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Project Title/Work Order		EDT No.
Transportation Impact Analysis for the Shipment of Low Specific Activity Nitric Acid		ECN No. 614595

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ENGINEERING CHANGE NOTICE

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1. ECN 614595

Proj. ECN

2. ECN Category (mark one) Supplemental [ ] Direct Revision [X] Change ECN [ ] Temporary [ ] Standby [ ] Supersedure [ ] Cancel/Void [ ]	3. Originator's Name, Organization, MSIN, and Telephone No. JR Green/84100/G2-02/376-0610	3a. USQ Required? [ ] Yes [X] No	4. Date 5/12/95
	5. Project Title/No./Work Order No. TIA for Nitric Acid	6. Bldg./Sys./Fac. No. 84100	7. Approval Designator ESQ
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-TP-RPT-015, Rev. 0	9. Related ECN No(s). NA	10. Related PO No. NA

11a. Modification Work	11b. Work Package No.	11c. Modification Work Complete	11d. Restored to Original Condition (Temp. or Standby ECN only)
[ ] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)	NA	NA Cog. Engineer Signature & Date	NA Cog. Engineer Signature & Date

12. Description of Change

Destination change from Norfolk, Virginia, to Portsmouth, Virginia.

~~(See ECN 614479 att. for add'l approvals)~~ J. Bishop Sta. 21 5/16

13a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[ ]	Environmental	[X]	Facility Deactivation	[ ]
As-Found	[ ]	Facilitate Const	[ ]	Const. Error/Omission	[ ]	Design Error/Omission	[ ]

13b. Justification Details

Destination change from Norfolk, Virginia, to Portsmouth, Virginia.

14. Distribution (include name, MSIN, and no. of copies)

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A-7900-013-2 (11/94) GEF095

A-7900-013-1 (04/94)

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15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[NA] $	Additional	[NA] $	Improvement	[NA]
[X] No	Savings	[NA] $	Savings	[NA] $	Delay	[NA]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]	NA	[X]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
NA		

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog. Eng. J. R. Green	5/12/95	PE	
Cog. Mgr. J. G. Field	5/12/95	QA	
QA C. R. Hoover	5/15/95	Safety	
Safety D. W. McNally	5/12/95	Design	
Environ. D. J. Carrell	5/15/95	Environ.	
Other P. M. Daling	5/16/95	Other	
M. T. Jansky	05/12/95		
		DEPARTMENT OF ENERGY	
		Signature or a Control Number that tracks the Approval Signature	
		ADDITIONAL	

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RELEASE AUTHORIZATION

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Document Title:	Transportation Impact Analysis for the Shipment of Low Specific Activity Nitric Acid
Release Date:	5/12/95

This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

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SUPPORTING DOCUMENT

1. Total Pages ~~80~~ 79

2. Title	3. Number	4. Rev No.
Transportation Impact Analysis for the Shipment of Low Specific Activity Nitric Acid	WHC-SD-TP-RPT-015	1

5. Key Words	6. Author
Risk assessment, transportation risk, RADTRAN 4 analysis, LSA nitric acid, toxicological and radiological risks	Name: J. R. Green J. R. Green 4/6/95 Signature Organization/Charge Code 84100/KP4BF

7. Abstract

This document was written in support of the Plutonium-Uranium Extraction (PUREX) Facility Low Specific Activity (LSA) Nitric Acid Shipment Environmental Assessment. It analyzes the potential toxicological and radiological risks associated with the transportation of PUREX Facility LSA Nitric Acid from the Hanford Site in Washington State to Portsmouth, Virginia, Baltimore, Maryland, and Port Elizabeth, New Jersey.

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RECORD OF REVISION

(1) Document Number: WHC-SD-TP-RPT-015 | Page 1

(2) Title
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CHANGE CONTROL RECORD

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1 RS	Destination change from Norfolk, Virginia, to Portsmouth, Virginia.	JR Green	JG Field

TRANSPORTATION IMPACT ANALYSIS FOR THE SHIPMENT OF LOW SPECIFIC ACTIVITY NITRIC ACID

Packaging Engineering

March 30, 1995

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LIST OF TERMS

ASME	American Society of Mechanical Engineers
BFS	Bundesamt fur Strahlenschutz
BNFL	British Nuclear Fuels Limited
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IDLH	Immediately Dangerous to Life and Health
IMDG	International Maritime Dangerous Goods
ISO	International Standards Organization
LD	Lethal Dose
LSA	low specific activity
MCEP	Motor Carrier Evaluation Program
NIOSH	National Institute of Occupational Safety and Health
NRC	U.S. Nuclear Regulatory Commission
PAG	Protective Action Guideline
PUREX	Plutonium-Uranium Extraction (Facility)
SNL	Sandia National Laboratories
STEL	Short Term Exposure Limit
TI	Transportation Index
TLV	Threshold Limit Value
TWA	Time-Weighted Average
UK	United Kingdom
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

The deactivation of the Plutonium-Uranium Extraction (PUREX) Facility located on the Hanford Site in Washington state includes the disposition of approximately 183,000 gallons (692,000 l) of surplus, slightly radioactive nitric acid solution, contaminated with a small amount of radioactive material. The nitric acid was recovered as a normal processing step during the operation of the PUREX and UO_3 Facilities. The average concentration of the nitric acid is approximately 10 moles per liter (not more than 52 weight percent aqueous solution. The total quantity of plutonium (Pu) in the nitric acid is less than 3×10^{-4} kg (6.6×10^{-4} lb). The total quantity of uranium (U) is approximately 7,400 kg (16,300 lb). The fissile components of the nitric acid consists of the negligible inventory of plutonium (as ^{238}Pu and ^{239}Pu) and approximately 72 kg (160 lb) of ^{235}U. The uranium enrichment, which is 1% enriched or less, is only slightly higher enrichment than naturally occuring uranium ore. The proposed action would export the nitric acid to British Nuclear Fuels Limited (BNFL) in Sellafield, England. BNFL would use the nitric acid in a similar fashion and for the same purpose as the PUREX Facility used it.

Three shipping routes are proposed for the movement of the material across the United States: Hanford Site to Portsmouth, Virginia; Hanford Site to Baltimore, Maryland; and Hanford Site to Port Elizabeth, New Jersey. The transportation impacts, both radiological and toxicological, of the proposed United States shipping activities have been assessed in the following sections.

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2.0 TRANSPORTATION ACTIVITIES

2.1 INTRODUCTION

The U.S. Department of Energy (DOE) mission of cleaning up the Hanford Site in Washington State includes the deactivation of the Hanford PUREX Facility. As part of the required deactivation activities, approximately 183,000 gallons of surplus nitric acid solution contaminated with a small amount of radioactive material must be dispositioned. BNFL, in the United Kingdom (UK), has agreed to purchase this material in its current condition and receive it at is Sellafield, England, Facility, where it would be used as a process chemical in the B205 (MAGNOX Fuels Reprocessing) Facility. The transportation activities associated with this effort have been identified in the *U.S. Department of Energy LSA/Nitric Acid Transportation Plan to British Nuclear Fuels, Ltd.* (WHC 1994a) and *ISO Tank Container Greater than 1000 Gallons Internal Volume for Shipment of Nitrating Liquids Greater than 50 Percent Nitric Acid: Specifications and Requirements* (WHC 1994b). The transportation activity elements contained within this section are taken from these two documents.

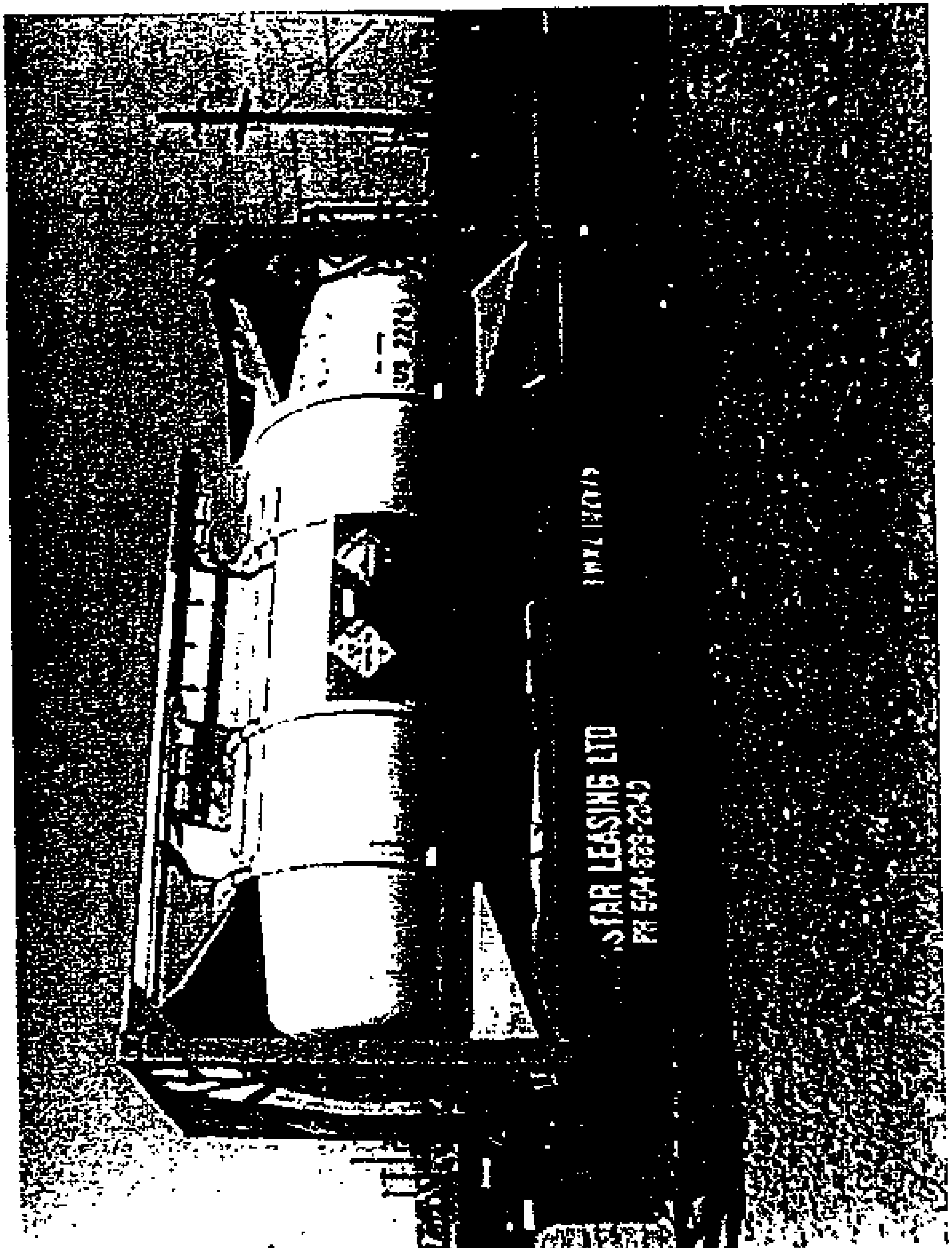
2.2 SHIPMENT CHARACTERISTICS

The shipment of nitric acid from the Hanford Site to the UK will be conducted in accordance with International Atomic Energy Agency (IAEA) regulations, the applicable U.S. Department of Transportation (DOT) regulations, and the International Maritime Dangerous Goods (IMDG) code. This transportation impact analysis addresses only one section of the overall campaign; the transport of the nitric acid within the United States from the Hanford Site to each of the three ports: Portsmouth, Virginia; Baltimore, Maryland; or Port Elizabeth, New Jersey.

