselaer Polytechnic Institute	879.0	16	1.41E+04	98.556
Oak Ridge Reservation	Pleasanton, CA	2532.0	4	1.01E+04	98.650
Oak Ridge Reservation	Cornell University	821.0	12	9.85E+03	98.743
Oak Ridge Reservation	State University of New York - Buffalo	744.0	12	8.93E+03	98.826
Oak Ridge Reservation	Denver, CO	1340.0	6	8.04E+03	98.901
Oak Ridge Reservation	San Ramon, CA	2538.0	3	7.61E+03	98.972
Oak Ridge Reservation	McClellan AFB, CA	2517.0	3	7.55E+03	99.043
Oak Ridge Reservation	University of Illinois	516.0	13	6.71E+03	99.106
Oak Ridge Reservation	University of California - Irvine	2209.0	3	6.63E+03	99.168
Oak Ridge Reservation	University of Wisconsin	730.0	9	6.57E+03	99.229
Oak Ridge Reservation	Argonne National Laboratory - East	584.0	11	6.42E+03	99.289
Oak Ridge Reservation	Kansas State University	857.0	7	6.00E+03	99.345
Oak Ridge Reservation	University of Utah	1864.0	3	5.59E+03	99.398
Oak Ridge Reservation	University of Arizona	1782.0	3	5.35E+03	99.448
Oak Ridge Reservation	Reed College	2585.0	2	5.17E+03	99.496
Oak Ridge Reservation	University of Virginia	402.0	12	4.82E+03	99.541
Oak Ridge Reservation	Pennsylvania State University	774.0	6	4.64E+03	99.585
Oak Ridge Reservation	University of Texas	1026.0	4	4.10E+03	99.623
Oak Ridge Reservation	University of Missouri - Rolla	571.0	7	4.00E+03	99.660
Oak Ridge Reservation	University of Lowell	970.0	4	3.88E+03	99.697
Oak Ridge Reservation	Georgia Institute of Technology	202.0	19	3.84E+03	99.732
Oak Ridge Reservation	University of Florida	546.0	7	3.82E+03	99.768
Oak Ridge Reservation	Worcester Polytechnic Institute	927.0	4	3.71E+03	99.803
Oak Ridge Reservation	Iowa State University	900.0	4	3.60E+03	99.837
Oak Ridge Reservation	North Carolina State University	408.0	8	3.26E+03	99.867
Oak Ridge Reservation	University of Maryland	537.0	5	2.69E+03	99.892
Oak Ridge Reservation	Manhattan College	754.0	3	2.26E+03	99.913
Oak Ridge Reservation	Midland, MI	719.0	3	2.16E+03	99.933
Oak Ridge Reservation	Idaho State University	1985.0	1	1.99E+03	99.952
Oak Ridge Reservation	Purdue University	460.0	4	1.84E+03	99.969
Oak Ridge Reservation	University of New Mexico	1391.0	1	1.39E+03	99.982
Oak Ridge Reservation	Ohio State University	400.0	3	1.20E+03	99.993
Oak Ridge Reservation	Babcock & Wilcox	350.0	2	7.00E+02	100.000
Total			**6698**	**1.07E+07**	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-5. Centralization at the Nevada Test Site cumulative shipment-miles for truck shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Nevada Test Site	Savannah River Site	2414.0	864	2.09E+06	20.469
Nevada Test Site	Hanford Site	1128.0	1716	1.94E+06	39.466
Nevada Test Site	Hampton Roads, VA	2590.0	541	1.40E+06	53.217
Nevada Test Site	Idaho National Engineering Laboratory	712.0	1918	1.37E+06	66.620
Nevada Test Site	Alexandria Bay, NY	2619.0	236	6.18E+05	72.685
Nevada Test Site	Gaithersburg, MD	2488.0	188	4.68E+05	77.276
Nevada Test Site	Seattle, WA	1322.0	231	3.05E+05	80.273
Nevada Test Site	Oak Ridge Reservation	2151.0	120	2.58E+05	82.806
Nevada Test Site	University of Missouri - Columbia	1557.0	145	2.26E+05	85.022
Nevada Test Site	Fort St. Vrain Nuclear Generating Station	852.0	247	2.10E+05	87.087
Nevada Test Site	West Valley Demonstration Project	2373.0	83	1.97E+05	89.020
Nevada Test Site	Massachusetts Institute of Technology	2802.0	69	1.93E+05	90.918
Nevada Test Site	Brookhaven National Laboratory	2670.0	71	1.90E+05	92.778
Nevada Test Site	University of Michigan	2044.0	72	1.47E+05	94.222
Nevada Test Site	Rhode Island Nuclear Science Center	2782.0	32	8.90E+04	95.096
Nevada Test Site	Georgia Institute of Technology	2238.0	19	4.25E+04	95.513
Nevada Test Site	Rensselaer Polytechnic Institute	2636.0	16	4.22E+04	95.927
Nevada Test Site	Cornell University	2547.0	12	3.06E+04	96.227
Nevada Test Site	University of Virginia	2444.0	12	2.93E+04	96.515
Nevada Test Site	State University of New York - Buffalo	2350.0	12	2.82E+04	96.792
Nevada Test Site	Texas A&M University	1852.0	15	2.78E+04	97.065
Nevada Test Site	Sandia National Laboratories-Albuquerque	909.0	27	2.45E+04	97.305
Nevada Test Site	University of Illinois	1850.0	13	2.41E+04	97.541
Nevada Test Site	North Carolina State University	2549.0	8	2.04E+04	97.742
Nevada Test Site	Argonne National Laboratory - East	1815.0	11	2.00E+04	97.937
Nevada Test Site	University of Florida	2582.0	7	1.81E+04	98.115
Nevada Test Site	Los Alamos National Laboratory	997.0	17	1.69E+04	98.281
Nevada Test Site	University of Wisconsin	1857.0	9	1.67E+04	98.445
Nevada Test Site	Pennsylvania State University	2395.0	6	1.44E+04	98.586
Nevada Test Site	University of Maryland	2509.0	5	1.25E+04	98.709
Nevada Test Site	University of Missouri - Rolla	1769.0	7	1.24E+04	98.831
Nevada Test Site	University of Lowell	2808.0	4	1.12E+04	98.941
Nevada Test Site	Worcester Polytechnic Institute	2765.0	4	1.11E+04	99.050
Nevada Test Site	Washington State University	1286.0	8	1.03E+04	99.151
Nevada Test Site	Kansas State University	1312.0	7	9.18E+03	99.241
Nevada Test Site	Manhattan College	2603.0	3	7.81E+03	99.317
Nevada Test Site	Purdue University	1928.0	4	7.71E+03	99.393
Nevada Test Site	Oregon State University	1245.0	6	7.47E+03	99.466
Nevada Test Site	University of Texas	1662.0	4	6.65E+03	99.532
Nevada Test Site	Midland, MI	2135.0	3	6.41E+03	99.595
Nevada Test Site	Ohio State University	2098.0	3	6.29E+03	99.656
Nevada Test Site	Iowa State University	1520.0	4	6.08E+03	99.716
Nevada Test Site	Babcock & Wilcox	2491.0	2	4.98E+03	99.765
Nevada Test Site	Denver, CO	819.0	6	4.91E+03	99.813
Nevada Test Site	San Diego, CA	398.0	8	3.18E+03	99.844
Nevada Test Site	Pleasanton, CA	697.0	4	2.79E+03	99.872
Nevada Test Site	Reed College	1250.0	2	2.50E+03	99.896
Nevada Test Site	McClellan AFB, CA	735.0	3	2.21E+03	99.918
Nevada Test Site	University of Arizona	723.0	3	2.17E+03	99.939
Nevada Test Site	San Ramon, CA	694.0	3	2.08E+03	99.960
Nevada Test Site	University of Utah	487.0	3	1.46E+03	99.974
Nevada Test Site	University of California - Irvine	364.0	3	1.09E+03	99.985
Nevada Test Site	University of New Mexico	918.0	1	9.18E+02	99.994
Nevada Test Site	Idaho State University	649.0	1	6.49E+02	100.000
Total			**6818**	**1.02E+07**	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-6. Centralization at the Hanford Site cumulative shipment-miles for train shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Hanford Site	Military Ocean Terminal Sunny Point, NC	3203.0	541	1.73E+06	31.974
Hanford Site	Gouvenour, NY	2878.0	236	6.79E+05	44.506
Hanford Site	Gaithersburg, MD	2881.0	188	5.42E+05	54.500
Hanford Site	Savannah River Site	2953.0	173	5.11E+05	63.926
Hanford Site	University of Missouri - Columbia	1948.0	145	2.82E+05	69.138
Hanford Site	Idaho National Engineering Laboratory	658.0	366	2.41E+05	73.582
Hanford Site	Oakland, CA	986.0	231	2.28E+05	77.785
Hanford Site	Massachusetts Institute of Technology	3105.0	69	2.14E+05	81.738
Hanford Site	University of Michigan	2369.0	72	1.71E+05	84.885
Hanford Site	Rhode Island Nuclear Science Center	3166.0	32	1.01E+05	86.754
Hanford Site	Oak Ridge Reservation	2601.0	26	6.76E+04	88.002
Hanford Site	Georgia Institute of Technology	2732.0	19	5.19E+04	88.960
Hanford Site	Rensselaer Polytechnic Institute	2934.0	16	4.69E+04	89.826
Hanford Site	Texas A&M University	2954.0	15	4.43E+04	90.644
Hanford Site	Brookhaven National Laboratory	3153.0	14	4.41E+04	91.458
Hanford Site	Fort St. Vrain Nuclear Generating Station	1218.0	35	4.26E+04	92.245
Hanford Site	University of Virginia	2902.0	12	3.48E+04	92.887
Hanford Site	Cornell University	2842.0	12	3.41E+04	93.517
Hanford Site	State University of New York - Buffalo	2637.0	12	3.16E+04	94.101
Hanford Site	University of Illinois	2158.0	13	2.81E+04	94.618
Hanford Site	North Carolina State University	3172.0	8	2.54E+04	95.087
Hanford Site	University of Florida	3138.0	7	2.20E+04	95.492
Hanford Site	University of Wisconsin	2210.0	9	1.99E+04	95.859
Hanford Site	Pennsylvania State University	2760.0	6	1.66E+04	96.164
Hanford Site	University of Missouri - Rolla	2246.0	7	1.57E+04	96.454
Hanford Site	University of Maryland	2900.0	5	1.45E+04	96.722
Hanford Site	San Diego, CA	1622.0	8	1.30E+04	96.961
Hanford Site	University of Lowell	3095.0	4	1.24E+04	97.190
Hanford Site	Worcester Polytechnic Institute	3089.0	4	1.24E+04	97.418
Hanford Site	Kansas State University	1743.0	7	1.22E+04	97.643
Hanford Site	Sandia National Laboratories-Albuquerque	1793.0	6	1.08E+04	97.842
Hanford Site	West Valley Demonstration Project	2654.0	4	1.06E+04	98.037
Hanford Site	University of Texas	2473.0	4	9.89E+03	98.220
Hanford Site	Purdue University	2359.0	4	9.44E+03	98.394
Hanford Site	Manhattan College	3070.0	3	9.21E+03	98.564
Hanford Site	Denver, CO	1254.0	6	7.52E+03	98.703
Hanford Site	Midland, MI	2507.0	3	7.52E+03	98.842
Hanford Site	Ohio State University	2482.0	3	7.45E+03	98.979
Hanford Site	Iowa State University	1788.0	4	7.15E+03	99.111
Hanford Site	Los Alamos National Laboratory	1725.0	4	6.90E+03	99.238
Hanford Site	Argonne National Laboratory - East	2200.0	3	6.60E+03	99.360
Hanford Site	Babcock & Wilcox	2879.0	2	5.76E+03	99.466
Hanford Site	University of Arizona	1804.0	3	5.41E+03	99.566
Hanford Site	University of California - Irvine	1528.0	3	4.58E+03	99.651
Hanford Site	Pleasanton, CA	1002.0	4	4.01E+03	99.725
Hanford Site	San Ramon, CA	1002.0	3	3.01E+03	99.780
Hanford Site	McClellan AFB, CA	890.0	3	2.67E+03	99.829
Hanford Site	University of Utah	774.0	3	2.32E+03	99.872
Hanford Site	Oregon State University	340.0	6	2.04E+03	99.910
Hanford Site	Washington State University	251.0	8	2.01E+03	99.947
Hanford Site	University of New Mexico	1796.0	1	1.80E+03	99.980
Hanford Site	Idaho State University	602.0	1	6.02E+02	99.991
Hanford Site	Reed College	239.0	2	4.78E+02	100.000
Total			**2375**	**5.42E+06**	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-7. Centralization at the Savannah River Site cumulative shipment-miles for train shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Savannah River Site	Hanford Site	2953.0	646	1.91E+06	38.105
Savannah River Site	Idaho National Engineering Laboratory	2407.0	366	8.81E+05	55.702
Savannah River Site	Oakland, CA	3192.0	231	7.37E+05	70.431
Savannah River Site	Gouvenour, NY	1281.0	236	3.02E+05	76.470
Savannah River Site	Hampton Roads, VA	529.0	541	2.86E+05	82.186
Savannah River Site	University of Missouri - Columbia	1011.0	145	1.47E+05	85.115
Savannah River Site	Gaithersburg, MD	659.0	188	1.24E+05	87.589
Savannah River Site	Massachusetts Institute of Technology	1223.0	69	8.44E+04	89.275
Savannah River Site	University of Michigan	913.0	72	6.57E+04	90.588
Savannah River Site	Fort St. Vrain Nuclear Generating Station	1853.0	35	6.49E+04	91.883
Savannah River Site	Rhode Island Nuclear Science Center	1252.0	32	4.01E+04	92.684
Savannah River Site	San Diego, CA	3274.0	8	2.62E+04	93.207
Savannah River Site	Washington State University	2864.0	8	2.29E+04	93.665
Savannah River Site	Oregon State University	3381.0	6	2.03E+04	94.070
Savannah River Site	Texas A&M University	1194.0	15	1.79E+04	94.428
Savannah River Site	Brookhaven National Laboratory	1239.0	14	1.73E+04	94.774
Savannah River Site	Rensselaer Polytechnic Institute	1044.0	16	1.67E+04	95.108
Savannah River Site	Sandia National Laboratories-Albuquerque	2315.0	6	1.39E+04	95.385
Savannah River Site	University of Illinois	1028.0	13	1.34E+04	95.652
Savannah River Site	Cornell University	1098.0	12	1.32E+04	95.915
Savannah River Site	Denver, CO	2125.0	6	1.28E+04	96.170
Savannah River Site	Pleasanton, CA	3170.0	4	1.27E+04	96.423
Savannah River Site	State University of New York - Buffalo	1051.0	12	1.26E+04	96.675
Savannah River Site	Oak Ridge Reservation	417.0	26	1.08E+04	96.892
Savannah River Site	University of Wisconsin	1092.0	9	9.83E+03	97.088
Savannah River Site	University of California - Irvine	3180.0	3	9.54E+03	97.279
Savannah River Site	San Ramon, CA	3170.0	3	9.51E+03	97.469
Savannah River Site	McClellan AFB, CA	3160.0	3	9.48E+03	97.658
Savannah River Site	Los Alamos National Laboratory	2252.0	4	9.01E+03	97.838
Savannah River Site	Kansas State University	1274.0	7	8.92E+03	98.016
Savannah River Site	University of Virginia	637.0	12	7.64E+03	98.169
Savannah River Site	University of Utah	2378.0	3	7.13E+03	98.311
Savannah River Site	University of Missouri - Rolla	966.0	7	6.76E+03	98.446
Savannah River Site	University of Arizona	2245.0	3	6.74E+03	98.581
Savannah River Site	Reed College	3154.0	2	6.31E+03	98.707
Savannah River Site	Pennsylvania State University	963.0	6	5.78E+03	98.822
Savannah River Site	University of Texas	1314.0	4	5.26E+03	98.927
Savannah River Site	Iowa State University	1281.0	4	5.12E+03	99.030
Savannah River Site	University of Lowell	1239.0	4	4.96E+03	99.129
Savannah River Site	West Valley Demonstration Project	1217.0	4	4.87E+03	99.226
Savannah River Site	Worcester Polytechnic Institute	1176.0	4	4.70E+03	99.320
Savannah River Site	Georgia Institute of Technology	221.0	19	4.20E+03	99.404
Savannah River Site	Purdue University	903.0	4	3.61E+03	99.476
Savannah River Site	Manhattan College	1156.0	3	3.47E+03	99.545
Savannah River Site	University of Maryland	669.0	5	3.35E+03	99.612
Savannah River Site	North Carolina State University	385.0	8	3.08E+03	99.673
Savannah River Site	Midland, MI	996.0	3	2.99E+03	99.733
Savannah River Site	Argonne National Laboratory - East	976.0	3	2.93E+03	99.792
Savannah River Site	Idaho State University	2323.0	1	2.32E+03	99.838
Savannah River Site	University of New Mexico	2315.0	1	2.32E+03	99.884
Savannah River Site	University of Florida	328.0	7	2.30E+03	99.930
Savannah River Site	Ohio State University	726.0	3	2.18E+03	99.974
Savannah River Site	Babcock & Wilcox	661.0	2	1.32E+03	100.000
Total			2848	5.01E+06	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-8. Centralization at the Idaho National Engineering Laboratory cumulative shipment-miles for train shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
INEL	Military Ocean Terminal Sunny Point, NC	2657.0	541	1.44E+06	30.744
INEL	Gouvenour, NY	2332.0	236	5.50E+05	42.516
INEL	Gaithersburg, MD	2335.0	188	4.39E+05	51.905
INEL	Hanford Site	658.0	646	4.25E+05	60.996
INEL	Savannah River Site	2407.0	173	4.16E+05	69.902
INEL	Oakland, CA	1102.0	231	2.55E+05	75.347
INEL	University of Missouri - Columbia	1402.0	145	2.03E+05	79.695
INEL	Massachusetts Institute of Technology	2559.0	69	1.77E+05	83.472
INEL	University of Michigan	1823.0	72	1.31E+05	86.279
INEL	Rhode Island Nuclear Science Center	2620.0	32	8.38E+04	88.072
INEL	Oak Ridge Reservation	2055.0	26	5.34E+04	89.215
INEL	Georgia Institute Technology	2186.0	19	4.15E+04	90.103
INEL	Rensselaer Polytechnic Institute	2388.0	16	3.82E+04	90.921
INEL	Brookhaven National Laboratory	2607.0	14	3.65E+04	91.701
INEL	Texas A&M University	1920.0	15	2.88E+04	92.317
INEL	University of Virginia	2357.0	12	2.83E+04	92.922
INEL	Cornell University	2296.0	12	2.76E+04	93.511
INEL	State University of New York - Buffalo	2091.0	12	2.51E+04	94.048
INEL	Fort St. Vrain Nuclear Generating Station	672.0	35	2.35E+04	94.551
INEL	North Carolina State University	2626.0	8	2.10E+04	95.001
INEL	University of Illinois	1612.0	13	2.10E+04	95.449
INEL	University of Florida	2592.0	7	1.81E+04	95.837
INEL	University of Wisconsin	1664.0	9	1.50E+04	96.157
INEL	Pennsylvania State University	2214.0	6	1.33E+04	96.441
INEL	University of Maryland	2354.0	5	1.18E+04	96.693
INEL	University of Missouri - Rolla	1619.0	7	1.13E+04	96.935
INEL	University of Lowell	2549.0	4	1.02E+04	97.153
INEL	Worcester Polytechnic Institute	2544.0	4	1.02E+04	97.371
INEL	San Diego, CA	1076.0	8	8.61E+03	97.555
INEL	West Valley Demonstration Project	2108.0	4	8.43E+03	97.736
INEL	Kansas State University	1197.0	7	8.38E+03	97.915
INEL	University of Texas	1927.0	4	7.71E+03	98.080
INEL	Manhattan College	2524.0	3	7.57E+03	98.242
INEL	Sandia National Laboratories-Albuquerque	1247.0	6	7.48E+03	98.402
INEL	Purdue University	1813.0	4	7.25E+03	98.557
INEL	Washington State University	876.0	8	7.01E+03	98.707
INEL	Midland, MI	1961.0	3	5.88E+03	98.832
INEL	Ohio State University	1936.0	3	5.81E+03	98.957
INEL	Oregon State University	878.0	6	5.27E+03	99.069
INEL	Iowa State University	1242.0	4	4.97E+03	99.176
INEL	Argonne National Laboratory - East	1655.0	3	4.97E+03	99.282
INEL	Los Alamos National Laboratory	1179.0	4	4.72E+03	99.383
INEL	Babcock & Wilcox	2333.0	2	4.67E+03	99.482
INEL	Denver, CO	708.0	6	4.25E+03	99.573
INEL	University of Arizona	1376.0	3	4.13E+03	99.662
INEL	Pleasanton, CA	965.0	4	3.86E+03	99.744
INEL	University of California - Irvine	982.0	3	2.95E+03	99.807
INEL	San Ramon, CA	965.0	3	2.90E+03	99.869
INEL	McClellan AFB, CA	853.0	3	2.56E+03	99.924
INEL	Reed College	785.0	2	1.57E+03	99.957
INEL	University of New Mexico	1250.0	1	1.25E+03	99.984
INEL	University of Utah	228.0	3	6.84E+02	99.999
INEL	Idaho State University	56.0	1	5.60E+01	100.000
Total			**2655**	**4.68E+06**	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-9. Centralization at the Oak Ridge Reservation cumulative shipment-miles for train shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Oak Ridge Reservation	Hanford Site	2601.0	646	1.68E+06	37.080
Oak Ridge Reservation	Idaho National Engineering Laboratory	2055.0	366	7.52E+05	53.678
Oak Ridge Reservation	Portland, OR	2827.0	231	6.53E+05	68.089
Oak Ridge Reservation	Hampton Roads, VA	689.0	541	3.73E+05	76.315
Oak Ridge Reservation	Gouvenour, NY	972.0	236	2.29E+05	81.378
Oak Ridge Reservation	Gaithersburg, MD	819.0	188	1.54E+05	84.775
Oak Ridge Reservation	University of Missouri - Columbia	695.0	145	1.01E+05	86.999
Oak Ridge Reservation	Massachusetts Institute of Technology	1199.0	69	8.27E+04	88.825
Oak Ridge Reservation	Savannah River Site	417.0	173	7.21E+04	90.417
Oak Ridge Reservation	Fort St. Vrain Nuclear Generating Station	1526.0	35	5.34E+04	91.596
Oak Ridge Reservation	University of Michigan	591.0	72	4.26E+04	92.535
Oak Ridge Reservation	Rhode Island Nuclear Science Center	1259.0	32	4.03E+04	93.424
Oak Ridge Reservation	San Diego, CA	2709.0	8	2.17E+04	93.902
Oak Ridge Reservation	Washington State University	2536.0	8	2.03E+04	94.350
Oak Ridge Reservation	Oregon State University	3055.0	6	1.83E+04	94.754
Oak Ridge Reservation	Rensselaer Polytechnic Institute	1028.0	16	1.64E+04	95.117
Oak Ridge Reservation	Brookhaven National Laboratory	1152.0	14	1.61E+04	95.473
Oak Ridge Reservation	Texas A&M University	1013.0	15	1.52E+04	95.809
Oak Ridge Reservation	Pleasanton, CA	3029.0	4	1.21E+04	96.076
Oak Ridge Reservation	Cornell University	935.0	12	1.12E+04	96.324
Oak Ridge Reservation	Sandia National Laboratory-Albuquerque	1749.0	6	1.05E+04	96.555
Oak Ridge Reservation	Denver, CO	1560.0	6	9.36E+03	96.762
Oak Ridge Reservation	San Ramon, CA	3029.0	3	9.09E+03	96.962
Oak Ridge Reservation	State University of New York - Buffalo	731.0	12	8.77E+03	97.156
Oak Ridge Reservation	McClellan AFB, CA	2747.0	3	8.24E+03	97.338
Oak Ridge Reservation	University of California - Irvine	2615.0	3	7.85E+03	97.511
Oak Ridge Reservation	University of Illinois	592.0	13	7.70E+03	97.681
Oak Ridge Reservation	University of Wisconsin	765.0	9	6.89E+03	97.833
Oak Ridge Reservation	Los Alamos National Laboratory	1686.0	4	6.74E+03	97.981
Oak Ridge Reservation	Kansas State University	948.0	7	6.64E+03	98.128
Oak Ridge Reservation	University of Arizona	2103.0	3	6.31E+03	98.267
Oak Ridge Reservation	University of Utah	2051.0	3	6.15E+03	98.403
Oak Ridge Reservation	Reed College	2827.0	2	5.65E+03	98.528
Oak Ridge Reservation	University of Virginia	451.0	12	5.41E+03	98.647
Oak Ridge Reservation	Pennsylvania State University	822.0	6	4.93E+03	98.756
Oak Ridge Reservation	University of Lowell	1189.0	4	4.76E+03	98.861
Oak Ridge Reservation	Worcester Polytechnic Institute	1183.0	4	4.73E+03	98.965
Oak Ridge Reservation	University of Missouri - Rolla	640.0	7	4.48E+03	99.064
Oak Ridge Reservation	University of Florida	634.0	7	4.44E+03	99.162
Oak Ridge Reservation	Georgia Institute of Technology	228.0	19	4.33E+03	99.258
Oak Ridge Reservation	University of Texas	1045.0	4	4.18E+03	99.350
Oak Ridge Reservation	North Carolina State University	511.0	8	4.09E+03	99.440
Oak Ridge Reservation	Iowa State University	954.0	4	3.82E+03	99.524
Oak Ridge Reservation	West Valley Demonstration Project	889.0	4	3.56E+03	99.603
Oak Ridge Reservation	Manhattan College	1164.0	3	3.49E+03	99.680
Oak Ridge Reservation	University of Maryland	582.0	5	2.91E+03	99.744
Oak Ridge Reservation	Idaho State University	1996.0	1	2.00E+03	99.788
Oak Ridge Reservation	Purdue University	495.0	4	1.98E+03	99.832
Oak Ridge Reservation	Argonne National Laboratory - East	648.0	3	1.94E+03	99.875
Oak Ridge Reservation	Midland, MI	645.0	3	1.94E+03	99.917
Oak Ridge Reservation	University of New Mexico	1749.0	1	1.75E+03	99.956
Oak Ridge Reservation	Ohio State University	406.0	3	1.22E+03	99.983
Oak Ridge Reservation	Babcock & Wilcox	386.0	2	7.72E+02	100.000
Total			**2995**	**4.53E+06**	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-10. Centralization at the Nevada Test Site cumulative shipment-miles for train shipments.[a]

Route		Miles	Shipments	Shipment-miles	Percent of Cumulative Shipment-miles
Nevada Test Site	Military Ocean Terminal Sunny Point, NC	3089.0	541	1.67E+06	26.834
Nevada Test Site	Hanford Site	1302.0	646	8.41E+05	40.340
Nevada Test Site	Gouvenour, NY	2763.0	236	6.52E+05	50.810
Nevada Test Site	Gaithersburg, MD	2767.0	188	5.20E+05	59.163
Nevada Test Site	Savannah River Site	2839.0	173	4.91E+05	67.050
Nevada Test Site	Seattle, WA	1620.0	231	3.74E+05	73.059
Nevada Test Site	Idaho National Engineering Laboratory	756.0	366	2.77E+05	77.502
Nevada Test Site	University of Missouri - Columbia	1833.0	145	2.66E+05	81.770
Nevada Test Site	Massachusetts Institute of Technology	2990.0	69	2.06E+05	85.082
Nevada Test Site	University of Michigan	2255.0	72	1.62E+05	87.689
Nevada Test Site	Rhode Island Nuclear Science Center	3051.0	32	9.76E+04	89.257
Nevada Test Site	Oak Ridge Reservation	2487.0	26	6.47E+04	90.295
Nevada Test Site	Georgia Institute of Technology	2618.0	19	4.97E+04	91.094
Nevada Test Site	Rensselaer Polytechnic Institute	2820.0	16	4.51E+04	91.819
Nevada Test Site	Brookhaven National Laboratory	3039.0	14	4.25E+04	92.502
Nevada Test Site	Fort St. Vrain Nuclear Generating Station	1104.0	35	3.86E+04	93.122
Nevada Test Site	University of Virginia	2788.0	12	3.35E+04	93.660
Nevada Test Site	Cornell University	2727.0	12	3.27E+04	94.185
Nevada Test Site	State University of New York - Buffalo	2522.0	12	3.03E+04	94.671
Nevada Test Site	Texas A&M University	1967.0	15	2.95E+04	95.145
Nevada Test Site	University of Illinois	2044.0	13	2.66E+04	95.571
Nevada Test Site	North Carolina State University	3058.0	8	2.45E+04	95.964
Nevada Test Site	University of Florida	3024.0	7	2.12E+04	96.304
Nevada Test Site	University of Wisconsin	2096.0	9	1.89E+04	96.607
Nevada Test Site	Pennsylvania State University	2646.0	6	1.59E+04	96.862
Nevada Test Site	University of Missouri - Rolla	2050.0	7	1.44E+04	97.092
Nevada Test Site	University of Maryland	2786.0	5	1.39E+04	97.316
Nevada Test Site	Washington State University	1520.0	8	1.22E+04	97.511
Nevada Test Site	University of Lowell	2980.0	4	1.19E+04	97.703
Nevada Test Site	Worcester Polytechnic Institute	2975.0	4	1.19E+04	97.894
Nevada Test Site	Kansas State University	1628.0	7	1.14E+04	98.077
Nevada Test Site	West Valley Demonstration Project	2554.0	4	1.02E+04	98.241
Nevada Test Site	University of Texas	2358.0	4	9.43E+03	98.392
Nevada Test Site	Purdue University	2245.0	4	8.98E+03	98.536
Nevada Test Site	Manhattan College	2956.0	3	8.87E+03	98.679
Nevada Test Site	Oregon State University	1400.0	6	8.40E+03	98.814
Nevada Test Site	Midland, MI	2392.0	3	7.18E+03	98.929
Nevada Test Site	Ohio State University	2367.0	3	7.10E+03	99.043
Nevada Test Site	Argonne National Laboratory - East	2348.0	3	7.04E+03	99.156
Nevada Test Site	Denver, CO	1140.0	6	6.84E+03	99.266
Nevada Test Site	Iowa State University	1674.0	4	6.70E+03	99.373
Nevada Test Site	Sandia National Laboratory-Albuquerque	1065.0	6	6.39E+03	99.476
Nevada Test Site	Babcock & Wilcox	2765.0	2	5.53E+03	99.565
Nevada Test Site	Los Alamos National Laboratory	1169.0	4	4.68E+03	99.640
Nevada Test Site	San Diego, CA	518.0	8	4.14E+03	99.706
Nevada Test Site	Pleasanton, CA	838.0	4	3.35E+03	99.760
Nevada Test Site	Reed College	1429.0	2	2.86E+03	99.806
Nevada Test Site	San Ramon, CA	838.0	3	2.51E+03	99.847
Nevada Test Site	McClellan AFB, CA	827.0	3	2.48E+03	99.886
Nevada Test Site	University of Arizona	818.0	3	2.45E+03	99.926
Nevada Test Site	University of Utah	528.0	3	1.58E+03	99.951
Nevada Test Site	University of California - Irvine	424.0	3	1.27E+03	99.972
Nevada Test Site	University of New Mexico	1065.0	1	1.07E+03	99.989
Nevada Test Site	Idaho State University	700.0	1	7.00E+02	100.00
Total			3021	6.23E+06	

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-11. Comparison of HIGHWAY mileage data with Map-n-Go mileage data.[a]

Centralization Alternative	Origin	(P) HIGHWAY Distance (miles)	(O) Map-n-Go Distance (miles)	Difference	Absolute Value of Percent Difference	$[(P-O)/P]^2$
Hanford Site	Savannah River Site	2727.0	2735.0	-8	0.29	8.61E-06
Hanford Site	Hampton Roads, VA	2903.0	2942.0	-39	1.34	1.80E-04
Hanford Site	INEL	599.0	623.0	-24	4.01	1.61E-03
Hanford Site	Alexandria Bay, NY	2768.0	2655.0	113	4.08	1.67E-03
Hanford Site	Gaithersburg, MD	2732.0	2728.0	4	0.15	2.14E-06
Hanford Site	Oak Ridge Reservation	2464.0	2484.0	-20	0.81	6.59E-05
Hanford Site	Fort St. Vrain Nuclear Generating Station	1108.0	1141.0	-33	2.98	8.87E-04
Hanford Site	University of Missouri - Columbia	1870.0	1880.0	-10	0.53	2.86E-05
Savannah River Site	Hanford Site	2727.0	2735.0	-8	0.29	8.61E-06
Savannah River Site	INEL	2311.0	2267.0	44	1.90	3.62E-04
Savannah River Site	Seattle, WA	2900.0	2876.0	24	0.83	6.85E-05
Idaho National Engineering Laboratory	Savannah River Site	2311.0	2267.0	44	1.90	3.62E-04
Idaho National Engineering Laboratory	Hampton Roads, VA	2487.0	2509.0	-22	0.88	7.83E-05
Idaho National Engineering Laboratory	Hanford Site	599.0	623.0	-24	4.01	1.61E-03
Idaho National Engineering Laboratory	Alexandria Bay, NY	2352.0	2232.0	120	5.10	2.60E-03
Idaho National Engineering Laboratory	Gaithersburg, MD	2316.0	2283.0	33	1.42	2.03E-04
Idaho National Engineering Laboratory	Oak Ridge Reservation	2048.0	2004.0	44	2.15	4.62E-04
Idaho National Engineering Laboratory	Oakland, CA	963.0	941.0	22	2.28	5.22E-04
Idaho National Engineering Laboratory	University of Missouri - Columbia	1454.0	1411.0	43	2.96	8.75E-04
Oak Ridge Reservation	Hanford Site	2464.0	2484.0	-20	0.81	6.59E-05
Oak Ridge Reservation	INEL	2048.0	2004.0	44	2.15	4.62E-04
Oak Ridge Reservation	Seattle, WA	2636.0	2613.0	23	0.87	7.61E-05
Nevada Test Site	Savannah River Site	2414.0	2383.0	31	1.28	1.65E-04
Nevada Test Site	Hanford Site	1128.0	1144.0	-16	1.42	2.01E-04
Nevada Test Site	Hampton Roads, VA	2590.0	2721.0	-131	5.06	2.56E-03
Nevada Test Site	INEL	712.0	688.0	24	3.37	1.14E-03
Nevada Test Site	Alexandria Bay, NY	2619.0	2503.0	116	4.43	1.96E-03
Nevada Test Site	Gaithersburg, MD	2488.0	2507.0	-19	0.76	5.83E-05
Nevada Test Site	Seattle, WA	1322.0	1304.0	18	1.36	1.85E-04
Nevada Test Site	Oak Ridge Reservation	2151.0	2120.0	31	1.44	2.08E-04
Maximum				120.0	5.10	
Minimum				-131.0	0.15	
Mean				13.5	2.03	
Relative Root Mean Square Error						2.49E-02

a. To convert from miles to kilometers, multiply by 1.6.