The liquid material being shipped is slightly radioactive, surplus nitric acid, not more than 52 weight percent aqueous solution, containing a low specific activity (LSA) radioactive component. There are approximately 183,000 gallons of the nitric acid at the PUREX Facility. The liquid will be shipped via intermodal tanks loaded on a late model International Standards Organization (ISO) chassis. Tank-frame containers have been designed and fabricated to meet the requirements of Specification DOT 51 [Section 49, *Code of Federal Regulations*, Part 178.245 (49 CFR 178.245)] and the IAEA Safety Series 6 (IAEA 1990). The tanks have been constructed and certified in accordance with the American Society of Mechanical Engineers (ASME) Code. The tanks have received Competent Authority Certification from the DOT, a Bundesamt fur Strahlenschutz (BFS) permit from Germany, a Transport Canada permit, and a Tank Container Certificate of Approval from the American Bureau of Shipping.

Figure 2-1 is a photograph of one of the ISO portable tank containers which has been fabricated for transporting the LSA nitric acid. Each tank will be loaded to a nominal 4,000 gallons (15,100 L) of liquid. The tank shell, piping, and fittings are constructed of Type 304L stainless steel. The piping and fittings are Schedule 80 or thicker; the tank has a minimum shell thickness of 0.295 in. (0.749 cm) and is approximately 8.0 ft (2.4 m) in

Figure 2-1. ISO Portable Tank and Tank-Frame.



diameter and 20 ft (6.1 m) long. The tank is top loaded and contains no bottom valves or vents. The tank also contains leakage containment enclosures to retain any leakage from valves and quick-connects. A five year corrosion allowance has been included in the design of the vessel. A container is assembled into an ISO tank-frame which has been designed to stabilize the tank and provide for lifting and handling. All designs, fabrications, inspections, examinations, and tests have been carried out as required by the ASME Code (WHC 1994c).

A portable tank will be loaded on a late model ISO chassis. The carrier will be a qualified Motor Carrier Evaluation Program (MCEP) motor carrier. Shipments will be satellite-tracked and the carrier will maintain communication capabilities with local and state authorities. Shipments will not proceed during adverse weather conditions. Ten ISO portable tanks have been manufactured and it is estimated that the entire transportation campaign will be complete within one year of the starting date. A maximum of 52 shipments will be made from the Hanford Site to Portsmouth, Virginia; Baltimore, Maryland; or Port Elizabeth, New Jersey. Figure 2-2 shows the Hanford Site to Portsmouth, Virginia, route. Figure 2-3 shows the Hanford Site to Baltimore, Maryland; and Figure 2-4 shows the Hanford Site to Port Elizabeth, New Jersey. Total one-way distances for the shipments are: Hanford Site to Portsmouth, Virginia, - 4778 km (2974 mi); Hanford Site to Baltimore, Maryland, - 4500 km (2800 mi); and Hanford Site to Port Elizabeth, New Jersey, - 4730 km (2940 mi).

2.3 PUREX NITRIC ACID SOURCE TERM

The slightly radioactive LSA material to be shipped from the PUREX Facility is an aqueous solution consisting of approximately 52 weight percent concentrated nitric acid. The acid component is Hazard Class 8, and the radioactive component is Hazard Class 7. Table 2-1 is a listing of the sample analyses performed on the four PUREX Facility nitric acid storage tanks. The sample analyses were provided by PUREX Process Shutdown Projects and represent a conservative source term. No precipitation or separation of the solution is anticipated.

Figure 2-2. Route from the Hanford Site to Portsmouth, Virginia.

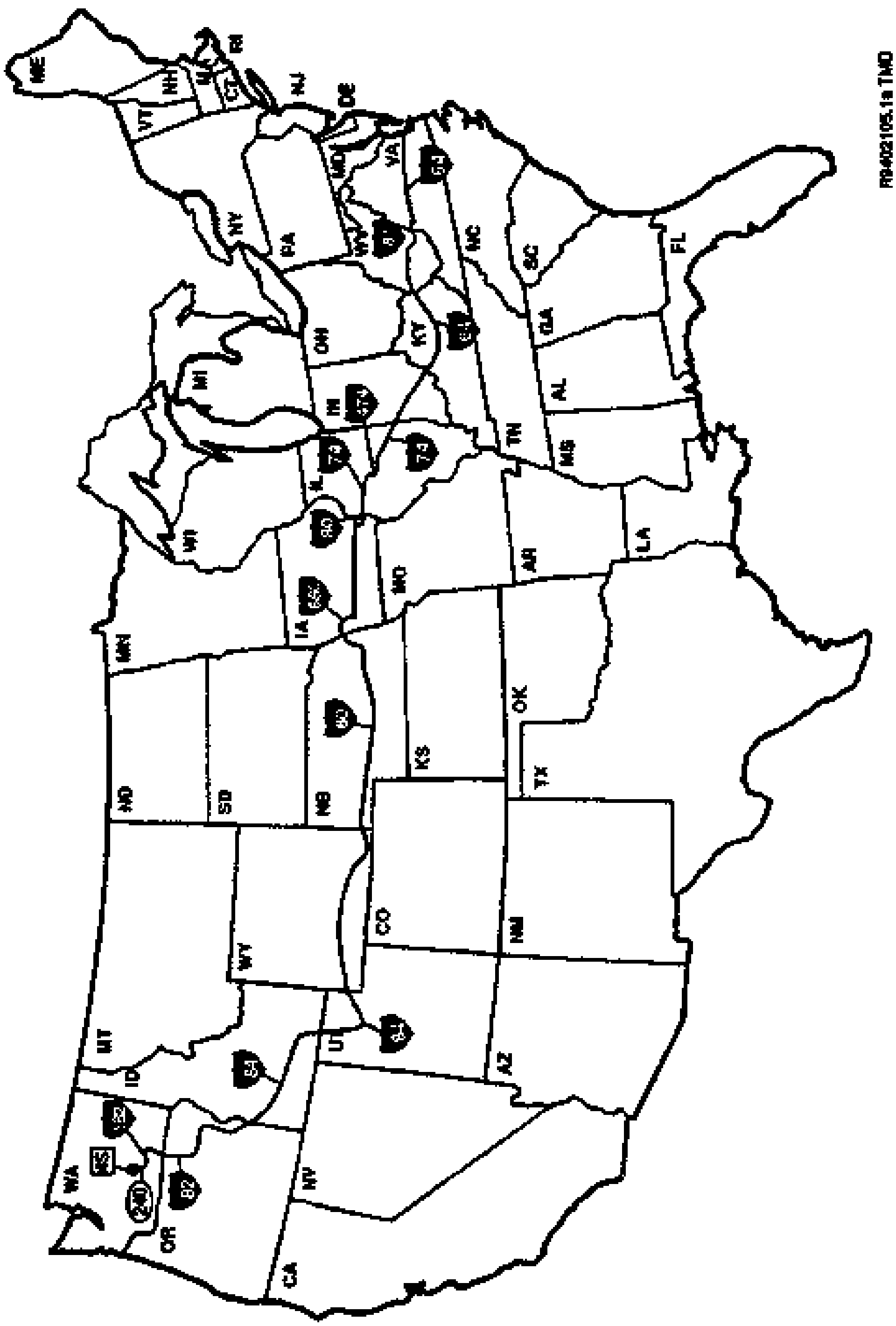


Figure 2-3. Route from the Hanford Site to Baltimore, Maryland.

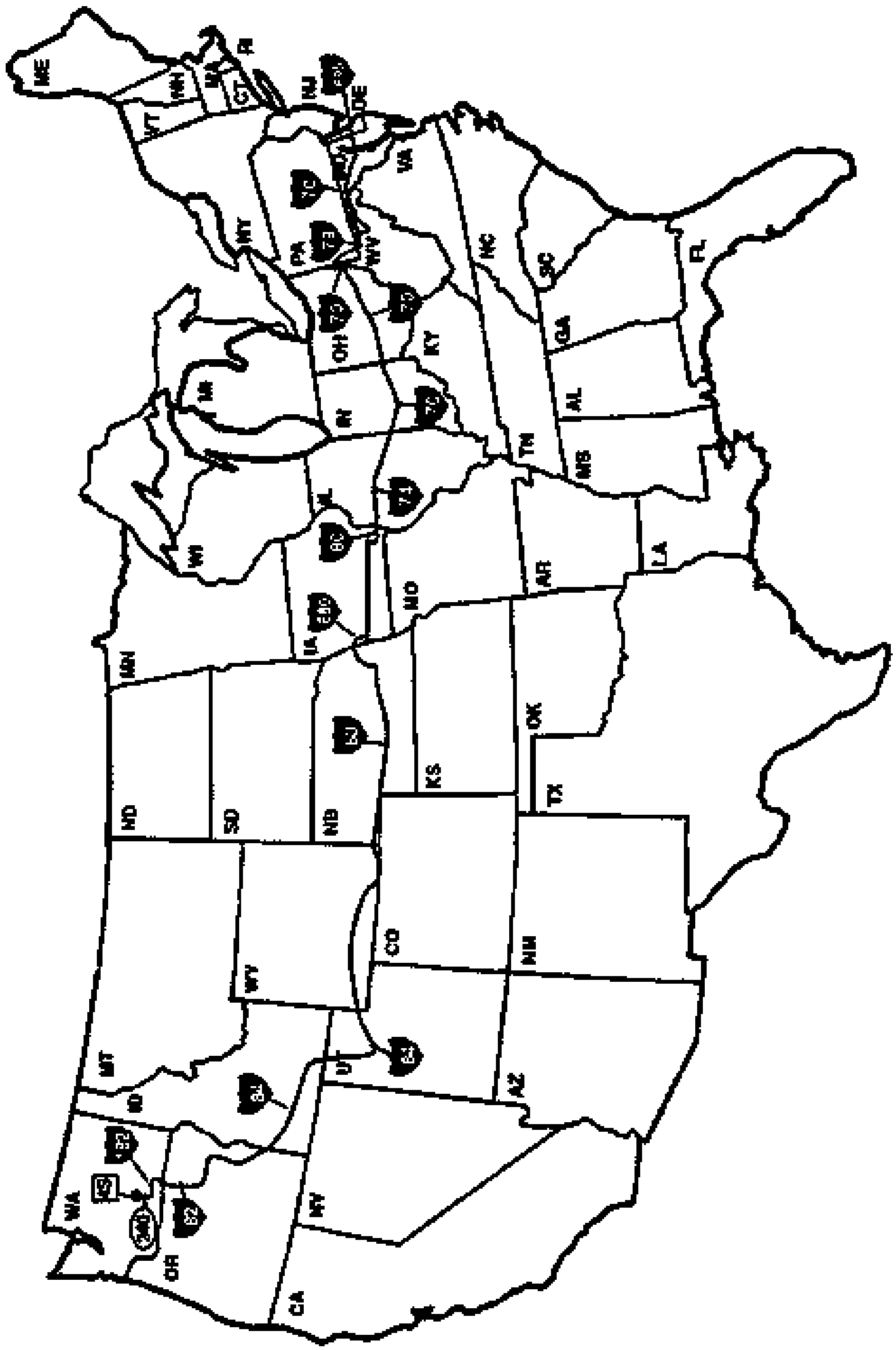


Figure 2-4. Route from the Hanford Site to Port Elizabeth, New Jersey.