Table 2-12. Comparison of INTERLINE mileage data with mileage data from the Railroad Information Service.[a]

Centralization Alternative	Origin	(P) INTERLINE Distance (miles)	(O) Railroad Information Service Distance (miles)	Difference	Absolute Value of Percent Difference	$[(P-O)/P]^2$
Hanford Site	Military Ocean Terminal Sunny Point, NC	3127.0	3139.0	-12	0.38	1.47E-05
Hanford Site	Gouvenour, NY	2784.0	2802.0	-18	0.65	4.18E-05
Hanford Site	Gaithersburg, MD	2787.0	2811.0	-24	0.86	7.42E-05
Hanford Site	Savannah River Site	2945.0	2961.0	-16	0.54	2.95E-05
Hanford Site	University of Missouri - Columbia	2044.0	2020.0	24	1.17	1.38E-04
Hanford Site	INEL	675.0	670.0	5	0.74	5.49E-05
Hanford Site	Oakland, CA	860.0	864.0	-4	0.47	2.16E-05
Hanford Site	Massachusetts Institute of Technology	3006.0	3040.0	-34	1.13	1.28E-04
Savannah River Site	Hanford Site	2944.0	2961.0	-17	0.58	3.33E-05
Savannah River Site	INEL	2384.0	2386.0	-2	0.08	7.04E-07
Savannah River Site	Oakland, CA	3180.0	3196.0	-16	0.50	2.53E-05
Savannah River Site	Gouvenour, NY	1280.0	1280.0	0	0.00	0.00
Savannah River Site	Hampton Roads, VA	604.0	603.0	1	0.17	2.74E-06
Idaho National Engineering Laboratory	Military Ocean Terminal Sunny Point, NC	2621.0	2606.0	15	0.57	3.28E-05
Idaho National Engineering Laboratory	Gouvenour, NY	2472.0	2477.0	-5	0.20	4.09E-06
Idaho National Engineering Laboratory	Gaithersburg, MD	2547.0	2539.0	8	0.31	9.87E-06
Idaho National Engineering Laboratory	Hanford Site	675.0	670.0	5	0.74	5.49E-05
Idaho National Engineering Laboratory	Savannah River Site	2362.0	2386.0	-24	1.02	1.03E-04
Idaho National Engineering Laboratory	Oakland, CA	1139.0	1147.0	-8	0.70	4.93E-05
Idaho National Engineering Laboratory	University of Missouri - Columbia	1404.0	1411.0	-7	0.50	2.49E-05
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2699.0	2718.0	-19	0.70	4.96E-05
Oak Ridge Reservation	Hanford Site	2647.0	2686.0	-39	1.47	2.17E-04
Oak Ridge Reservation	INEL	2111.0	2142.0	-31	1.47	2.16E-04
Oak Ridge Reservation	Portland, OR	2839.0	2860.0	-21	0.74	5.47E-05
Oak Ridge Reservation	Hampton Roads, VA	901.0	904.0	-3	0.33	1.11E-05
Oak Ridge Reservation	Gouvenour, NY	950.0	968.0	-18	1.89	3.59E-04
Nevada Test Site	Military Ocean Terminal Sunny Point, NC	2973.0	2968.0	5	0.17	2.83E-06
Nevada Test Site	Hanford Site	1235.0	1234.0	1	0.08	6.56E-07
Nevada Test Site	Gouvenour, NY	2824.0	2839.0	-15	0.53	2.82E-05
Nevada Test Site	Gaithersburg, MD	2899.0	2901.0	-2	0.07	4.76E-07
Nevada Test Site	Savannah River Site	2741.0	2748.0	-7	0.26	6.52E-06
Nevada Test Site	Seattle, WA	1532.0	1529.0	3	0.20	3.83E-06
Nevada Test Site	INEL	672.0	676.0	-4	0.60	3.54E-05
Nevada Test Site	University of Missouri - Columbia	1761.0	1773.0	-12	0.68	4.64E-05
Maximum				24.0	1.89	
Minimum				-39.0	0.0	
Mean				-8.6	0.60	
Relative Root Mean Square Error						7.43E-03

a. To convert from miles to kilometers, multiply by 1.6.

3. VALIDATION OF THE INCIDENT-FREE UNIT RISK FACTORS CALCULATED USING THE RADTRAN 4 COMPUTER CODE

3.1 Validation Analysis

The RADTRAN 4 computer code (Neuhauser and Kanipe 1995) was used to estimate incident-free unit risk factors for the transportation analyses in (DOE 1995). Unit risk factors provide estimates of the radiation dose to groups of people from transporting a shipment of radioactive material over a unit distance of travel in a population density zone (rural, suburban, and urban). Unit risk factors have units of collective dose (person-rem).

The purpose of this analysis was to validate the incident-free unit risk factors for spent nuclear fuel shipments calculated using the RADTRAN 4 computer code by comparing them to hand-calculated values using identical data and equations. The definition of validation used in this analysis was "the test and evaluation of the completed software to ensure compliance with software requirements" (ASME 1989). In the context of this analysis, compliance with software requirements means that the differences between the unit risk factors calculated by RADTRAN 4 and the hand-calculated unit risk factors should be small (i.e., within the acceptance criterion established for the validation).

The acceptance criterion for this validation was a percent difference of 5 percent. If the RADTRAN 4 calculated unit risk factor differed from the hand-calculated unit risk factor by more than 5 percent, then the result was considered unacceptable. If the RADTRAN 4 calculated unit risk factor differed from the hand-calculated unit risk factor by less than 5 percent, then the result was considered acceptable.

Radiation doses were estimated for two groups of people during incident-free transportation of radioactive material, the crew and the general population. For truck shipments, the crew were the drivers of the vehicle. For rail shipments, the crew were workers in close proximity to the shipping containers during inspection or classification of railcars. The general population was persons within 800 m (0.5 mile) of the road (off-link), persons sharing the road (on-link), and persons at stops. For rail shipments, there is also a nonlinear component to the radiation dose to the crew and persons at stops from inspections that occur at the beginning and end of the shipment. The unit risk factors estimated using the RADTRAN 4 computer code are listed in Table 3-1. These unit risk factors were estimated using a radiation dose rate of 14 mrem/hr at 1 m (3.25 feet) from the shipping container and assumed 100 percent gamma radiation. Appendix A contains the RADTRAN 4 output for these unit risk factors.

The equations used to calculate the unit risk factors are listed in Chapter 4 of the RADTRAN 4 Technical Manual (Neuhauser and Kanipe 1995). The unit risk factors estimated using hand calculations are listed in Table 3-2. Sections 3.4 and 3.5 contain the detailed hand calculations used to estimate the unit risk factors. Table 3-3 contains the percent differences between the RADTRAN 4 and the hand-calculated unit risk factors.

3.2 Results of Validation Analysis

The minimum percent difference observed in Table 3-3 was zero, which meant that RADTRAN 4 and the hand calculation yielded identical results. The maximum percent difference observed in Table 3-3 was 1.2 percent, well within the 5 percent validation criterion. These results show that the differences between the unit risk factors estimated by RADTRAN 4 and the unit risk factors estimated using hand calculations are small and are within the acceptance criterion established

Table 3-1. Unit risk factors calculated using the RADTRAN 4 computer code.

		Unit risk factors (person-rem)		
Mode	Exposure group	Rural	Suburban	Urban
Truck				
	Crew	4.56E-5	1.00E-4	1.67E-4
	Off-link	1.23E-7	1.63E-5	1.08E-4
	On-link	5.03E-6	1.45E-5	1.50E-4
	Stops	1.20E-4	1.20E-4	1.20E-4
Rail				
	Crew	1.01E-5	1.01E-5	1.01E-5
	Nonlinear crew	1.12E-2	1.12E-2	1.12E-2
	Off-link	1.70E-7	3.25E-5	2.91E-4
	On-link	6.62E-8	8.47E-7	2.35E-6
	Stops	4.78E-6	4.78E-6	4.78E-6
	Nonlinear stops	8.68E-3	8.68E-3	8.68E-3

for the validation. Therefore, the unit risk factors generated using the RADTRAN 4 computer code are considered validated.

Table 3-2. Hand-calculated unit risk factors.

		Unit risk factors (person-rem)		
Mode	Exposure group	Rural	Suburban	Urban
Truck				
	Crew	4.52E-5	9.94E-5	1.66E-4
	Off-link	1.22E-7	1.61E-5	1.07E-4
	On-link	5.04E-6	1.45E-5	1.50E-4
	Stops	1.20E-4	1.20E-4	1.20E-4
Rail				
	Crew	1.01E-5	1.01E-5	1.01E-5
	Nonlinear crew	1.12E-2	1.12E-2	1.12E-2
	Off-link	1.68E-7	3.22E-5	2.88E-4
	On-link	6.63E-8	8.48E-7	2.35E-6
	Stops	4.81E-6	4.81E-6	4.81E-6
	Nonlinear stops	8.75E-3	8.75E-3	8.75E-3

Table 3-3. Percent differences between RADTRAN 4- and hand-calculated unit risk factors.

		Percent differences		
Mode	Exposure group	Rural	Suburban	Urban
Truck				
	Crew	0.88	0.60	0.60
	Off-link	0.82	1.2	0.93
	On-link	0.20	0.0	0.0
	Stops	0.0	0.0	0.0
Rail				
	Linear crew	0.0	0.0	0.0
	Nonlinear crew	0.0	0.0	0.0
	Off-link	1.2	0.93	1.0
	On-link	-0.15	-0.12	0.0
	Linear stops	-0.62	-0.62	-0.62
	Nonlinear stops	-0.80	-0.80	-0.80

3.3 Critiques of RADTRAN

As part of this validation analysis, the following documents were examined for specific comments on the incident-free conceptual models used in RADTRAN:

- Public comments contained in Volume II of the *Final Environmental Impact Statement on the Transportation of Radioactive Materials By Air and Other Modes* (NRC 1977a)
- *The Latest Nuclear Dilemma: Waste Shipment Peril Explored* (Resnikoff et al. 1982)
- *Analysis of Recent Council on Economic Priorities Newsletter* (Jefferson et al. 1982)
- *Transporting Spent Nuclear Fuel Allegations and Responses* (Jefferson 1983)
- *The Next Nuclear Gamble: Transportation and Storage of Nuclear Waste* (Resnikoff 1983)
- *Probabilistic Risk Assessment and Nuclear Waste Transportation: A Case Study of the Use of RADTRAN in the 1986 Environmental Assessment for Yucca Mountain* (Resnikoff 1990)
- *A Comparison of RISKIND and RADTRAN 4* (Brumburgh and Alesso 1993)

Based on these documents, five specific comments on the incident-free conceptual models used in RADTRAN were identified (some of these comments do not apply to the current version of RADTRAN, but do apply to previous versions of RADTRAN):

1. Radiation doses are underestimated because RADTRAN III does not include neutron doses.

2. Radiation doses are underestimated because RADTRAN does not account for skyscatter and groundscatter. Skyscatter and groundscatter can increase radiation doses

by up to 25 percent, with groundscatter being much more significant because of the difference in density between the air and the ground.

3. Radiation doses are underestimated because RADTRAN uses a point-source configuration rather than a line-source or plane-source configuration for calculating radiation doses to the crew and persons sharing the transport link. In addition, a reference or justification is not provided for the method used to adjust the package size.

4. The values of $V_r/2$, $V_s/2$, and $V_u/2$ are not justified for urban or suburban areas.

5. No reference or derivation is provided to support the equation:

$$I(x) = \int_{r=x}^{r=\infty} \frac{\exp(-\mu r) \cdot B(r)}{r(r^2 - x^2)^{1/2}} \, dr$$

These comments were evaluated for their applicability to RADTRAN 4. Responses to the comments are listed below:

1. Incident-free neutron doses have been incorporated in RADTRAN 4.

2. RADTRAN 4 does not account for skyscatter and groundscatter. To compensate for this, radiation doses in DOE (1995) were estimated using shielding factors of 1.0 for rural, suburban, and urban zones. For the population, the U.S. Nuclear Regulatory Commission recommends a time-weighted shielding factor of 0.50 (NRC 1977b). For people in cars, shielding factors range from 0.25 to 0.30 (Lauridsen and Hedemann-Jensen 1983). If the incident-free radiation doses were increased by 25 percent to account for skyscatter and groundscatter, this increase would be offset by the use of the shielding factors for the population and people in cars. In addition, the off-link radiation doses calculated using RADTRAN 4 were compared to the off-link radiation doses calculated using the RISKIND computer code (Yuan et al. 1993). RADTRAN 4 does not account for the processes of attenuation, build-up, or groundscatter; RISKIND accounts for the processes of attenuation, build-up, and

groundscatter. The process of attenuation decreases radiation doses; the processes of build-up and groundscatter increase radiation doses. RADTRAN 4 was found to overestimate off-link radiation doses by a factor of 1.5 to 2.3 when compared to RISKIND. Similar results were also obtained by Weiner and Neuhauser (1992), who found that the radiation doses calculated using RADTRAN 4 were overestimated when compared to radiation doses that were calculated accounting for attenuation, build-up, and groundscatter.

3. RADTRAN 4 uses the package shape factor, k_0, to convert a line source to an equivalent point source. The radiation dose rate for the crew calculated using RADTRAN 4 was compared to the radiation dose rate for the crew calculated using the RISKIND computer code, which accounts for the length and radius of the shipping container. RADTRAN 4 yielded a radiation dose rate of 9.1 mrem/hr for the crew, RISKIND yielded a radiation dose rate of 3.9 mrem/hr; therefore, the approach used by RADTRAN 4 overestimates radiation doses.

4. The values of $V_r/2$, $V_s/2$, and $V_u/2$ are intended to represent the average speed during rush hour; as such, they are considered to be reasonable estimates.

5. The derivation for this equation is presented in Yuan et al. (1993).

3.4 Detailed Hand Calculations for Incident-Free Truck Unit Risk Factors

This section presents the detailed hand calculations for the incident-free truck crew dose, off-link dose, on-link dose, and dose at stops.

3.4.1 List of Symbols - Truck

DR_p	=	Package dose rate (14 mrem/hr)
DIST	=	Distance (1 km)
f_{cs}	=	Fraction of travel on city streets in urban zone (0.050)
f_{fwy}	=	Fraction of travel on freeways in rural and suburban zones (1.0)
f_{rh}	=	Fraction of travel during rush hour in rural and suburban zones (0.10)
k_0	=	Package shape factor (6.25 m^2)
N_c	=	Number of people in truck crew (2 people)
N_r	=	One-way traffic count in rural zone (470 vehicles/hr)
N_s	=	One-way traffic count in suburban zone (780 vehicles/hr)
N_u	=	One-way traffic count in urban zone (2800 vehicles/hr)
P_{st}	=	Number of people exposed at stops (50 people)
PD_r	=	Population density in rural zone (6 people/km^2)
PD_s	=	Population density in suburban zone (719 people/km^2)
PD_u	=	Population density in urban zone (3861 people/km^2)
PDR	=	Pedestrian ratio (if RR, RS, or RU = 1.0, then RADTRAN 4 sets the value of PDR to 1.0, otherwise the default value of PDR is 6.0)
PPV	=	Number of people per vehicle (2 people/vehicle)
r	=	Distance from shipping container to truck crew (3.1 m)
r_{st}	=	Distance from shipping container to people exposed at stops (20 m)
RR	=	Building shielding factor in rural zone (1.0)
RS	=	Building shielding factor in suburban zone (1.0)
RU	=	Building shielding factor in urban zone (1.0)
T_{st}	=	Stop time (0.011 hr/km)
V_r	=	Speed in rural zone (88.49 km/hr)
V_s	=	Speed in suburban zone (40.25 km/hr)
V_u	=	Speed in urban zone (24.16 km/hr)

$$H_{min,max} = \int_{x=min}^{x=max} \left[\int_{r=x}^{r=\infty} \frac{dr}{r(r^2 - x^2)^{1/2}} \right] dx = \frac{\pi}{2} \cdot \ln \left(\frac{max}{min} \right)$$

$H_{min,max}$ is unitless

$$Z_{x,\infty} = \int_{r=x}^{r=\infty} \frac{dr}{r(r^2 - x^2)^{1/2}} = \frac{\pi}{2} \cdot \frac{1}{x}$$

$Z_{x,\infty}$ has units of m $^{-1}$

$$Y(min) = \int_{r=4\ m}^{r=\infty} \frac{dr}{r^2} = \frac{1}{4\ m}$$

Y(min) has units of m $^{-1}$

$$Y(x) = \int_{r=y}^{r=\infty} \frac{dr}{r^2} = \frac{1}{y}$$

where $y = x\ \text{km/hr} \cdot \frac{1000\ m}{1\ km} \cdot \frac{1\ hr}{3600\ s} \cdot 2\ s$

Y(x) has units of m $^{-1}$

3.4.2 Crew Dose - Truck

RADTRAN 4 first performs a regulatory check to determine if the dose rate for the crew exceeds 2 mrem/hr, the regulatory limit. If the dose rate for the crew exceeds 2 mrem/hr, then RADTRAN 4 resets the dose rate to 2 mrem/hr for the crew dose calculations.

$$\text{Dose} = \frac{k_0 \cdot DR_p}{r^2}$$

$$\text{Dose} = \frac{6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr}}{(3.1\ \text{m})^2} = 9.11\ \text{mrem/hr}$$

3.4.2.1 Rural Crew Dose - Truck.

$$\text{Dose} = \frac{2\ \text{mrem/hr}}{V_r} \cdot \text{DIST} \cdot N_c$$

$$\text{Dose} = \frac{2\ \text{mrem/hr}}{88.49\ \text{km/hr}} \cdot 1\ \text{km} \cdot 2\ \text{persons} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}}$$

$$\text{Dose} = 4.52\text{E}{-5}\ \text{person-rem}$$

3.4.2.2 Suburban Crew Dose - Truck.

$$\text{Dose} = \frac{2 \text{ mrem/hr}}{V_s} \cdot \text{DIST} \cdot N_c$$

$$\text{Dose} = \frac{2 \text{ mrem/hr}}{40.25 \text{ km/hr}} \cdot 1 \text{ km} \cdot 2 \text{ persons} \cdot \frac{1 \text{ rem}}{1000 \text{ mrem}}$$

$$\text{Dose} = 9.94\text{E}{-5} \text{ person-rem}$$

3.4.2.3 Urban Crew Dose - Truck.

$$\text{Dose} = \frac{2 \text{ mrem/hr}}{V_u} \cdot \text{DIST} \cdot N_c$$

$$\text{Dose} = \frac{2 \text{ mrem/hr}}{24.16 \text{ km/hr}} \cdot 1 \text{ km} \cdot 2 \text{ persons} \cdot \frac{1 \text{ rem}}{1000 \text{ mrem}}$$

$$\text{Dose} = 1.66\text{E}{-4} \text{ person-rem}$$

3.4.3 Off-Link Dose - Truck

This section presents the detailed hand calculations for the rural, suburban, and urban off-link truck doses.

3.4.3.1 Rural Off-Link Dose - Truck.

$$\text{Dose} = 4 \cdot k_0 \cdot DR_p \cdot DIST \cdot PD_r \cdot \left[\frac{f_{fwy} \cdot H_{30,800} \cdot RR}{V_r} + \frac{(1 - f_{fwy})\,(H_{27,30} \cdot PDR + H_{30,800} \cdot RR)}{V_r} \right]$$

$$\text{Dose} = 4 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 6\ \text{people/km}^2 \cdot$$

$$\left[\frac{1.0 \cdot \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 1.0}{88.49\ \text{km/hr}} + \frac{(1 - 1.0)\, \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 1.0}{88.49\ \text{km/hr}} \right] \cdot \left[\frac{1\ \text{rem}}{1000\ \text{mrem}} \right] \cdot \left(\frac{1\ \text{km}}{1000\ \text{m}} \right)^2$$

$$\text{Dose} = 1.22\text{E}{-7}\ \text{person-rem}$$

3.4.3.2 Suburban Off-Link Dose - Truck.

$$\text{Dose} = 4 \cdot k_0 \cdot DR_p \cdot DIST \cdot PD_s \cdot \left\{ H_{30,800} \cdot RS \cdot f_{fwy} \cdot \left[\frac{f_{rh}}{V_r/2} + \frac{1 - f_{rh}}{V_r} \right] + \right.$$

$$\left. (H_{27,30} \cdot PDR + H_{30,800} \cdot RS) \cdot (1 - f_{fwy}) \cdot \left[\frac{f_{rh}}{V_s/2} + \frac{1 - f_{rh}}{V_s} \right] \right\}$$

$$\text{Dose} = 4 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 719\ \text{people/km}^2 \cdot \left\{ \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 1.0 \cdot 1.0 \cdot \left[\frac{0.1 \cdot 2}{88.49\ \text{km/hr}} + \frac{1 - 0.1}{88.49\ \text{km/hr}} \right] + \right.$$

$$\left. \left[\frac{\pi}{2} \cdot \ln \frac{30\ \text{m}}{27\ \text{m}} \cdot 1.0 + \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 1.0 \right] \cdot (1 - 1.0) \cdot \left[\frac{0.1 \cdot 2}{40.25\ \text{km/hr}} + \frac{1 - 0.1}{40.25\ \text{km/hr}} \right] \right\} \cdot$$

$$\left[\frac{1\ \text{rem}}{1000\ \text{mrem}} \right] \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}} \right]^2$$

$$\text{Dose} = 1.61\text{E}{-5}\ \text{person-rem}$$

3.4.3.3 *Urban Off-Link Dose - Truck.*

$$\text{Dose} = 4 \cdot k_0 \cdot DR_p \cdot DIST \cdot PD_u \cdot \left\{ H_{30,800} \cdot RU \cdot (1 - f_{cs}) \cdot \left[\frac{f_{rh}}{V_r/2} + \frac{1 - f_{rh}}{V_r} \right] + \right.$$

$$\left. (H_{5,8} \cdot PDR + H_{8,800} \cdot RU) \cdot f_{cs} \cdot \left[\frac{f_{rh}}{V_u/2} + \frac{1 - f_{rh}}{V_u} \right] \right\}$$

$$\text{Dose} = 4 \cdot 6.25 \text{ m}^2 \cdot 14 \text{ mrem/hr} \cdot 1 \text{ km} \cdot 3861 \text{ people/km}^2 \cdot$$

$$\left\{ \frac{\pi}{2} \cdot \ln \frac{800 \text{ m}}{30 \text{ m}} \cdot 1.0 \cdot (1.0 - 0.050) \cdot \left[\frac{0.1 \cdot 2}{88.49 \text{ km/hr}} + \frac{1 - 0.1}{88.49 \text{ km/hr}} \right] + \right.$$

$$\left. \left(\frac{\pi}{2} \cdot \ln \frac{8 \text{ m}}{5 \text{ m}} \cdot 1.0 + \frac{\pi}{2} \cdot \ln \frac{800 \text{ m}}{8 \text{ m}} \cdot 1.0 \right) \cdot 0.050 \cdot \left[\frac{0.1 \cdot 2}{24.16 \text{ km/hr}} + \frac{1 - 0.1}{24.16 \text{ km/hr}} \right] \right\} \cdot$$

$$\left(\frac{1 \text{ rem}}{1000 \text{ mrem}} \right) \cdot \left(\frac{1 \text{ km}}{1000 \text{ m}} \right)^2$$

$$\text{Dose} = 1.07\text{E}{-4} \text{ person-rem}$$

3.4.4 On-Link Dose - Truck

The on-link dose is comprised of three parts: (1) the dose to persons traveling in the same direction as the shipment, (2) the dose to persons traveling in the opposite direction as the shipment, and (3) the dose to persons passing the shipment.

3.4.4.1 Rural On-Link Dose - Truck. This section presents the detailed hand calculations for the doses to persons traveling in the same direction as the shipment, persons traveling in the opposite direction of the shipment, persons passing the shipment, and total rural on-link doses.

3.4.4.1.1 Persons Traveling in the Same Direction as the Shipment—

$$\text{Dose} = \frac{2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_r \cdot Y(V_r)}{(V_r)^2}$$

$$\text{Dose} = \frac{2 \cdot 6.25\,\text{m}^2 \cdot 14\,\text{mrem/hr} \cdot 1\,\text{km} \cdot 2\,\text{people/vehicle} \cdot 470\,\text{vehicles/hr}}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{49.16\,\text{m}} \cdot \frac{1\,\text{rem}}{1000\,\text{mrem}} \cdot \frac{1000\,\text{m}}{1\,\text{km}} \cdot \left[\frac{1\,\text{km}}{1000\,\text{m}}\right]^2$$

Dose = 4.27E-7 person-rem

3.4.4.1.2 Persons Traveling in the Opposite Direction as the Shipment

$$\text{Dose} = \frac{2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_r}{(V_r)^2} \cdot \left[f_{fwy} \cdot Z_{15,\infty} + (1 - f_{fwy}) \cdot Z_{3,\infty} \right]$$

$$\text{Dose} = \frac{2 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 2\ \text{people/vehicle} \cdot 470\ \text{vehicles/hr}}{(88.49\ \text{km/hr})^2} \cdot$$

$$\left[1.0 \cdot \frac{\pi}{2} \cdot \frac{1}{15\ \text{m}} + (1 - 1.0) \cdot \frac{\pi}{2} \cdot \frac{1}{3\ \text{m}} \right] \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left(\frac{1\ \text{km}}{1000\ \text{m}} \right)^2$$

$$\text{Dose} = 2.20\text{E}{-6}\ \text{person-rem}$$

3.4.4.1.3 Persons Passing the Shipment—

$$\text{Dose} = \frac{2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_r}{(V_r)^2} \cdot \frac{1}{2} \cdot \left[Y(\text{min}) - Y(V_r) \right]$$

$$\text{Dose} = \frac{2 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 2\ \text{people/vehicle} \cdot 470\ \text{vehicles/hr}}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4\ \text{m}} - \frac{1}{49.16\ \text{m}} \right] \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}} \right]^2$$

Dose = 2.41E-6 person-rem

3.4.4.1.4 Total Rural On-Link Dose - Truck—

Total On-Link Dose = 4.27E-7 person-rem + 2.20E-6 person-rem + 2.41E-6 person-rem = 5.04E-6 person-rem

3.4.4.2 ***Suburban On-Link Dose - Truck.*** This section presents the detailed hand calculations for the doses to persons traveling in the same direction as the shipment, persons traveling in the opposite direction of the shipment, persons passing the shipment, and total suburban on-link doses.