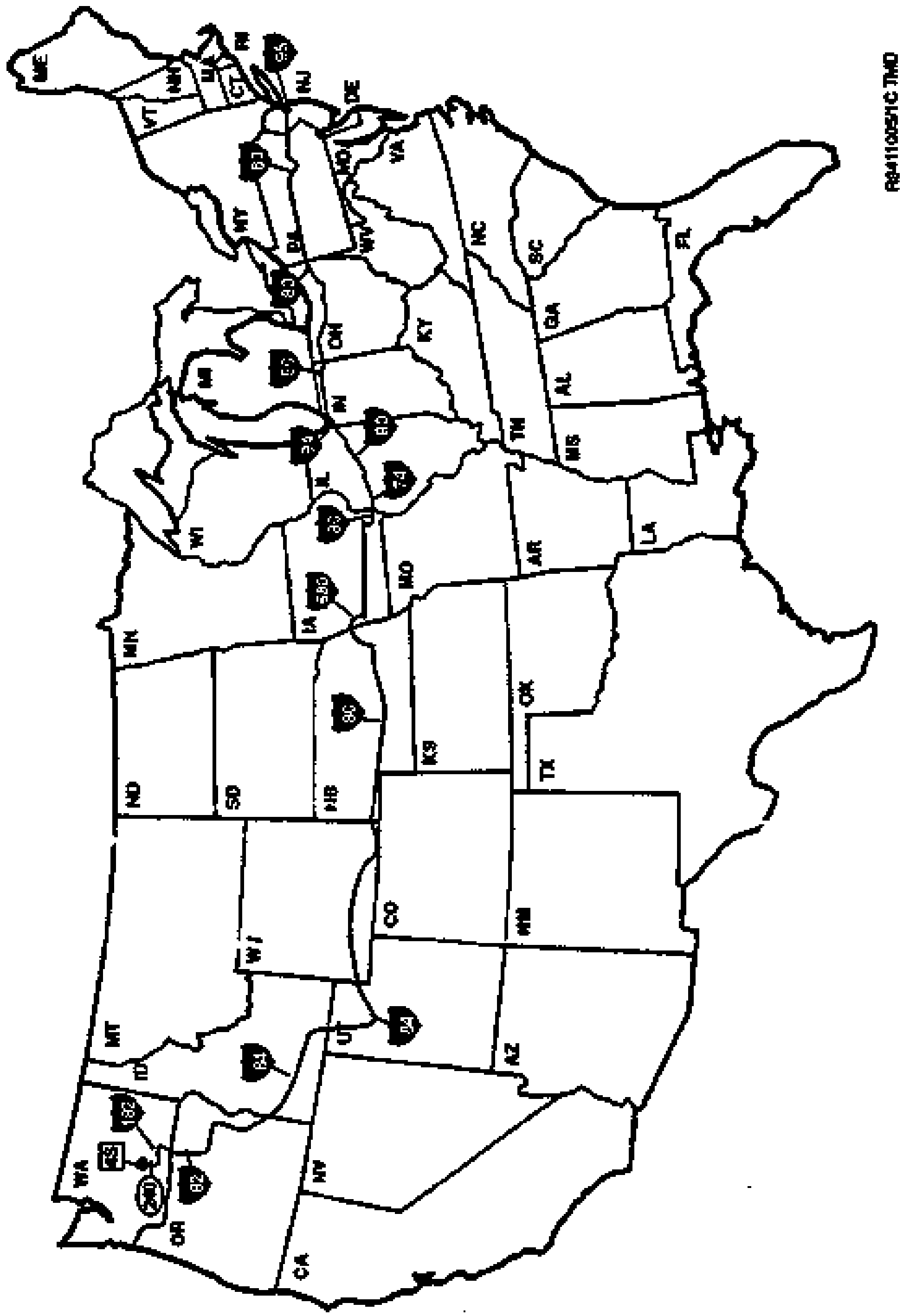


Table 2-1. PUREX LSA Nitric Acid Sample Analyses.

APPR/OTR	TANK P2	TANK P3	TANK U1	TANK U2
	<1% Solids, Clear, Colorless, <0.5 MR	<1% Solids, Clear, Yellow, <0.5 MR	<1% Solids, Clear, Light Brown, <0.5 MR	<1% Solids, Colorless
H^+	7.6 M	9.4 M	11.3 M	10.65 M
Pu	<9.33E-08 G/L	<1.34E-07 G/L	2.70E-06 G/L	1.77E-06 G/L
U	16.95 G/L	10.4 G/L	1.15E-04 G/L	1.21E-04 G/L
SpG	1.26	1.29	1.29	1.31
TOC	616 uG C/mL	496 uG C/mL	789 uG C/mL	1050 uG C/mL
TB	10.7 uCi/L	9.14 uCi/L	16.4 uCi/L	28.1 uCi/L
AT	8.57 uCi/L	7.31 uCi/L	2.4E-02 uCi/L	2.4E-02 uCi/L
$^{144}Ce/^{144}Pr$	<2.56E-01 uCi/L	<2.09E-01 uCi/L	3.5E-01 uCi/L	6.5E-01 uCi/L
^{60}Co	<2.75E-02 uCi/L	<4.26E-02 uCi/L	<1.09E-02 uCi/L	<4.08E-02 uCi/L
^{134}Cs	<2.81E-02 uCi/L	<2.16E-02 uCi/L	4.7E-02 uCi/L	9.1E-02 uCi/L
^{137}Cs	3.01E-02 uCi/L	4.25E-02 uCi/L	4.03 uCi/L	9.02 uCi/L
^{95}Nb	2.78E-02 uCi/L	<2.07E-02 uCi/L	<9.25E-03 uCi/L	<1.31E-02 uCi/L
^{103}Ru	<1.74E-02 uCi/L	<1.41E-02 uCi/L	<2.12E-02 uCi/L	<5.2E-02 uCi/L
$^{106}Ru/^{106}Rh$	<2.5E-01 uCi/L	<3.11E-01 uCi/L	<3.45E-01 uCi/L	<7.78E-01 uCi/L
^{95}Zr	<3.63E-02 uCi/L	<3.48E-02 uCi/L	<1.37E-02 uCi/L	<3.93E-02 uCi/L
$^{228}Th/Pb$	1.58 uCi/L	None Detected	<0.122 uCi/L	None Detected
^{235}U	2.69E-01 uCi/L	1.98E-01 uCi/L	None Detected	None Detected
F^-	<2.12E+02 uG/mL	<2.12E+02 uG/mL	<2.09E+02 uG/mL	<2.12E+02 uG/mL
Cl^-	<4.24E+02 uG/mL	<4.24E+02 uG/mL	<4.18E+02 uG/mL	<4.24E+02 uG/mL
PO_4^-	<2.12E+03 uG/mL	<2.12E+03 uG/mL	<2.09E+03 uG/mL	<2.12E+03 uG/mL
SO_4^-	<2.12E+03 uG/mL	<2.12E+03 uG/mL	<2.09E+03 uG/mL	<2.12E+03 uG/mL
^{241}Am	<1.7E-05 uCi/mL	<1.7E-05 uCi/mL	4.71E-05 uCi/mL	4.41E-05 uCi/mL
^{237}Np	6.9E-05 uCi/mL	6.06E-05 uCi/mL	4.2E-05 uCi/mL	<2.06E-05 uCi/mL
As	1.4E-02 uG/mL	9.0E-03 uG/mL	2.0E-02 uG/mL	2.3E-02 uG/mL
Se	<5.0E-03 uG/mL	<5.0E-03 uG/mL	<5.0E-03 uG/mL	<5.0E-03 uG/mL
Hg LIQ	10.4 uG/L	23.5 uG/L	51.4 uG/L	52.7 uG/L
Fe	55 uG/mL	32.3 uG/mL	108.5 uG/mL	76.1 uG/mL
Ca	14 uG/mL	2.43 uG/mL	5.03 uG/mL	10 uG/mL
Cr	12 uG/mL	8.46 uG/mL	29.0 uG/mL	20.6 uG/mL
P	27.7 uG/mL	2.30 uG/mL	24.6 uG/mL	24 uG/mL
Mg	2.4 uG/mL	None Detected	2.6E-01 uG/mL	5.0E-01 uG/mL
Na	24.2 uG/mL	3.36 uG/mL	5.47 uG/mL	6.05 uG/mL
K	36.4 uG/mL	3.24 uG/mL	None Detected	None Detected
Ni	7.4 uG/mL	4.96 uG/mL	15.65 uG/mL	12.4 uG/mL

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3.0 RADIOLOGICAL RISK ASSESSMENT

3.1 METHODOLOGY

The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used to perform the analyses of the transportation of LSA nitric acid to the ports at Portsmouth, Virginia; Baltimore, Maryland; and Port Elizabeth, New Jersey, from the PUREX Facility on the Hanford Site in Washington State. RADTRAN was developed by Sandia National Laboratories (SNL) to calculate the risks associated with the transportation of radioactive materials. The original code was written by SNL in 1977 in association with the preparation of NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977). The code has since been refined and expanded and is currently maintained by SNL under contract from DOE.

The RADTRAN 4 computer code is organized into the following seven models (Neuhauser and Kanipe 1994):

- material model
- transportation model
- population distribution model
- health effects model
- accident severity and package release model
- meteorological dispersion model
- economic model.

The code uses the first three models to calculate the potential population dose due to normal, incident-free transportation and the first six models to calculate the risk to the population from user-defined accident scenarios. The economic model is not used in this study.

3.1.1 Material Model

The material model defines the source as either a point source or as a line source. For exposure distances less than twice the package dimension, the source is conservatively assumed to be a line source. For all other cases, the source is modeled as a point source which emits radiation equally in all directions.

The material model also contains a library of 59 isotopes each of which has 11 defining parameters which are used in the calculation of dose. The user can add isotopes not in the RADTRAN library by creating a data table in the input file consisting of eleven parameters.

3.1.2 Transportation Model

The transportation model allows the user to input descriptions of the transportation route. A transportation route may be divided into links or segments of the journey with information for each link on population density, mode of travel (e.g., trailer truck, ship, etc.), accident rate, vehicle speed, road type, vehicle density, and link length. Alternatively, the transportation route can also be described by aggregate route data for rural, urban, and suburban areas. For the LSA nitric acid shipments, the aggregate route method was used for separate sections for each of the three destinations. Routes to three destinations were subdivided into the following:

- Hanford Site, Washington to Portsmouth, Virginia:
  Hanford Site, Washington to Ogden, Utah
  Ogden, Utah to Lexington, Kentucky
  Lexington, Kentucky to Portsmouth, Virginia

- Hanford Site, Washington to Baltimore, Maryland:
  Hanford Site, Washington to Ogden, Utah
  Ogden, Utah to Columbus, Ohio
  Columbus, Ohio to Baltimore, Maryland

- Hanford Site, Washington to Port Elizabeth, New Jersey:
  Hanford Site, Washington to Ogden, Utah
  Ogden, Utah to Columbus, Ohio
  Columbus, Ohio to Port Elizabeth, New Jersey

3.1.3 Health Effects Model

The health effects model in RADTRAN 4 is outdated and is replaced by hand calculations. The health effects are determined by multiplying the population dose (person-rem) supplied by RADTRAN 4 by a conversion factor. The conversion factors relate population dose to latent cancer fatalities and total detriment from cancer fatalities, cancer incidents, and genetic effects. They are taken from the International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991) and are listed in Table 3-1.

Table 3-1. Health Effect Conversion Factors (ICRP 1991).

	Worker	Public
Latent Cancer Fatality (per person-rem)	4.0 E-04	5.0 E-04
Total Detriment (per person-rem)	5.6 E-04	7.3 E-03

3.1.4 Accident Severity and Package Release Model

Accident analysis in RADTRAN 4 is performed using the accident severity and package release model. The user can define up to 20 severity categories for three population densities (urban, suburban and rural), each increasing in magnitude. NUREG-0170 (NRC 1977) defines eight severity categories for spent fuel containers that are related to fire, puncture, crush, and immersion environments. Various other studies have also been performed for small (Clarke et al. 1976) and large (Dennis et al. 1978) packages which can also be used to generate severity categories. The accident scenarios are further defined by allowing the user to input release fractions, and aerosol and respirable fractions for each severity category. These fractions are also a function of the physical-chemical properties of the materials being transported.