3.4.4.2.1 Persons Traveling in the Same Direction as the Shipment—

$$\text{Dose} = 2 \cdot k_0 \cdot DR_p' \cdot DIST \cdot PPV \cdot N_s \cdot \left\{ f_{fwy} \cdot \left[\frac{f_{rh} \cdot 2}{(V_r/2)^2} \cdot Y(V_r/2) + \frac{1 - f_{rh}}{(V_r)^2} \cdot Y(V_r) \right] + \right.$$

$$\left. (1 - f_{fwy}) \cdot \left[\frac{f_{rh} \cdot 2}{(V_s/2)^2} \cdot Y(V_s/2) + \frac{(1 - f_{rh})}{(V_s)^2} \cdot Y(V_s) \right] \right\}$$

$$\text{Dose} = 2 \cdot 6.25\ m^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 2\ \text{people/vehicle} \cdot 780\ \text{vehicles/hr} \cdot$$

$$\left\{ 1.0 \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{24.58\ \text{m}} + \frac{(1 - 0.1)}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{49.16\ \text{m}} \right] + \right.$$

$$\left. (1 - 1.0) \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(40.25\ \text{km/hr})^2} \cdot \frac{1}{11.18\ \text{m}} + \frac{(1 - 0.1)}{(40.25\ \text{km/hr})^2} \cdot \frac{1}{22.36\ \text{m})} \right] \right\} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}} \right]^2$$

$$\text{Dose} = 1.77\text{E-}6\ \text{person-rem}$$

3.4.4.2.2 Persons Traveling in the Opposite Direction as the Shipment—

$$\text{Dose} = 2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_s \cdot \left\{ f_{fwy} \cdot Z_{15,\infty} \left[\frac{f_{rh} \cdot 2}{(V_r/2)^2} + \frac{1 - f_{rh}}{(V_r)^2} \right] + \right.$$

$$\left. (1 - f_{fwy}) \cdot Z_{3,\infty} \cdot \left[\frac{f_{rh} \cdot 2}{(V_s/2)^2} + \frac{(1 - f_{rh})}{(V_s)^2} \right] \right\}$$

$$\text{Dose} = 2 \cdot 6.25 \text{ m}^2 \cdot 14 \text{ mrem/hr} \cdot 1 \text{ km} \cdot 2 \text{ people/vehicle} \cdot 780 \text{ vehicles/hr} \cdot$$

$$\left\{ 1.0 \cdot \frac{\pi}{2} \cdot \frac{1}{15 \text{ m}} \left[\frac{0.1 \cdot 2 \cdot 4}{(88.49 \text{ km/hr})^2} + \frac{(1 - 0.1)}{(88.49 \text{ km/hr})^2} \right] + \right.$$

$$\left. (1 - 1.0) \cdot \frac{\pi}{2} \cdot \frac{1}{3 \text{ m}} \left[\frac{0.1 \cdot 2 \cdot 4}{(40.25 \text{ km/hr})^2} + \frac{(1 - 0.1)}{(40.25 \text{ km/hr})^2} \right] \right\} \cdot \frac{1 \text{ rem}}{1000 \text{ mrem}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \left(\frac{1 \text{ km}}{1000 \text{ m}} \right)^2$$

$$\text{Dose} = 6.21\text{E}{-6} \text{ person-rem}$$

3.4.4.2.3 Persons Passing the Shipment–

$$\text{Dose} = 2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_s \cdot \left\{ f_{fwy} \cdot \left[\frac{f_{rh} \cdot 2}{(V_r/2)^2} \cdot \frac{1}{2} \cdot \left[Y(min) - Y(V_r/2) \right] + \frac{(1 - f_{rh})}{(V_r)^2} \cdot \frac{1}{2} \cdot \left[Y(min) - Y(V_r) \right] \right] + \right.$$

$$\left. (1 - f_{fwy}) \cdot \left[\frac{f_{rh} \cdot 2}{(V_s/2)^2} \cdot \frac{1}{2} \cdot \left[Y(min) - Y(V_s/2) \right] + \frac{(1 - f_{rh})}{(V_s)^2} \cdot \frac{1}{2} \cdot \left[Y(min) - Y(V_s) \right] \right] \right\}$$

$$\text{Dose} = 2 \cdot 6.25 \text{ m}^2 \cdot 14 \text{ mrem/hr} \cdot 1 \text{ km} \cdot 2 \text{ people/vehicle} \cdot 780 \text{ vehicles/hr} \cdot$$

$$\left\{ 1.0 \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(88.49 \text{ km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4 \text{ m}} - \frac{1}{24.58 \text{ m}} \right] + \frac{(1 - 0.1)}{(88.49 \text{ km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4 \text{ m}} - \frac{1}{49.16 \text{ m}} \right] \right] + \right.$$

$$\left. (1 - 1.0) \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(40.25 \text{ km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4 \text{ m}} - \frac{1}{11.18 \text{ m}} \right] + \frac{(1 - 0.1)}{(40.25 \text{ km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4 \text{ m}} - \frac{1}{22.36 \text{ m}} \right] \right] \right\} \cdot$$

$$\frac{1 \text{ rem}}{1000 \text{ mrem}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \left[\frac{1 \text{ km}}{1000 \text{ m}} \right]^2$$

$$\text{Dose} = 6.52\text{E}{-6} \text{ person-rem}$$

3.4.4.2.4 Total Suburban On-Link Dose - Truck—

Total On-Link Dose = 1.77E-6 person-rem + 6.21E-6 person-rem + 6.52E-6 person-rem = 1.45E-5 person-rem

3.4.4.3 Urban On-Link Dose - Truck. This section presents the detailed hand calculations for the doses to persons traveling in the same direction as the shipment, persons traveling in the opposite direction of the shipment, persons passing the shipment, and total urban on-link doses.

3.4.4.3.1 Persons Traveling in the Same Direction as the Shipment—

$$\text{Dose} = 2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_u \cdot \left\{ (1 - f_{cs}) \cdot \left[\frac{f_{rh} \cdot 2}{(V_r/2)^2} \cdot Y(V_r/2) + \frac{(1 - f_{rh})}{(V_r)^2} \cdot Y(V_r) \right] + \right.$$

$$\left. f_{cs} \cdot \left[\frac{f_{rh} \cdot 2}{(V_u/2)^2} \cdot Y(V_u/2) + \frac{(1 - f_{rh})}{(V_u)^2} \cdot Y(V_u) \right] \right\}$$

$$\text{Dose} = 2 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 2\ \text{people/vehicle} \cdot 2800\ \text{vehicles/hr} \cdot$$

$$\left\{ (1 - 0.050) \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{24.58\ \text{m}} + \frac{(1 - 0.1)}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{49.16\ \text{m}} \right] + \right.$$

$$\left. 0.050 \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(24.16\ \text{km/hr})^2} \cdot \frac{1}{6.711\ \text{m}} + \frac{(1 - 0.1)}{(24.16\ \text{km/hr})^2} \cdot \frac{1}{13.42\ \text{m})} \right] \right\} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left(\frac{1\ \text{km}}{1000\ \text{m}} \right)^2$$

Dose = 2.17E-5 person-rem

3.4.4.3.2 *Persons Traveling in the Opposite Direction as the Shipment—*

$$\text{Dose} = 2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_u \cdot \left\{ Z_{15,\infty} \cdot (1 - f_{cs}) \cdot \left[\frac{f_{rh} \cdot 2}{(V_r/2)^2} + \frac{(1 - f_{rh})}{(V_r)^2} \right] + Z_{3,\infty} \cdot f_{cs} \cdot \left[\frac{f_{rh} \cdot 2}{(V_u/2)^2} + \frac{(1 - f_{rh})}{(V_u)^2} \right] \right\}$$

$$\text{Dose} = 2 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 2\ \text{people/vehicle} \cdot 2800\ \text{vehicles/hr} \cdot$$

$$\left\{ \frac{\pi}{2} \cdot \frac{1}{15\ \text{m}} \cdot (1 - 0.050) \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(88.49\ \text{km/hr})^2} + \frac{(1 - 0.1)}{(88.49\ \text{km/hr})^2} \right] + \right.$$

$$\left. \frac{\pi}{2} \cdot \frac{1}{3\ \text{m}} \cdot 0.050 \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(24.16\ \text{km/hr})^2} + \frac{(1 - 0.1)}{(24.16\ \text{km/hr})^2} \right] \right\} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left(\frac{1\ \text{km}}{1000\ \text{m}} \right)^2$$

$$\text{Dose} = 9.59\text{E-}5\ \text{person-rem}$$

3.4.4.3.3 Persons Passing the Shipment—

$$\text{Dose} = 2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_u \cdot \left\{ (1-f_{cs}) \cdot \left[\frac{f_{rh} \cdot 2}{(V_r/2)^2} \cdot \frac{1}{2} \cdot \left[Y(\min) - Y(V_r/2) \right] + \frac{(1-f_{rh})}{(V_r)^2} \cdot \frac{1}{2} \cdot \left[Y(\min) - Y(V_r) \right] \right] + \right.$$

$$\left. f_{cs} \cdot \left[\frac{f_{rh} \cdot 2}{(V_u/2)^2} \cdot \frac{1}{2} \cdot \left[Y(\min) - Y(V_u/2) \right] + \frac{(1-f_{rh})}{(V_u)^2} \cdot \frac{1}{2} \cdot \left[Y(\min) - Y(V_u) \right] \right] \right\}$$

$$\text{Dose} = 2 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 2\ \text{people/vehicle} \cdot 2800\ \text{vehicles/hr} \cdot$$

$$\left\{ (1 - 0.050) \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4\ \text{m}} - \frac{1}{24.58\ \text{m}} \right] + \frac{(1 - 0.1)}{(88.49\ \text{km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4\ \text{m}} - \frac{1}{49.16\ \text{m}} \right] \right] + \right.$$

$$\left. 0.050 \cdot \left[\frac{0.1 \cdot 2 \cdot 4}{(24.16\ \text{km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4\ \text{m}} - \frac{1}{6.711\ \text{m}} \right] + \frac{(1 - 0.1)}{(24.16\ \text{km/hr})^2} \cdot \frac{1}{2} \cdot \left[\frac{1}{4\ \text{m}} - \frac{1}{13.42\ \text{m}} \right] \right] \right\} \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left(\frac{1\ \text{km}}{1000\ \text{m}} \right)^2$$

Dose = 3.23E−5 person−rem

3.4.4.3.4 Total Urban On-Link Dose - Truck—

Total On-Link Dose = 2.17E-5 person-rem + 9.59E-5 person-rem + 3.23E-5 person-rem = 1.50E-4 person-rem

3.4.5 Dose at Stops - Truck

This section presents the detailed hand calculations for doses at rural, suburban, and urban stops.

3.4.5.1 Rural Stop Dose - Truck.

$$\text{Dose} = \frac{k_0 \cdot DR_p \cdot T_{st} \cdot P_{st} \cdot DIST}{(r_{st})^2}$$

$$\text{Dose} = \frac{6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 0.011\ \text{hr/km} \cdot 50\ \text{people} \cdot 1\ \text{km}}{(20\ \text{m})^2} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}}$$

Dose = 1.20E−4 person−rem

3.4.5.2 Suburban Stop Dose - Truck.

$$\text{Dose} = \frac{k_0 \cdot DR_p \cdot T_{st} \cdot P_{st} \cdot DIST}{(r_{st})^2}$$

$$\text{Dose} = \frac{6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 0.011\ \text{hr/km} \cdot 50\ \text{people} \cdot 1\ \text{km}}{(20\ \text{m})^2} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}}$$

Dose = 1.20E−4 person−rem

3.4.5.3 Urban Stop Dose - Truck.

$$\text{Dose} = \frac{k_0 \cdot DR_p \cdot T_{st} \cdot P_{st} \cdot DIST}{(r_{st})^2}$$

$$\text{Dose} = \frac{6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 0.011\ \text{hr/km} \cdot 50\ \text{people} \cdot 1\ \text{km}}{(20\ \text{m})^2} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}}$$

$$\text{Dose} = 1.20\text{E}{-4}\ \text{person-rem}$$

3.5 Detailed Hand Calculations for Incident-Free Rail Unit Risk Factors

This section presents the detailed hand calculations for (a) linear and nonlinear rural, suburban, and urban crew doses and (b) off-link and on-link doses.

3.5.1 List of Symbols - Truck

d_e	=	Effective package dimension (3 m)
DR_p	=	Package dose rate (14 mrem/hr)
DIST	=	Distance (1 km)
EF	=	Exposure factor (0.16 hr/km)
k_0	=	Package shape factor (6.25 m^2)
k_0'	=	Line-source package shape factor (2.5 m)
MINCL	=	Minimum number of rail classifications or inspections (2)
N_r	=	One-way traffic count in rural zone (1 vehicle/hr)
N_s	=	One-way traffic count in suburban zone (5 vehicles/hr)
N_u	=	One-way traffic count in urban zone (5 vehicle/hr)
PD_{st}	=	Population density at stops (719 people/km^2)
PD_r	=	Population density in rural zone (6 people/km^2)
PD_s	=	Population density in suburban zone (719 people/km^2)
PD_u	=	Population density in urban zone (3861 people/km^2)
PPV	=	Number of people per vehicle (3 people/vehicle)
r_a	=	Minimum distance at stops (10 m)
r_b	=	Maximum distance at stops (400 m)
SF_{st}	=	Shielding factor at stops (0.1)
T_a	=	Distance-independent stop time (60 hr)
T_{st}	=	Distance-dependent stop time (0.033 hr/km)
V_r	=	Speed in rural zone (64.37 km/hr)
V_s	=	Speed in suburban zone (40.25 km/hr)
V_u	=	Speed in urban zone (24.16 km/hr)

$$H_{min,max} = \int_{x=min}^{x=max} \left[\int_{r=x}^{r=\infty} \frac{dr}{r(r^2 - x^2)^{1/2}} \right] dx = \frac{\pi}{2} \cdot \ln \left[\frac{max}{min} \right]$$

$H_{min,max}$ is unitless

$$Z_{x,\infty} = \int_{r=x}^{r=\infty} \frac{dr}{r(r^2 - x^2)^{1/2}} = \frac{\pi}{2} \cdot \frac{1}{x}$$

$Z_{x,\infty}$ has units of m^{-1}

3.5.2 Linear Rural, Suburban, and Urban Crew Dose - Rail

$$\text{Dose} = k_0' \cdot DR_p \cdot EF \cdot 0.0018 \cdot DIST$$

$$k_0' = 1 + 0.5 \cdot d_e$$

$$k_0' = 1 + 0.5 \cdot 3\text{ m} = 2.5\text{ m}$$

$$\text{Dose} = 2.5\text{ m} \cdot 14\text{ mrem/hr} \cdot 0.16\text{ person-hr/m} \cdot \frac{1\text{ rem}}{1000\text{ mrem}} \cdot \frac{0.0018}{\text{km}} \cdot 1\text{ km}$$

$$\text{Dose} = 1.01\text{E}{-5}\text{ person-rem}$$

3.5.3 Nonlinear Rural, Suburban, and Urban Crew Dose - Rail

$$\text{Dose} = k_0' \cdot DR_p \cdot EF \cdot MINCL$$

$$\text{Dose} = 2.5\text{ m} \cdot 14\text{ mrem/hr} \cdot 0.16\text{ person-hr/m} \cdot 2 \cdot \frac{1\text{ rem}}{1000\text{ mrem}}$$

$$\text{Dose} = 1.12\text{E}{-2}\text{ person-rem}$$

3.5.4 Off-Link Dose - Rail

This section presents the detailed hand calculations for rural, suburban, and urban off-link doses.

3.5.4.1 Rural Off-Link Dose - Rail.

$$\text{Dose} = \frac{4 \cdot k_0 \cdot DR_p \cdot DIST \cdot H_{30,800} \cdot PD_r}{V_r}$$

$$\text{Dose} = \frac{4 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 6\ \text{people/km}^2}{64.37\ \text{km/hr}} \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}}\right]^2$$

$$\text{Dose} = 1.68\text{E}{-7}\ \text{person-rem}$$

3.5.4.2 Suburban Off-Link Dose - Rail.

$$\text{Dose} = \frac{4 \cdot k_0 \cdot DR_p \cdot DIST \cdot H_{30,800} \cdot PD_s}{V_s}$$

$$\text{Dose} = \frac{4 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 719\ \text{people/km}^2}{40.25\ \text{km/hr}} \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}}\right]^2$$

$$\text{Dose} = 3.22\text{E}{-5}\ \text{person-rem}$$

3.5.4.3 Urban Off-Link Dose - Rail.

$$\text{Dose} = \frac{4 \cdot k_0 \cdot DR_p \cdot DIST \cdot H_{30,800} \cdot PD_u}{V_u}$$

$$\text{Dose} = \frac{4 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot \frac{\pi}{2} \cdot \ln \frac{800\ \text{m}}{30\ \text{m}} \cdot 3861\ \text{people/km}^2}{24.16\ \text{km/hr}} \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}} \right]^2$$

Dose = 2.88E−4 person−rem

3.5.5 On-Link Dose - Rail

This section presents the detailed hand calculations for rural, suburban, and urban on-link doses.

3.5.5.1 Rural On-Link Dose - Rail.

$$\text{Dose} = \frac{2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_r \cdot Z_{3,\infty}}{(V_r)^2}$$

$$\text{Dose} = \frac{2 \cdot 6.25 \text{ m}^2 \cdot 14 \text{ mrem/hr} \cdot 1 \text{ km} \cdot 3 \text{ people/vehicle} \cdot 1 \text{ vehicle/hr} \cdot \frac{\pi}{2} \cdot \frac{1}{3 \text{ m}}}{(64.37 \text{ km/hr})^2} \cdot$$

$$\frac{1 \text{ rem}}{1000 \text{ mrem}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \left[\frac{1 \text{ km}}{1000 \text{ m}}\right]^2$$

$$\text{Dose} = 6.63\text{E}{-8} \text{ person-rem}$$

3.5.5.2 Suburban On-Link Dose - Rail.

$$\text{Dose} = \frac{2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_s \cdot Z_{3,\infty}}{(V_s)^2}$$

$$\text{Dose} = \frac{2 \cdot 6.25 \text{ m}^2 \cdot 14 \text{ mrem/hr} \cdot 1 \text{ km} \cdot 3 \text{ people/vehicle} \cdot 5 \text{ vehicles/hr} \cdot \frac{\pi}{2} \cdot \frac{1}{3 \text{ m}}}{(40.25 \text{ km/hr})^2} \cdot$$

$$\frac{1 \text{ rem}}{1000 \text{ mrem}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \left[\frac{1 \text{ km}}{1000 \text{ m}}\right]^2$$

$$\text{Dose} = 8.48\text{E}{-7} \text{ person-rem}$$

3.5.5.3 Urban On-Link Dose - Rail.

$$\text{Dose} = \frac{2 \cdot k_0 \cdot DR_p \cdot DIST \cdot PPV \cdot N_u \cdot Z_{3,\infty}}{(V_u)^2}$$

$$\text{Dose} = \frac{2 \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 1\ \text{km} \cdot 3\ \text{people/vehicle} \cdot 5\ \text{vehicles/hr} \cdot \frac{\pi}{2} \cdot \frac{1}{3\ \text{m}}}{(24.16\ \text{km/hr})^2} \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}}\right]^2$$

Dose = 2.35E−6 person−rem

3.5.6 Dose at Stops - Rail

This section presents the detailed hand calculations for linear and nonlinear rural, suburban, and urban stop doses.

3.5.6.1 Linear Rural, Suburban, and Urban Stop Dose - Rail.

$$\text{Dose} = 2 \cdot \pi \cdot k_0 \cdot DR_p \cdot T_{st} \cdot PD_{st} \cdot DIST \cdot SF_{st} \cdot \ln \frac{r_b}{r_a}$$

$$\text{Dose} = 2 \cdot \pi \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 0.033\ \text{hr/km} \cdot 719\ \text{people/km}^2 \cdot 1\ \text{km} \cdot 0.1 \cdot$$

$$\ln \frac{400\ \text{m}}{10\ \text{m}} \cdot \frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}}\right]^2$$

$$\text{Dose} = 4.81\text{E}{-6}\ \text{person-rem}$$

3.5.6.2 Nonlinear Rural, Suburban, and Urban Stop Dose - Rail.

$$\text{Dose} = 2 \cdot \pi \cdot k_0 \cdot DR_p \cdot T_a \cdot PD_{st} \cdot SF_{st} \cdot \ln \frac{r_b}{r_a}$$

$$\text{Dose} = 2 \cdot \pi \cdot 6.25\ \text{m}^2 \cdot 14\ \text{mrem/hr} \cdot 60\ \text{hr} \cdot 719\ \text{people/km}^2 \cdot 0.1 \cdot \ln \frac{400\ \text{m}}{10\ \text{m}} \cdot$$

$$\frac{1\ \text{rem}}{1000\ \text{mrem}} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}}\right]^2$$

$$\text{Dose} = 8.75\text{E}{-3}\ \text{person-rem}$$

4. VALIDATION OF THE ACCIDENT RISKS CALCULATED USING THE RADTRAN 4 COMPUTER CODE

4.1 Validation Analysis

The RADTRAN 4 computer code (Neuhauser and Kanipe 1995) was used to estimate accident risks for the transportation analyses in DOE (1995). The accident risks represent the probability × consequences for a complete spectrum of accidents.

The purpose of this analysis was to validate the accident risks calculated by RADTRAN 4 by comparing them to hand-calculated values using identical data and equations. The definition of validation used in this analysis was "the test and evaluation of the completed software to ensure compliance with software requirements" (ASME 1989). In the context of this analysis, compliance with software requirements means that the differences between the accident risks calculated by RADTRAN 4 and the hand-calculated accident risks should be small (i.e., within the acceptance criterion established for the validation).

The acceptance criterion for this validation was a percent difference of 5 percent. If the RADTRAN 4 calculated accident risk differed from the hand-calculated accident risk by more than 5 percent, then the result was considered unacceptable. If the RADTRAN 4 calculated accident risk differed from the hand-calculated accident risk by less than 5 percent, then the result was considered acceptable.

Two simple cases were constructed for this validation analysis. In the first case, one radionuclide, cesium-137, was used in the validation analysis and risks were estimated through the groundshine, inhalation, resuspension, cloudshine, and ingestion pathways. This case was designed to test the consequence analysis modules of RADTRAN 4 by setting the accident probability, conditional probabilities, release fractions, aerosolized fractions, and respirable fractions equal to 1.0. The assumptions for the first case are listed below:

- The distance traveled was 1 kilometer (0.6 mile) in a rural population zone.
- The accident probability was 1.0 per kilometer (0.6 mile).
- The package inventory was 1.0E-6 Ci of cesium-137.

- There was one accident severity class with a conditional probability of 1.0.
- The release fraction, aerosolized fraction, and respirable fraction associated with the accident severity class were 1.0.
- There were two contaminated areas consisting of 459 square meters (550 square yards) and 1530 square meters (1836 square yards) with dilution factors of 3.42E-3 s/m^3 and 1.72E-3 s/m^3, respectively.

The accident risks calculated by the RADTRAN 4 computer code for the first case are listed in Table 4-1. Appendix B contains the RADTRAN 4 output for the first case.

The equations used to calculate the accident risks are listed in Chapter 5 of the RADTRAN 4 Technical Manual (Neuhauser and Kanipe 1995). The accident risks estimated using hand calculations are listed in Table 4-1. Section 4.4 contains the detailed hand calculations used to estimate these accident risks. Table 4-1 also contains the percent differences between the RADTRAN 4 and the hand-calculated accident risks.

The second case analyzed in the validation analysis was designed to test the probabilistic modules of RADTRAN 4. It was identical to the first case, except that an accident probability [1.0E-7 accidents per kilometer (1.6E-7 per mile)], conditional probabilities, release fractions, aerosolized fractions, and respirable fractions were incorporated into the analysis (see Table 4-2). As in the first case, risks were estimated through the groundshine, inhalation, resuspension, cloudshine, and ingestion pathways.

To calculate to radiation doses through the groundshine pathway, the groundshine dose calculated in the first case (see Table 4-1) was multiplied by the product of the accident rate, the conditional probability, release fraction, and aerosolized fraction for each severity class. The total groundshine dose is the sum of groundshine doses for each severity class.

To calculate to radiation doses through the inhalation pathway, the inhalation dose calculated in the first case (see Table 4-1) was multiplied by the product of the accident rate, the conditional probability, release fraction, aerosolized fraction, and respirable fraction for each severity class. The total inhalation dose is the sum of inhalation doses for each severity class.

To calculate to radiation doses through the resuspension pathway, the resuspension dose calculated in the first case (see Table 4-1) was multiplied by the product of the accident rate, the conditional probability, release fraction, aerosolized fraction, and respirable fraction for each severity class. The total resuspension dose is the sum of resuspension doses for each severity class.

To calculate to radiation doses through the cloudshine pathway, the cloudshine dose calculated in the first case (see Table 4-1) was multiplied by the product of the accident rate, the conditional probability, release fraction, and aerosolized fraction for each severity class. The total cloudshine dose is the sum of cloudshine doses for each severity class.

To calculate to radiation doses through the ingestion pathway, the ingestion dose calculated in the first case (see Table 4-1) was multiplied by the product of the accident rate, the conditional probability, release fraction, and aerosolized fraction for each severity class. The total ingestion dose is the sum of ingestion doses for each severity class.

Appendix B contains the RADTRAN 4 output for the second case. Table 4-3 summarizes the radiation doses for each severity class and pathway. Table 4-4 contains the percent differences between the RADTRAN 4- and the hand-calculated accident risks.

4.2 Results of Validation Analysis

For the first case, designed to test the consequence analysis modules of RADTRAN 4, the minimum percent difference observed in Table 4-1 was zero, which meant that RADTRAN 4 and the hand calculation yielded identical results. The maximum percent difference observed in Table 4-1 was -0.38 percent, well within the 5 percent validation criterion.

For the second case, designed to test the probabilistic modules of RADTRAN 4, the minimum percent difference observed in Table 4-4 was also zero, which meant that RADTRAN 4 and the hand calculation yielded identical results. The maximum percent difference observed in Table 4-4 was -0.17 percent, well within the 5 percent validation criterion.

These results show that the differences between the accident risks estimated by RADTRAN 4 and the accident risks estimated using hand calculations are small and are within the acceptance criterion established for the validation. Therefore, the accident risks generated using the RADTRAN 4 computer code are considered validated.

Table 4-1. RADTRAN 4-calculated and hand-calculated accident risks for case one.

	Accident risks (person-rem)		
Pathway	RADTRAN 4	Hand-calculated	Percent difference
Groundshine	1.35E-7	1.35E-7	0.0
Inhalation	2.84E-10	2.84E-10	0.0
Resuspension	1.25E-9	1.25E-9	0.0
Cloudshine	2.61E-12	2.62E-12	-0.38
Ingestion	5.23E-7	5.24E-7	-0.19

Table 4-2. Conditional probabilities, release fractions, aerosolized fractions, and respirable fractions for case two.

Severity class	Conditional probability	Release fraction	Aerosolized fraction	Respirable fraction
1	9.94E-01	0.00	0.00	5.00E-01
2	2.72E-03	1.00E-01	4.00E-04	5.00E-01
3	5.54E-04	1.00E+00	4.00E-04	5.00E-01
4	1.79E-09	1.00E+00	4.00E-03	5.00E-01
5	1.23E-03	3.00E-02	4.00E-04	5.00E-01
6	5.01E-07	1.00E-01	4.00E-04	5.00E-01
7	1.02E-07	1.00E+00	4.00E-04	5.00E-01
8	3.29E-13	1.00E+00	4.00E-03	5.00E-01
9	7.95E-04	3.00E-02	4.00E-04	5.00E-01
10	3.26E-07	1.00E-01	4.00E-04	5.00E-01
11	6.63E-08	1.00E+00	4.00E-04	5.00E-01
12	2.14E-13	1.00E+00	4.00E-03	5.00E-01
13	6.14E-04	1.00E+00	4.00E-04	5.00E-01
14	2.53E-07	1.00E+00	4.00E-04	5.00E-01
15	5.16E-08	1.00E+00	4.00E-04	5.00E-01
16	1.64E-13	1.00E+00	4.00E-03	5.00E-01
17	1.25E-04	1.00E+00	4.00E-03	5.00E-01
18	1.08E-08	1.00E+00	4.00E-03	5.00E-01
19	5.30E-08	1.00E+00	4.00E-03	5.00E-01
20	3.46E-14	1.00E+00	4.00E-03	5.00E-01

Table 4-3. Radiation doses by pathway and severity class for case two.

Severity class	Inhalation dose (person-rem)	Resuspension dose (person-rem)	Cloudshine dose (person-rem)	Ingestion dose (person-rem)	Groundshine dose (person-rem)
1	0.00	0.00	0.00	0.00	0.00
2	1.55E-24	6.82E-24	2.85E-26	5.70E-21	1.47E-21
3	3.15E-24	1.39E-23	5.80E-26	1.16E-20	3.00E-21
4	1.02E-28	4.49E-28	1.87E-30	3.75E-25	9.70E-26
5	2.10E-25	9.26E-25	3.86E-27	7.73E-22	2.00E-22
6	2.85E-28	1.26E-27	5.24E-30	1.05E-24	2.72E-25
7	5.80E-28	2.56E-27	1.07E-29	2.14E-24	5.53E-25
8	1.87E-32	8.25E-32	3.44E-34	6.89E-29	1.78E-29
9	1.36E-25	5.98E-25	2.50E-27	5.00E-22	1.29E-22
10	1.85E-28	8.18E-28	3.41E-30	6.83E-25	1.77E-25
11	3.77E-28	1.66E-27	6.94E-30	1.39E-24	3.59E-25
12	1.22E-32	5.37E-32	2.24E-34	4.48E-29	1.16E-29
13	3.49E-24	1.54E-23	6.42E-26	1.29E-20	3.33E-21
14	1.44E-27	6.35E-27	2.65E-29	5.30E-24	1.37E-24
15	2.94E-28	1.29E-27	5.40E-30	1.08E-24	2.80E-25
16	9.33E-33	4.11E-32	1.72E-34	3.44E-29	8.89E-30
17	7.11E-24	3.14E-23	1.31E-25	2.62E-20	6.77E-21
18	6.14E-28	2.71E-27	1.13E-29	2.26E-24	5.85E-25
19	3.02E-27	1.33E-26	5.54E-29	1.11E-23	2.87E-24
20	1.97E-33	8.68E-33	3.62E-35	7.25E-30	1.88E-30
Total	1.57E-23	6.90E-23	2.88E-25	5.77E-20	1.49E-20

Table 4-4. RADTRAN 4-calculated and hand-calculated accident risks for case two.

	Accident risks (person-rem)		
Pathway	RADTRAN 4	Hand-calculated	Percent difference
Groundshine	1.49E-20	1.49E-20	0.0
Inhalation	1.57E-23	1.57E-23	0.0
Resuspension	6.91E-23	6.90E-23	0.14
Cloudshine	2.88E-25	2.88E-25	0.0
Ingestion	5.76E-20	5.77E-20	-0.17

4.3 Critiques of RADTRAN

As part of this validation analysis, the following documents were examined for specific comments on the accident risk conceptual models used in RADTRAN:

- Public comments contained in Volume II of the *Final Environmental Impact Statement on the Transportation of Radioactive Materials By Air and Other Modes* (NRC 1977a)

- *The Latest Nuclear Dilemma: Waste Shipment Peril Explored* (Resnikoff et al. 1982)

- *Analysis of Recent Council on Economic Priorities Newsletter* (Jefferson et al. 1982)

- *Transporting Spent Nuclear Fuel Allegations and Responses* (Jefferson 1983)

- *The Next Nuclear Gamble: Transportation and Storage of Nuclear Waste* (Resnikoff 1983)

- *Probabilistic Risk Assessment and Nuclear Waste Transportation: A Case Study of the Use of RADTRAN in the 1986 Environmental Assessment for Yucca Mountain* (Resnikoff 1990)

- *A Comparison of RISKIND and RADTRAN 4* (Brumburgh and Alesso 1993)

It should be noted that there have been many comments on the accident rates, conditional probabilities, and release fractions used in specific analyses performed using RADTRAN (i.e., see Resnikoff 1990). These comments questioned the data that were used in the analyses, not the conceptual models contained in RADTRAN. Therefore, they are not addressed in this validation analysis.

Based on these documents, four specific comments on the accident risk conceptual models used in RADTRAN were identified (some of these comments do not apply to the current version of RADTRAN, but do apply to previous versions of RADTRAN):

1. The health effects models in RADTRAN are out of date.

2. The consequence models in RADTRAN are not detailed enough and should be more realistic.

3. The inhalation dose conversion factors in RADTRAN are inappropriate.

4. The clean-up criteria used in RADTRAN are inappropriate.

These comments were evaluated for their applicability to RADTRAN 4. Responses to the comments are listed below:

1. It is correct that the health effects models in RADTRAN are based on the Reactor Safety Study (NRC 1975). However, RADTRAN provides sufficient data so that health effects may be estimated using more current methods outside the code. In DOE (1995), health effects were estimated from the radiation doses calculated using RADTRAN 4 by using the risk coefficients recommended by the International Commission on Radiological Protection in ICRP Publication 60 (ICRP 1991).

2. The consequence models in RADTRAN are meant to be assessment level models. In DOE (1995), more detailed evaluations of the consequences of transportation accidents were conducted using the RISKIND computer code (Yuan et al. 1993).

3. The dose conversion factors used in RADTRAN are based on methods established by the International Commission on Radiological Protection in ICRP-30. In addition, the RADTRAN data base may be modified to use dose conversion factors from other data bases.

4. The value used for the cleanup criteria is an input parameter that may be modified by the user. In DOE (1995), no credit was taken for cleanup.