3.1.5 Meteorological Dispersion Model

RADTRAN 4 allows the user the choice of two different methods for the modeling of the atmospheric transport of radionuclides after a potential accident. The user can either input Pasquill atmospheric stability category data or averaged time-integrated concentrations. In the LSA nitric acid analyses, the dispersion of radionuclides after a potential accident is modeled by the use of time-integrated concentration values in downwind areas compiled from national averages by SNL.

3.1.6 Incident-Free Transport

The models described above are used by RADTRAN 4 to determine dose from incident-free transportation or risk from potential accidents. The public and worker doses calculated by RADTRAN 4 for incident-free transportation are dependent upon the type of material being transported and the Transportation Index (TI) of the package or packages. The TI is defined in 49 CFR 173.403(bb) as the highest package dose rate in millirem per hour at a distance of 1 m from the external surface of the package. Dose consequences are also dependent upon the size of the package, which as described in the material model description, will determine whether the package is modeled as a point source or line source for close-proximity exposures.

3.1.7 Potential Accident Analysis

The potential accident analysis performed in RADTRAN 4 calculates population doses for each accident severity category using six exposure pathway models. They include inhalation, resuspension, groundshine, cloudshine, ingestion, and direct exposure. This RADTRAN 4 analysis assumes that any contaminated area is either mitigated or public access controlled so the dose via the ingestion pathway equals zero. The consequences calculated for each severity category are multiplied by the appropriate probabilities for each category and summed to give a total radiological accident risk.

3.2 RADTRAN 4 INPUT PARAMETERS

RADTRAN 4 computer code input files divide into parameters associated with the source term, parameters which are used for incident-free transportation, and data that are associated with potential accidents. Input file listings for each of the trip segments can be found in the Appendix.

3.2.1 Source Term Parameters

The LSA nitric acid is currently located at the PUREX Facility on the Hanford Site. The LSA source term was developed using the information given in Table 2-1 in Section 2. This table gives the results of measurements performed on the material currently located at the PUREX Facility. Some of the radionuclides listed in Table 2-1 show a "less than value." These values are the detection limits of the equipment used for measurement. Although, in most cases, these radionuclides are not present, they were included in the source term. In developing the source for the RADTRAN 4 input, the highest recorded concentration or "less than" value of a radionuclide was multiplied by the shipment quantity of 4000 gallons (15,100 L); all beta activity (TB in Table 2-1) was assumed to be ^{90}Sr. Uranium and plutonium values were taken from the source term developed in the Westinghouse internal memo, 84100-94-JEM-056, which is contained in the Appendix. The resulting source term represents a worst case and is conservative. Table 3-2 lists the RADTRAN 4 source term developed for the nitric acid shipments. The total activity per 4000 gallons (15,100 L) shipment will be less than 0.9 Ci.

Table 3-2. LSA Nitric Acid Shipment Source Term.

Nitric Acid Source Term	Ci/Shipment	Nitric Acid Source Term	Ci/Shipment
^{90}Sr*	4.25 E-01	^{235}U	8.09 E-03
^{144}Ce*	9.84 E-03	^{236}U	1.27 E-02
^{60}Co	6.45 E-04	^{238}U	7.51 E-02
^{134}Cs	1.38 E-03	^{241}Am	7.13 E-04
^{137}Cs*	1.37 E-01	^{237}Np	1.04 E-03
^{95}Nb	4.21 E-04	^{238}Pu	2.10 E-04
^{103}Ru	7.87 E-04	^{239}Pu	2.37 E-03
^{106}Ru*	1.18 E-02	^{240}Pu	5.6 E-04
^{95}Zr	5.95 E-04	^{241}Pu	2.28 E-02
^{228}Th	2.39 E-02	^{242}Pu	5.64 E-08
^{234}U	1.55 E-01	TOTAL	8.90 E-01

* RADTRAN automatically includes daughter activity from these radionuclides.

RADTRAN 4 has a radionuclide library which contains data for 59 isotopes. Of the 21 radionuclides in the nitric acid solution, three of them were not contained within the RADTRAN 4 library. Accordingly, the radionuclide data needed for RADTRAN was compiled. To maintain consistency with RADTRAN 4, the original references were used for the sources of this information. The eleven values needed for each radionuclide and the reference for the data follow.

1. Half-life (ICRP 1983)

2. Photon energy (ICRP 1983)

3. Cloudshine dose factor, external immersion (DOE 1988a) (Eckerman et al. 1988)

4. Committed effective dose equivalent for inhalation (DOE 1988b) (Eckerman et al. 1988)

5. Committed effective dose equivalent for ingestion (DOE 1988b) (Dunning 1983) (Eckerman et al. 1988)

6. Food transfer factor - set to zero since any contamination from accidents will be mitigated

7. Soil transfer factor - also set to zero

8. Deposition velocity of aerosol particles (Neuhauser and Kanipe 1992)

9. Lung type - determined by radiation characteristics

10. One-year lung dose for inhalation (Dunning 1983)

11. One-year marrow dose for inhalation (Dunning 1983).

Section 7.2 of the Appendix contains the data set generated for the radionuclides not contained in the RADTRAN 4 library. As previously discussed, these eleven parameters are used in RADTRAN 4 to calculate population dose from potential accidents.

Two additional parameters are associated with the source term. These parameters determine the release of the radionuclides given an accident of a certain magnitude. The parameters define the physical-chemical properties of the radionuclides being shipped. They are the physical-chemical group and the dispersibility category of the radionuclide. The nitric acid payload is in liquid form and has the dispersibility category default value taken from the RADTRAN user's manual for liquids (Neuhauser and Kanipe 1992).

3.2.2 Incident-Free Transportation Input Parameters

Table 3-3 is a list of input parameters that are used by RADTRAN 4 in the calculation of population dose for incident-free transportation. The LSA nitric acid will be shipped to the chosen Eastern port in up to 52 shipments. The tank will contain up to 4000 gallons (15,100 L) of LSA nitric acid solution.

RADTRAN 4 uses the dose rate at 1 m in calculating dose to the public and worker. Historical dose rate data are available for the shipment of LSA nitric acid in tanks on the Hanford Site (see Appendix, Section 7.3). The dose rate measured on the surface of the tank was less than 0.5 mrem/h. Accordingly, the use of 0.5 mrem/h at 1 m is a conservative value that will overestimate the dose to the public and workers.

Table 3-3. Input Parameters for Incident Free Transport.[a]

Parameter	Input Number
Number of Shipments	52
Dose rate 1 m from Vehicle/Package (mrem/h)	0.5
Length of Package (m)	6.1
Exclusive Use	Yes
Velocity in Rural Population Zone (km/h)[b]	88.6
Velocity in Suburban Population Zone (km/h)[b]	40.3
Velocity in Urban Population Zone (km/h)[b]	24.2
Number of Crewmen	2
Distance from Source to Crew (m)	10.0
Stop Time per km (h/km)[b]	0.011
Persons Exposed While Stopped[b]	50
Average Exposure Distance While Stopped (m)[b]	20.0
Number of People per Vehicle on Link[b]	2
Traffic Count Passing a Specific Point-Rural Zone, One-Way[b]	470
Traffic Count Passing a Specific Point-Suburban Zone, One-Way[b]	780
Traffic Count Passing a Specific Point-Urban Zone, One-Way[b]	2,800

(a) Values shown are shipment specific unless otherwise noted.
(b) Default values from RADTRAN 4 (Neuhauser and Kanipe 1992).

Travel fractions and population densities, as shown in Table 3-4, were generated using the computer code HIGHWAY 3.1 (Johnson et al. 1993). The data are used in both incident-free and accident analyses. The information was generated for six different sections identified as part of the routes from the Hanford Site to the three Eastern ports. Since population densities and accident rates in the West are significantly different from those in the Midwest and East, the sections are roughly broken into geographical areas which cover travel across Western, Midwestern and Eastern states. The input parameters generated were used in six different RADTRAN 4 input files. Copies of the input files can be found in the Appendix. The output for the six different runs were summed to give total integrated population doses and risks for the three different routes from the Hanford Site to Eastern ports. Accident rates are discussed in the following section.

Table 3-4. Transportation Statistics and Frequency Data.

From	To	Description	Rural	Suburban	Urban	Total km (mi)
Hanford, WA	Ogden, UT					1013.9 (630.0)
		Accident Rate (km^{-1})	2.31E-07	2.59E-07	2.59E-07	
		People/km^2	5.0	320.7	2038.5	
		Percentage of Travel	91.8	7.2	1.0	
Ogden, UT	Lexington, KY					2797.0 (1738.0)
		Accident Rate (km^{-1})	2.21E-07	5.28E-07	5.28E-07	
		People/km^2	6.1	314.9	2094.8	
		Percentage of Travel	88.0	11.3	0.7	
Lexington, KY	Portsmouth, VA					967.2 (601.0)
		Accident Rate (km^{-1})	2.40E-07	3.39E-07	3.39E-07	
		People/km^2	16.0	305.3	2043.7	
		Percentage of Travel	72.1	25.8	2.1	
Ogden, UT	Columbus, OH					2801.8 (1741.0)
		Accident Rate (km^{-1})	2.23E-07	5.15E-07	5.15E-07	
		People/km^2	5.9	331.8	2111.7	
		Percentage of Travel	87.1	11.7	1.2	
Columbus, OH	Port Elizabeth, NJ					914.1 (568.0)
		Accident Rate (km^{-1})	3.62E-07	3.04E-07	3.04E-07	
		People/km^2	19.4	288.1	2346.8	
		Percentage of Travel	69.3	26.9	3.8	
Columbus, OH	Baltimore, MD					680.7 (423.0)
		Accident Rate (km^{-1})	3.31E-07	3.07E-07	3.07E-07	
		People/km^2	18.7	257.2	2330.2	
		Percentage of Travel	62.7	33.6	3.7	

3.2.3 Accident Input Parameters

Radiological accident impacts are addressed in this report as integrated population risks (i.e., accident frequencies times consequences integrated over the entire shipping campaign), as well as the consequences of the maximum credible accident. Population risk calculations were performed using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). This section presents descriptions of the analyses performed using this computer code.

For this analysis, risk is defined as the product of the probability of occurrence of an accident involving the LSA nitric acid shipments and the consequences of an accident. Consequences are expressed in terms of the radiological exposures and latent cancer fatalities from a release of radioactive material from the tank or the exposure of persons to radiation that could result from damaged package shielding. The probability of an accident that involves radioactive materials is expressed in terms of the expected number of accidents per unit distance integrated over the total distance traveled. The response of the tank to the accident environment, and hence, the probability of release or loss of shielding, is related to the severity of the accident.

The probabilities of occurrence of transportation accidents that would release significant quantities of radioactive material are relatively small because the tank is designed to withstand certain transportation accident conditions (i.e., the tank is designed and fabricated to the requirements of DOT Specification 51 - see 49 CFR 178.425). Accidents on the road are difficult to totally eliminate. However, because the shipping tanks and frames are capable of withstanding certain accident environments, including mechanical and thermal environments, only a relatively small fraction of accidents involve conditions that are severe enough to result in a release of nitric acid.

Should an accident involving an LSA nitric acid tank occur, a release of radioactive material could occur only if the tank were to fail. A failure would most likely be a small gap in a seal or valve failure. For the radioactive material to reach the environment, it would have to pass through the tank walls or through a failed valve. Materials released to the environment would form a pool of nitric acid, evaporate, and then become dispersed and diluted by weather action and a fraction would be deposited on the ground (i.e., drop out of the contaminated plume) in the surrounding region. Emergency response crews arriving on the scene would evacuate and secure the area to exclude bystanders from the accident scene. The released material would then be cleaned up using standard decontamination techniques, such as excavation and removal of contaminated soil. Monitoring of the area would be performed to locate contaminated areas and to guide cleanup crews in their choice of protective clothing and equipment (e.g., fresh-air equipment, filtered masks, etc.). Access to the area would be restricted by Federal and/or state radiation control agencies until it had been decontaminated to safe levels.

The RADTRAN 4 computer code was used to calculate the radiological risk of transportation accidents involving LSA nitric acid shipments. The RADTRAN 4 methodology was summarized previously. For further details, refer to the discussions presented by *RADTRAN III* (Madsen et al. 1986) and *RADTRAN 4: Volume 2--Technical Manual* (Neuhauser and Kanipe 1994).

There are five major categories of input data needed to calculate potential accident transportation risk impacts using the RADTRAN 4 computer code. These are (1) accident probability, (2) release quantities, (3) atmospheric dispersion parameters, (4) population distribution parameters, and (5) human uptake and dosimetry models. Accident probability and release quantities are discussed below, the remaining parameters have been discussed in previous sections.

3.2.3.1 Accident Probability. The probability of a severe accident is calculated by multiplying an overall accident rate (accidents per truck-kilometer) by the conditional probability that an accident will involve mechanical and/or thermal conditions that are severe enough to result in container failure and subsequent release of radioactive material. For this analysis, four accident severity categories were defined, with category 1 as the least severe and category 4 as the most severe. The conditional probabilities of encountering accident conditions in each severity category were taken from an U.S. Nuclear Regulatory Commission (NRC) document (Fischer et al. 1987), which were developed based on reviews of accident records and statistics compiled by various State and Federal agencies. The derivation of the accident rates and conditional probabilities used in this analysis is discussed below.

Accident rates were developed for each of the six transport links using state-level accident data developed by *Trends in State-Level Freight Accident Rates* (Saricks and Kvitek 1991). Since each link encompasses more than one state, a weighted-average accident rate was developed for each link. The weighted-average was derived by determining the fraction of the total distance in each link that passes through a certain state, multiplying the fraction by the accident rate in the state, and then summing over all the states in the link. Since the accident rates given by *Trends in State-Level Freight Accident Rates* (Saricks and Kvitek 1991) are split into accidents per mile for rural and urban travel, it was necessary to incorporate this factor into the analysis. This was done by determining the distance traveled in urban and rural zones in each state in a link using the HIGHWAY computer code (Johnson et al. 1993) output (fractions of travel in rural and urban/suburban population zones) and then performing the weighted-average calculations to develop the accident rates in each population zone each link. These calculations are illustrated for a specific link (Hanford to Ogden, Utah) in Table 3-5. The accident rates for each link are presented in Table 3-6.

Table 3-5. Illustration of Calculations Performed to Develop Link-by-Link Accident Rates.

State	Distance Miles[a]	Fractions of Travel in Each Zone[a]			Distance in each Zone, km[b]			State Accident Rate, per 1.0 E+07 km[c]		Rate, per 1.0 E+07 km[d]	
		Rural	Suburban	Urban	Rural	Suburban	Urban	Rural	Urban	Rural	Urban
WA	46	0.918	0.072	0.010	68	5	1	2.50	1.61	0.17	0.11
OR	209	0.918	0.071	0.010	309	24	3	2.20	3.99	0.68	1.23
ID	274	0.918	0.071	0.010	405	32	4	2.30	1.73	0.93	0.70
UT	148	0.918	0.071	0.010	219	17	2	2.41	2.52	0.53	0.55
	677				1000	78	11			2.31	2.59

(a) These data were taken from the HIGHWAY computer code results for this link.
(b) Obtained by multiplying the total travel distance in each state by the rural, suburban, and urban travel fractions and then converting to kilometers.
(c) Data taken from Trends in State-Level Freight Accident Rates (Saricks and Kvitek 1991).
(d) Calculated by multiplying the fraction of rural and urban/suburban travel in each zone (e.g., rural distance/total distance) by the rural and suburban/urban accident rates in each state. The total accident rate for this link is the sum of the weighted averages in each state.

Table 3-6. Accident Rates for Each Link in this Analysis.

Link No.	From	To	Accident Rate, per 1.0 E+07 km	
			Rural	Urban/Suburban
1	Hanford, WA	Ogden, UT	2.31	2.59
2	Ogden, UT	Lexington, KY	2.21	5.28
3	Lexington, KY	Portsmouth, VA	2.40	3.87
4	Ogden, UT	Columbus, OH	2.25	5.15
5	Columbus, OH	Port Elizabeth, NJ	4.62	3.04
6	Columbus, OH	Baltimore, MD	3.31	3.07

Four severity categories were defined to model the response of the nitric acid tank to accidents. Severity category 1 was defined as encompassing all accidents that are not severe enough to result in failure of the tank (i.e., accidents with zero release). Category 4 was defined to include all accidents that are severe enough to result in a spill of the entire tank contents. No data on the accident-resistance of the tank to be used for the nitric acid shipments was found so gasoline tanks (Rhoads 1978) were used to approximate the structural and thermal capabilities of the LSA nitric acid tank. This is believed to be conservative because gasoline tanks are not protected during transport by the rollover protectors and ISO container frame provided for the nitric acid. In addition, gasoline tanks are constructed of an aluminum alloy which provides less structural strength than the 304L stainless steel nitric acid tank.

The structural analysis of a gasoline tank described by *An Assessment of the Risk of Transporting by Gasoline Truck* (Rhoads 1978) concluded that the failure threshold for aluminum gasoline tanks involved in impact accidents is about 23.6 mph. This study also concluded that the gasoline tank can withstand the pressures produced in an 1850 °F fire for up to 40 minutes with all relief valves failing to function. Therefore, it is conservative to assume that the nitric acid tank can withstand a 10 minute fire without failing. These failure thresholds were used to determine the conditional probabilities of severity categories 1 and 2. According to *Shipping Container Response to Severe Highway and Railway Accident Conditions* (Fischer et al. 1987), 15.3% of all truck accidents that involve impact velocities less than 22 mph is 0.56877 (includes small percentage of non-impact accidents involving fires). Since severity category 1 does not include fire occurrences, the fraction of these accidents was modified to remove the non-collision fire events. *Shipping Container Response to Severe Highway and Railway Accident Conditions* (Fischer et al. 1987) indicated that 15.3% of all truck accidents involve fires and that when a fire occurred, about 66% of the fires were less than 10 minutes in duration. Therefore, the fraction of impact-only accidents less than 22 mph was calculated as follows:

$$\text{PROB (Sev. Cat. 1)} = 0.56877 - (0.153)(0.6596)(0.56877) = 0.5114$$

The probability of severity category 2, which was defined as a minor collision (less than 22 mph) for which a fire occurs, is the product of the last three terms in the above equation; i.e., (0.153)(0.6596)(0.56877) = 0.0574.

Severity category 3 was defined to encompass collision-only accidents at velocities between 22 mph and 30 mph. The latter velocity was estimated by

An Assessment of the Risk of Transporting Gasoline by Truck (Rhoads 1978) as the failure threshold for axial impact events for a gasoline tank. According to *Shipping Container Response to Severe Highway and Railway Accident Conditions* (Fischer et al. 1987), the cumulative probability of accidents less than 30 mph is about 0.74353. Therefore, the conditional probability of accident severity category 3 is 0.74353 - 0.56877 = 0.1748. The conditional probability of accident severity category 4, which encompasses all accidents more severe than 30 mph collisions, with and without fires, is 1.0 - 0.74353 = 0.2565.

3.2.3.2 Release Fractions for Nitric Acid Shipments. Release fractions (array RFRAC in RADTRAN 4) are used to determine the quantity of radioactive material released to the environment as a result of an accident. The quantity of material released is a function of the severity of the accident (i.e., thermal and mechanical conditions produced in the accident), the response of the tank to these conditions, and the physical and chemical properties of the material being shipped. The basis for the release fractions used in this analysis are discussed below.

A four-parameter array was established to describe the release fractions. Release fractions were developed to describe the quantity of nitric acid estimated to be released given the occurrence of an accident in each severity category. The release fraction for severity category 1 relates to the releases expected from non-fire accidents less than 22 mph. These accidents are not expected to result in tank failure. Consequently, the release fraction for severity category 1 was set equal to zero.

The release fractions for the remaining severity categories were developed using information in *An Assessment of the Risk of Transporting Gasoline by Truck* (Rhoads 1978). Severity category 2 involves a relatively minor thermal accident environment. The most likely failure mode for this category is overpressure resulting in leakage through pressure relief valves. *An Assessment of the Risk of Transporting Gasoline by Truck* (Rhoads 1978) estimated the release fraction for gasoline under these conditions at 1% of the tank contents, as long as the tank does not overturn (overturn is unlikely at vehicle speeds less than 22 mph so this release fraction appears to be reasonable).

The severity category 3 release fraction would be substantially larger than that for category 2 because the nitric acid tank walls are projected to fail under category 3 conditions. *An Assessment of the Risk of Transporting Gasoline by Truck* (Rhoads 1978) estimated the release fraction for a gasoline tank under similar conditions to be 50% (representative of a failure of tank walls under impact or pressure conditions and failure of outlet valves in overturn accidents). This appears to be conservative because of the overturn protection provided for the nitric acid tank and its stronger and tougher stainless steel construction relative to gasoline tanks. The release fraction for severity category 4 was assumed conservatively to be 1.0 (100% of the tank contents released). Furthermore, it was assumed that 100% of the released material in all severity categories is in dispersible and respirable form.

3.3 INCIDENT-FREE RADIOLOGICAL TRANSPORTATION IMPACTS

Results from the normal, incident-free transportation of the 52 LSA nitric acid shipments from the Hanford Site to the three different Eastern ports are shown in Table 3-7. Travel from the Hanford Site to Portsmouth, Virginia, results in a total dose to the worker and public of 3.6 person-rem. Using the ICRP 60 health effects conversion factors given in Table 3-1 this would result in 1.7×10^{-03} latent cancer fatalities with a total detriment of 2.3×10^{-02}. Travel from the Hanford Site to Baltimore, Maryland, results in 2.6 person-rem with 1.3×10^{-03} latent cancer fatalities and 1.6×10^{-02} total detriments. The results to Port Elizabeth, New Jersey, give 2.7 person-rem and 1.3×10^{-03} latent cancer fatalities with a total detriment of 1.7×10^{-02}.

Table 3-7. Incident-Free Radiological Impacts from 52 LSA Nitric Acid Shipments.