4.4 Detailed Hand Calculations for Accident Risks

This section provides the hand calculations used to estimate accident risks in order to compare the result of RADTRAN 4 analyses. The section covers risks estimated through the following pathways: groundshine, inhalation, resuspension, cloudshine, and ingestion. Also included is a list of symbols.

4.4.1 List of Symbols

AREA	=	Area associated with the atmospheric dilution factor, DF (459 m^2 and 1,530 m^2)
$AREA_1$	=	First area (459 m^2)
$AREA_2$	=	Second area (1530 m^2)
BR	=	Breathing rate (3.3E-4 m^3/s)
DCF_{imm}	=	Immersion dose conversion factor (9.71E-2 rem-m^3/Ci-s)
DCF_{ing}	=	Ingestion dose conversion factor (5.0E+4 rem/Ci)
DCF_{inh}	=	Inhalation dose conversion factor (3.2E+4 rem/Ci)
DF	=	Atmospheric dilution factor associated with area, AREA (3.42E-3 s/m^3 and 1.72E-3 s/m^3)
DF_1	=	First atmospheric dilution factor (3.42E-3 s/m^3)
DF_2	=	Second atmospheric dilution factor (1.72E-3 s/m^3)
DIST	=	distance (1 km)
E_γ	=	Gamma energy (0.596 MeV)
F_a	=	Aerosolized fraction (1.0)
F_r	=	Respirable fraction (1.0)
Γ	=	Groundshine dose conversion factor (3.04E-4 mrem-m^2/day-μCi-MeV)
INV	=	Container inventory (10^{-6} Ci)
k_1	=	Rate constant for short term loss from soil (3.16E-3 d^{-1})
k_2	=	Rate constant for long term loss from soil (8.40E-5 d^{-1})
PD	=	Population density (6 people/km^2)
P_{sc}	=	Conditional probability of severity class (1.0)
RATE	=	Accident rate (1.0 accidents/km)
RF	=	Release fraction associated with severity class (1.0)
T	=	Exposure time for groundshine pathway (1.83E+4 days)
TC	=	Food transfer factor (3.07E-4)
v_d	=	Deposition velocity (0.01 m/s)

4.4.2 Groundshine Pathway

For each area, the accident risk through the groundshine pathway is given by:

$$\text{Dose} = \text{INV} \cdot \text{RATE} \cdot \text{DIST} \cdot P_{sc} \cdot \text{RF} \cdot F_a \cdot \text{DF} \cdot v_d \cdot \Gamma \cdot E_\gamma \cdot \text{PD} \cdot \text{AREA} \cdot$$

$$\left[0.63\,\frac{1 - \exp(-Tk_1)}{k_1} + 0.37\,\frac{1 - \exp(-Tk_2)}{k_2}\right] \cdot \left(\frac{1\text{ km}}{1000\text{ m}}\right)^2$$

For the first area (459 m^2) with a dilution factor of 3.42E-3 s/m^3:

$$\text{Dose} = 1\ \mu\text{Ci} \cdot 1\ \text{accident/km} \cdot 1\ \text{km} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 3.42\text{E-3 s/m}^3 \cdot 0.01\ \text{m/s} \cdot 3.04\text{E-4}\ \frac{\text{rem-m}^2}{\text{day-}\mu\text{Ci-MeV}} \cdot 0.596\ \text{MeV} \cdot$$

$$6\,\text{people/km}^2 \cdot 4.59\text{E+2m}^2 \cdot \left[0.63\,\frac{1-\exp(-1.83\text{E+4d} \cdot 3.16\text{E-3d}^{-1})}{3.16\text{E-3d}^{-1}} + 0.37\,\frac{1-\exp(-1.83\text{E+4d} \cdot 8.40\text{E-5d}^{-1})}{8.40\text{E-5d}^{-1}}\right] \cdot \left(\frac{1\text{km}}{1000\text{m}}\right)^2$$

$$\text{Dose} = 6.23\text{E-8 person-rem}$$

For the second area ($1071\ m^2 = 1530\ m^2 - 459\ m^2$) with a dilution factor of 1.72E-5 s/m^3:

$$\text{Dose} = 1\ \mu\text{Ci} \cdot 1\ \text{accident/km} \cdot 1\ \text{km} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 1.72\text{E}{-3}\ \text{s/m}^3 \cdot 0.01\ \text{m/s} \cdot 3.04\text{E}{-4}\ \frac{\text{rem-m}^2}{\text{day-}\mu\text{Ci-MeV}} \cdot 0.596\ \text{MeV} \cdot$$

$$6\,\text{people/km}^2 \cdot 1.07\text{E}{+3}\,\text{m}^2 \cdot \left[0.63\ \frac{1-\exp(-1.83\text{E}{+4}\text{d} \cdot 3.16\text{E}{-3}\text{d}^{-1})}{3.16\text{E}{-3}\text{d}^{-1}} + 0.37\ \frac{1-\exp(-1.83\text{E}{+4}\text{d} \cdot 8.40\text{E}{-5}\text{d}^{-1})}{8.40\text{E}{-5}\text{d}^{-1}}\right] \cdot \left(\frac{1\text{km}}{1000\text{m}}\right)^2$$

$$\text{Dose} = 7.32\text{E}{-8}\ \text{person-rem}$$

$$\text{Total Groundshine Dose} = 6.23\text{E}{-8}\ \text{person-rem} + 7.32\text{E}{-8}\ \text{person-rem} = 1.35\text{E}{-7}\ \text{person-rem}$$

4.4.3 Inhalation Pathway

$$\text{Dose} = \text{INV} \cdot \text{RATE} \cdot \text{DIST} \cdot P_{sc} \cdot \text{RF} \cdot F_a \cdot F_r \cdot \text{PD} \cdot \text{BR} \cdot \text{DCF}_{inh} \cdot \text{IF} \cdot \left[\frac{1\ \text{km}}{1000\ \text{m}}\right]^2$$

$$\text{IF} = \text{AREA}_2 \cdot \frac{\text{DF}_1 + \text{DF}_2 - \text{AREA}_1 \cdot \text{SLOPE}}{2}$$

$$\text{SLOPE} = \frac{\text{DF}_2 - \text{DF}_1}{\text{AREA}_2 - \text{AREA}_1}$$

$$\text{SLOPE} = \frac{1.72\text{E}{-3}\ \text{s/m}^3 - 3.42\text{E}{-3}\ \text{s/m}^3}{1530\ \text{m}^2 - 459\ \text{m}^2} = -1.59\text{E}{-6}\ \text{s/m}^5$$

$$\text{IF} = 1530\ \text{m}^2 \cdot \frac{3.42\text{E}{-3}\ \text{s/m}^3 + 1.72\text{E}{-3}\ \text{s/m}^3 - (459\ \text{m}^2 \cdot -1.59\text{E}{-6}\ \text{s/m}^5)}{2} = 4.49\ \text{s/m}$$

$$\text{Dose} = 10^{-6}\ \text{Ci} \cdot 1\,\text{accident/km} \cdot 1\,\text{km} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 6\,\text{people/km}^2 \cdot 3.3\text{E}{-4}\,\text{m}^3\text{/s} \cdot 3.2\text{E}{+4}\,\text{rem/Ci} \cdot 4.49\,\text{s/m} \cdot \left[\frac{1\,\text{km}}{1000\,\text{m}}\right]^2$$

$$\text{Dose} = 2.84\text{E}{-10}\ \text{person-rem}$$

4.4.4 Resuspension Pathway

Dose = Inhalation Dose • (Resuspension Factor - 1)

Dose = 2.84E-10 person-rem • (5.41 - 1) = 1.25E-9 person-rem

4.4.5 Cloudshine Pathway

$$\text{Dose} = \text{INV} \cdot \text{RATE} \cdot \text{DIST} \cdot P_{sc} \cdot \text{RF} \cdot F_a \cdot \text{PD} \cdot \text{DCF}_{imm} \cdot \text{IF} \cdot \left(\frac{1 \text{ km}}{1000 \text{ m}} \right)^2$$

$$\text{IF} = \text{AREA}_2 \cdot \frac{\text{DF}_1 + \text{DF}_2 - \text{AREA}_1 \cdot \text{SLOPE}}{2}$$

$$\text{SLOPE} = \frac{\text{DF}_2 - \text{DF}_1}{\text{AREA}_2 - \text{AREA}_1}$$

$$\text{SLOPE} = \frac{1.72\text{E-3 s/m}^3 - 3.42\text{E-3 s/m}^3}{1530 \text{ m}^2 - 459 \text{ m}^2} = -1.59\text{E-6 s/m}^5$$

$$\text{IF} = 1530 \text{ m}^2 \cdot \frac{3.42\text{E-3 s/m}^3 + 1.72\text{E-3 s/m}^3 - (459 \text{ m}^2 \cdot -1.59\text{E-6 s/m}^5)}{2} = 4.49 \text{ s/m}$$

$$\text{Dose} = 10^{-6} \text{ Ci} \cdot 1 \text{ accident/km} \cdot 1 \text{ km} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 6 \text{ people/km}^2 \cdot 9.71\text{E-2} \frac{\text{rem-m}^3}{\text{Ci-s}} \cdot 4.49 \text{ s/m} \cdot \left(\frac{1 \text{ km}}{1000 \text{ m}} \right)^2$$

$$\text{Dose} = 2.62\text{E-12 person-rem}$$

4.4.6 Ingestion Pathway

For each area, the accident risk through the ingestion pathway is given by:

$$\text{Dose} = \text{INV} \cdot \text{RATE} \cdot \text{DIST} \cdot P_{sc} \cdot \text{RF} \cdot F_a \cdot \text{DF} \cdot v_d \cdot \text{AREA} \cdot \text{TC} \cdot \text{DCF}_{ing}$$

For the first area (459 m^2) with a dilution factor of 3.42E-3 s/m^3:

$$\text{Dose} = 10^{-6}\ \text{Ci} \cdot 1\ \text{accident/km} \cdot 1\ \text{km} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 3.42\text{E}{-3}\ \text{s/m}^3 \cdot 0.01\ \text{m/s} \cdot 4.59\text{E}{+2}\ \text{m}^2 \cdot$$
$$3.07\text{E}{-4} \cdot 5.0\text{E}{+4}\ \text{rem/Ci}$$

$$\text{Dose} = 2.41\text{E}{-7}\ \text{person-rem}$$

For the second area ($1071\ m^2 = 1530\ m^2 - 459\ m^2$) with a dilution factor of $1.72E\text{-}3\ s/m^3$:

$$\text{Dose} = 10^{-6}\ \text{Ci} \cdot 1\ \text{accident/km} \cdot 1\ \text{km} \cdot 1.0 \cdot 1.0 \cdot 1.0 \cdot 1.72E{-3}\ s/m^3 \cdot 0.01\ m/s \cdot 1.07E{+3}\ m^2 \cdot 3.07E{-4} \cdot 5.0E{+4}\ \text{rem/Ci}$$

Dose = 2.83E−7 person−rem

Total Ingestion Dose = 2.41E−7 person−rem + 2.83E−7 person−rem = 5.24E−7 person−rem

5. VALIDATION OF THE INCIDENT-FREE RADIATION DOSES CALCULATED USING THE RISKIND COMPUTER CODE

5.1 Validation Analysis

The RISKIND computer code (Yuan et al. 1993) was used to estimate incident-free radiation doses for maximally exposed individuals for the transportation analyses in DOE (1995).

The purpose of this analysis was to validate the incident-free radiation doses for maximally exposed individuals calculated by RISKIND by comparing them to hand-calculated values using identical data and equations. The definition of validation used in this analysis was "the test and evaluation of the completed software to ensure compliance with software requirements" (ASME 1989). In the context of this analysis, compliance with software requirements means that the differences between the radiation doses calculated by RISKIND and the hand-calculated radiation doses should be small (i.e., within the acceptance criterion established for the validation).

The acceptance criterion for this validation was a percent difference of 5 percent. If the RISKIND calculated radiation doses differed from the hand-calculated radiation doses by more than 5 percent, then the result was considered unacceptable. If the RISKIND calculated radiation doses differed from the hand-calculated radiation doses by less than 5 percent, then the result was considered acceptable.

Two types of incident-free maximally exposed individual scenarios were evaluated in DOE (1995): (1) occupational scenarios and (2) general population scenarios. Two transport modes were also evaluated in DOE (1995): (1) truck and (2) rail. The equations used to calculate incident-free radiation doses are contained in Yuan et al. (1993); the output from the RISKIND computer code for these scenarios is contained in Appendix C. Occupational doses for truck shipments were evaluated using hand calculations and a radiation dose rate of 2 mrem/hr in the truck cab; RISKIND was not used. Therefore, occupational doses for truck shipments were not included in this validation analysis.

Occupational doses for rail shipments were calculated using a radiation dose rate of 21.1 mrem/hr at 1 meter (3.25 feet) from the shipping container; this dose rate yields a dose rate of

10 mrem/hr at 2 meters (6.5 feet) from the shipping container, the regulatory limit. The rail worker was an individual in a railyard who spent a time- and distance-weighted average of 0.16 hours inspecting, classifying, and repairing railcars (Wooden 1986). Radiation doses for this scenario were calculated using the equation:

$$\text{Dose} = \text{Dose rate} \cdot \text{Time}$$

$$\text{Dose} = 21.1 \text{ mrem/hr} \cdot 0.16 \text{ hour} \cdot \frac{1 \text{ rem}}{1000 \text{ mrem}} = 3.38\text{E}{-03} \text{ rem}$$

General population doses for truck and rail shipments were also calculated using a radiation dose rate of 21.1 mrem/hr at 1 meter (3.25 feet) from the shipping container; this dose rate yields a dose rate of 10 mrem/hr at 2 meters (6.5 feet) from the shipping container, the regulatory limit. For truck shipments, the largest radiation dose for the maximally exposed individual was for a service station attendant working at a distance of 20 meters (65 feet) from the shipping container for 2 hours. Radiation doses for this scenario were calculated using the equation:

$$\text{Dose} = \text{Dose rate} \cdot \text{Time}$$

$$\text{Normalized dose rate} = A_0 \cdot \frac{1}{r^2} + A_1 \cdot \frac{1}{r} + A_2 \qquad \text{for } 10 \text{ m} < r \leq 2000 \text{ m}$$

$$\text{Normalized dose rate} = 3.79031\text{E}{+01} \cdot \frac{1}{20^2} + 1.09056\text{E}{-01} \cdot \frac{1}{20} + -2.44353\text{E}{-03}$$

$$\text{Normalized dose rate} = 0.0978 \text{ mrem/hr}$$

$$\text{Dose rate} = \text{normalized dose rate} \cdot \frac{21.1 \text{ mrem/hr}}{10 \text{ mrem/hr}} = 0.0978 \text{ mrem/hr} \cdot \frac{21.1 \text{ mrem/hr}}{10 \text{ mrem/hr}}$$

$$\text{Dose rate} = 0.206 \text{ mrem/hr}$$

$$\text{Dose} = 0.206 \text{ mrem/hr} \cdot 2 \text{ hour} \cdot \frac{1 \text{ rem}}{1000 \text{ mrem}} = 4.13\text{E}{-04} \text{ rem}$$

For rail shipments, the largest radiation dose for the maximally exposed individual was for a railyard worker working at a distance of 10 m (32.5 feet) from the shipping container for 2 hours. Radiation doses for this scenario were calculated using the equation:

$$\text{Dose} = \text{Dose rate} \cdot \text{Time}$$

$$\text{Normalized dose rate} = A_0 \cdot \frac{1}{r} + A_1 + A_2 \cdot r \qquad \text{for } 1 \text{ m} \leq r \leq 10 \text{ m}$$

$$\text{Normalized dose rate} = 1.03586\text{E+01} \cdot \frac{1}{10} + -9.70747\text{E-01} + 3.18380\text{E-02} \cdot 10$$

$$\text{Normalized dose rate} = 0.383 \text{ mrem/hr}$$

$$\text{Dose rate} = \text{Normalized dose rate} \cdot \frac{21.1 \text{ mrem/hr}}{10 \text{ mrem/hr}} = 0.383 \text{ mrem/hr} \cdot \frac{21.1 \text{ mrem/hr}}{10 \text{ mrem/hr}}$$

$$\text{Dose rate} = 0.808 \text{ mrem/hr}$$

$$\text{Dose} = 0.808 \text{ mrem/hr} \cdot 2 \text{ hour} \cdot \frac{1 \text{ rem}}{1000 \text{ mrem}} = 1.62\text{E-03 rem}$$

Table 5-1 provides the radiation doses calculated by the RISKIND computer code, the radiation doses estimated using hand calculations, and the percent differences between the RISKIND- and hand-calculated radiation doses.

5.2 Results of Validation Analysis

The minimum percent difference observed in Table 5-1 was zero, which meant that RISKIND and the hand calculations yielded identical results. The maximum percent difference observed in Table 5-1 was 3.1 percent, within the 5 percent validation criterion. These results show that the differences between the radiation doses estimated by RISKIND and the radiation doses estimated using hand calculations are small and are within the acceptance criterion established for the validation. Therefore, the incident-free radiation doses generated using the RISKIND computer code are considered validated.

Table 5-1. RISKIND-calculated and hand-calculated incident-free radiation doses.

Scenario	Radiation dose (rem)		Percent difference
	RISKIND	Hand-calculated	
Rail - occupational	3.38E-3	3.38E-3	0.0
Truck - general population	4.07E-4	4.13E-4	-1.5
Train - general population	1.67E-3	1.62E-3	3.1

6. VALIDATION OF THE ACCIDENT RADIATION DOSES CALCULATED USING THE RISKIND COMPUTER CODE

6.1 Validation Analysis

The RISKIND computer code (Yuan et al. 1993) was used to estimate the consequences from reasonably foreseeable transportation accidents for the transportation analyses in DOE (1995).

The purpose of this analysis was to validate the accident consequences (radiation doses) for maximally exposed individuals calculated by RISKIND by comparing them to hand-calculated values using identical data and equations. The definition of validation used in this analysis was "the test and evaluation of the completed software to ensure compliance with software requirements" (ASME 1989). In the context of this analysis, compliance with software requirements means that the differences between the radiation doses calculated by RISKIND and the hand-calculated radiation doses should be small (i.e., within the acceptance criterion established for the validation).

The acceptance criterion for this validation was a percent difference of 5 percent. If the RISKIND calculated radiation doses differed from the hand-calculated radiation doses by more than 5 percent, then the result was considered unacceptable. If the RISKIND calculated radiation doses differed from the hand-calculated radiation doses by less than 5 percent, then the result was considered acceptable.

A simple case was constructed for this validation analysis. One radionuclide, cesium-137, was used in the validation analysis and radiation doses were estimated through the groundshine, cloudshine, inhalation, and ingestion pathways. The radiation doses calculated by the RISKIND computer code are listed in Table 6-1. Appendix D contains the RISKIND output.

The equations used to calculate the radiation doses are listed in Yuan et al. (1993). The radiation doses calculated using hand calculations are listed in Table 6-1. Section 6.4 contains the detailed hand calculations used to calculate these radiation doses. Table 6-1 also contains the percent differences between the RISKIND and the hand calculated radiation doses.

Table 6-1. RISKIND-calculated and hand-calculated radiation doses.

Pathway	Radiation dose (rem) RISKIND	Radiation dose (rem) Hand-calculated	Percent difference
Short term	2.29E-1	2.30E-1	-0.43
Long term			
Groundshine	5.16E-1	5.25E-1	-1.7
Cloudshine	7.99E-5	7.97E-5	0.25
Inhalation	7.60E-3	7.51E-3	1.2
Ingestion			
Vegetables	4.68E-1	4.69E-1	-0.21
Meat	7.87E-2	7.90E-2	-0.38
Milk	6.69E-1	6.69E-1	0.0

6.2 Results of Validation Analysis

The minimum percent difference observed in Table 6-1 was zero, which meant that RISKIND and the hand calculation yielded identical results. The maximum percent difference observed in Table 6-1 was 1.7 percent, well within the 5 percent validation criterion. These results show that the differences between the radiation doses estimated by RISKIND and the radiation doses estimated using hand calculations are small and are within the acceptance criterion established for the validation. Therefore, the radiation doses generated using the RISKIND computer code are considered validated.

6.3 Detailed Hand Calculations for the Transportation Accident Scenario

This section gives hand calculations for the following: atmospheric concentration at the receptor, short-term radiation doses, and long-term radiation doses. It also includes a list of symbols used in the calculations.

6.3.1 List of Symbols

BR	=	Breathing rate (2.5E-4 m^3/s for short-term doses, 3.5E-4 m^3/s for long-term doses)
B_v	=	Concentration ratio (wet weight) (0.10)
χ	=	Time-integrated atmospheric concentration (2.04E-2 Ci-s/m^3)
D	=	Decontamination factor for vegetables (0.5)
DCF_{cld}	=	Cloudshine dose conversion factor (2.86E-6 rem-m^3/pCi-yr)
DCF_{grd}	=	Groundshine dose conversion factor (5.82E-8 rem-m^2/pCi-yr)
DCF_{ing}	=	Ingestion dose conversion factor (5.00E-8 rem/pCi)
DCF_{inh}	=	Inhalation dose conversion factor (3.19E-8 rem/pCi)
F_b	=	Beef transfer coefficient (0.004 d/kg)
F_m	=	Milk transfer coefficient (0.012 d/L)
FG	=	Fraction of beef and milk from home garden (0.5)
H	=	Effective release height (10 m)
λ_i	=	Decay constant (2.30E-2 yr^{-1})
λ_g	=	Environmental loss rate constant (0.0139 yr^{-1})
λ_r	=	Resuspension factor decay constant (5.06 yr^{-1})
λ_w	=	Weathering rate constant (0.0495 d^{-1})
P	=	Surface soil density (dry weight) (240 kg/m^2)
Q	=	Release (77 Ci)
Q_{for}	=	Feed consumption rate (50 kg/d)
r	=	Interception fraction (0.2)
R	=	Resuspension factor (1.0E-5 m^{-1})
SF_{cld}	=	Shielding factor for cloudshine doses (0.70)
SF_{grd}	=	Shielding factor for groundshine doses (0.45)

SF_{inh}	=	Shielding factor for inhalation doses (0.75)
σ_y	=	Standard deviation in y direction
σ_z	=	Standard deviation in z direction
t_{for}	=	Forage grow time (30 d)
t_{veg}	=	Vegetable grow time (60 d)
T	=	Long-term build-up time (1 yr)
T_{grd}	=	Short-term groundshine exposure time
TF	=	Translocation factor (1.0)
u	=	Wind speed (4 m/s)
U_b	=	Beef consumption rate (0.30 kg/d)
U_m	=	Milk consumption rate (0.85 L/d)
U_v	=	Vegetable consumption rate (0.77 kg/d)
v_d	=	Deposition velocity on soil (0.001 m/s)
v_d(soil)	=	Deposition velocity on soil (0.001 m/s)
v_d(for)	=	Deposition velocity on forage (0.01 m/s)
x	=	Distance in x-direction to receptor (130 m)
y	=	Crosswind distance to receptor (0 m)
Y_{for}	=	Forage yield (0.75 kg/m^2)
Y_{veg}	=	Vegetable yield (2.0 kg/m^2)

Fitted parameters for calculating σ_y and σ_z:

σ_θ	=	10
a	=	0.222
b	=	0.725
c	=	-1.7

6.3.2 Atmospheric Concentration at Receptor

The RISKIND computer code calculates the atmospheric concentration of a radionuclide at the location of the receptor using the Gaussian plume atmospheric dispersion model:

$$\chi = \frac{Q}{\pi \cdot \sigma_y \cdot \sigma_z \cdot u} \cdot \exp\left[-\left(\frac{y^2}{2\sigma_y^2} + \frac{H^2}{2\sigma_z^2}\right)\right]$$

$$\sigma_y(x) = (0.000246 \cdot \sigma_\theta^2 + 0.00576 \cdot \sigma_\theta + 0.066) \cdot x^{0.9031}$$

$$\sigma_z(x) = a \cdot x^b + c$$

From Yuan et al. (1993), at a distance of 130 m for class D stability:

Q	=	77 Ci
x	=	130 m
σ_θ	=	10
a	=	0.222
b	=	0.725
c	=	-1.7
u	=	4 m/s
y	=	0 m
H	=	10 m

$$\sigma_y(130\text{m}) = (0.000246 \cdot 10^2 + 0.00576 \cdot 10 + 0.066) \cdot 130^{0.9031} = 12.0 \text{ m}$$

$$\sigma_z(130\text{m}) = 0.222 \cdot 130^{0.725} + -1.7 = 5.87 \text{ m}$$

$$\chi = \frac{77\,\text{Ci}}{\pi \cdot 12.0\text{m} \cdot 5.87\text{m} \cdot 4\text{m/s}} \cdot \exp\left[-\left[\frac{(0\text{m})^2}{2 \cdot (12.0\text{m})^2} + \frac{(10\text{m})^2}{2 \cdot (5.87\text{m})^2}\right]\right]$$

$$\chi = 2.04\text{E}{-2}\ \text{Ci-s/m}^3$$

6.3.3 Short-Term Radiation Doses

The short-term radiation dose calculated by RISKIND has three components: (1) groundshine, (2) cloudshine, and (3) inhalation.

6.3.3.1 Short-Term Groundshine Radiation Dose.

$$\text{Dose} = \chi \cdot v_d \cdot DCF_{grd} \cdot T_{grd}$$

$$\text{Dose} = 2.04\text{E}{-2}\ \text{Ci-s/m}^3 \cdot 0.001\ \text{m/s} \cdot 5.82\text{E}{-8}\ \frac{\text{rem-m}^2}{\text{pCi-yr}} \cdot 2\ \text{hr} \cdot \frac{1\ \text{yr}}{8760\ \text{hr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 2.71\text{E}{-4}\ \text{rem}$$

6.3.3.2 Short-Term Cloudshine Radiation Dose.

$$\text{Dose} = \chi \cdot DCF_{cld}$$

$$\text{Dose} = 2.04\text{E}{-2}\ \text{Ci-s/m}^3 \cdot 2.86\text{E}{-6}\ \frac{\text{rem-m}^3}{\text{pCi-yr}} \cdot \frac{1\ \text{yr}}{3.154\text{E}{+7}\ \text{s}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 1.85\text{E}{-3}\ \text{rem}$$

6.3.3.3 Short-Term Inhalation Radiation Dose.

$$\text{Dose} = \chi \cdot \text{BR} \cdot \text{DCF}_{inh}$$

$$\text{Dose} = 2.04\text{E}{-2}\ \text{Ci-s/m}^3 \cdot 3.5\text{E}{-4}\ \text{m}^3\text{/s} \cdot 3.19\text{E}{-8}\ \text{rem/pCi} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 2.28\text{E}{-1}\ \text{rem}$$

6.3.3.4 Total Short-Term Radiation Dose.

$$\text{Dose} = \text{Dose}_{grd} + \text{Dose}_{cld} + \text{Dose}_{inh}$$

$$2.71\text{E}{-4}\ \text{rem} + 1.85\text{E}{-3}\ \text{rem} + 2.28\text{E}{-1}\ \text{rem} = 2.30\text{E}{-1}\ \text{rem}$$

6.3.4 Long-Term Radiation Doses

The long-term radiation dose calculated by RISKIND has four components: (1) groundshine, (2) cloudshine, (3) inhalation, and (4) ingestion.

6.3.4.1 Long-Term Groundshine Radiation Dose.

$$\text{Dose} = \chi \cdot v_d \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g) \cdot T]}{\lambda_i + \lambda_g} \cdot DCF_{grd} \cdot SF_{grd}$$

$$\text{Dose} = 2.04\text{E}{-2}\ \text{Ci-s/m}^3 \cdot 0.001\ \text{m/s} \cdot \frac{1 - \exp[-(2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1}) \cdot 1\ \text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1}} \cdot$$

$$5.82\text{E}{-8}\ \frac{\text{rem-m}^2}{\text{pCi-yr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}} \cdot 0.45$$

$$\text{Dose} = 5.25\text{E}{-1}\ \text{rem}$$

6.3.4.2 Long-Term Cloudshine Radiation Dose.

$$\text{Dose} = \chi \cdot v_d \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g + \lambda_r) \cdot T]}{\lambda_i + \lambda_g + \lambda_r} \cdot R \cdot DCF_{cld} \cdot SF_{cld}$$

$$\text{Dose} = 2.04\text{E}{-2}\,\text{Ci-s/m}^3 \cdot 0.001\,\text{m/s} \cdot \frac{1 - \exp[-(2.30\text{E}{-2}\text{yr}^{-1} + 0.0139\text{yr}^{-1} + 5.06\text{yr}^{-1}) \cdot 1\text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1} + 5.06\ \text{yr}^{-1}} \cdot$$

$$1.0\text{E}{-5}\ \text{m}^{-1} \cdot 2.86\text{E}{-6}\ \frac{\text{rem-m}^3}{\text{pCi-yr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}} \cdot 0.70$$

$$\text{Dose} = 7.97\text{E}{-5}\ \text{rem}$$

6.3.4.3 Long-Term Inhalation Radiation Dose.

$$\text{Dose} = \chi \cdot v_d \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g + \lambda_r) \cdot T]}{\lambda_i + \lambda_g + \lambda_r} \cdot R \cdot BR \cdot DCF_{inh} \cdot SF_{inh}$$

$$\text{Dose} = 2.04E{-}2\,\text{Ci-s/m}^3 \cdot 0.001\,\text{m/s} \cdot \frac{1 - \exp[-(2.30E{-}2\,\text{yr}^{-1} + 0.0139\,\text{yr}^{-1} + 5.06\,\text{yr}^{-1}) \cdot 1\,\text{yr}]}{2.30E{-}2\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1} + 5.06\ \text{yr}^{-1}} \cdot$$

$$1.0E{-}5\ \text{m}^{-1} \cdot 2.5E{-}4\ \text{m}^3/\text{s} \cdot 3.19E{-}8\ \text{rem/pCi} \cdot \frac{3.154E{+}7\ \text{s}}{1\ \text{yr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}} \cdot 0.75$$

$$\text{Dose} = 7.51E{-}3\ \text{rem}$$

6.3.4.4 Long-Term Ingestion Radiation Dose. The long-term ingestion radiation dose calculated by RISKIND has two components: (1) the radiation dose from root uptake into plants after initial deposition on soil, and (2) the radiation dose from the deposition of resuspended radioactivity on plants after initial deposition on soil. Three pathways are considered by RISKIND: (1) vegetables, (2) meat, and (3) milk. In this validation analysis, initially contaminated food was assumed to be discarded.

6.3.4.4.1 Long-Term Ingestion Radiation Dose Through the Vegetable Pathway—This section provides calculations on root uptake of radioactivity, deposition of resuspended radioactivity, and total long-term ingestion radiation dose.