Description	Worker	Public	Total
Hanford, Washington to Portsmouth, Virginia			
Total Dose (person-rem)	4.3 E-01	3.1 E+00	3.6 E+00
Latent Cancer Fatalities	1.7 E-04	1.6 E-03	1.7 E-03
Total Detriment	2.4 E-04	2.3 E-02	2.3 E-02
Hanford, Washington to Baltimore, Maryland			
Total Dose (person-rem)	4.1 E-01	2.2 E+00	2.6 E+00
Latent Cancer Fatalities	1.6 E-04	1.1 E-03	1.3 E-03
Total Detriment	2.3 E-04	1.6 E-02	1.6 E-02
Hanford, Washington to Port Elizabeth, New Jersey			
Total Dose (person-rem)	4.3 E-01	2.3 E+00	2.7 E+00
Latent Cancer Fatalities	1.7 E-04	1.2 E-03	1.3 E-03
Total Detriment	2.4 E-04	1.7 E-02	1.7 E-02

To place the above numbers in perspective, a calculation was performed to determine the dose rate and health effects from naturally occurring radiation to the population which could potentially be affected by the shipments. The National Council on Radiation Protection and Measurements (NCRP 1987) has determined that the average exposure from background radiation to individuals in the United States is approximately 300 mrem/yr. To determine a population dose for the area traversed by the three different shipments, a 60 m strip (30 m on each side of the highway) is multiplied by the length of each shipment. These areas were then multiplied by the population densities and travel fractions given in Table 3-4 for rural, suburban and urban zones respectively. The following example for the Hanford to Portsmouth route illustrates the calculation:

Total shipping distance	=	4778.1 km
Total exposure area	=	(0.06 km) x (4778.1 km) = 286.69 km^2
Total exposed population	=	Area x Σ {(Link Fraction) x Σ [(Population Density) x (Travel Fraction)]}
	=	286.69 km^2 x {1013.9/4786.1 (5 x 0.918 + 320.7 x 0.072 + 2038.5 x 0.01) + 2797.0/4786.1 (6.1 x 0.88 + 314.9 x 0.113 + 2094.8 x 0.007) + 975.2/4786.1 (16 x 0.719 + 342.2 x 0.256 + 2103.7 x 0.025)}
	=	21,098.0
Person-rem	=	21,098.0 person x 0.3 rem/yr
	=	6,329 person-rem/yr

The average exposure in person-rem from background radiation for the three proposed routes yields a dose of 5,860 person-rem resulting in 2.9 latent cancer fatalities. The highest incident-free population dose from Table 3-7 is less than 0.1% of the calculated national average person-rem from background radiation for the same population.

3.4 POTENTIAL ACCIDENT RISKS

The results from RADTRAN 4 analyses for potential accidents are shown in Table 3-8. The Hanford to Portsmouth, Virginia, route yields a risk of $1.2 \times 10^{+01}$ person-rem which may result in 6.2×10^{-03} latent cancer fatalities and 9.1×10^{-02} total detriments. The Baltimore, Maryland, route produces a risk of $1.3 \times 10^{+01}$ person-rem and 6.6×10^{-03} latent cancer fatalities and 9.6×10^{-02} total detriments. The Port Elizabeth, New Jersey, route results in a risk of $1.4 \times 10^{+01}$ person-rem and 7.1×10^{-03} latent cancer fatalities and 1.0×10^{-01} total detriments. These numbers reflect no excess latent cancer fatalities.

Table 3-8. Potential Accident Risks from 52 LSA Nitric Acid Shipments.

Hanford, Washington to Portsmouth, Virginia	
Total Dose (person-rem)	1.2 E+01
Latent Cancer Fatalities	6.2 E-03
Total Detriment	9.1 E-02
Hanford, Washington to Baltimore, Maryland	
Total Dose (person-rem)	1.3 E+01
Latent Cancer Fatalities	6.6 E-03
Total Detriment	9.6 E-02
Hanford, Washington to Port Elizabeth, New Jersey	
Total Dose (person-rem)	1.4 E+01
Latent Cancer Fatalities	7.1 E-03
Total Detriment	1.0 E-01

4.0 TOXICOLOGICAL IMPACT ASSESSMENT

This chapter evaluates the impacts of an accidental release of toxic materials to the environment during transport of the LSA nitric acid. The toxicological impacts are presented in terms of the concentration of nitric acid fumes at various receptor locations. The calculated concentrations are then compared to various exposure limits to evaluate the effects of the release on the public.

4.1 METHODOLOGY

Hand calculations were performed to calculate the concentrations of nitric acid that could result from the maximum credible release during transport. For this assessment, the maximum credible release was assumed to be a full tank or 4000 gallons (15,100 L) of liquid. This is conservative as it is the entire contents of the tank.

Nitric acid released from the tank during a transportation accident was hypothesized to form a pool of spilled liquid. The liquid will then begin to evaporate and become dispersed by wind. The formula used to calculate the evaporation rate of the nitric acid from this pool of spilled liquid was taken from the *B-Plant Preliminary Accident Analysis* (Marusich 1989), which, in turn, was taken from *Perry's Chemical Engineer's Handbook* (Perry and Green 1984). This formula is as follows:

$$w = 0.00138(P_w - P)^{1.2}$$

where :
- w = evaporation rate, lb/h-ft^2
- P_w = partial pressure of solution vapor, mmHg
- P = reference pressure, assumed here to be 0 mmHg which maximizes the evaporation rate.

After the evaporation rate is calculated, the next step is to calculate the release rate, which is a function of the evaporation rate and the spill area. The formula is as follows:

$$RR = wA$$

where:
- RR = release rate, lb/h
- w = evaporation rate, lb/h-ft^2
- A = spill area, ft^2.

The final calculation determines the downwind concentration of nitric acid vapors at the specified receptor locations. The formula for this is as follows:

$$Conc = RR(X/Q)$$

where: X/Q = atmospheric dispersion parameter, sec/m^3.

The X/Q values for the various receptor locations were calculated using the formulas and data provided in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.145 (NRC 1982). Three separate formulas are provided in Regulatory Guide 1.145 and the intent is to select the largest X/Q value from those calculated using the three formulas.

The discussion above indicated that the release concentrations are a function of receptor location (and other variables, as well, to be discussed later). In a transportation accident, the potential receptor locations are difficult to characterize because the accident may occur anywhere along a route. Therefore, it is nearly impossible to predict the location of the nearest receptor. As a result, three potential receptor locations will be examined, including 100 m, 200 m, and 1000 m downwind from the accident location. This should effectively bracket the potential nearest individual location and provides a reasonable basis for comparing the calculated concentrations to the applicable exposure limit values. Distances closer than 100 m were not selected because the atmospheric dispersion calculations are highly uncertain at shorter distances and 100 m is a reasonable estimate of the distance between an interstate highway and the nearest resident.

Release concentrations are also a function of the weather conditions present when the accident occurs. For this analysis, two sets of meteorological conditions were examined. The first represents the weather conditions that result in the worst-case consequences; i.e., Pasquill Stability Class F and wind speed at 1 m/s. These conditions tend to disperse the released material very slowly, resulting in the highest possible downwind concentrations. However, these conditions are rarely encountered, except perhaps for night conditions, and tend to overstate the actual impacts. Therefore, a more likely, yet still relatively rare, set of conditions were examined to more closely approximate the actual impacts. The weather conditions are referred to as neutral stability (Pasquill Stability Class D) with a relatively low wind speed (2 m/s). The latter set of conditions will be used to calculate the concentrations at all three potential receptor locations and the former will be used to calculate the worst-case conditions at the shortest distance (100 m).

4.2 INPUT PARAMETERS

The input parameters required to perform the calculations described in Section 4.1 include material (nitric acid) properties, atmospheric dispersion parameters, and spill area. Each parameter is discussed below.

4.2.1 Material Properties

The properties of nitric acid that are pertinent to the consequence calculations are given below:

- P_w: Partial pressure of solution (nitric acid) vapor over an aqueous solution of nitric acid. This parameter is a function of the weight percentage of HNO_3 in solution and the ambient temperature. The HNO_3 concentration used here was 55% which is greater than the estimated maximum weight percentage of 52%. The ambient temperature was assumed to be about 50 °C (120 °F), a conservative estimate to model the effects of a release during a hot summer day. The partial pressure of HNO_3 under these conditions is 3.41 mmHg (Perry and Green 1984, p. 3-70).

- Molecular Weight: The molecular weight of nitric acid is 63.02 g/mol.

4.2.2 Atmospheric Dispersion Parameters (X/Q)

The X/Q values calculated using the methods described in *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants* (NRC 1982) are summarized below:

- X/Q for 100 m receptor, Pasquill F, and 1 m/sec wind speed was calculated to be 2.85×10^{-02} sec/m^3.
- X/Q for 100 m receptor, Pasquill D, and 2 m/sec wind speed was calculated to be 3.76×10^{-03} sec/m^3.
- X/Q for 200 m receptor, Pasquill D, and 2 m/sec wind speed was calculated to be 9.68×10^{-04} sec/m^3.
- X/Q for 1000 m receptor, Pasquill D, and 2 m/sec wind speed was calculated to be 6.63×10^{-05} sec/m^3.

4.2.3 Spill Area

Spill area was calculated assuming that the entire tank contents were released as a result of the accident. The quantity of nitric acid spilled was 4000 gallons (15,100 L), or 534.6 ft^3. Assuming that the spilled acid collects in a pool 3 in. deep, the spill area will cover 534.6/0.25 = 2138 ft^2. The pool depth is highly uncertain because it depends on the local terrain near the accident site, the presence of surface-water drainage pathways, release rate, evaporation rate, and the absorptive properties of the ground. These parameters are not well defined because the accident could occur anywhere along the potential routes. The 3 in. pool depth assumption seems reasonable given that the routes are dominated by interstate highways which are typically provided with rainwater drainage paths so a pool depth of 3 in. could easily be obtained. Absorption into the ground would reduce this pool depth estimate but would also reduce pool area. Therefore, a 3 in. pool depth seems to be reasonable approximation for this assessment.

4.3 TOXICOLOGICAL IMPACTS

This section presents the calculations leading to the concentrations of nitric acid vapors at the various receptor locations under both sets of meteorological conditions. An example is provided to guide the reader through the calculations.

The first step is to calculate the evaporation rate using the equation given in Section 4.1. The parameter values are specified in Section 4.2. These calculations are illustrated below:

$$w = 0.00138(P_w - P)^{1.2}$$

$$= 0.00138(3.41 - 0.0)^{1.2}$$

$$= 6.01E\text{-}03 \text{ lb/h-ft}^2.$$

This value was multiplied by the spill area to calculate the release rate from the spilled liquid, as shown below:

$$RR = wA$$

$$= (6.01E\text{-}03 \text{ lb/h-ft}^2)(2138 \text{ ft}^2)$$

$$= 12.86 \text{ lb/h } (0.214 \text{ lb/min}).$$

The next step is to calculate the downwind concentration of nitric acid vapors by multiplying the release rate and X/Q value together and making the necessary unit conversions. The calculation using the X/Q value for Pasquill D, 1 m/sec windspeed, and 100 m receptor distance is shown below:

$$\text{Conc} = RR(X/Q)$$

$$= (0.214 \text{ lb/min})(3.76E\text{-}03 \text{ sec/m}^3)(\text{min}/60 \text{ sec})(454{,}000 \text{ mg/lb})$$

$$= 6.1 \text{ mg/m}^3.$$

This concentration was converted to parts-per-million using the following standard formula:

$$\text{Conc(ppm)} = [\text{Conc (mg/m}^3) \times 24.45]/ \text{ Molecular Wt.}$$

$$= (6.1 \times 24.45)/63.02$$

$$= 2.4 \text{ ppm.}$$

This calculational sequence was repeated to develop estimates of the concentrations of HNO_3 for the other receptor locations and weather conditions. The results are presented in Table 4-1.

Table 4-1. Results of Toxicological Impact Calculations.

Pasquill Stability Category	Wind Speed, m/sec	Receptor Distance, m	Concentration, ppm
D	2.0	100	2.4
D	2.0	200	0.61
D	2.0	1000	0.041
F	1.0	100	17.9

The results in Table 4-1 were compared to the various HNO_3 exposure limits established in various documents. These limits are as follows:

- Toxicity: The LD_{50} (lethal dose to 50% of the population) is 88 ppm/4 hours (inhalation of NO_2) or 315 ppm (inhalation of NO; Sax and Lewis 1989).