6.3.4.4.1.1 Root Uptake of Radioactivity—

$$\text{Dose} = \chi \cdot v_d(\text{soil}) \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g) \cdot T]}{\lambda_i + \lambda_g} \cdot B_v \cdot \frac{1}{P} \cdot U_v \cdot D \cdot DCF_{ing}$$

$$\text{Dose} = 2.04\text{E}{-2}\ \text{Ci-s/m}^3 \cdot 0.001\ \text{m/s} \cdot \frac{1 - \exp[-(2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1}) \cdot 1\ \text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1}} \cdot$$

$$0.010\ \frac{\text{pCi/kg(wet veg)}}{\text{pCi/kg(dry soil)}} \cdot \frac{1}{240\ \text{kg(dry soil)/m}^2} \cdot 0.77\ \text{kg/d} \cdot 365\ \text{d/yr} \cdot$$

$$0.50 \cdot 5.00\text{E}{-8}\ \text{rem/pCi} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 5.85\text{E}{-3}\ \text{rem}$$

6.3.4.4.1.2 Deposition of Resuspended Radioactivity—

$$\text{Dose} = \chi \cdot v_d(\text{soil}) \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g + \lambda_r) \cdot T]}{\lambda_i + \lambda_g + \lambda_r} \cdot R \cdot v_d(\text{veg}) \cdot r \cdot TF \cdot$$

$$\frac{1 - \exp[-\lambda_w \cdot t_{veg}]}{\lambda_w \cdot Y_{veg}} \cdot U_v \cdot D \cdot DCF_{ing}$$

$$\text{Dose} = 2.04\text{E}{-2}\,\text{Ci-s/m}^3 \cdot 0.001\,\text{m/s} \cdot \frac{1 - \exp[-(2.30\text{E}{-2}\,\text{yr}^{-1} + 0.0139\,\text{yr}^{-1} + 5.06\,\text{yr}^{-1}) \cdot 1\,\text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1} + 5.06\ \text{yr}^{-1}} \cdot$$

$$1.0\text{E}{-5}\ \text{m}^{-1} \cdot 0.01\ \text{m/s} \cdot 0.2 \cdot 1.0 \cdot \frac{1 - \exp[-0.0495\ \text{d}^{-1} \cdot 60\ \text{d}]}{0.0495\ \text{d}^{-1} \cdot 2.0\ \text{kg/m}^2} \cdot 0.77\ \text{kg/d} \cdot$$

$$0.50 \cdot 5.0\text{E}{-8}\ \text{rem/pCi} \cdot \frac{3.154\text{E}{+7}\ \text{s}}{1\ \text{yr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 4.63\text{E}{-1}\ \text{rem}$$

6.3.4.4.1.3 Total Long-Term Ingestion Radiation Dose Through the Vegetable Pathway—

$$\text{Dose} = 5.85\text{E}-3 \text{ rem} + 4.63\text{E}-1 \text{ rem} = 4.69\text{E}-1 \text{ rem}$$

6.3.4.4.2 Long-Term Ingestion Radiation Dose Through the Meat Pathway— This section provides calculations on root uptake of radioactivity, deposition of resuspended radioactivity, and total long-term ingestion radiation dose.

6.3.4.4.2.1 Root Uptake of Radioactivity—

$$\text{Dose} = \chi \cdot v_d(\text{soil}) \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g) \cdot T]}{\lambda_i + \lambda_g} \cdot B_v \cdot \frac{1}{P} \cdot Q_{for} \cdot F_b \cdot FG \cdot U_b \cdot DCF_{ing}$$

$$\text{Dose} = 2.04\text{E}-2 \text{ Ci-s/m}^3 \cdot 0.001 \text{ m/s} \cdot \frac{1 - \exp[-(2.30\text{E}-2 \text{ yr}^{-1} + 0.0139 \text{ yr}^{-1}) \cdot 1 \text{ yr}]}{2.30\text{E}-2 \text{ yr}^{-1} + 0.0139 \text{ yr}^{-1}} \cdot$$

$$0.010 \frac{\text{pCi/kg(wet veg)}}{\text{pCi/kg(dry soil)}} \cdot \frac{1}{240 \text{ kg(dry soil)/m}^2} \cdot 50 \text{ kg/d} \cdot 0.004 \text{ d/kg} \cdot 0.50 \cdot$$

$$0.30 \text{ kg/d} \cdot 365 \text{ d/yr} \cdot 5.00\text{E}-8 \text{ rem/pCi} \cdot \frac{10^{12} \text{ pCi}}{1 \text{ Ci}}$$

$$\text{Dose} = 4.57\text{E}-4 \text{ rem}$$

6.3.4.4.2.2 Deposition of Resuspended Radioactivity—

$$\text{Dose} = \chi \cdot v_d(\text{soil}) \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g + \lambda_r) \cdot T]}{\lambda_i + \lambda_g + \lambda_r} \cdot R \cdot v_d(\text{for}) \cdot r \cdot TF \cdot$$

$$\frac{1 - \exp[-\lambda_w \cdot t_{for}]}{\lambda_w \cdot Y_{for}} \cdot Q_{for} \cdot F_b \cdot FG \cdot U_b \cdot DCF_{ing}$$

$$\text{Dose} = 2.04\text{E}{-2}\,\text{Ci-s/m}^3 \cdot 0.001\,\text{m/s} \cdot \frac{1-\exp[-(2.30\text{E}{-2}\,\text{yr}^{-1} + 0.0139\,\text{yr}^{-1} + 5.06\,\text{yr}^{-1}) \cdot 1\,\text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1} + 5.06\ \text{yr}^{-1}} \cdot$$

$$1.0\text{E}{-5}\ \text{m}^{-1} \cdot 0.01\ \text{m/s} \cdot 0.2 \cdot 1.0 \cdot \frac{1 - \exp[-0.0495\ \text{d}^{-1} \cdot 30\ \text{d}]}{0.0495\ \text{d}^{-1} \cdot 0.75\ \text{kg/m}^2} \cdot$$

$$50\ \text{kg/d} \cdot 0.004\ \text{d/kg} \cdot 0.50 \cdot 0.30\ \text{kg/d} \cdot 5.0\text{E}{-8}\ \text{rem/pCi} \cdot \frac{3.154\text{E}{+7}\ \text{s}}{1\ \text{yr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 7.85\text{E}{-2}\ \text{rem}$$

6.3.4.4.2.3 Total Long-Term Ingestion Radiation Dose Through the Meat Pathway—

$$\text{Dose} = 4.57\text{E}{-4}\ \text{rem} + 7.85\text{E}{-2}\ \text{rem} = 7.90\text{E}{-2}\ \text{rem}$$

6.3.4.4.3 Long-Term Ingestion Radiation Dose Through the Milk Pathway—This section provides calculations on root uptake of radioactivity, deposition of resuspended radioactivity, and total long-term ingestion radiation dose.

6.3.4.4.3.1 Root Uptake of Radioactivity—

$$\text{Dose} = \chi \cdot v_d(\text{soil}) \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g) \cdot T]}{\lambda_i + \lambda_g} \cdot B_v \cdot \frac{1}{P} \cdot Q_{for} \cdot F_m \cdot FG \cdot U_m \cdot DCF_{ing}$$

$$\text{Dose} = 2.04\text{E}{-2}\ \text{Ci-s/m}^3 \cdot 0.001\ \text{m/s} \cdot \frac{1 - \exp[-(2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1}) \cdot 1\ \text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1}} \cdot$$

$$0.010\ \frac{\text{pCi/kg(wet veg)}}{\text{pCi/kg(dry soil)}} \cdot \frac{1}{240\ \text{kg(dry soil)/m}^2} \cdot 50\ \text{kg/d} \cdot 0.012\ \text{d/L} \cdot 0.50 \cdot$$

$$0.85\ \text{L/d} \cdot 365\ \text{d/yr} \cdot 5.00\text{E}{-8}\ \text{rem/pCi} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 3.88\text{E}{-3}\ \text{rem}$$

6.3.4.4.3.2 Deposition of Resuspended Radioactivity—

$$\text{Dose} = \chi \cdot v_d(\text{soil}) \cdot \frac{1 - \exp[-(\lambda_i + \lambda_g + \lambda_r) \cdot T]}{\lambda_i + \lambda_g + \lambda_r} \cdot R \cdot v_d(\text{for}) \cdot r \cdot TF \cdot$$

$$\frac{1 - \exp[-\lambda_w \cdot t_{for}]}{\lambda_w \cdot Y_{for}} \cdot Q_{for} \cdot F_m \cdot FG \cdot U_m \cdot DCF_{ing}$$

$$\text{Dose} = 2.04\text{E}{-2}\,\text{Ci-s/m}^3 \cdot 0.001\,\text{m/s} \cdot \frac{1 - \exp[-(2.30\text{E}{-2}\,\text{yr}^{-1} + 0.0139\,\text{yr}^{-1} + 5.06\,\text{yr}^{-1}) \cdot 1\,\text{yr}]}{2.30\text{E}{-2}\ \text{yr}^{-1} + 0.0139\ \text{yr}^{-1} + 5.06\ \text{yr}^{-1}} \cdot$$

$$1.0\text{E}{-5}\ \text{m}^{-1} \cdot 0.01\ \text{m/s} \cdot 0.2 \cdot 1.0 \cdot \frac{1 - \exp[-0.0495\ \text{d}^{-1} \cdot 30\ \text{d}]}{0.0495\ \text{d}^{-1} \cdot 0.75\ \text{kg/m}^2} \cdot$$

$$50\ \text{kg/d} \cdot 0.012\ \text{d/L} \cdot 0.5 \cdot 0.85\ \text{L/d} \cdot 5.0\text{E}{-8}\ \text{rem/pCi} \cdot \frac{3.154\text{E}{+7}\ \text{s}}{1\ \text{yr}} \cdot \frac{10^{12}\ \text{pCi}}{1\ \text{Ci}}$$

$$\text{Dose} = 6.65\text{E}{-1}\ \text{rem}$$

6.3.4.4.3.3 Total Long-Term Ingestion Radiation Dose Through the Milk Pathway—

Dose = 3.88E-3 rem + 6.65E-1 rem = 6.69E-1 rem

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APPENDIX A

RADTRAN 4 OUTPUT FOR INCIDENT-FREE UNIT RISK FACTORS

A.1 TURFR.OUT

UNIT RISK FACTORS FOR TRUCKS IN RURAL POPULATION ZONE

```
RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N
R   R  A   A  D   D    T    R   R  A   A  NN  N
R   R  A   A  D   D    T    R   R  A   A  N N N
RRRR   A   A  D   D    T    RRRR   A   A  N  NN
R R    AAAAA  D   D    T    R R    AAAAA  N   N
R  R   A   A  D   D    T    R  R   A   A  N   N
R   R  A   A  DDDD     T    R   R  A   A  N   N


                         4
                     4   4
                     4   4
                     44444
                         4
                         4
                         4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

```
&& Edited Sun Apr 16 15:48:07 1995
&& _RADTRAN_4_UNIT_RISK_FACTORS_
&& _TRUCK_RURAL_POPULATION_ZONE_
TITLE _INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 4 0
POPDEN     6.000    719.000   3861.000
PACKAGE
   LABGRP
       GRP1
SHIPMENT
   LABISO
      CR-51
NORMAL
   NMODE=1
       1.000E+00  0.000E+00  0.000E+00  8.849E+01  4.025E+01  2.416E+01
       2.000E+00  3.100E+00  0.000E+00  1.100E-02  0.000E+00  0.000E+00
       0.000E+00  5.000E+01  2.000E+01  0.000E+00  0.000E+00  1.000E+02
       2.000E+00  1.000E-01  5.000E-02  1.000E+00  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   ARATMZ
       NMODE=1   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
       4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
       1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
       2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
       3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
       3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
```

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

```
       3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
       2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
       0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM     0.44
EOF
ISOTOPES  1    1     1.00   14.000   1.00   0.00  SNF
        CR-51  1.00E+00      GRP1   2
DISTKM
         NMODE=1  1.00
PKGSIZ
         SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

NO	DNORML INPUT	TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	1.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	8.849E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	3.100E+00
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	1.000E-01
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	5.000E-02
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	1.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 1.000E+09
BREATHING RATE (M**3/SEC) = 3.300E-04

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

REGULATORY CHECKS

MODE 1 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF   SNF BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

FOR THE SHIPMENT OF   SNF BY MODE 1
THE DOSE RATE IN THE CREW COMPARTMENT COULD EXCEED 2 MREM/HR
THE DOSE RATE HAS BEEN RESET FROM 9.11 TO 2 FOR CREW CALCULATIONS

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	4.56E-05	0.00E+00	1.23E-07	5.03E-06	1.20E-04	0.00E+00	1.71E-04
TOTALS:	0.00E+00	4.56E-05	0.00E+00	1.23E-07	5.03E-06	1.20E-04	0.00E+00	1.71E-04

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_TRUCK_RURAL_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DISTANCE TRAVELED	1.710E-06
2	NUMBER OF SHIPMENTS	1.710E-06
3	PACKAGES PER SHIPMENT	1.255E-06
4	K ZERO	1.255E-06
5	DOSE RATE (TRANSPORT INDEX)	1.255E-06
6	PERSONS EXPOSED WHILE STOPPED	1.203E-06
7	STOP TIME	1.203E-06
8	FRACTION OF TRAVEL - RURAL	5.072E-07
9	NUMBER OF CREW MEMBERS	4.556E-07
10	FRACTION OF TRAVEL ON FREEWAYS	5.152E-08
11	NUMBER OF PEOPLE PER VEHICLE	5.029E-08
12	TRAFFIC COUNT - RURAL	5.029E-08
13	POPULATION DENSITY - RURAL	1.234E-09
14	NUMBER OF HANDLINGS	0.000E+00
15	DISTANCE FROM SOURCE TO CREW	0.000E+00
16	EXPOSURE TIME FOR HANDLERS	0.000E+00
17	PERSONS EXPOSED PER HANDLING	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - URBAN	0.000E+00
20	TRAFFIC COUNT - SUBURBAN	0.000E+00
21	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
22	HANDLER EXPOSURE DISTANCE	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
26	VELOCITY - SUBURBAN	0.000E+00
27	POPULATION DENSITY - SUBURBAN	0.000E+00
28	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
29	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
30	FRACTION OF TRAVEL - URBAN	0.000E+00
31	POPULATION DENSITY - URBAN	0.000E+00
32	STORAGE TIME PER SHIPMENT	0.000E+00
33	URBAN SHIELDING FACTOR (RU)	0.000E+00
34	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
35	VELOCITY - URBAN	0.000E+00
36	RURAL SHIELDING FACTOR (RR)	0.000E+00
37	VELOCITY - RURAL	-5.575E-07
38	EXPOSURE DISTANCE WHILE STOPPED	-2.406E-06

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

TRUCK RURAL	9.60E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	0.00E+00	PERSONS
TOTAL	9.60E+00	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

TRUCK RURAL	0.00E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	0.00E+00	PERSONS

EOI
END OF RUN

A.2 TURFS.OUT

UNIT RISK FACTORS FOR TRUCKS IN SUBURBAN POPULATION ZONE

```
RRRR   AAA  DDDD  TTTTT RRRR   AAA  N   N
R   R A   A D   D   T   R   R A   A NN  N
R   R A   A D   D   T   R   R A   A N N N
RRRR  A   A D   D   T   RRRR  A   A N  NN
R R   AAAAA D   D   T   R R   AAAAA N   N
R  R  A   A D   D   T   R  R  A   A N   N
R   R A   A DDDD    T   R   R A   A N   N


                     4
                 4   4
                 4   4
                 44444
                     4
                     4
                     4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sun Apr 16 15:52:09 1995
&& _RADTRAN_4_UNIT_RISK_FACTORS_
&& _TRUCK_SUBURBAN_POPULATION_ZONE_
TITLE _INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 4 0
POPDEN     6.000    719.000   3861.000
PACKAGE
   LABGRP
       GRP1
SHIPMENT
   LABISO
      CR-51
NORMAL
   NMODE=1
       0.000E+00  1.000E+00  0.000E+00  8.849E+01  4.025E+01  2.416E+01
       2.000E+00  3.100E+00  0.000E+00  1.100E-02  0.000E+00  0.000E+00
       0.000E+00  5.000E+01  2.000E+01  0.000E+00  0.000E+00  1.000E+02
       2.000E+00  1.000E-01  5.000E-02  1.000E+00  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   ARATMZ
       NMODE=1   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
       4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
       1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
       2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
       3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
       3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
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_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

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       3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
       2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
       0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM      0.44
EOF
ISOTOPES  1    1     1.00    14.000   1.00    0.00   SNF
        CR-51  1.00E+00      GRP1    2
DISTKM
         NMODE=1  1.00
PKGSIZ
         SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)

PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

DNORML INPUT

NO		TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	0.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	1.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	8.849E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	3.100E+00
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	1.000E-01
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	5.000E-02
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	1.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 1.000E+09
BREATHING RATE (M**3/SEC) = 3.300E-04

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

REGULATORY CHECKS

MODE 1 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF   SNF BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

FOR THE SHIPMENT OF   SNF BY MODE 1
THE DOSE RATE IN THE CREW COMPARTMENT COULD EXCEED 2 MREM/HR
THE DOSE RATE HAS BEEN RESET FROM 9.11 TO 2 FOR CREW CALCULATIONS

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.00E-04	0.00E+00	1.63E-05	1.45E-05	1.20E-04	0.00E+00	2.51E-04
TOTALS:	0.00E+00	1.00E-04	0.00E+00	1.63E-05	1.45E-05	1.20E-04	0.00E+00	2.51E-04

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_TRUCK_SUBURBAN_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	NUMBER OF SHIPMENTS	2.512E-06
2	DISTANCE TRAVELED	2.512E-06
3	PACKAGES PER SHIPMENT	1.510E-06
4	DOSE RATE (TRANSPORT INDEX)	1.510E-06
5	K ZERO	1.510E-06
6	FRACTION OF TRAVEL - SUBURBAN	1.309E-06
7	STOP TIME	1.203E-06
8	PERSONS EXPOSED WHILE STOPPED	1.203E-06
9	NUMBER OF CREW MEMBERS	1.002E-06
10	FRACTION OF TRAVEL ON FREEWAYS	3.073E-07
11	POPULATION DENSITY - SUBURBAN	1.626E-07
12	NUMBER OF PEOPLE PER VEHICLE	1.447E-07
13	TRAFFIC COUNT - SUBURBAN	1.447E-07
14	FRACTION OF RUSH HOUR TRAVEL	7.604E-08
15	DISTANCE FROM SOURCE TO CREW	0.000E+00
16	NUMBER OF HANDLINGS	0.000E+00
17	EXPOSURE TIME FOR HANDLERS	0.000E+00
18	PERSONS EXPOSED PER HANDLING	0.000E+00
19	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
20	TRAFFIC COUNT - RURAL	0.000E+00
21	TRAFFIC COUNT - URBAN	0.000E+00
22	HANDLER EXPOSURE DISTANCE	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
26	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
27	POPULATION DENSITY - RURAL	0.000E+00
28	FRACTION OF TRAVEL - RURAL	0.000E+00
29	FRACTION OF TRAVEL - URBAN	0.000E+00
30	POPULATION DENSITY - URBAN	0.000E+00
31	VELOCITY - URBAN	0.000E+00
32	STORAGE TIME PER SHIPMENT	0.000E+00
33	URBAN SHIELDING FACTOR (RU)	0.000E+00
34	RURAL SHIELDING FACTOR (RR)	0.000E+00
35	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
36	VELOCITY - RURAL	-4.521E-07
37	VELOCITY - SUBURBAN	-1.002E-06
38	EXPOSURE DISTANCE WHILE STOPPED	-2.406E-06

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

TRUCK RURAL	0.00E+00	PERSONS
TRUCK SUBURBAN	1.15E+03	PERSONS
TRUCK URBAN	0.00E+00	PERSONS
TOTAL	1.15E+03	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

TRUCK RURAL	0.00E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	0.00E+00	PERSONS

EOI
END OF RUN

A.3 TURFU.OUT

UNIT RISK FACTORS FOR TRUCKS IN URBAN POPULATION ZONE

```
RRRR   AAA  DDDD  TTTTT RRRR   AAA  N   N
R   R A   A D   D   T   R   R A   A NN  N
R   R A   A D   D   T   R   R A   A N N N
RRRR  A   A D   D   T   RRRR  A   A N  NN
R R   AAAAA D   D   T   R R   AAAAA N   N
R  R  A   A D   D   T   R  R  A   A N   N
R   R A   A DDDD    T   R   R A   A N   N


                    4
                4   4
                4   4
                44444
                    4
                    4
                    4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sun Apr 16 15:54:02 1995
&& _RADTRAN_4_UNIT_RISK_FACTORS_
&& _TRUCK_URBAN_POPULATION_ZONE_
TITLE _INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 4 0
POPDEN     6.000    719.000   3861.000
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LABISO
     CR-51
NORMAL
   NMODE=1
      0.000E+00  0.000E+00  1.000E+00  8.849E+01  4.025E+01  2.416E+01
      2.000E+00  3.100E+00  0.000E+00  1.100E-02  0.000E+00  0.000E+00
      0.000E+00  5.000E+01  2.000E+01  0.000E+00  0.000E+00  1.000E+02
      2.000E+00  1.000E-01  5.000E-02  1.000E+00  4.700E+02  7.800E+02
      2.800E+03
ACCIDENT
   ARATMZ
      NMODE=1   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
      NMODE=1
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
      NMODE=1
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
      NMODE=1
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
      4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
      1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
      2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
      3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
      3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
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      3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
      2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
      0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM     0.44
EOF
ISOTOPES  1    1     1.00    14.000    1.00    0.00  SNF
        CR-51  1.00E+00      GRP1   2
DISTKM
         NMODE=1  1.00
PKGSIZ
         SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

NO		DNORML INPUT TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	0.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	1.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	8.849E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	3.100E+00
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	1.000E-01
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	5.000E-02
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	1.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 1.000E+09
BREATHING RATE (M**3/SEC) = 3.300E-04

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

REGULATORY CHECKS

MODE 1 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF   SNF BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

FOR THE SHIPMENT OF   SNF BY MODE 1
THE DOSE RATE IN THE CREW COMPARTMENT COULD EXCEED 2 MREM/HR
THE DOSE RATE HAS BEEN RESET FROM 9.11 TO 2 FOR CREW CALCULATIONS

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.67E-04	0.00E+00	1.08E-04	1.50E-04	1.20E-04	0.00E+00	5.44E-04
TOTALS:	0.00E+00	1.67E-04	0.00E+00	1.08E-04	1.50E-04	1.20E-04	0.00E+00	5.44E-04

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_TRUCK_URBAN_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	NUMBER OF SHIPMENTS	5.444E-06
2	DISTANCE TRAVELED	5.444E-06
3	FRACTION OF TRAVEL - URBAN	4.241E-06
4	PACKAGES PER SHIPMENT	3.775E-06
5	K ZERO	3.775E-06
6	DOSE RATE (TRANSPORT INDEX)	3.775E-06
7	NUMBER OF CREW MEMBERS	1.669E-06
8	NUMBER OF PEOPLE PER VEHICLE	1.495E-06
9	TRAFFIC COUNT - URBAN	1.495E-06
10	STOP TIME	1.203E-06
11	PERSONS EXPOSED WHILE STOPPED	1.203E-06
12	FRACTION OF TRAVEL ON CITY STREETS	1.179E-06
13	POPULATION DENSITY - URBAN	1.077E-06
14	FRACTION OF RUSH HOUR TRAVEL	7.339E-07
15	NUMBER OF HANDLINGS	0.000E+00
16	EXPOSURE TIME FOR HANDLERS	0.000E+00
17	PERSONS EXPOSED PER HANDLING	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - SUBURBAN	0.000E+00
20	TRAFFIC COUNT - RURAL	0.000E+00
21	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
22	HANDLER EXPOSURE DISTANCE	0.000E+00
23	DISTANCE FROM SOURCE TO CREW	0.000E+00
24	STORAGE EXPOSURE DISTANCE	0.000E+00
25	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
26	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
27	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
28	POPULATION DENSITY - RURAL	0.000E+00
29	FRACTION OF TRAVEL - RURAL	0.000E+00
30	POPULATION DENSITY - SUBURBAN	0.000E+00
31	VELOCITY - SUBURBAN	0.000E+00
32	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
33	STORAGE TIME PER SHIPMENT	0.000E+00
34	URBAN SHIELDING FACTOR (RU)	0.000E+00
35	RURAL SHIELDING FACTOR (RR)	0.000E+00
36	VELOCITY - RURAL	-1.817E-06
37	EXPOSURE DISTANCE WHILE STOPPED	-2.406E-06
38	VELOCITY - URBAN	-3.919E-06

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

TRUCK RURAL	0.00E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	6.18E+03	PERSONS
TOTAL	6.18E+03	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

TRUCK RURAL	0.00E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	0.00E+00	PERSONS

EOI
END OF RUN

A.4 RURFR.OUT

UNIT RISK FACTORS FOR RAIL IN RURAL POPULATION ZONE

```
RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N
R   R  A   A  D   D    T    R   R  A   A  NN  N
R   R  A   A  D   D    T    R   R  A   A  N N N
RRRR   A   A  D   D    T    RRRR   A   A  N  NN
R R    AAAAA  D   D    T    R R    AAAAA  N   N
R  R   A   A  D   D    T    R  R   A   A  N   N
R   R  A   A  DDDD     T    R   R  A   A  N   N


                          4
                       4  4
                       4  4
                       44444
                          4
                          4
                          4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sun Apr 16 15:58:06 1995
&& _RADTRAN_4_UNIT_RISK_FACTORS_
&& _RAIL_RURAL_POPULATION_ZONE_
TITLE _INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 3 0
POPDEN     6.000    719.000    3861.000
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LABISO
      CR-51
NORMAL
   NMODE=2
      1.000E+00  0.000E+00  0.000E+00  6.437E+01  4.025E+01  2.416E+01
      5.000E+00  1.524E+02  0.000E+00  3.300E-02  0.000E+00  0.000E+00
      0.000E+00  1.000E+02  2.000E+01  0.000E+00  0.000E+00  1.000E+02
      3.000E+00  0.000E+00  0.000E+00  0.000E+00  1.000E+00  5.000E+00
      5.000E+00
ACCIDENT
   ARATMZ
      NMODE=2   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
      NMODE=2
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
      NMODE=2
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
      NMODE=2
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
      4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
      1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
      2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
      3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
      3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
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_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

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       3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
       2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
       0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM     0.44
EOF
ISOTOPES  2    1     1.00    14.000   1.00   0.00  SNF
        CR-51  1.00E+00      GRP1   2
DISTKM
         NMODE=2  1.00
PKGSIZ
         SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
RAIL	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

DNORML INPUT

NO		RAIL
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	1.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	6.437E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	5.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.524E+02
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	3.300E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	1.000E+02
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	3.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	0.000E+00
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	0.000E+00
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	0.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	1.000E+00
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	5.000E+00
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	5.000E+00

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
RAIL	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR RAIL

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 1.000E+09
BREATHING RATE (M**3/SEC) = 3.300E-04

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

REGULATORY CHECKS

MODE 2 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF   SNF BY MODE 2
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.01E-05	0.00E+00	1.70E-07	6.62E-08	4.78E-06	0.00E+00	1.51E-05
TOTALS:	0.00E+00	1.01E-05	0.00E+00	1.70E-07	6.62E-08	4.78E-06	0.00E+00	1.51E-05

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_RAIL_RURAL_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DOSE RATE (TRANSPORT INDEX)	1.509E-07
2	NUMBER OF SHIPMENTS	1.509E-07
3	K ZERO	1.509E-07
4	PACKAGES PER SHIPMENT	1.509E-07
5	DISTANCE TRAVELED	5.011E-08
6	PERSONS EXPOSED WHILE STOPPED	4.775E-08
7	STOP TIME	4.775E-08
8	FRACTION OF TRAVEL - RURAL	2.358E-09
9	POPULATION DENSITY - RURAL	1.696E-09
10	TRAFFIC COUNT - RURAL	6.620E-10
11	NUMBER OF PEOPLE PER VEHICLE	6.620E-10
12	NUMBER OF HANDLINGS	0.000E+00
13	DISTANCE FROM SOURCE TO CREW	0.000E+00
14	NUMBER OF CREW MEMBERS	0.000E+00
15	EXPOSURE TIME FOR HANDLERS	0.000E+00
16	PERSONS EXPOSED PER HANDLING	0.000E+00
17	HANDLER EXPOSURE DISTANCE	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - URBAN	0.000E+00
20	TRAFFIC COUNT - SUBURBAN	0.000E+00
21	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
22	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
26	VELOCITY - SUBURBAN	0.000E+00
27	POPULATION DENSITY - SUBURBAN	0.000E+00
28	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
29	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
30	FRACTION OF TRAVEL - URBAN	0.000E+00
31	POPULATION DENSITY - URBAN	0.000E+00
32	STORAGE TIME PER SHIPMENT	0.000E+00
33	URBAN SHIELDING FACTOR (RU)	0.000E+00
34	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
35	VELOCITY - URBAN	0.000E+00
36	RURAL SHIELDING FACTOR (RR)	0.000E+00
37	VELOCITY - RURAL	-3.020E-09
38	EXPOSURE DISTANCE WHILE STOPPED	-9.550E-08

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

RAIL RURAL	9.60E+00	PERSONS
RAIL SUBURBAN	0.00E+00	PERSONS
RAIL URBAN	0.00E+00	PERSONS
TOTAL	9.60E+00	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

RAIL RURAL	0.00E+00	PERSONS
RAIL SUBURBAN	0.00E+00	PERSONS
RAIL URBAN	0.00E+00	PERSONS

EOI
END OF RUN

A.5 RURFS.OUT

UNIT RISK FACTORS FOR RAIL IN SUBURBAN POPULATION ZONE

```
RRRR   AAA  DDDD  TTTTT RRRR   AAA  N   N
R   R A   A D   D   T   R   R A   A NN  N
R   R A   A D   D   T   R   R A   A N N N
RRRR  A   A D   D   T   RRRR  A   A N  NN
R R   AAAAA D   D   T   R R   AAAAA N   N
R  R  A   A D   D   T   R  R  A   A N   N
R   R A   A DDDD    T   R   R A   A N   N
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```
    4
4   4
4   4
44444
    4
    4
    4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sun Apr 16 15:59:49 1995
&& _RADTRAN_4_UNIT_RISK_FACTORS_
&& _RAIL_SUBURBAN_POPULATION_ZONE_
TITLE _INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 3 0
POPDEN     6.000    719.000   3861.000
PACKAGE
   LABGRP
       GRP1
SHIPMENT
   LABISO
      CR-51
NORMAL
   NMODE=2
       0.000E+00  1.000E+00  0.000E+00  6.437E+01  4.025E+01  2.416E+01
       5.000E+00  1.524E+02  0.000E+00  3.300E-02  0.000E+00  0.000E+00
       0.000E+00  1.000E+02  2.000E+01  0.000E+00  0.000E+00  1.000E+02
       3.000E+00  0.000E+00  0.000E+00  0.000E+00  1.000E+00  5.000E+00
       5.000E+00
ACCIDENT
   ARATMZ
       NMODE=2   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
       NMODE=2
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
       NMODE=2
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
       NMODE=2
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
       4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
       1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
       2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
       3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
       3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
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_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

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       3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
       2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
       0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM     0.44
EOF
ISOTOPES  2    1     1.00    14.000    1.00    0.00  SNF
        CR-51  1.00E+00      GRP1    2
DISTKM
         NMODE=2  1.00
PKGSIZ
         SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
RAIL	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

DNORML INPUT

NO		RAIL
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	0.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	1.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	6.437E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	5.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.524E+02
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	3.300E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	1.000E+02
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	3.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	0.000E+00
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	0.000E+00
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	0.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	1.000E+00
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	5.000E+00
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	5.000E+00

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
RAIL	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR RAIL

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 1.000E+09
BREATHING RATE (M**3/SEC) = 3.300E-04

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

REGULATORY CHECKS

MODE 2 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF   SNF BY MODE 2
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.01E-05	0.00E+00	3.25E-05	8.47E-07	4.78E-06	0.00E+00	4.82E-05
TOTALS:	0.00E+00	1.01E-05	0.00E+00	3.25E-05	8.47E-07	4.78E-06	0.00E+00	4.82E-05