- Threshold Limit Value/Time-Weighted Average (TLV/TWA): The TLV/TWA is 2 ppm (ACGIH 1992).

- TLV/Short Term Exposure Limit (STEL): The STEL (15 minute average) is 4 ppm (ACGIH 1992).

- Protective Action Guideline (PAG): The National Institute of Occupational Safety and Health (NIOSH) established the Immediately Dangerous to Life and Health (IDLH) value for nitric acid at 100 ppm (NIOSH 1985). The PAG is 50 ppm.

The reader is referred to the source documents for detailed descriptions of these exposure indices.

The concentrations in the table are all well below the exposures that could result in acute health effects, namely the LD_{50}, IDLH, and PAG. Therefore, even under the worst-case meteorological conditions (Pasquill F and 1 m/sec windspeed), no health effects were projected to occur. The 8-hour TLV/TWA limit is exceeded under the worst-case weather conditions but this limit represents the maximum allowable exposure to which a worker may be exposed for an 8-hour workday and 40-hour workweek. Exposures at this level on a daily basis would not adversely affect a worker's health. The calculated concentrations may also exceed the STEL at short distances from the release point and under worst-case weather conditions. The STEL represents the concentration to which workers can be exposed for a short period of time without suffering, for example, irritation, tissue damage, or effects which could impair self-rescue. Exposures at the STEL concentration would not be life-threatening exposures. Therefore, no adverse health effects are projected to result from the maximum credible toxicological release during the LSA nitric acid shipping campaign.

The results in the table also illustrate the reduction in concentration as the distance from the release point increases. At 100 m, the concentration is near the TLV/TWA concentration for nitric acid. Although this does not result in any health effects for short durations, it still may cause discomfort (e.g., irritation of the eyes and skin). At twice this distance, the concentration is well below the TLV and is probably below the level at which the vapor could be detected by humans. At 1000 m away from the release point, the concentration is even lower than at 200 m and is most likely undetectable.

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5.0 CONCLUSION

The radiological and toxicological transportation impacts of the shipment activities defined for the proposed campaign for recycled PUREX Facility LSA nitric acid have been assessed. The shipping activities addressed in this document include the transportation of the LSA nitric acid along three possible routes from the Hanford Site in Washington state to the Eastern seaboard ports of Portsmouth, Virginia; Baltimore, Maryland; and Port Elizabeth, New Jersey.

RADTRAN 4 was used to assess the radiological risks from both incident-free and potential accidents relating to the shipping campaigns. The radiological risks for the incident-free transportation of the LSA nitric acid gave no excess latent cancer fatalities or total detriments. The highest incident-free population dose was less than 0.1% of the exposure calculated from naturally occurring radiation to the same population. Potential accidents also resulted in no excess latent cancer fatalities or total detriments.

Hand calculations were used to assess the toxicological health effects for three maximum individual receptor locations and two weather conditions for a potential accident that results in a release of the entire tank contents. An evaporative release model was used to determine the release rate from the spilled pool of nitric acid. The concentrations at the receptor locations were calculated using atmospheric dispersion parameters were calculated using the methods recommended by the NRC. At all three receptor locations and under worst-case weather conditions, the concentrations calculated were below the levels that could result in acute health effects.

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WHC, 1994c, *Specification for ISO Tank Container Greater than 1000 Gallons Internal Volume for Shipment of Nitrating Liquids Greater than 50 Percent Nitric Acid*, WHC-S-0269, Westinghouse Hanford Company, Richland, Washington.

7.0 APPENDICES

7.1 INPUT FILES

7.1.1 Hanford Site, Washington to Ogden, Utah

```
&& Edited Tue Apr 18 09:11:54 1995
&& _NITRIC ACID_LSA SHIPMENTS - Link 1 - Hanford to Ogden
&& _lnk1b.in4_
TITLE _LNK1B.IN4_
FORM UNIT
DIMEN 21 4 1 10 18
PARM 1 3 2 1 0
POPDEN     5.000   320.700   2038.500
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LABISO
      SR90      CE144     CO60      CS134     CS137     NB95
      RU103     RU106     ZR95      TH228     U234      U235
      U236      U238      AM241     NP237     PU238     PU239
      PU240     PU241     PU242
NORMAL
   NMODE=1
      9.180E-01  7.200E-02  1.000E-02  8.856E+01  4.032E+01  2.416E+01
      2.000E+00  1.000E+01  0.000E+00  1.100E-02  0.000E+00  0.000E+00
      0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
      2.000E+00  0.000E+00  0.000E+00  1.000E+00  4.700E+02  7.800E-02
      2.800E+03
ACCIDENT
   ARATNZ
      NMODE=1   2.310E-07    2.590E-07    2.590E-07
   SEVFRC
     NPOP=1
       NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=2
       NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=3
       NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
RELEASE
   RFRAC
     GROUP=1
      0.00E+00  1.00E-02  5.00E-01  1.00E+00
   AERSOL
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
DEFINE  TH228
      6.98E+02  3.30E-03  2.88E-04  2.60E+06  3.80E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  4.50E+06  7.90E+07
DEFINE  U234
      8.93E+07  1.73E-03  2.43E-05  1.30E+08  2.60E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  8.20E+07  6.50E+04
DEFINE  U236
      8.54E+09  1.57E-03  1.92E-05  6.70E+06  2.50E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  7.70E+07  6.10E+04
EOF
ISOTOPES -1   52    1.00    0.500   1.00   0.00  NITAC
        SR90  4.25E-01      GRP1   8
       CE144  9.84E-03      GRP1   8
        CO60  6.45E-04      GRP1   8
       CS134  1.38E-03      GRP1   8
       CS137  1.37E-01      GRP1   8
        NB95  4.21E-04      GRP1   8
```

```
         RU103  7.87E-04        GRP1   8
         RU106  1.18E-02        GRP1   8
          ZR95  5.95E-04        GRP1   8
         TH228  2.39E-02        GRP1   8
          U234  1.55E-01        GRP1   8
          U235  8.09E-03        GRP1   8
          U236  1.27E-02        GRP1   8
          U238  7.51E-02        GRP1   8
         AM241  7.13E-04        GRP1   8
         NP237  1.04E-03        GRP1   8
         PU238  2.10E-04        GRP1   8
         PU239  2.37E-03        GRP1   8
         PU240  5.60E-04        GRP1   8
         PU241  2.28E-02        GRP1   8
         PU242  5.64E-08        GRP1   8
DISTION
          NMODE=1  1013.90
PKGSIZ
          NITAC       6.10
EOF
EOI
```

7.1.2 Ogden, Utah to Lexington, Kentucky

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## Edited Tue Apr 18 09:25:04 1995
## _NITRIC ACID_LSA SHIPMENTS - Link 2 - Ogden UT to Lexington KY
## _lnk2b.in4_
TITLE _LNK2B.IN4_
FORM UNIT
DIMEN 21 4 1 10 18
PARM 1 3 2 1 0
POPDEN     6.100    314.900   2094.800
PACKAGE
   LABGRP
       GRP1
SHIPMENT
   LABISO
       SR90      CE144      CO60      CS134      CS137      NB95
      RU103      RU106      ZR95      TH228       U234      U235
       U236       U238     AM241      NP237      PU238     PU239
      PU240      PU241     PU242
NORMAL
   NMODE=1
       8.800E-01  1.130E-01  7.000E-03  8.856E+01  4.052E+01  2.416E+01
       2.000E+00  1.000E+01  0.000E+00  1.100E-02  0.000E+00  0.000E+00
       0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  0.000E+00  0.000E+00  1.000E+01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   ARATNZ
       NMODE=1   2.210E-07   5.280E-07   5.280E-07
   SEVFRC
     NPOP=1
       NMODE=1
       5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=2
       NMODE=1
       5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=3
       NMODE=1
       5.11E-01  5.74E-02  1.75E-01  2.56E-01
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  1.00E-02  5.00E-01  1.00E+00
   AERSOL
     DISP=8
       1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=8
       1.00E+00  1.00E+00  1.00E+00  1.00E+00
DEFINE  TH228
       6.98E+02  3.30E-03  2.88E-04  2.60E+08  3.80E+05  0.00E+00
       0.00E+00  1.00E-02  3.00E+00  4.50E+08  7.90E+07
DEFINE   U234
       8.93E+07  1.73E-03  2.43E-05  1.30E+08  2.60E+05  0.00E+00
       0.00E+00  1.00E-02  3.00E+00  8.20E+07  6.50E+04
DEFINE   U236
       8.54E+09  1.57E-03  1.92E-05  6.70E+06  2.50E+05  0.00E+00
       0.00E+00  1.00E-02  3.00E+00  7.70E+07  6.10E+04
EOF
ISOTOPES  -1    52     1.00    0.500   1.00   0.00  NITAC
          SR90  4.25E-01      GRP1   8
         CE144  9.84E-03      GRP1   8
          CO60  6.45E-04      GRP1   8
         CS134  1.38E-03      GRP1   8
         CS137  1.37E-01      GRP1   8
          NB95  4.21E-04      GRP1   8
         RU103  7.87E-04      GRP1   8
         RU106  1.18E-02      GRP1   8
          ZR95  5.95E-04      GRP1   8
         TH228  2.39E-02      GRP1   8
          U234  1.55E-01      GRP1   8
          U235  8.09E-03      GRP1   8
```

```
           U236  1.27E-02       GRP1   8
           U238  7.51E-02       GRP1   8
          AM241  7.13E-04       GRP1   8
          NP237  1.04E-03       GRP1   8
          PU238  2.10E+04       GRP1   8
          PU239  2.37E-03       GRP1   8
          PU240  5.60E-04       GRP1   8
          PU241  2.28E-02       GRP1   8
          PU242  5.64E-08       GRP1   8
DISTKM
           NMODE=1  2797.00
PKGSIZ
           NJTAC      6.10
EOF
EOI
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7.1.3 Lexington, Kentucky to Portsmouth, Virginia

```
&& Edited Tue Apr 18 09:45:04 1995
&& _Nitric_Acid_LSA_Shipments_-_Lexington,_KY_to_Portsmouth,_VA_
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PARM 1 3 2 1 0
POPDEN    16.000    305.300   2043.700
PACKAGE
   LABGRP
       GRP1
SHIPMENT
   LABISO
       SR90       CE144       CO60       CS134       CS137       NB95
      RU103       RU106       ZR95       TH228        U234       U235
       U236        U238      AM241       NP237       PU238      PU239
      PU240       PU241      PU242
NORMAL
   NMODE=1
       7.210E-01  2.580E-01  2.100E-02  8.856E+01  4.032E+01  2.416E+01
       2.000E+00  1.000E+01  0.000E+00  1.100E-02  0.000E+00  0.000E+00
       0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
       2.000E+00  0.000E+00  0.000E+00  1.000E+01  4.700E+02  7.800E+02
       2.800E+03
ACCIDENT
   ARATMZ
       NMODE=1    2.400E-07    3.390E-07    3.390E-07
   SEVFRC
     NPOP=1
       NMODE=1
       5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=2
       NMODE=1
       5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=3
       NMODE=1
       5.11E-01  5.74E-02  1.75E-01  2.56E-01
RELEASE
   RFRAC
     GROUP=1
       0.00E+00  1.00E-02  5.00E-01  1.00E+00
   AERSOL
     DISP=8
       1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=8
       1.00E+00  1.00E+00  1.00E+00  1.00E+00
DEFINE  TH228
       6.98E+02  3.30E-03  2.88E-04  2.60E+08  3.80E+05  0.00E+00
       0.00E+00  1.00E-02  3.00E+00  4.50E+08  7.90E+07
DEFINE   U234
       8.93E+07  1.73E-03  2.43E-05  1.30E+08  2.60E+05  0.00E+00
       0.00E+00  1.00E-02  3.00E+00  8.20E+07  6.50E+04
DEFINE   U236
       8.54E+09  1.57E-03  1.92E-05  6.70E+06  2.50E+05  0.00E+00
       0.00E+00  1.00E-02  3.00E+00  7.70E+07  6.10E+04
EOF
ISOTOPES  -1   52     1.00    0.500   1.00   0.00  NITAC
          SR90  4.25E-01      GRP1   8
         CE144  9.84E-03      GRP1   8
          CO60  6.45E-04      GRP1   8
         CS134  1.38E-03      GRP1   8
         CS137  1.37E-01      GRP1   8
          NB95  4.21E-04      GRP1   8
         RU103  7.87E-04      GRP1   8
         RU106  1.18E-02      GRP1   8
          ZR95  5.95E-04      GRP1   8
         TH228  2.39E-02      GRP1   8
          U234  1.55E-01      GRP1   8
          U235  8.09E-03      GRP1   8
```

```
          U236  1.27E-02       GRP1   8
          U238  7.51E-02       GRP1   8
         AM241  7.13E-04       GRP1   8
         NP237  1.04E-03       GRP1   8
         PU238  2.10E-04       GRP1   8
         PU239  2.37E-03       GRP1   8
         PU240  5.60E-04       GRP1   8
         PU241  2.28E-02       GRP1   8
         PU242  5.64E-08       GRP1   8
DISTON
          NNODE=1  967.20
PKGS12
          NITAC      6.10
EOF
EOJ
```