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_RAIL_SUBURBAN_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	PACKAGES PER SHIPMENT	4.821E-07
2	NUMBER OF SHIPMENTS	4.821E-07
3	DOSE RATE (TRANSPORT INDEX)	4.821E-07
4	K ZERO	4.821E-07
5	DISTANCE TRAVELED	3.813E-07
6	FRACTION OF TRAVEL - SUBURBAN	3.335E-07
7	POPULATION DENSITY - SUBURBAN	3.250E-07
8	STOP TIME	4.775E-08
9	PERSONS EXPOSED WHILE STOPPED	4.775E-08
10	NUMBER OF PEOPLE PER VEHICLE	8.466E-09
11	TRAFFIC COUNT - SUBURBAN	8.466E-09
12	TRAFFIC COUNT - URBAN	0.000E+00
13	NUMBER OF HANDLINGS	0.000E+00
14	NUMBER OF CREW MEMBERS	0.000E+00
15	DISTANCE FROM SOURCE TO CREW	0.000E+00
16	EXPOSURE TIME FOR HANDLERS	0.000E+00
17	PERSONS EXPOSED PER HANDLING	0.000E+00
18	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
19	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
20	TRAFFIC COUNT - RURAL	0.000E+00
21	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
22	HANDLER EXPOSURE DISTANCE	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
26	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
27	VELOCITY - RURAL	0.000E+00
28	POPULATION DENSITY - RURAL	0.000E+00
29	FRACTION OF TRAVEL - RURAL	0.000E+00
30	FRACTION OF TRAVEL - URBAN	0.000E+00
31	POPULATION DENSITY - URBAN	0.000E+00
32	STORAGE TIME PER SHIPMENT	0.000E+00
33	URBAN SHIELDING FACTOR (RU)	0.000E+00
34	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
35	RURAL SHIELDING FACTOR (RR)	0.000E+00
36	VELOCITY - URBAN	0.000E+00
37	EXPOSURE DISTANCE WHILE STOPPED	-9.550E-08
38	VELOCITY - SUBURBAN	-3.420E-07

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

RAIL RURAL	0.00E+00 PERSONS
RAIL SUBURBAN	1.15E+03 PERSONS
RAIL URBAN	0.00E+00 PERSONS
TOTAL	1.15E+03 PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

RAIL RURAL	0.00E+00 PERSONS
RAIL SUBURBAN	0.00E+00 PERSONS
RAIL URBAN	0.00E+00 PERSONS

EOI
END OF RUN

A.6 RURFU.OUT

UNIT RISK FACTORS FOR RAIL IN URBAN POPULATION ZONE

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RRRR   AAA  DDDD  TTTTT RRRR   AAA  N   N
R   R A   A D   D   T   R   R A   A NN  N
R   R A   A D   D   T   R   R A   A N N N
RRRR  A   A D   D   T   RRRR  A   A N  NN
R R   AAAAA D   D   T   R R   AAAAA N   N
R  R  A   A D   D   T   R  R  A   A N   N
R   R A   A DDDD    T   R   R A   A N   N
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```
    4
4   4
4   4
44444
    4
    4
    4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sun Apr 16 16:01:37 1995
&& _RADTRAN_4_UNIT_RISK_FACTORS_
&& _RAIL_URBAN_POPULATION_ZONE_
TITLE _INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 3 0
POPDEN     6.000     719.000    3861.000
PACKAGE
   LABGRP
       GRP1
SHIPMENT
   LABISO
      CR-51
NORMAL
   NMODE=2
       0.000E+00  0.000E+00  1.000E+00  6.437E+01  4.025E+01  2.416E+01
       5.000E+00  1.524E+02  0.000E+00  3.300E-02  0.000E+00  0.000E+00
       0.000E+00  1.000E+02  2.000E+01  0.000E+00  0.000E+00  1.000E+02
       3.000E+00  0.000E+00  0.000E+00  0.000E+00  1.000E+00  5.000E+00
       5.000E+00
ACCIDENT
   ARATMZ
       NMODE=2   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
       NMODE=2
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
       NMODE=2
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
       NMODE=2
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
       4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
       1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
       2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
       3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
       3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
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       3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
       2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
       0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM     0.44
EOF
ISOTOPES  2    1     1.00   14.000   1.00   0.00  SNF
        CR-51  1.00E+00      GRP1   2
DISTKM
         NMODE=2  1.00
PKGSIZ
         SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
RAIL	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

DNORML INPUT

NO		RAIL
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	0.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	1.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	6.437E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	5.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.524E+02
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	3.300E-02
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	1.000E+02
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	3.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	0.000E+00
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	0.000E+00
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	0.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	1.000E+00
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	5.000E+00
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	5.000E+00

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	50-YR EFFECTIVE REM/CI INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
RAIL	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR RAIL

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 1.000E+09
BREATHING RATE (M**3/SEC) = 3.300E-04

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

REGULATORY CHECKS

MODE 2 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF SNF BY MODE 2
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.01E-05	0.00E+00	2.91E-04	2.35E-06	4.78E-06	0.00E+00	3.08E-04
TOTALS:	0.00E+00	1.01E-05	0.00E+00	2.91E-04	2.35E-06	4.78E-06	0.00E+00	3.08E-04

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_RAIL_URBAN_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	K ZERO	3.080E-06
2	NUMBER OF SHIPMENTS	3.080E-06
3	PACKAGES PER SHIPMENT	3.080E-06
4	DOSE RATE (TRANSPORT INDEX)	3.080E-06
5	DISTANCE TRAVELED	2.979E-06
6	FRACTION OF TRAVEL - URBAN	2.931E-06
7	POPULATION DENSITY - URBAN	2.908E-06
8	STOP TIME	4.775E-08
9	PERSONS EXPOSED WHILE STOPPED	4.775E-08
10	NUMBER OF PEOPLE PER VEHICLE	2.350E-08
11	TRAFFIC COUNT - URBAN	2.350E-08
12	NUMBER OF CREW MEMBERS	0.000E+00
13	EXPOSURE TIME FOR HANDLERS	0.000E+00
14	NUMBER OF HANDLINGS	0.000E+00
15	DISTANCE FROM SOURCE TO CREW	0.000E+00
16	PERSONS EXPOSED PER HANDLING	0.000E+00
17	HANDLER EXPOSURE DISTANCE	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - SUBURBAN	0.000E+00
20	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
21	TRAFFIC COUNT - RURAL	0.000E+00
22	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
23	STORAGE EXPOSURE DISTANCE	0.000E+00
24	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
25	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
26	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
27	VELOCITY - RURAL	0.000E+00
28	POPULATION DENSITY - RURAL	0.000E+00
29	FRACTION OF TRAVEL - RURAL	0.000E+00
30	POPULATION DENSITY - SUBURBAN	0.000E+00
31	VELOCITY - SUBURBAN	0.000E+00
32	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
33	STORAGE TIME PER SHIPMENT	0.000E+00
34	URBAN SHIELDING FACTOR (RU)	0.000E+00
35	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
36	RURAL SHIELDING FACTOR (RR)	0.000E+00
37	EXPOSURE DISTANCE WHILE STOPPED	-9.550E-08
38	VELOCITY - URBAN	-2.955E-06

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

RAIL RURAL	0.00E+00	PERSONS
RAIL SUBURBAN	0.00E+00	PERSONS
RAIL URBAN	6.18E+03	PERSONS
TOTAL	6.18E+03	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

RAIL RURAL	0.00E+00	PERSONS
RAIL SUBURBAN	0.00E+00	PERSONS
RAIL URBAN	0.00E+00	PERSONS

EOI
END OF RUN

A.7 RURFN.OUT

NONLINEAR UNIT RISK FACTORS FOR RAIL IN ALL POPULATION ZONES

RUN DATE: [16-APR-95 AT 15:56:13]   PAGE   1

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RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N
R   R  A   A  D   D    T    R   R  A   A  NN  N
R   R  A   A  D   D    T    R   R  A   A  N N N
RRRR   A   A  D   D    T    RRRR   A   A  N  NN
R R    AAAAA  D   D    T    R R    AAAAA  N   N
R  R   A   A  D   D    T    R  R   A   A  N   N
R   R  A   A  DDDD     T    R   R  A   A  N   N

                          4
                       4  4
                       4  4
                       44444
                          4
                          4
                          4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sun Apr 16 15:55:53 1995
&& _RADTRAN4_NONLINEAR_UNIT_RISK_FACTORS_
&& _RAIL_CREW_AND_STOPS_ALL_POPULATION_ZONES_
TITLE _INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_
FORM UNIT
DIMEN 1 6 1 10 18
PARM 1 1 3 3 0
POPDEN     6.000     719.000    3861.000
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LABISO
     CR-51
NORMAL
   NMODE=2
      1.000E+00  0.000E+00  0.000E+00  6.437E+01  4.025E+01  2.416E+01
      5.000E+00  1.524E+02  0.000E+00  0.000E+00  0.000E+00  6.000E+01
      2.000E+00  1.000E+02  2.000E+01  0.000E+00  0.000E+00  1.000E+02
      3.000E+00  0.000E+00  0.000E+00  0.000E+00  1.000E+00  5.000E+00
      5.000E+00
ACCIDENT
   ARATMZ
      NMODE=2   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
      NMODE=2
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
      NMODE=2
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
      NMODE=2
      1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AERSOL
     DISP=2
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=2
      1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
      4.59E+02  1.53E+03  3.94E+03  1.25E+04  3.04E+04  6.85E+04
      1.76E+05  4.45E+05  8.59E+05  2.55E+06  4.45E+06  1.03E+07
      2.16E+07  5.52E+07  1.77E+08  4.89E+08  8.12E+08  1.35E+09
   DFLEV
      3.42E-03  1.72E-03  8.58E-04  3.42E-04  1.72E-04  8.58E-05
      3.42E-05  1.72E-05  8.58E-06  3.42E-06  1.72E-06  8.58E-07
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_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

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      3.42E-07  1.72E-07  8.58E-08  5.42E-08  4.30E-08  3.42E-08
DEFINE  CR-51
      2.77E+01  3.26E-02  5.01E-03  2.60E+02  1.30E+02  1.00E+00
      0.00E+00  1.00E-02  1.00E+00  0.00E+00  0.00E+00
OTHER
   CULVL 10000000000.00
   XFARM      0.44
EOF
ISOTOPES  2    1     1.00    14.000   1.00    0.00   SNF
       CR-51  1.00E+00      GRP1    2
DISTKM
        NMODE=2  1.00
PKGSIZ
        SNF     3.00
EOF
```

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SNF	3.000E+00	3.000E+00	6.250E+00

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SNF	1.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
RAIL	1.00E+00	NO	1.00E+00			
				SNF	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

DNORML INPUT

NO		RAIL
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	1.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	6.437E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.025E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	5.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.524E+02
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	0.000E+00
11	MINIMUM STOP TIME PER TRIP (HR)	0.000E+00
12	ZERO STOP TIME PER TRIP (HR)	6.000E+01
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	2.000E+00
14	PERSONS EXPOSED WHILE STOPPED	1.000E+02
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	0.000E+00
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	3.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	0.000E+00
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	0.000E+00
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	0.000E+00
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	1.000E+00
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	5.000E+00
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	5.000E+00

*(ONE WAY VEHICLES/HR)

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL REM/CI LUNG	1YR INHAL REM/CI MARROW
SNF							
CR-51	1.00E+00	GRP1	1.32E+00	1	2	0.00E+00	0.00E+00

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	TRANSFER SOIL	DEPOS SPEED
SNF						
CR-51	2.77E+01	3.26E-02	5.01E-03	1.00E+00	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	50-YR EFFECTIVE REM/CI INGEST
SNF		
CR-51	2.60E+02	1.30E+02

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
RAIL	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR RAIL

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03
3.940E+03	8.580E-04
1.250E+04	3.420E-04
3.040E+04	1.720E-04
6.850E+04	8.580E-05
1.760E+05	3.420E-05
4.450E+05	1.720E-05
8.590E+05	8.580E-06
2.550E+06	3.420E-06
4.450E+06	1.720E-06
1.030E+07	8.580E-07
2.160E+07	3.420E-07
5.520E+07	1.720E-07
1.770E+08	8.580E-08
4.890E+08	5.420E-08
8.120E+08	4.300E-08
1.350E+09	3.420E-08

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

RADIST(M)		
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR	= 8.600E-03
FRACTION OF LAND UNDER CULTIVATION	= 4.400E-01
CONTAMINATION CLEAN UP LEVEL (UCI/M**2)	= 1.000E+09
BREATHING RATE (M**3/SEC)	= 3.300E-04

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

REGULATORY CHECKS

MODE 2 HAS BEEN REDESIGNATED AS EXCLUSIVE USE

FOR THE SHIPMENT OF SNF BY MODE 2
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 14.00

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	1.12E-02	0.00E+00	1.70E-07	6.62E-08	8.68E-03	0.00E+00	1.99E-02
TOTALS:	0.00E+00	1.12E-02	0.00E+00	1.70E-07	6.62E-08	8.68E-03	0.00E+00	1.99E-02

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 3.34E-07 REM

_INCIDENT-FREE_HAND_CHECK_RAIL_NONLINEAR_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DOSE RATE (TRANSPORT INDEX)	1.989E-04
2	NUMBER OF SHIPMENTS	1.989E-04
3	K ZERO	1.989E-04
4	PACKAGES PER SHIPMENT	1.989E-04
5	DISTANCE TRAVELED	8.682E-05
6	PERSONS EXPOSED WHILE STOPPED	8.682E-05
7	FRACTION OF TRAVEL - RURAL	2.358E-09
8	POPULATION DENSITY - RURAL	1.696E-09
9	NUMBER OF PEOPLE PER VEHICLE	6.620E-10
10	TRAFFIC COUNT - RURAL	6.620E-10
11	EXPOSURE TIME FOR HANDLERS	0.000E+00
12	NUMBER OF CREW MEMBERS	0.000E+00
13	NUMBER OF HANDLINGS	0.000E+00
14	DISTANCE FROM SOURCE TO CREW	0.000E+00
15	PERSONS EXPOSED PER HANDLING	0.000E+00
16	HANDLER EXPOSURE DISTANCE	0.000E+00
17	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
18	TRAFFIC COUNT - URBAN	0.000E+00
19	TRAFFIC COUNT - SUBURBAN	0.000E+00
20	FRACTION OF RUSH HOUR TRAVEL	0.000E+00
21	FRACTION OF TRAVEL ON FREEWAYS	0.000E+00
22	STORAGE EXPOSURE DISTANCE	0.000E+00
23	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
24	STORAGE TIME PER SHIPMENT	0.000E+00
25	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
26	VELOCITY - SUBURBAN	0.000E+00
27	POPULATION DENSITY - SUBURBAN	0.000E+00
28	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
29	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
30	FRACTION OF TRAVEL - URBAN	0.000E+00
31	POPULATION DENSITY - URBAN	0.000E+00
32	STOP TIME	0.000E+00
33	URBAN SHIELDING FACTOR (RU)	0.000E+00
34	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
35	VELOCITY - URBAN	0.000E+00
36	RURAL SHIELDING FACTOR (RR)	0.000E+00
37	VELOCITY - RURAL	-3.020E-09
38	EXPOSURE DISTANCE WHILE STOPPED	-1.736E-04

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

TOTAL EXPOSED POPULATION: INCIDENT-FREE

RAIL RURAL	9.60E+00	PERSONS
RAIL SUBURBAN	0.00E+00	PERSONS
RAIL URBAN	0.00E+00	PERSONS
TOTAL	9.60E+00	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

RAIL RURAL	0.00E+00	PERSONS
RAIL SUBURBAN	0.00E+00	PERSONS
RAIL URBAN	0.00E+00	PERSONS

EOI
END OF RUN

APPENDIX B

RADTRAN 4 OUTPUT FOR ACCIDENT RISKS

B.1 ACC6.OUT

RADTRAN4 OUTPUT FOR FIRST CASE

```
RRRR    AAA   DDDD  TTTTT RRRR    AAA   N   N
R   R  A   A  D   D   T   R   R  A   A  NN  N
R   R  A   A  D   D   T   R   R  A   A  N N N
RRRR   A   A  D   D   T   RRRR   A   A  N  NN
R R    AAAAA  D   D   T   R R    AAAAA  N   N
R  R   A   A  D   D   T   R  R   A   A  N   N
R   R  A   A  DDDD    T   R   R  A   A  N   N


                 4
              4  4
              4  4
              44444
                 4
                 4
                 4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

```
&& Edited Fri Mar  3 08:35:28 1995
&& _RADTRAN_ACCIDENT_CHECK_
TITLE _ACCIDENT_HAND_CHECK_
FORM UNIT
DIMEN 1 6 1 10 2
PARM 1 3 3 1 0
PACKAGE
   LABGRP
       PKG3
SHIPMENT
   LABISO
     CS-137
NORMAL
   NMODE=1
       1.000E+00  0.000E+00  0.000E+00  8.856E+01  4.032E+01  2.416E+01
       2.000E+00  1.000E+01  0.000E+00  1.100E-02  5.300E+01  0.000E+00
       0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  1.000E-01  5.000E-02  7.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   ARATMZ
       NMODE=1   1.000E+00    1.000E+00    1.000E+00
   SEVFRC
     NPOP=1
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=2
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
     NPOP=3
       NMODE=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
RELEASE
   RFRAC
     GROUP=1
       1.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   AERSOL
     DISP=4
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=4
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
   AREADA
       4.59E+02  1.53E+03
   DFLEV
       3.42E-03  1.72E-03
DEFINE CS-137
       1.10E+04  5.96E-01  9.71E-02  3.20E+04  5.00E+04  3.07E-04
       0.00E+00  1.00E-02  2.00E+00  3.10E+04  2.60E+04
OTHER
   XFARM     1.00
```

_ACCIDENT_HAND_CHECK_

```
EOF
ISOTOPES  -1    1     1.00   14.000   1.00   0.00  SFUEL
       CS-137  1.00E-06      PKG3   4
DISTKM
         NMODE=1  1.00
PKGSIZ
         SFUEL     5.20
EOF
```

_ACCIDENT_HAND_CHECK_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SFUEL	5.200E+00	4.677E+00	1.115E+01

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SFUEL	1.000E+00	0.000E+00

_ACCIDENT_HAND_CHECK_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.00E+00	YES	1.00E+00			
				SFUEL	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_ACCIDENT_HAND_CHECK_

NO	DNORML	INPUT TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	1.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	8.856E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.032E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.000E+01
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP (HR)	5.300E+01
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	1.000E+02
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	1.000E-01
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	5.000E-02
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	7.500E-01
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*(ONE WAY VEHICLES/HR)

_ACCIDENT_HAND_CHECK_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL REM/CI LUNG	MARROW
SFUEL CS-137	1.00E-06	PKG3	5.41E+00	2	4	3.10E+04	2.60E+04

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	SOIL	DEPOS SPEED
SFUEL CS-137	1.10E+04	5.96E-01	9.71E-02	3.07E-04	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SFUEL CS-137	3.20E+04	5.00E+04

_ACCIDENT_HAND_CHECK_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	1.000E+00	1.000E+00	1.000E+00

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_ACCIDENT_HAND_CHECK_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_ACCIDENT_HAND_CHECK_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_ACCIDENT_HAND_CHECK_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 1.000E+00
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 2.000E-01
BREATHING RATE (M**3/SEC) = 3.300E-04

_ACCIDENT_HAND_CHECK_

REGULATORY CHECKS

FOR THE SHIPMENT OF   SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

_ACCIDENT_HAND_CHECK_

CALCULATIONAL INFORMATION FOR MODE TRUCK

_ACCIDENT_HAND_CHECK_

MODE TRUCK

1-YEAR LUNG DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	3.50E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.76E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

1-YEAR MARROW DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	2.93E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.47E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_ACCIDENT_HAND_CHECK_

MODE TRUCK

GROUND SURFACE CONTAMINATION TABLE (MICRO CI/M**2)
BEFORE CLEANUP

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
1	3.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

_ACCIDENT_HAND_CHECK_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	3.55E-05	0.00E+00	2.06E-07	1.19E-05	9.60E-01	0.00E+00	9.60E-01
TOTALS:	0.00E+00	3.55E-05	0.00E+00	2.06E-07	1.19E-05	9.60E-01	0.00E+00	9.60E-01

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 5.96E-07 REM

_ACCIDENT_HAND_CHECK_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DOSE RATE (TRANSPORT INDEX)	9.596E-03
2	K ZERO	9.596E-03
3	NUMBER OF SHIPMENTS	9.596E-03
4	PACKAGES PER SHIPMENT	9.596E-03
5	DISTANCE TRAVELED	9.596E-03
6	PERSONS EXPOSED WHILE STOPPED	9.596E-03
7	STOP TIME	9.596E-03
8	FRACTION OF TRAVEL - RURAL	4.767E-07
9	NUMBER OF CREW MEMBERS	3.552E-07
10	NUMBER OF PEOPLE PER VEHICLE	1.194E-07
11	TRAFFIC COUNT - RURAL	1.194E-07
12	POPULATION DENSITY - RURAL	2.057E-09
13	FRACTION OF RUSH HOUR TRAVEL	9.237E-16
14	STORAGE EXPOSURE DISTANCE	0.000E+00
15	NUMBER OF HANDLINGS	0.000E+00
16	EXPOSURE TIME FOR HANDLERS	0.000E+00
17	PERSONS EXPOSED PER HANDLING	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - URBAN	0.000E+00
20	TRAFFIC COUNT - SUBURBAN	0.000E+00
21	HANDLER EXPOSURE DISTANCE	0.000E+00
22	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
23	STORAGE TIME PER SHIPMENT	0.000E+00
24	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
25	VELOCITY - SUBURBAN	0.000E+00
26	POPULATION DENSITY - SUBURBAN	0.000E+00
27	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
28	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
29	FRACTION OF TRAVEL - URBAN	0.000E+00
30	POPULATION DENSITY - URBAN	0.000E+00
31	URBAN SHIELDING FACTOR (RU)	0.000E+00
32	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
33	RURAL SHIELDING FACTOR (RR)	0.000E+00
34	VELOCITY - URBAN	0.000E+00
35	FRACTION OF TRAVEL ON FREEWAYS	-1.089E-07
36	VELOCITY - RURAL	-5.961E-07
37	DISTANCE FROM SOURCE TO CREW	-6.594E-07
38	EXPOSURE DISTANCE WHILE STOPPED	-1.919E-02

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

_ACCIDENT_HAND_CHECK_

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	1.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

EARLY FATALITY CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

ECONOMIC CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

RADIOLOGICAL CONSEQUENCES -- MODE TRUCK
50 YEAR POPULATION DOSE IN PERSON REM

CATEGORY	RURAL	SUBURB	URBAN
1	6.60E-07	1.64E-05	5.32E-05
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00

_ACCIDENT_HAND_CHECK_

EXPECTED VALUES OF POPULATION RISK IN PERSON REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
SFUEL CS-137	1.35E-07	2.84E-10	1.25E-09	2.61E-12	5.23E-07	6.60E-07
TOTALS:	1.35E-07	2.84E-10	1.25E-09	2.61E-12	5.23E-07	6.60E-07

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

_ACCIDENT_HAND_CHECK_

EXPECTED RISK VALUES - OTHER

LINK	ECON $$	EARLY FATALITY
1	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

TOTAL EXPOSED POPULATION: INCIDENT-FREE

TRUCK RURAL	9.60E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	0.00E+00	PERSONS
TOTAL	9.60E+00	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

TRUCK RURAL	9.18E-03	PERSONS
TRUCK SUBURBAN	1.10E+00	PERSONS
TRUCK URBAN	5.91E+00	PERSONS

EOI
END OF RUN

B.2 RISK2.OUT

RADTRAN 4 OUTPUT FOR SECOND CASE

```
RRRR   AAA  DDDD  TTTTT RRRR   AAA  N   N
R   R A   A D   D   T   R   R A   A NN  N
R   R A   A D   D   T   R   R A   A N N N
RRRR  A   A D   D   T   RRRR  A   A N  NN
R R   AAAAA D   D   T   R R   AAAAA N   N
R  R  A   A D   D   T   R  R  A   A N   N
R   R A   A DDDD    T   R   R A   A N   N

                       4
                    4  4
                    4  4
                    44444
                       4
                       4
                       4
```

RADTRAN 4.0.17 VERSION DATE: NOVEMBER 8, 1994

MODE DESCRIPTIONS

NUMBER	NAME	CHARACTERIZATION
1	TRUCK	LONG HAUL VEHICLE
2	RAIL	COMMERCIAL TRAIN
3	BARGE	INLAND VESSEL
4	SHIP	OPEN SEA VESSEL
5	CARGO AIR	CARGO AIRCRAFT
6	PASS AIR	PASSENGER AIRCRAFT
7	P-VAN	PASSENGER VAN
8	CVAN-T	COMMERCIAL VAN
9	CVAN-R	COMMERCIAL VAN
10	CVAN-CA	COMMERCIAL VAN

ECHO CHECK

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&& Edited Sat Mar 25 14:06:36 1995
&& _RADTRAN_ACCIDENT_CHECK_
TITLE _ACCIDENT_HAND_CHECK_
FORM UNIT
DIMEN 1 20 1 10 2
PARM 1 3 3 1 0
PACKAGE
   LABGRP
       PKG3
SHIPMENT
   LABISO
     CS-137
NORMAL
   NMODE=1
       1.000E+00  0.000E+00  0.000E+00  8.856E+01  4.032E+01  2.416E+01
       2.000E+00  1.000E+01  0.000E+00  1.100E-02  5.300E+01  0.000E+00
       0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  1.000E-01  5.000E-02  7.500E-01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   ARATMZ
       NMODE=1   1.000E-07    1.900E-06    1.500E-05
   SEVFRC
     NPOP=1
       NMODE=1
       9.94E-01  2.72E-03  5.54E-04  1.79E-09  1.23E-03  5.01E-07
       1.02E-07  3.29E-13  7.95E-04  3.26E-07  6.63E-08  2.14E-13
       6.14E-04  2.53E-07  5.16E-08  1.64E-13  1.25E-04  1.08E-08
       5.30E-08  3.46E-14
     NPOP=2
       NMODE=1
       0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
       0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
       0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
       0.00E+00  1.00E+00
     NPOP=3
       NMODE=1
       0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
       0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
       0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
       0.00E+00  1.00E+00
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  1.00E-01  1.00E+00  1.00E+00  3.00E-02  1.00E-01
       1.00E+00  1.00E+00  3.00E-02  1.00E-01  1.00E+00  1.00E+00
       1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
       1.00E+00  1.00E+00
   AERSOL
     DISP=4
       0.00E+00  4.00E-04  4.00E-04  4.00E-03  4.00E-04  4.00E-04
```

_ACCIDENT_HAND_CHECK_

```
      4.00E-04  4.00E-03  4.00E-04  4.00E-04  4.00E-04  4.00E-03
      4.00E-04  4.00E-04  4.00E-04  4.00E-03  4.00E-03  4.00E-03
      4.00E-03  4.00E-03
   RESP
     DISP=4
      0.00E+00  5.00E-01  5.00E-01  5.00E-01  5.00E-01  5.00E-01
      5.00E-01  5.00E-01  5.00E-01  5.00E-01  5.00E-01  5.00E-01
      5.00E-01  5.00E-01  5.00E-01  5.00E-01  5.00E-01  5.00E-01
      5.00E-01  5.00E-01
   AREADA
      4.59E+02  1.53E+03
   DFLEV
      3.42E-03  1.72E-03
DEFINE CS-137
      1.10E+04  5.96E-01  9.71E-02  3.20E+04  5.00E+04  3.07E-04
      0.00E+00  1.00E-02  2.00E+00  3.10E+04  2.60E+04
OTHER
   XFARM     1.00
EOF
ISOTOPES  -1    1     1.00   14.000   1.00   0.00  SFUEL
      CS-137  1.00E-06      PKG3   4
DISTKM
        NMODE=1  1.00
PKGSIZ
        SFUEL     5.20
EOF
```

_ACCIDENT_HAND_CHECK_

ZONE	POPULATION DENSITY (PERSONS PER SQ KM)
RURAL	6.
SUBURBAN	719.
URBAN	3861.

PACKAGE CHARACTERISTICS

FOR MATERIAL	DIMENSION (METERS)	EFFECTIVE DIMENSION	K(0) METERS SQ.
SFUEL	5.200E+00	4.677E+00	1.115E+01

K(0) IS TI TO DOSE RATE CONVERSION FACTOR

PACKAGE HANDLING THRESHOLDS (METERS)
PKGSZ1= 5.000E-01
PKGSZ2= 1.000E+00
PACKAGES .LE. PKGSZ1 ARE HAND CARRIED
PACKAGES .GT. PKGSZ1 AND .LE. PKGSZ2 ARE HANDLED BY SMALL EQUIPMENT
PACKAGES .GT. PKGSZ2 ARE HANDLED BY HEAVY EQUIPMENT

MATERIAL CHARACTERISTICS

MATERIAL	FRACTION OF GAMMA	FRACTION OF NEUTRON
SFUEL	1.000E+00	0.000E+00

_ACCIDENT_HAND_CHECK_

MODE CHARACTERISTICS

MODE	DISTANCE TRAVELED	EXCLUSIVE USE	NUMBER OF SHIPMENTS	MATERIALS	TRANSPORT INDEX (TI)	PACKAGES/ SHIPMENT
TRUCK	1.00E+00	YES	1.00E+00			
				SFUEL	1.40E+01	1.00E+00

BUILDING SHIELDING OPTION= 3
(1=TOTAL SHIELDING, 2=PARTIAL SHIELDING, 3=NO SHIELDING)

RPD= 6.000E+00
(RATIO OF PEDESTRIAN DENSITY (PEDESTRIAN/KM SQ OF SIDEWALK)
TO POPULATION DENSITY (PEOPLE/KM SQ IN URBAN AREAS)

RR = 1.000E+00
(TRANSMISSION FACTOR FOR RURAL AREAS)

RS = 1.000E+00
(TRANSMISSION FACTOR FOR SUBURBAN AREAS)

RU = 1.000E+00
(TRANSMISSION FACTOR FOR URBAN AREAS)

_ACCIDENT_HAND_CHECK_

NO	DNORML INPUT	TRUCK
1	FRACTION OF TRAVEL IN RURAL POPULATION ZONE	1.000E+00
2	FRACTION OF TRAVEL IN SUBURBAN POPULATION ZONE	0.000E+00
3	FRACTION OF TRAVEL IN URBAN POPULATION ZONE	0.000E+00
4	VELOCITY IN RURAL POPULATION ZONE (KILOMETERS/HOUR)	8.856E+01
5	VELOCITY IN SUBURBAN POP. ZONE (KILOMETERS/HOUR)	4.032E+01
6	VELOCITY IN URBAN POPULATION ZONE (KILOMETERS/HOUR)	2.416E+01
7	NUMBER OF CREWMEN	2.000E+00
8	DISTANCE FROM SOURCE TO CREW (METERS)	1.000E+01
9	NUMBER OF HANDLINGS	0.000E+00
10	STOP TIME PER KM (HR/KM)	1.100E-02
11	MINIMUM STOP TIME PER TRIP (HR)	5.300E+01
12	ZERO STOP TIME PER TRIP (HR)	0.000E+00
13	MINIMUM NUMBER OF RAIL CLASSIF ICATIONS/INSPECTIONS	0.000E+00
14	PERSONS EXPOSED WHILE STOPPED	5.000E+01
15	AVERAGE EXPOSURE DISTANCE WHILE STOPPED (METERS)	2.000E+01
16	STORAGE TIME PER SHIPMENT (HR)	0.000E+00
17	NUMBER OF EXPOSED PERSONS DURING STORAGE	1.000E+02
18	AVERAGE EXPOSURE DISTANCE WHILE IN STORAGE (METERS)	1.000E+02
19	NUMBER OF PEOPLE PER VEHICLE ON LINK	2.000E+00
20	FRACTION OF URBAN TRAVEL DURING RUSH HOUR TRAFFIC	1.000E-01
21	FRACTION OF URBAN TRAVEL ON CITY STREETS	5.000E-02
22	FRACTION OF RURAL-SUBURBAN TRAVEL ON FREEWAYS	7.500E-01
23	*TRAFFIC COUNT PASSING A SPECIFIC POINT-RURAL ZONE	4.700E+02
24	*TRAFFIC COUNT PASSING A SPECIFIC POINT-SUBURBAN ZONE	7.800E+02
25	*TRAFFIC COUNT PASSING A SPECIFIC POINT-URBAN ZONE	2.800E+03

*(ONE WAY VEHICLES/HR)

_ACCIDENT_HAND_CHECK_

ISOTOPE RELATED DATA

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSP FACTOR	LUNG TYPE	DISPERS. CATEGORY	1YR INHAL LUNG	REM/CI MARROW
SFUEL							
CS-137	1.00E-06	PKG3	5.41E+00	2	4	3.10E+04	2.60E+04

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	TRANSFER CROPS	SOIL	DEPOS SPEED
SFUEL						
CS-137	1.10E+04	5.96E-01	9.71E-02	3.07E-04	0.00E+00	1.00E-02

NUCLIDE	50-YR EFFECTIVE REM/CI INHALE	INGEST
SFUEL		
CS-137	3.20E+04	5.00E+04

_ACCIDENT_HAND_CHECK_

RELEASE RELATED DATA

ACCIDENT RATES (PER KM)

MODE	RURAL	SUBURBAN	URBAN
TRUCK	1.000E-07	1.900E-06	1.500E-05

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	1.00E-01	1.00E+00	1.00E+00	3.00E-02	1.00E-01	1.00E+00

GROUP	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	1.00E+00	3.00E-02	1.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00

GROUP	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

ACCIDENT SEVERITY FRACTIONS
FOR TRUCK

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	9.94E-01	2.72E-03	5.54E-04	1.79E-09	1.23E-03	5.01E-07	1.02E-07
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ZONE	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	3.29E-13	7.95E-04	3.26E-07	6.63E-08	2.14E-13	6.14E-04	2.53E-07
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ZONE	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	5.16E-08	1.64E-13	1.25E-04	1.08E-08	5.30E-08	3.46E-14
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00

_ACCIDENT_HAND_CHECK_

AEROSOLIZED FRACTION OF RELEASED MATERIAL

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	0.00E+00	4.00E-04	4.00E-04	4.00E-03	4.00E-04	4.00E-04	4.00E-04
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

DISP CAT	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	4.00E-03	4.00E-04	4.00E-04	4.00E-04	4.00E-03	4.00E-04	4.00E-04
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

DISP CAT	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
3	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
4	4.00E-04	4.00E-03	4.00E-03	4.00E-03	4.00E-03	4.00E-03
5	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
6	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

FRACTION OF AEROSOLS BELOW 10 MICRONS AED

DISP CAT	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	0.00E+00	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

DISP CAT	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

DISP CAT	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
3	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
4	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01
5	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
6	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
8	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
9	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
10	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
11	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

_ACCIDENT_HAND_CHECK_

COST RELATED DATA

EMERGENCY RESPONSE COST

	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ON-SCENE COSTS
(RF=RELEASE FRACTION)

RF=0.	0.<RF<=.01	.01<RF<=0.1	.1<RF<=1.
0.	0.	0.	0.

_ACCIDENT_HAND_CHECK_

HEALTH RELATED DATA

EARLY FATALITY PROBABILITIES

DOSE(REM)	LUNG-1	LUNG-2	LUNG-3	MARROW
100000.000	1.000E+00	1.000E+00	1.000E+00	1.000E+00
80000.000	1.000E+00	8.500E-01	8.000E-01	1.000E+00
70000.000	1.000E+00	8.000E-01	5.000E-01	1.000E+00
40000.000	1.000E+00	7.000E-01	0.000E+00	1.000E+00
30000.000	1.000E+00	5.000E-01	0.000E+00	1.000E+00
25000.000	1.000E+00	2.000E-01	0.000E+00	1.000E+00
20000.000	1.000E+00	8.000E-02	0.000E+00	1.000E+00
10000.000	6.000E-01	0.000E+00	0.000E+00	1.000E+00
8000.000	1.000E-01	0.000E+00	0.000E+00	1.000E+00
6000.000	6.000E-02	0.000E+00	0.000E+00	1.000E+00
4000.000	3.000E-02	0.000E+00	0.000E+00	1.000E+00
3000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
2000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
1000.000	0.000E+00	0.000E+00	0.000E+00	1.000E+00
800.000	0.000E+00	0.000E+00	0.000E+00	9.960E-01
700.000	0.000E+00	0.000E+00	0.000E+00	9.000E-01
600.000	0.000E+00	0.000E+00	0.000E+00	4.000E-01
500.000	0.000E+00	0.000E+00	0.000E+00	5.000E-02
400.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
300.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
75.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
50.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
30.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.100	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00
0.010	0.000E+00	0.000E+00	0.000E+00	0.000E+00

_ACCIDENT_HAND_CHECK_

DISPERSAL ACCIDENT INPUT

AREADA (M SQ)	DILUTION FACTOR*
4.590E+02	3.420E-03
1.530E+03	1.720E-03

* DILUTION FACTOR UNITS ARE (CI-SEC/M**3/CI-RELEASED)

NON-DISPERSAL ACCIDENT INPUT

	RADIST(M)	
RURAL	SUBURBAN	URBAN
3.050E+00	3.050E+00	3.050E+00
6.100E+00	6.100E+00	6.100E+00
9.100E+00	9.100E+00	9.100E+00
1.220E+01	1.220E+01	1.220E+01
1.520E+01	1.520E+01	1.520E+01
3.050E+01	3.050E+01	3.050E+01
6.100E+01	6.100E+01	6.100E+01
9.140E+01	9.140E+01	9.140E+01
1.524E+02	1.524E+02	1.524E+02
3.050E+02	3.050E+02	3.050E+02

BUILDING DOSE FACTOR = 8.600E-03
FRACTION OF LAND UNDER CULTIVATION = 1.000E+00
CONTAMINATION CLEAN UP LEVEL (UCI/M**2) = 2.000E-01
BREATHING RATE (M**3/SEC) = 3.300E-04

_ACCIDENT_HAND_CHECK_

REGULATORY CHECKS

FOR THE SHIPMENT OF   SFUEL BY MODE 1
THE DOSE RATE AT 2 METERS COULD EXCEED 10 MR/HR
PPS*TI HAS BEEN RESET TO EQUAL 13.00

_ACCIDENT_HAND_CHECK_

CALCULATIONAL INFORMATION FOR MODE TRUCK

_ACCIDENT_HAND_CHECK_

MODE   TRUCK

1-YEAR LUNG DOSE - INHALATION PATHWAY
BDF = 1   (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	7.00E-13	7.00E-12	7.00E-11	2.10E-13	7.00E-13	7.00E-12
2	0.00E+00	3.51E-13	3.51E-12	3.51E-11	1.05E-13	3.51E-13	3.51E-12

AREA #	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	7.00E-11	2.10E-13	7.00E-13	7.00E-12	7.00E-11	7.00E-12	7.00E-12
2	3.51E-11	1.05E-13	3.51E-13	3.51E-12	3.51E-11	3.51E-12	3.51E-12

AREA #	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	7.00E-12	7.00E-11	7.00E-11	7.00E-11	7.00E-11	7.00E-11
2	3.51E-12	3.51E-11	3.51E-11	3.51E-11	3.51E-11	3.51E-11

_ACCIDENT_HAND_CHECK_

1-YEAR MARROW DOSE - INHALATION PATHWAY
BDF = 1 (REM)

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	5.87E-13	5.87E-12	5.87E-11	1.76E-13	5.87E-13	5.87E-12
2	0.00E+00	2.95E-13	2.95E-12	2.95E-11	8.84E-14	2.95E-13	2.95E-12

AREA #	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	5.87E-11	1.76E-13	5.87E-13	5.87E-12	5.87E-11	5.87E-12	5.87E-12
2	2.95E-11	8.84E-14	2.95E-13	2.95E-12	2.95E-11	2.95E-12	2.95E-12

AREA #	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	5.87E-12	5.87E-11	5.87E-11	5.87E-11	5.87E-11	5.87E-11
2	2.95E-12	2.95E-11	2.95E-11	2.95E-11	2.95E-11	2.95E-11

_ACCIDENT_HAND_CHECK_

MODE TRUCK

GROUND SURFACE CONTAMINATION TABLE (MICRO CI/M**2)
BEFORE CLEANUP

AREA #	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6	SEVER: 7
1	0.00E+00	1.37E-09	1.37E-08	1.37E-07	4.10E-10	1.37E-09	1.37E-08
2	0.00E+00	6.87E-10	6.87E-09	6.87E-08	2.06E-10	6.87E-10	6.87E-09

AREA #	SEVER: 8	SEVER: 9	SEVER:10	SEVER:11	SEVER:12	SEVER:13	SEVER:14
1	1.37E-07	4.10E-10	1.37E-09	1.37E-08	1.37E-07	1.37E-08	1.37E-08
2	6.87E-08	2.06E-10	6.87E-10	6.87E-09	6.87E-08	6.87E-09	6.87E-09

AREA #	SEVER:15	SEVER:16	SEVER:17	SEVER:18	SEVER:19	SEVER:20
1	1.37E-08	1.37E-07	1.37E-07	1.37E-07	1.37E-07	1.37E-07
2	6.87E-09	6.87E-08	6.87E-08	6.87E-08	6.87E-08	6.87E-08

_ACCIDENT_HAND_CHECK_

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

INCIDENT-FREE POPULATION EXPOSURE IN PERSON-REM

	PASSENGR	CREW	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
LINK 1	0.00E+00	3.55E-05	0.00E+00	2.06E-07	1.19E-05	9.60E-01	0.00E+00	9.60E-01
TOTALS:	0.00E+00	3.55E-05	0.00E+00	2.06E-07	1.19E-05	9.60E-01	0.00E+00	9.60E-01

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

LINK 1 5.96E-07 REM

_ACCIDENT_HAND_CHECK_

INCIDENT-FREE IMPORTANCE ANALYSIS SUMMARY FOR LINK 1
****

INDEX	DESCRIPTION OF PARAMETER	IMPORTANCE
1	DOSE RATE (TRANSPORT INDEX)	9.596E-03
2	K ZERO	9.596E-03
3	NUMBER OF SHIPMENTS	9.596E-03
4	PACKAGES PER SHIPMENT	9.596E-03
5	DISTANCE TRAVELED	9.596E-03
6	PERSONS EXPOSED WHILE STOPPED	9.596E-03
7	STOP TIME	9.596E-03
8	FRACTION OF TRAVEL - RURAL	4.767E-07
9	NUMBER OF CREW MEMBERS	3.552E-07
10	NUMBER OF PEOPLE PER VEHICLE	1.194E-07
11	TRAFFIC COUNT - RURAL	1.194E-07
12	POPULATION DENSITY - RURAL	2.057E-09
13	FRACTION OF RUSH HOUR TRAVEL	9.237E-16
14	STORAGE EXPOSURE DISTANCE	0.000E+00
15	NUMBER OF HANDLINGS	0.000E+00
16	EXPOSURE TIME FOR HANDLERS	0.000E+00
17	PERSONS EXPOSED PER HANDLING	0.000E+00
18	NUMBER OF FLIGHT ATTENDANTS	0.000E+00
19	TRAFFIC COUNT - URBAN	0.000E+00
20	TRAFFIC COUNT - SUBURBAN	0.000E+00
21	HANDLER EXPOSURE DISTANCE	0.000E+00
22	NUMBER OF PERSONS EXPOSED DURING STORAGE	0.000E+00
23	STORAGE TIME PER SHIPMENT	0.000E+00
24	SUBURBAN SHIELDING FACTOR (RS)	0.000E+00
25	VELOCITY - SUBURBAN	0.000E+00
26	POPULATION DENSITY - SUBURBAN	0.000E+00
27	FRACTION OF TRAVEL - SUBURBAN	0.000E+00
28	RATIO OF PEDESTRIAN DENSITY (RPD)	0.000E+00
29	FRACTION OF TRAVEL - URBAN	0.000E+00
30	POPULATION DENSITY - URBAN	0.000E+00
31	URBAN SHIELDING FACTOR (RU)	0.000E+00
32	FRACTION OF TRAVEL ON CITY STREETS	0.000E+00
33	RURAL SHIELDING FACTOR (RR)	0.000E+00
34	VELOCITY - URBAN	0.000E+00
35	FRACTION OF TRAVEL ON FREEWAYS	-1.089E-07
36	VELOCITY - RURAL	-5.961E-07
37	DISTANCE FROM SOURCE TO CREW	-6.594E-07
38	EXPOSURE DISTANCE WHILE STOPPED	-1.919E-02

THE IMPORTANCE VALUE ESTIMATES THE PERSON-REM INFLUENCE
OF A ONE PERCENT INCREASE IN THE PARAMETER

_ACCIDENT_HAND_CHECK_

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	9.94E-08	0.00E+00	0.00E+00
2	2.72E-10	0.00E+00	0.00E+00
3	5.54E-11	0.00E+00	0.00E+00
4	1.79E-16	0.00E+00	0.00E+00
5	1.23E-10	0.00E+00	0.00E+00
6	5.01E-14	0.00E+00	0.00E+00
7	1.02E-14	0.00E+00	0.00E+00
8	3.29E-20	0.00E+00	0.00E+00
9	7.95E-11	0.00E+00	0.00E+00
10	3.26E-14	0.00E+00	0.00E+00
11	6.63E-15	0.00E+00	0.00E+00
12	2.14E-20	0.00E+00	0.00E+00
13	6.14E-11	0.00E+00	0.00E+00
14	2.53E-14	0.00E+00	0.00E+00
15	5.16E-15	0.00E+00	0.00E+00
16	1.64E-20	0.00E+00	0.00E+00
17	1.25E-11	0.00E+00	0.00E+00
18	1.08E-15	0.00E+00	0.00E+00
19	5.30E-15	0.00E+00	0.00E+00
20	3.46E-21	0.00E+00	0.00E+00

_ACCIDENT_HAND_CHECK_

EARLY FATALITY CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	0.00E+00	0.00E+00

_ACCIDENT_HAND_CHECK_

ECONOMIC CONSEQUENCES -- MODE TRUCK

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	0.00E+00	0.00E+00

_ACCIDENT_HAND_CHECK_

RADIOLOGICAL CONSEQUENCES -- MODE TRUCK
50 YEAR POPULATION DOSE IN PERSON REM

CATEGORY	RURAL	SUBURB	URBAN
1	0.00E+00	0.00E+00	0.00E+00
2	2.64E-11	6.52E-10	2.12E-09
3	2.64E-10	6.52E-09	2.12E-08
4	2.64E-09	6.52E-08	2.12E-07
5	7.91E-12	1.96E-10	6.35E-10
6	2.64E-11	6.52E-10	2.12E-09
7	2.64E-10	6.52E-09	2.12E-08
8	2.64E-09	6.52E-08	2.12E-07
9	7.91E-12	1.96E-10	6.35E-10
10	2.64E-11	6.52E-10	2.12E-09
11	2.64E-10	6.52E-09	2.12E-08
12	2.64E-09	6.52E-08	2.12E-07
13	2.64E-10	6.52E-09	2.12E-08
14	2.64E-10	6.52E-09	2.12E-08
15	2.64E-10	6.52E-09	2.12E-08
16	2.64E-09	6.52E-08	2.12E-07
17	2.64E-09	6.52E-08	2.12E-07
18	2.64E-09	6.52E-08	2.12E-07
19	2.64E-09	6.52E-08	2.12E-07
20	2.64E-09	6.52E-08	2.12E-07

_ACCIDENT_HAND_CHECK_

EXPECTED VALUES OF POPULATION RISK IN PERSON REM

	GROUND	INHALED	RESUSPD	CLOUDSH	*INGESTION	TOTAL
SFUEL						
CS-137	1.49E-20	1.57E-23	6.91E-23	2.88E-25	5.76E-20	7.26E-20
TOTALS:	1.49E-20	1.57E-23	6.91E-23	2.88E-25	5.76E-20	7.26E-20

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

_ACCIDENT_HAND_CHECK_

EXPECTED RISK VALUES - OTHER

LINK	ECON $$	EARLY FATALITY
1	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

TOTAL EXPOSED POPULATION: INCIDENT-FREE

TRUCK RURAL	9.60E+00	PERSONS
TRUCK SUBURBAN	0.00E+00	PERSONS
TRUCK URBAN	0.00E+00	PERSONS
TOTAL	9.60E+00	PERSONS

TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

TRUCK RURAL	9.18E-03	PERSONS
TRUCK SUBURBAN	1.10E+00	PERSONS
TRUCK URBAN	5.91E+00	PERSONS

EOI
END OF RUN

APPENDIX C

RISKIND OUTPUT FOR INCIDENT-FREE MAXIMALLY EXPOSED INDIVIDUAL SCENARIOS

C.1 T14-PUB.OUT

RADIATION DOSES FOR GENERAL POPULATION TRUCK SCENARIO

```
&INDATA

TITLE = ' TRUCK INCIDENT FREE PUBLIC - SNF',
OUTFIL = 'RISKIND.OUT',
IACDT = 0, IRUTIN = 1,
FRAD = 1.0, 0.0, TIDX =21.1, HSIZE = 4.77, RSIZE = 0.5048,
ISTATE = 10, IMOD = 1, IZONE = 3, IRDTY = 3,

IADD = 4,
SPEED = 56.3,

XNAME =
        ' TRAFFIC JAM',
        ' REGULATORY CHECK',
        ' SERVICE STATION',
        ' RESIDENT',

XRECEP =
         .001,  2*0,
         .002,  2*0,
         .020,  2*0,
         .030,  2*0,

INDR =  1, 0, 0, 1,
ISHLT = 4, 0, 0, 1,
TSTP =  0.5, 1.0, 2.0, 0.0,

&END
```

```
1*********************************************************************************
 TRUCK INCIDENT FREE PUBLIC - SNF                        05/15/94  21:47   PAGE   1
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in

   BACKGROUND POPULATION INFORMATION :
    POLULATION ZONE =                          URBAN
    AVERAGE TRAVEL SPEED (KM/HR) =             5.63E+01

    INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA


    ***     RECEPTOR LOCATION DATA :  4  LOCATIONS THIS RUN  ***

   I     LOCATION NAMES     X(KM)   Y(KM)    Z(M)   DIST(KM)
 ---------------------------------------------------------------------------
   1   TRAFFIC JAM          0.001   0.000   0.000   0.001
   2   REGULATORY CHECK     0.002   0.000   0.000   0.002
   3   SERVICE STATION      0.020   0.000   0.000   0.020
   4   RESIDENT             0.030   0.000   0.000   0.030
 ---------------------------------------------------------------------------
1*********************************************************************************
 TRUCK INCIDENT FREE PUBLIC - SNF                        05/15/94  21:47   PAGE   2
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in


    CASK SIZE : RADIUS(M) =               5.05E-01
                LENGTH(M) =               4.77E+00
    FRACTION GAMMA SOURCE =                   1.00
    FRACTION NEUTRON SOURCE =                 0.00
    TRANSPORTATION INDEX =                   21.10


                   RECEPTOR ROUTINE DOSE FROM EACH SHIPMENT

                                              DURING             DURING
                                               STOP             TRANSPORT
                                          ---------------       --------
    I  LOCATION NAMES         DISTANCE(M)  HOUR       REM           REM
    ------------------------------------------------------------------------
    1   TRAFFIC JAM               1.0       0.5    5.28E-03      1.06E-06
    2   REGULATORY CHECK          2.0       1.0    1.00E-02      1.56E-06
    3   SERVICE STATION          20.0       2.0    4.07E-04      2.02E-07
    4   RESIDENT                 30.0       0.0    0.00E+00      5.02E-08
    ------------------------------------------------------------------------
```

C.2 R14-OCC.OUT

RADIATION DOSES FOR OCCUPATIONAL RAIL SCENARIO

```
&INDATA

TITLE = ' RAIL INCIDENT FREE OCCUPATIONAL - SNF',
OUTFIL = 'RISKIND.OUT',
IACDT = 0, IRUTIN = 1,
FRAD = 1.0, 0.0, TIDX = 21.1, HSIZE = 5.13, RSIZE = 1.041,
ISTATE = 10, IMOD = 1, IZONE = 3,

IADD = 2,
SPEED = 56.3,

XNAME =
        ' WORKER',
        ' REGULATORY CHECK',

XRECEP =
         .001, 2*0,
         .002, 2*0,

INDR =  0, 0,
ISHLT = 0, 0,
TSTP =  0.16, 1.0,

&END
```

```
1*******************************************************************************
 RAIL INCIDENT FREE OCCUPATIONAL - SNF             05/15/94  21:49   PAGE   1
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in

   BACKGROUND POPULATION INFORMATION :
    POLULATION ZONE =                        URBAN
    AVERAGE TRAVEL SPEED (KM/HR) =           5.63E+01

    INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA


    ***     RECEPTOR LOCATION DATA :  2  LOCATIONS THIS RUN  ***

  I     LOCATION NAMES     X(KM)   Y(KM)    Z(M)   DIST(KM)
 ------------------------------------------------------------------------------
  1   WORKER                0.001   0.000   0.000   0.001
  2   REGULATORY CHECK      0.002   0.000   0.000   0.002
 ------------------------------------------------------------------------------
1*******************************************************************************
 RAIL INCIDENT FREE OCCUPATIONAL - SNF             05/15/94  21:49   PAGE   2
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in


    CASK SIZE : RADIUS(M) =               1.04E+00
                LENGTH(M) =               5.13E+00
    FRACTION GAMMA SOURCE =                   1.00
    FRACTION NEUTRON SOURCE =                 0.00
    TRANSPORTATION INDEX =                   21.10


                     RECEPTOR ROUTINE DOSE FROM EACH SHIPMENT

                                              DURING             DURING
                                               STOP             TRANSPORT
                                         ---------------        --------
    I  LOCATION NAMES          DISTANCE(M)  HOUR       REM          REM
   ------------------------------------------------------------------------
    1   WORKER                     1.0      0.2    3.38E-03     2.17E-06
    2   REGULATORY CHECK           2.0      1.0    1.01E-02     1.61E-06
   ------------------------------------------------------------------------
```

C.3 R14-PUB.OUT

RADIATION DOSES FOR GENERAL POPULATION RAIL SCENARIO

```
&INDATA

TITLE = ' RAIL INCIDENT FREE PUBLIC - SNF',
OUTFIL = 'RISKIND.OUT',
IACDT = 0, IRUTIN = 1,
FRAD = 1.0, 0.0, TIDX =21.1, HSIZE = 5.13, RSIZE = 1.041,
ISTATE = 10, IMOD = 2, IZONE = 3,

IADD = 4,
SPEED = 56.3,

XNAME =
        ' REGULATORY CHECK',
        ' RAILYARD',
        ' RESIDENT',
        ' STRANDED CASK',

XRECEP =
         .002,  2*0,
         .010,  2*0,
         .030,  2*0,
         .200,  2*0,

INDR =  0, 0, 1, 1,
ISHLT = 0, 0, 4, 4,
TSTP =  1.0, 2.0, 0.0, 20.0,

&END
```

1***

RAIL INCIDENT FREE PUBLIC - SNF 05/15/94 21:49 PAGE 1
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

BACKGROUND POPULATION INFORMATION :
POLULATION ZONE = URBAN
AVERAGE TRAVEL SPEED (KM/HR) = 5.63E+01

INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA

*** RECEPTOR LOCATION DATA : 4 LOCATIONS THIS RUN ***

I	LOCATION NAMES	X(KM)	Y(KM)	Z(M)	DIST(KM)
1	REGULATORY CHECK	0.002	0.000	0.000	0.002
2	RAILYARD	0.010	0.000	0.000	0.010
3	RESIDENT	0.030	0.000	0.000	0.030
4	STRANDED CASK	0.200	0.000	0.000	0.200

1***

RAIL INCIDENT FREE PUBLIC - SNF 05/15/94 21:49 PAGE 2
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

CASK SIZE : RADIUS(M) = 1.04E+00
LENGTH(M) = 5.13E+00
FRACTION GAMMA SOURCE = 1.00
FRACTION NEUTRON SOURCE = 0.00
TRANSPORTATION INDEX = 21.10

RECEPTOR ROUTINE DOSE FROM EACH SHIPMENT

			DURING STOP		DURING TRANSPORT
I	LOCATION NAMES	DISTANCE(M)	HOUR	REM	REM
1	REGULATORY CHECK	2.0	1.0	1.01E-02	1.61E-06
2	RAILYARD	10.0	2.0	1.67E-03	4.72E-07
3	RESIDENT	30.0	0.0	0.00E+00	7.17E-08
4	STRANDED CASK	200.0	20.0	1.10E-05	3.71E-09

APPENDIX D

RISKIND OUTPUT FOR TRANSPORTATION ACCIDENT SCENARIO

D.1 VAL.OUT

RADIATION DOSES FOR ALL EXPOSURE PATHWAYS

```
&INDATA
IACDT =1, IRUTIN=0, IADD =1, IACFOD=1,
IYOURS=2,  HEATF=5*0., HS=10., ACTA=1, IPFOD=0, PAG=1.0E+13,
HSIZE = .1, RSIZE = .1,
HTEXP=2.0, INDR = 20*0, IDFOOD=20*1, IRTP=20*1, YEVD = 1 ,
XRECEP =.13,0,0,
VDEP=0.001, RAIN=0.,
FRAD = 1.00 ,0.0 , IZONE=3,
JC = 1, 1, MREM = 0,
OUTFIL ='riskind.OUT' , PBUNIT ='1/YR',
AMIX = 1000., ANH =  10 , DMIX = 1000.,
DFREQ =
 0.0015, 0.0030, 0.0000, 0.0000, 0.0000, 0.0000,
 0.0129, 0.0235, 0.0147, 0.0000, 0.0000, 0.0000,
 0.0082, 0.0317, 0.0612, 0.0112, 0.0005, 0.0000,
 0.0369, 0.1016, 0.1647, 0.1493, 0.0299, 0.0067,
 0.0000, 0.0881, 0.0547, 0.0000, 0.0000, 0.0000,
 0.0850, 0.1147, 0.0000, 0.0000, 0.0000, 0.0000,
IFREQ = 1, IMET = 1,
IYOURW = 1,
ITYPE=4, WSM= 4.,
PMIX = 1000.,
ISRTYP = 2,
ISPENT=0,
IPLOT = 0,
FRELS=100*1.0,
FSEV=0,1,18*0,
     0,1,18*0,
     0,1,18*0,
FDISP=100*1.,
FAILS=20*1.,
XIN=0.30,0.85,0.77,
&END
'CS',' ',' ',' ','1','3','7',  7.70E+01
' ',' ',' ',' ',' ',' ',' ',  0.00
```

1***

MODAL STUDY 03/23/95 16:45 PAGE 1

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

BACKGROUND POPULATION INFORMATION :

POLULATION ZONE = URBAN

AVERAGE TRAVEL SPEED (KM/HR) = 2.40E+01

INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA

*** RECEPTOR LOCATION DATA : 1 LOCATIONS THIS RUN ***

I	LOCATION NAMES	X(KM)	Y(KM)	Z(M)	DIST(KM)
1	RECEPTOR XNAME (I)	0.130	0.000	0.000	0.130

ACCIDENT DATA FROM STATE OF UT

ACCIDENT TRAFFIC FATALITY(1/KM) = 0.00E+00

ACCIDENT PROBABILITY (1/KM) = 1.00E+00

INDIVIDUAL DRINKING WATER INTAKE (L/DAY) = 1.00E+00

ALL INITIALLY CONTAMINATED FOOD STUFFS ARE DISCARDED

TRANSPORTATION MODE = TRUCK

1***

MODAL STUDY 03/23/95 16:45 PAGE 2

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION 1	2	3	4	5	6	7	8	9	10
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	1.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION 11	12	13	14	15	16	17	18	19	20
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

1***

MODAL STUDY 03/23/95 16:45 PAGE 3

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 1	2	3	4	5	6	7	8	9	10
GAMMA	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 11	12	13	14	15	16	17	18	19	20
GAMMA	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

1***

MODAL STUDY 03/23/95 16:45 PAGE 4

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

CASK SIZE : RADIUS(M) = 1.00E-01
LENGTH(M) = 1.00E-01
FRACTION GAMMA SOURCE = 1.00
FRACTION NEUTRON SOURCE = 0.00
TRANSPORTATION INDEX = 10.00

1***

MODAL STUDY 03/23/95 16:45 PAGE 5

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ACCIDENT SEVERITY NUMBER = 2
ACCIDENT SCENARIO PROBABILITY, 1/YR = 1.00E+00

NUCLIDE	DCAY(1/YR)	CURIES	RELATIVE HAZARD PLUME	INGESTION	G.SHINE
CS 137	2.30E-02	7.70E+01	1.00E+00	1.00E+00	1.00E+00
TOTAL			1.00E+00	1.00E+00	1.00E+00

1***

MODAL STUDY 03/23/95 16:45 PAGE 6

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

NUCLIDE	INVENTORY(Ci)	FRAC-REL	Ci-REL
CS 137	7.70E+01	1.00E+00	7.70E+01

1***

MODAL STUDY 03/23/95 16:45 PAGE 7

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ONE YEAR COMMITTED ACUTE INHALATION DOSE CONVERSION FACTORS
(RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.80E-12	1.05E-11	1.05E-11	1.02E-11	9.45E-12

50 YEAR CHRONIC INHALATION DOSE COMMITMENT FACTORS (REM/YR/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS

CS137	2.46E-04	2.62E-04	2.64E-04	2.56E-04	2.60E-04

1***
MODAL STUDY 03/23/95 16:45 PAGE 8
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ACUTE CLOUD SHINE DOSE FACTORS (RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.14E-14	9.14E-14	9.14E-14	9.14E-14	9.14E-14

ACUTE GROUND SHINE DOSE FACTORS (RAD/SEC/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	1.83E-15	1.83E-15	1.83E-15	1.83E-15	1.83E-15

1***
MODAL STUDY 03/23/95 16:45 PAGE 9
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

CHRONIC CLOUD DOSE CONVERSION FACTORS (REM/YR/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	2.89E-06	2.89E-06	2.89E-06	2.89E-06	2.89E-06

CHRONIC GROUND DOSE CONVERSION FACTORS (REM/YR/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	5.76E-08	5.76E-08	5.76E-08	5.76E-08	5.76E-08

INGESTION DOSE CONVERSION FACTORS (REM/PCI)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	4.90E-08	4.72E-08	5.30E-08	5.02E-08	5.16E-08

DISPERSION CALCULATION PARAMETERS (PUFIND):

PHYSICAL RELEASE HEIGHT =	10.00 (M)
SOURCE EFFECTIVE SIZE =	0.14 (M)
ANAMETER HEIGHT =	10.00 (M)
AMBIENT TEMPERATURE =	288.15 (K)
DRY DEPOSITION VELOCITY =	0.0010 (M/S)
DEPOSITION VEL OVER WATER =	0.010 (M/S)
DEPOSITION VEL OVER VEGETATION =	0.010 (M/S)
STABILITY CLASS =	4
WIND SPEED =	4.00 (M/S)
SOURCE TEMPERATURE =	0.00 (K)
HEAT FLUX =	0.00 (CAL/SEC)
FINAL EFFECTIVE RELEASE HEIGHT =	10.00 (M)

SUMMARY OF RECEPTOR CONCENTRATION AND DEPLETION FACTORS

RCPTR	DIST(KM)	ANGLE	XOQ(GAS) (SEC/M**3)	XOQ(PART) (SEC/M**3)	DEPLTION FRACTION	DEPOSITION (1/M**2)
1	1.30E-01	0.00E+00	2.64E-04	2.63E-04	2.55E-04	2.63E-07

1***

MODAL STUDY 03/23/95 16:45 PAGE 10

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

SUMMARY OF RECEPTOR POTENTIAL DOSE CONSEQUENCES
FATALITY AND GENETIC RISKS

I	LOCATION NAMES	ACUTE		LONG TERM		
		EDE REM	CHANCE FATALITY	EDE REM	CHANCE FATALITY	CHANCE GENETIC.E
1	RECEPTOR XNAME (I)	2.29E-01	0.00E+00	1.97E+00	9.84E-04	2.56E-04

1***

MODAL STUDY 03/23/95 16:45 PAGE 11

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

TIME-INTEGRATED(1 YEARS) DOSE CONSEQUENCE (REM)

RECEPTOR 1 : RECEPTOR XNAME (I)
DOWN WIND DIST (KM) = 1.30E-01
CROSS WIND DIST (KM) = 0.00E+00

PATHWAY	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
PLUME	2.21E-01	2.34E-01	2.36E-01	2.29E-01	2.33E-01
EXT CASK	2.42E-07	2.42E-07	2.42E-07	2.42E-07	2.42E-07
RESUSPENSN.	7.31E-03	7.76E-03	7.84E-03	7.60E-03	7.72E-03
INGESTION	1.19E+00	1.14E+00	1.28E+00	1.22E+00	1.25E+00
EXT GROUND	5.16E-01	5.16E-01	5.16E-01	5.16E-01	5.16E-01
EXT CLOUD	7.99E-05	7.99E-05	7.99E-05	7.99E-05	7.99E-05
WATER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	1.93E+00	1.90E+00	2.04E+00	1.97E+00	2.01E+00

1***

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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

SUMMARY OF PROBABILITY WEIGHTED RISKS
RECEPTOR 1 : RECEPTOR XNAME (I)
DOWN WIND DIST (KM) = 1.30E-01
CROSS WIND DIST (KM) = 0.00E+00

	INCIDENT FREE		ACCIDENTS	
	TRANSIT 1/CASK	STOP 1/STOP	AIR/GROUND 1/EVENT	WATER 1/EVENT
EFFECTIVE DOSE (REM)	0.00E+00	0.00E+00	1.97E+00	0.00E+00
LATENT CANCER MORTALITY (CHANCE)	0.00E+00	0.00E+00	9.84E-04	0.00E+00
GENETIC EFFECT (CHANCE)	0.00E+00	0.00E+00	2.56E-04	0.00E+00
ACUTE MORTALITY (CHANCE)			0.00E+00	

D.2 VAL-V.OUT

RADIATION DOSES INCLUDING ONLY VEGETABLE INGESTION PATHWAY

```
&INDATA
IACDT =1, IRUTIN=0, IADD =1, IACFOD=1,
IYOURS=2,  HEATF=5*0., HS=10., ACTA=1, IPFOD=0, PAG=1.0E+13,
HSIZE = .1, RSIZE = .1,
HTEXP=2.0, INDR = 20*0, IDFOOD=20*1, IRTP=20*1, YEVD = 1 ,
XRECEP =.13,0,0,
VDEP=0.001, RAIN=0.,
FRAD = 1.00 ,0.0 , IZONE=3,
JC = 1, 1, MREM = 0,
OUTFIL ='riskind.OUT' , PBUNIT ='1/YR',
AMIX = 1000., ANH =  10 , DMIX = 1000.,
DFREQ =
 0.0015, 0.0030, 0.0000, 0.0000, 0.0000, 0.0000,
 0.0129, 0.0235, 0.0147, 0.0000, 0.0000, 0.0000,
 0.0082, 0.0317, 0.0612, 0.0112, 0.0005, 0.0000,
 0.0369, 0.1016, 0.1647, 0.1493, 0.0299, 0.0067,
 0.0000, 0.0881, 0.0547, 0.0000, 0.0000, 0.0000,
 0.0850, 0.1147, 0.0000, 0.0000, 0.0000, 0.0000,
IFREQ = 1, IMET = 1,
IYOURW = 1,
ITYPE=4, WSM= 4.,
PMIX = 1000.,
ISRTYP = 2,
ISPENT=0,
IPLOT = 0,
FRELS=100*1.0,
FSEV=0,1,18*0,
     0,1,18*0,
     0,1,18*0,
FDISP=100*1.,
FAILS=20*1.,
XIN=0.00,0.00,0.77,
&END
'CS',' ',' ','1','3','7',  7.70E+01
' ',' ',' ',' ',' ',' ',  0.00
```

1***

MODAL STUDY 03/23/95 16:36 PAGE 1

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

BACKGROUND POPULATION INFORMATION :

POLULATION ZONE =	URBAN
AVERAGE TRAVEL SPEED (KM/HR) =	2.40E+01

INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA

*** RECEPTOR LOCATION DATA : 1 LOCATIONS THIS RUN ***

I	LOCATION NAMES	X(KM)	Y(KM)	Z(M)	DIST(KM)
1	RECEPTOR XNAME (I)	0.130	0.000	0.000	0.130

ACCIDENT DATA FROM STATE OF UT

ACCIDENT TRAFFIC FATALITY(1/KM) =	0.00E+00
ACCIDENT PROBABILITY (1/KM) =	1.00E+00
INDIVIDUAL DRINKING WATER INTAKE (L/DAY) =	1.00E+00

ALL INITIALLY CONTAMINATED FOOD STUFFS ARE DISCARDED

TRANSPORTATION MODE = TRUCK

1***

MODAL STUDY 03/23/95 16:36 PAGE 2

RISKIND-RW: RADIOACTIVE MATE File: riskind.in

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION									
	1	2	3	4	5	6	7	8	9	10
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	1.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION									
	11	12	13	14	15	16	17	18	19	20
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

1***
MODAL STUDY 03/23/95 16:36 PAGE 3
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 1	2	3	4	5	6	7	8	9	10
GAMMA	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 11	12	13	14	15	16	17	18	19	20
GAMMA	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

1***
MODAL STUDY 03/23/95 16:36 PAGE 4
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

CASK SIZE : RADIUS(M) = 1.00E-01
LENGTH(M) = 1.00E-01
FRACTION GAMMA SOURCE = 1.00
FRACTION NEUTRON SOURCE = 0.00
TRANSPORTATION INDEX = 10.00

1***
MODAL STUDY 03/23/95 16:36 PAGE 5
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ACCIDENT SEVERITY NUMBER = 2
ACCIDENT SCENARIO PROBABILITY, 1/YR = 1.00E+00

NUCLIDE	DCAY(1/YR)	CURIES	RELATIVE HAZARD PLUME	INGESTION	G.SHINE
CS 137	2.30E-02	7.70E+01	1.00E+00	1.00E+00	1.00E+00
TOTAL			1.00E+00	1.00E+00	1.00E+00

1***
MODAL STUDY 03/23/95 16:36 PAGE 6
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

NUCLIDE	INVENTORY(Ci)	FRAC-REL	Ci-REL
CS 137	7.70E+01	1.00E+00	7.70E+01

1***
MODAL STUDY 03/23/95 16:36 PAGE 7
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ONE YEAR COMMITTED ACUTE INHALATION DOSE CONVERSION FACTORS
(RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.80E-12	1.05E-11	1.05E-11	1.02E-11	9.45E-12

50 YEAR CHRONIC INHALATION DOSE COMMITMENT FACTORS (REM/YR/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS

CS137	2.46E-04	2.62E-04	2.64E-04	2.56E-04	2.60E-04

1***

ACUTE CLOUD SHINE DOSE FACTORS (RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.14E-14	9.14E-14	9.14E-14	9.14E-14	9.14E-14

ACUTE GROUND SHINE DOSE FACTORS (RAD/SEC/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	1.83E-15	1.83E-15	1.83E-15	1.83E-15	1.83E-15

1***

CHRONIC CLOUD DOSE CONVERSION FACTORS (REM/YR/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	2.89E-06	2.89E-06	2.89E-06	2.89E-06	2.89E-06

CHRONIC GROUND DOSE CONVERSION FACTORS (REM/YR/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	5.76E-08	5.76E-08	5.76E-08	5.76E-08	5.76E-08

INGESTION DOSE CONVERSION FACTORS (REM/PCI)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	4.90E-08	4.72E-08	5.30E-08	5.02E-08	5.16E-08

DISPERSION CALCULATION PARAMETERS (PUFIND):

```
PHYSICAL RELEASE HEIGHT =            10.00 (M)
SOURCE EFFECTIVE SIZE =               0.14 (M)
ANAMETER HEIGHT =                    10.00 (M)
AMBIENT TEMPERATURE =               288.15 (K)
DRY DEPOSITION VELOCITY =           0.0010 (M/S)
DEPOSITION VEL OVER WATER =          0.010 (M/S)
DEPOSITION VEL OVER VEGETATION =     0.010 (M/S)
STABILITY CLASS =                    4
WIND SPEED =                          4.00 (M/S)
SOURCE TEMPERATURE =                  0.00 (K)
HEAT FLUX =                           0.00 (CAL/SEC)
FINAL EFFECTIVE RELEASE HEIGHT =     10.00 (M)
```

SUMMARY OF RECEPTOR CONCENTRATION AND DEPLETION FACTORS

RCPTR	DIST(KM)	ANGLE	XOQ(GAS) (SEC/M**3)	XOQ(PART) (SEC/M**3)	DEPLTION FRACTION	DEPOSITION (1/M**2)
1	1.30E-01	0.00E+00	2.64E-04	2.63E-04	2.55E-04	2.63E-07

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1*******************************************************************************
 MODAL STUDY                                       03/23/95  16:36    PAGE  10
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in
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SUMMARY OF RECEPTOR POTENTIAL DOSE CONSEQUENCES
FATALITY AND GENETIC RISKS

I	LOCATION NAMES	ACUTE		LONG TERM		
		EDE REM	CHANCE FATALITY	EDE REM	CHANCE FATALITY	CHANCE GENETIC.E
1	RECEPTOR XNAME (I)	2.29E-01	0.00E+00	1.22E+00	6.10E-04	1.59E-04

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1*******************************************************************************
 MODAL STUDY                                       03/23/95  16:36    PAGE  11
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in
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TIME-INTEGRATED(1 YEARS) DOSE CONSEQUENCE (REM)

RECEPTOR 1 : RECEPTOR XNAME (I)
DOWN WIND DIST (KM) =   1.30E-01
CROSS WIND DIST (KM) =   0.00E+00

PATHWAY	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
PLUME	2.21E-01	2.34E-01	2.36E-01	2.29E-01	2.33E-01
EXT CASK	2.42E-07	2.42E-07	2.42E-07	2.42E-07	2.42E-07
RESUSPENSN.	7.31E-03	7.76E-03	7.84E-03	7.60E-03	7.72E-03
INGESTION	4.57E-01	4.40E-01	4.94E-01	4.68E-01	4.81E-01
EXT GROUND	5.16E-01	5.16E-01	5.16E-01	5.16E-01	5.16E-01
EXT CLOUD	7.99E-05	7.99E-05	7.99E-05	7.99E-05	7.99E-05
WATER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	1.20E+00	1.20E+00	1.25E+00	1.22E+00	1.24E+00

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1*******************************************************************************
 MODAL STUDY                                       03/23/95  16:36    PAGE  12
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in
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SUMMARY OF PROBABILITY WEIGHTED RISKS
RECEPTOR 1 : RECEPTOR XNAME (I)
DOWN WIND DIST (KM) = 1.30E-01
CROSS WIND DIST (KM) =   0.00E+00

	INCIDENT FREE		ACCIDENTS	
	TRANSIT 1/CASK	STOP 1/STOP	AIR/GROUND 1/EVENT	WATER 1/EVENT
EFFECTIVE DOSE (REM)	0.00E+00	0.00E+00	1.22E+00	0.00E+00
LATENT CANCER MORTALITY (CHANCE)	0.00E+00	0.00E+00	6.10E-04	0.00E+00
GENETIC EFFECT (CHANCE)	0.00E+00	0.00E+00	1.59E-04	0.00E+00
ACUTE MORTALITY (CHANCE)			0.00E+00	

D.3 VAL-B.OUT

RADIATION DOSES INCLUDING ONLY BEEF INGESTION PATHWAY

```
&INDATA
IACDT =1, IRUTIN=0, IADD =1, IACFOD=1,
IYOURS=2,  HEATF=5*0., HS=10., ACTA=1, IPFOD=0, PAG=1.0E+13,
HSIZE = .1, RSIZE = .1,
HTEXP=2.0, INDR = 20*0, IDFOOD=20*1, IRTP=20*1, YEVD = 1 ,
XRECEP =.13,0,0,
VDEP=0.001, RAIN=0.,
FRAD = 1.00 ,0.0 , IZONE=3,
JC = 1, 1, MREM = 0,
OUTFIL ='riskind.OUT' , PBUNIT ='1/YR',
AMIX = 1000., ANH =  10 , DMIX = 1000.,
DFREQ =
 0.0015, 0.0030, 0.0000, 0.0000, 0.0000, 0.0000,
 0.0129, 0.0235, 0.0147, 0.0000, 0.0000, 0.0000,
 0.0082, 0.0317, 0.0612, 0.0112, 0.0005, 0.0000,
 0.0369, 0.1016, 0.1647, 0.1493, 0.0299, 0.0067,
 0.0000, 0.0881, 0.0547, 0.0000, 0.0000, 0.0000,
 0.0850, 0.1147, 0.0000, 0.0000, 0.0000, 0.0000,
IFREQ = 1, IMET = 1,
IYOURW = 1,
ITYPE=4, WSM= 4.,
PMIX = 1000.,
ISRTYP = 2,
ISPENT=0,
IPLOT = 0,
FRELS=100*1.0,
FSEV=0,1,18*0,
     0,1,18*0,
     0,1,18*0,
FDISP=100*1.,
FAILS=20*1.,
XIN=0.30,0.00,0.00,
&END
'CS',' ',' ','1','3','7',  7.70E+01
' ',' ',' ',' ',' ',' ',  0.00
```

1**

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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

BACKGROUND POPULATION INFORMATION :

POLULATION ZONE =	URBAN
AVERAGE TRAVEL SPEED (KM/HR) =	2.40E+01

INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA

*** RECEPTOR LOCATION DATA : 1 LOCATIONS THIS RUN ***

I	LOCATION NAMES	X(KM)	Y(KM)	Z(M)	DIST(KM)
1	RECEPTOR XNAME (I)	0.130	0.000	0.000	0.130

ACCIDENT DATA FROM STATE OF UT

ACCIDENT TRAFFIC FATALITY(1/KM) =	0.00E+00
ACCIDENT PROBABILITY (1/KM) =	1.00E+00
INDIVIDUAL DRINKING WATER INTAKE (L/DAY) =	1.00E+00

ALL INITIALLY CONTAMINATED FOOD STUFFS ARE DISCARDED

TRANSPORTATION MODE = TRUCK

1**

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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION									
	1	2	3	4	5	6	7	8	9	10
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+0C	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+0C	1.E+00
PROB	0.E+00	1.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION									
	11	12	13	14	15	16	17	18	19	20
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 1	2	3	4	5	6	7	8	9	10
GAMMA	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 11	12	13	14	15	16	17	18	19	20
GAMMA	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

CASK SIZE : RADIUS(M) = 1.00E-01
LENGTH(M) = 1.00E-01
FRACTION GAMMA SOURCE = 1.00
FRACTION NEUTRON SOURCE = 0.00
TRANSPORTATION INDEX = 10.00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ACCIDENT SEVERITY NUMBER = 2
ACCIDENT SCENARIO PROBABILITY, 1/YR = 1.00E+00

NUCLIDE	DCAY(1/YR)	CURIES	RELATIVE HAZARD PLUME	INGESTION	G.SHINE
CS 137	2.30E-02	7.70E+01	1.00E+00	1.00E+00	1.00E+00
TOTAL			1.00E+00	1.00E+00	1.00E+00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

NUCLIDE	INVENTORY(Ci)	FRAC-REL	Ci-REL
CS 137	7.70E+01	1.00E+00	7.70E+01

1***
MODAL STUDY 03/23/95 16:36 PAGE 7
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ONE YEAR COMMITTED ACUTE INHALATION DOSE CONVERSION FACTORS
(RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.80E-12	1.05E-11	1.05E-11	1.02E-11	9.45E-12

50 YEAR CHRONIC INHALATION DOSE COMMITMENT FACTORS (REM/YR/PCI/M3)
NUCLIDE R.MARROW LUNG GI-LLI EFFECTIVE GONADS

CS137	2.46E-04	2.62E-04	2.64E-04	2.56E-04	2.60E-04

ACUTE CLOUD SHINE DOSE FACTORS (RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.14E-14	9.14E-14	9.14E-14	9.14E-14	9.14E-14

ACUTE GROUND SHINE DOSE FACTORS (RAD/SEC/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	1.83E-15	1.83E-15	1.83E-15	1.83E-15	1.83E-15

CHRONIC CLOUD DOSE CONVERSION FACTORS (REM/YR/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	2.89E-06	2.89E-06	2.89E-06	2.89E-06	2.89E-06

CHRONIC GROUND DOSE CONVERSION FACTORS (REM/YR/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	5.76E-08	5.76E-08	5.76E-08	5.76E-08	5.76E-08

INGESTION DOSE CONVERSION FACTORS (REM/PCI)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	4.90E-08	4.72E-08	5.30E-08	5.02E-08	5.16E-08

DISPERSION CALCULATION PARAMETERS (PUFIND):

```
PHYSICAL RELEASE HEIGHT =            10.00 (M)
SOURCE EFFECTIVE SIZE =               0.14 (M)
ANAMETER HEIGHT =                    10.00 (M)
AMBIENT TEMPERATURE =               288.15 (K)
DRY DEPOSITION VELOCITY =           0.0010 (M/S)
DEPOSITION VEL OVER WATER =          0.010 (M/S)
DEPOSITION VEL OVER VEGETATION =     0.010 (M/S)
STABILITY CLASS =                    4
WIND SPEED =                          4.00 (M/S)
SOURCE TEMPERATURE =                  0.00 (K)
HEAT FLUX =                           0.00 (CAL/SEC)
FINAL EFFECTIVE RELEASE HEIGHT =     10.00 (M)
```

SUMMARY OF RECEPTOR CONCENTRATION AND DEPLETION FACTORS

RCPTR	DIST(KM)	ANGLE	XOQ(GAS) (SEC/M**3)	XOQ(PART) (SEC/M**3)	DEPLTION FRACTION	DEPOSITION (1/M**2)
1	1.30E-01	0.00E+00	2.64E-04	2.63E-04	2.55E-04	2.63E-07

1**
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

SUMMARY OF RECEPTOR POTENTIAL DOSE CONSEQUENCES
FATALITY AND GENETIC RISKS

I	LOCATION NAMES	ACUTE EDE REM	ACUTE CHANCE FATALITY	LONG TERM EDE REM	LONG TERM CHANCE FATALITY	LONG TERM CHANCE GENETIC.E
1	RECEPTOR XNAME (I)	2.29E-01	0.00E+00	8.32E-01	4.16E-04	1.08E-04

1**
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

TIME-INTEGRATED(1 YEARS) DOSE CONSEQUENCE (REM)

RECEPTOR 1 : RECEPTOR XNAME (I)
DOWN WIND DIST (KM) = 1.30E-01
CROSS WIND DIST (KM) = 0.00E+00

PATHWAY	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
PLUME	2.21E-01	2.34E-01	2.36E-01	2.29E-01	2.33E-01
EXT CASK	2.42E-07	2.42E-07	2.42E-07	2.42E-07	2.42E-07
RESUSPENSN.	7.31E-03	7.76E-03	7.84E-03	7.60E-03	7.72E-03
INGESTION	7.69E-02	7.40E-02	8.32E-02	7.87E-02	8.09E-02
EXT GROUND	5.16E-01	5.16E-01	5.16E-01	5.16E-01	5.16E-01
EXT CLOUD	7.99E-05	7.99E-05	7.99E-05	7.99E-05	7.99E-05
WATER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	8.21E-01	8.32E-01	8.44E-01	8.32E-01	8.38E-01

1**
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

SUMMARY OF PROBABILITY WEIGHTED RISKS
RECEPTOR 1 : RECEPTOR XNAME (I)
DOWN WIND DIST (KM) = 1.30E-01
CROSS WIND DIST (KM) = 0.00E+00

	INCIDENT FREE TRANSIT 1/CASK	INCIDENT FREE STOP 1/STOP	ACCIDENTS AIR/GROUND 1/EVENT	ACCIDENTS WATER 1/EVENT
EFFECTIVE DOSE (REM)	0.00E+00	0.00E+00	8.32E-01	0.00E+00
LATENT CANCER MORTALITY (CHANCE)	0.00E+00	0.00E+00	4.16E-04	0.00E+00
GENETIC EFFECT (CHANCE)	0.00E+00	0.00E+00	1.08E-04	0.00E+00
ACUTE MORTALITY (CHANCE)			0.00E+00	

D.4 VAL-M.OUT

RADIATION DOSES INCLUDING ONLY MILK INGESTION PATHWAY

```
&INDATA
IACDT =1, IRUTIN=0, IADD =1, IACFOD=1,
IYOURS=2,  HEATF=5*0., HS=10., ACTA=1, IPFOD=0, PAG=1.0E+13,
HSIZE = .1, RSIZE = .1,
HTEXP=2.0, INDR = 20*0, IDFOOD=20*1, IRTP=20*1, YEVD = 1 ,
XRECEP =.13,0,0,
VDEP=0.001, RAIN=0.,
FRAD = 1.00 ,0.0 , IZONE=3,
JC = 1, 1, MREM = 0,
OUTFIL ='riskind.OUT' , PBUNIT ='1/YR',
AMIX = 1000., ANH =  10 , DMIX = 1000.,
DFREQ =
 0.0015, 0.0030, 0.0000, 0.0000, 0.0000, 0.0000,
 0.0129, 0.0235, 0.0147, 0.0000, 0.0000, 0.0000,
 0.0082, 0.0317, 0.0612, 0.0112, 0.0005, 0.0000,
 0.0369, 0.1016, 0.1647, 0.1493, 0.0299, 0.0067,
 0.0000, 0.0881, 0.0547, 0.0000, 0.0000, 0.0000,
 0.0850, 0.1147, 0.0000, 0.0000, 0.0000, 0.0000,
IFREQ = 1, IMET = 1,
IYOURW = 1,
ITYPE=4, WSM= 4.,
PMIX = 1000.,
ISRTYP = 2,
ISPENT=0,
IPLOT = 0,
FRELS=100*1.0,
FSEV=0,1,18*0,
     0,1,18*0,
     0,1,18*0,
FDISP=100*1.,
FAILS=20*1.,
XIN=0.00,0.85,0.00,
&END
'CS',' ',' ','1','3','7',  7.70E+01
'  ','  ','  ','  ','  ','  ',  0.00
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1*******************************************************************************
 MODAL STUDY                                           03/23/95  16:36   PAGE   1
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in

   BACKGROUND POPULATION INFORMATION :
    POLULATION ZONE =                              URBAN
    AVERAGE TRAVEL SPEED (KM/HR) =                 2.40E+01

    INDIVIDUAL RECEPTORS & MISCELLANEOUS INPUT DATA

    ***     RECEPTOR LOCATION DATA :  1  LOCATIONS THIS RUN  ***

  I      LOCATION NAMES      X(KM)   Y(KM)    Z(M)   DIST(KM)
 ------------------------------------------------------------------------------
  1    RECEPTOR XNAME (I)     0.130   0.000   0.000   0.130
--------------------------------------------------------------------------------

    ACCIDENT DATA FROM STATE OF  UT
    ACCIDENT TRAFFIC FATALITY(1/KM) =              0.00E+00
    ACCIDENT PROBABILITY (1/KM)   =                1.00E+00
    INDIVIDUAL DRINKING WATER INTAKE (L/DAY) =  1.00E+00
    ALL INITIALLY CONTAMINATED FOOD STUFFS ARE DISCARDED

    TRANSPORTATION MODE =                          TRUCK
1*******************************************************************************
 MODAL STUDY                                           03/23/95  16:36   PAGE   2
RISKIND-RW: RADIOACTIVE MATE  File: riskind.in
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FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION 1	2	3	4	5	6	7	8	9	10
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	1.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

FRACTION RELEASED AND ALSO DISPERSED FOR EACH RESPONSE REGION

NUCLIDE TYPE	RESPONSE REGION 11	12	13	14	15	16	17	18	19	20
PART.	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
RU	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
CS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
IODINE	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
I.GAS	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00	1.E+00
PROB	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00	0.E+00

1***
MODAL STUDY 03/23/95 16:36 PAGE 3
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 1	2	3	4	5	6	7	8	9	10
GAMMA	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

EXTERNAL DOSE RATE MULTIPLIER FOR EACH ACCIDENT RESPONSE REGION
(MULTIPLIER OF TI)

TYPE	RESPONSE REGION 11	12	13	14	15	16	17	18	19	20
GAMMA	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
NUTRN	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

CASK SIZE : RADIUS(M) = 1.00E-01
LENGTH(M) = 1.00E-01
FRACTION GAMMA SOURCE = 1.00
FRACTION NEUTRON SOURCE = 0.00
TRANSPORTATION INDEX = 10.00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ACCIDENT SEVERITY NUMBER = 2
ACCIDENT SCENARIO PROBABILITY, 1/YR = 1.00E+00

NUCLIDE	DCAY(1/YR)	CURIES	RELATIVE HAZARD PLUME	INGESTION	G.SHINE
CS 137	2.30E-02	7.70E+01	1.00E+00	1.00E+00	1.00E+00
TOTAL			1.00E+00	1.00E+00	1.00E+00

1***
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RISKIND-RW: RADIOACTIVE MATE File: riskind.in

NUCLIDE	INVENTORY(Ci)	FRAC-REL	Ci-REL
CS 137	7.70E+01	1.00E+00	7.70E+01

1***
MODAL STUDY 03/23/95 16:36 PAGE 7
RISKIND-RW: RADIOACTIVE MATE File: riskind.in

ONE YEAR COMMITTED ACUTE INHALATION DOSE CONVERSION FACTORS
(RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.80E-12	1.05E-11	1.05E-11	1.02E-11	9.45E-12

50 YEAR CHRONIC INHALATION DOSE COMMITMENT FACTORS (REM/YR/PCI/M3)
NUCLIDE R.MARROW LUNG GI-LLI EFFECTIVE GONADS

CS137	2.46E-04	2.62E-04	2.64E-04	2.56E-04	2.60E-04

ACUTE CLOUD SHINE DOSE FACTORS (RAD/SEC/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	9.14E-14	9.14E-14	9.14E-14	9.14E-14	9.14E-14

ACUTE GROUND SHINE DOSE FACTORS (RAD/SEC/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	1.83E-15	1.83E-15	1.83E-15	1.83E-15	1.83E-15

CHRONIC CLOUD DOSE CONVERSION FACTORS (REM/YR/PCI/M3)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	2.89E-06	2.89E-06	2.89E-06	2.89E-06	2.89E-06

CHRONIC GROUND DOSE CONVERSION FACTORS (REM/YR/PCI/M2)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	5.76E-08	5.76E-08	5.76E-08	5.76E-08	5.76E-08

INGESTION DOSE CONVERSION FACTORS (REM/PCI)

NUCLIDE	R.MARROW	LUNG	GI-LLI	EFFECTIVE	GONADS
CS137	4.90E-08	4.72E-08	5.30E-08	5.02E-08	5.16E-08

DISPERSION CALCULATION PARAMETERS (PUFIND):

PHYSICAL RELEASE HEIGHT =	10.00 (M)
SOURCE EFFECTIVE SIZE =	0.14 (M)
ANAMETER HEIGHT =	10.00 (M)
AMBIENT TEMPERATURE =	288.15 (K)
DRY DEPOSITION VELOCITY =	0.0010 (M/S)
DEPOSITION VEL OVER WATER =	0.010 (M/S)
DEPOSITION VEL OVER VEGETATION =	0.010 (M/S)
STABILITY CLASS =	4
WIND SPEED =	4.00 (M/S)
SOURCE TEMPERATURE =	0.00 (K)
HEAT FLUX =	0.00 (CAL/SEC)
FINAL EFFECTIVE RELEASE HEIGHT =	10.00 (M)

SUMMARY OF RECEPTOR CONCENTRATION AND DEPLETION FACTORS

RCPTR	DIST(KM)	ANGLE	XOQ(GAS) (SEC/M**3)	XOQ(PART) (SEC/M**3)	DEPLTION FRACTION	DEPOSITION (1/M**2)
1	1.30E-01	0.00E+00	2.64E-04	2.63E-04	2.55E-04	2.63E-07

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1*******************************************************************************
  MODAL STUDY                                          03/23/95  16:36   PAGE  10
 RISKIND-RW: RADIOACTIVE MATE  File: riskind.in


                SUMMARY OF RECEPTOR POTENTIAL DOSE CONSEQUENCES
                              FATALITY AND GENETIC RISKS

  I  LOCATION NAMES              ACUTE                    LONG TERM
                            ------------------   ----------------------------
                              EDE      CHANCE      EDE         CHANCE
                              REM     FATALITY     REM    FATALITY  GENETIC.E
  ---------------------------------------------------------------------------
  1   RECEPTOR XNAME (I)   2.29E-01  0.00E+00  1.42E+00  7.11E-04  1.85E-04
  ---------------------------------------------------------------------------
1*******************************************************************************
  MODAL STUDY                                          03/23/95  16:36   PAGE  11
 RISKIND-RW: RADIOACTIVE MATE  File: riskind.in


                TIME-INTEGRATED(   1 YEARS) DOSE CONSEQUENCE  (REM)

                      RECEPTOR  1 : RECEPTOR XNAME (I)
                      DOWN WIND DIST (KM) =    1.30E-01
                      CROSS WIND DIST (KM) =   0.00E+00

     PATHWAY        R.MARROW      LUNG       GI-LLI     EFFECTIVE    GONADS
 ------------------------------------------------------------------------------
     PLUME          2.21E-01    2.34E-01    2.36E-01    2.29E-01    2.33E-01
     EXT CASK       2.42E-07    2.42E-07    2.42E-07    2.42E-07    2.42E-07
     RESUSPENSN.    7.31E-03    7.76E-03    7.84E-03    7.60E-03    7.72E-03
     INGESTION      6.53E-01    6.29E-01    7.07E-01    6.69E-01    6.88E-01
     EXT GROUND     5.16E-01    5.16E-01    5.16E-01    5.16E-01    5.16E-01
     EXT CLOUD      7.99E-05    7.99E-05    7.99E-05    7.99E-05    7.99E-05
     WATER          0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
 ------------------------------------------------------------------------------
     TOTAL          1.40E+00    1.39E+00    1.47E+00    1.42E+00    1.44E+00
 ------------------------------------------------------------------------------
1*******************************************************************************
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                      SUMMARY OF PROBABILITY WEIGHTED RISKS
                        RECEPTOR  1 : RECEPTOR XNAME (I)
                        DOWN WIND DIST (KM) =  1.30E-01
                        CROSS WIND DIST (KM) =  0.00E+00

                         INCIDENT FREE                ACCIDENTS
                      TRANSIT       STOP        AIR/GROUND      WATER
                      1/CASK       1/STOP        1/EVENT       1/EVENT
 ------------------------------------------------------------------------------
    EFFECTIVE DOSE    0.00E+00    0.00E+00     1.42E+00     0.00E+00
        (REM)
    LATENT CANCER
      MORTALITY       0.00E+00    0.00E+00     7.11E-04     0.00E+00
        (CHANCE)
    GENETIC EFFECT    0.00E+00    0.00E+00     1.85E-04     0.00E+00
        (CHANCE)
    ACUTE MORTALITY                            0.00E+00
        (CHANCE)
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