7.1.4 Ogden, Utah to Columbus, Ohio

```
&& Edited Tue Apr 18 10:26:50 1995
&& _NITRIC ACID_LSA SHIPMENTS - Link 5 - Ogden UT to Columbus OH
&& _lnk5b.in4_
TITLE _LNK5B.IN4_
FORM UNIT
DIMEN 21 4 1 10 18
PARM 1 3 2 1 0
POPDEN     5.900    331.800   2111.700
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LAB15D
      SR90       CE144      CO60       CS134      CS137      NB95
      RU103      RU106      ZR95       TH228      U234       U235
      U236       U238       AM241      NP237      PU238      PU239
      PU240      PU241      PU242
NORMAL
   NMODE=1
      8.710E-01  1.170E-01  1.200E-02  8.856E+01  4.032E+01  2.416E+01
      2.000E+00  1.000E+01  0.000E+00  1.100E-02  0.000E+00  0.000E+00
      0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
      2.000E+00  0.000E+00  0.000E+00  1.000E+00  4.700E+02  7.800E+02
      2.800E+03
ACCIDENT
   ARATMZ
      NMODE=1    2.230E-07    5.150E-07    5.150E-07
   SEVFRC
     NPOP=1
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=2
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=3
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
RELEASE
   RFRAC
     GROUP=1
      0.00E+00  1.00E-02  5.00E-01  1.00E+00
   AERSOL
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
DEFINE  TH228
      6.98E+02  3.30E-03  2.88E-04  2.60E+08  3.80E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  4.50E+08  7.90E+07
DEFINE   U234
      8.93E+07  1.73E-03  2.43E-05  1.30E+08  2.60E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  8.20E+07  6.50E+04
DEFINE   U236
      8.54E+09  1.57E-03  1.92E-05  6.70E+06  2.50E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  7.70E+07  6.10E+04
EOF
ISOTOPES  -1   52    1.00    0.500   1.00    0.00  NITAC
         SR90  4.25E-01      GRP1   8
        CE144  9.84E-03      GRP1   8
         CO60  6.45E-04      GRP1   8
        CS134  1.38E-03      GRP1   8
        CS137  1.37E-01      GRP1   8
         NB95  4.21E-04      GRP1   8
        RU103  7.87E-04      GRP1   8
        RU106  1.18E-02      GRP1   8
         ZR95  5.95E-04      GRP1   8
        TH228  2.39E-02      GRP1   8
         U234  1.55E-01      GRP1   8
         U235  8.09E-03      GRP1   8
```

```
         U236  1.27E-02       GRP1   8
         U238  7.51E-02       GRP1   8
        AM241  7.13E-04       GRP1   8
        NP237  1.04E-03       GRP1   8
        PU238  2.10E-04       GRP1   8
        PU239  2.37E-03       GRP1   8
        PU240  5.60E-04       GRP1   8
        PU241  2.28E-02       GRP1   8
        PU242  5.64E-08       GRP1   8
DISTKM
         #MODE=1  2801.60
PKGSIZ
         NITAC     6.10
EOF
EOI
```

7.1.5 Columbus, Ohio to Port Elizabeth, New Jersey

```
&& Edited Tue Apr 18 10:11:00 1995
&& _NITRIC ACID_LSA SHIPMENTS - Link 6 - Columbus OH to Port Elizabeth NJ
&& _lnk6b.in4_
TITLE _LNK6B.IN4_
FORM UNIT
DIMEN 21 4 1 10 18
PARM 1 3 2 1 0
POPDEN    19.400    288.100   2346.800
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LABISO
      SR90       CE144      CO60       CS134      CS137      NB95
     RU103       RU106      ZR95       TH228       U234       U235
      U236        U238     AM241       NP237      PU238      PU239
     PU240       PU241     PU242
NORMAL
   NMODE=1
      6.930E-01  2.690E-01  3.800E-02  8.856E+01  4.032E+01  2.416E+01
      2.000E+00  1.000E+01  0.000E+00  1.100E-02  0.000E+00  0.000E+00
      0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
      2.000E+00  0.000E+00  0.000E+00  1.000E+00  4.700E+02  7.800E+02
      2.800E+03
ACCIDENT
   ARATMZ
      NMODE=1   3.620E-07   3.040E-07   3.040E-07
   SEVFRC
     NPOP=1
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=2
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=3
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
RELEASE
   RFRAC
     GROUP=1
      0.00E+00  1.00E-02  5.00E-01  1.00E+00
   AERSOL
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
DEFINE  TH228
      6.98E+02  3.30E-03  2.88E-04  2.60E+08  3.80E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  4.50E+08  7.90E+07
DEFINE   U234
      8.93E+07  1.73E-03  2.43E-05  1.30E+08  2.60E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  8.20E+07  6.50E+04
DEFINE   U236
      8.54E+09  1.57E-03  1.92E-05  6.70E+06  2.50E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  7.70E+07  6.10E+04
EOF
ISOTOPES  -1   52    1.00    0.500   1.00   0.00  NITAC
       SR90  4.25E-01      GRP1   8
      CE144  9.84E-03      GRP1   8
       CO60  6.45E-04      GRP1   8
      CS134  1.38E-03      GRP1   8
      CS137  1.37E-01      GRP1   8
       NB95  4.21E-04      GRP1   8
      RU103  7.87E-04      GRP1   8
      RU106  1.18E-02      GRP1   8
       ZR95  5.95E-04      GRP1   8
      TH228  2.39E-02      GRP1   8
       U234  1.55E-01      GRP1   8
       U235  8.09E-03      GRP1   8
```

```
          U236  1.27E-02      GRP1   8
          U238  7.51E-02      GRP1   8
          AM241  7.13E-04     GRP1   8
          NP237  1.04E-03     GRP1   8
          PU238  2.10E-04     GRP1   8
          PU239  2.37E-03     GRP1   8
          PU240  5.60E-04     GRP1   8
          PU241  2.28E-02     GRP1   8
          PU242  5.64E-08     GRP1   8
DISTKM
           MMODE=1  914.10
PKGSIZ
           NITAC      6.10
EOF
EOI
```

7.1.6 Columbus, Ohio to Baltimore, Maryland

```
&& Edited Tue Apr 18 10:23:15 1995
&& _NITRIC ACID_LSA SHIPMENTS - Link 7 - Columbus OH to Baltimore MD
&& _lnk7b.in4_
TITLE _LNK7B.IN4_
FORM UNIT
DIMEN 21 4 1 10 18
PARM 1 3 2 1 0
POPDEN    18.700    257.200    2330.200
PACKAGE
   LABGRP
      GRP1
SHIPMENT
   LABISO
      SR90      CE144     CO60      CS134     CS137     NB95
      RU103     RU106     ZR95      TH228     U234      U235
      U236      U238      AM241     NP237     PU238     PU239
      PU240     PU241     PU242
NORMAL
   NMODE=1
      6.270E-01  3.360E-01  3.700E-02  8.856E+01  4.032E+01  2.416E+01
      2.000E+00  1.000E+01  0.000E+00  1.100E-02  0.000E+00  0.000E+00
      0.000E+00  5.000E+01  2.000E+01  0.000E+00  1.000E+02  1.000E+02
      2.000E+00  0.000E+00  0.000E+00  1.000E+00  4.700E+02  7.800E+02
      2.800E+03
ACCIDENT
   ARATHZ
      NMODE=1   3.310E-07   3.070E-07   3.070E-07
   SEVFRC
     NPOP=1
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=2
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
     NPOP=3
      NMODE=1
      5.11E-01  5.74E-02  1.75E-01  2.56E-01
RELEASE
   RFRAC
     GROUP=1
      0.00E+00  1.00E-02  5.00E-01  1.00E+00
   AERSOL
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
   RESP
     DISP=8
      1.00E+00  1.00E+00  1.00E+00  1.00E+00
DEFINE  TH228
      6.98E+02  3.30E-03  2.88E-04  2.60E+08  3.80E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  4.50E+08  7.90E+07
DEFINE  U234
      8.93E+07  1.73E-03  2.43E-05  1.30E+08  2.60E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  8.20E+07  6.50E+04
DEFINE  U236
      8.54E+09  1.57E-03  1.92E-05  6.70E+06  2.50E+05  0.00E+00
      0.00E+00  1.00E-02  3.00E+00  7.70E+07  6.10E+04
EOF
ISOTOPES -1   52    1.00    0.500   1.00   0.00  KITAC
         SR90  4.25E-01      GRP1   8
        CE144  9.84E-03      GRP1   8
         CO60  6.45E-04      GRP1   8
        CS134  1.38E-03      GRP1   8
        CS137  1.37E-01      GRP1   8
         NB95  4.21E-04      GRP1   8
        RU103  7.87E-04      GRP1   8
        RU106  1.18E-02      GRP1   8
         ZR95  5.95E-04      GRP1   8
        TH228  2.39E-02      GRP1   8
         U234  1.55E-01      GRP1   8
         U235  8.09E-03      GRP1   8
```

```
        U236  1.27E-02      GRP1   8
        U238  7.51E-02      GRP1   8
       AM241  7.13E-04      GRP1   8
       NP237  1.04E-03      GRP1   8
       PU238  2.10E-04      GRP1   8
       PU239  2.37E-03      GRP1   8
       PU240  5.60E-04      GRP1   8
       PU241  2.28E-02      GRP1   8
       PU242  5.64E-08      GRP1   8
DISTKM
        MMCODE=1  680.70
PKGSIZ
        NITAC      6.10
EOF
EOI
```

7.2 DATA SET

Nitric Acid											
RADTRAN LIBRARY DATA											
A	B	C	D	E	F	G	H	I	J	K	L
	HALF-LIFE (DAYS)	PHOTON E (MEV/DIS)	CLOUDSHINE DOSE FACTOR (REM-M^3/CI-SEC)	CEDE INHAL. (REM/CI)	CEDE ING. (REM/CI)	FOOD TR. FACTOR	SOIL TR. FACTOR	DEP. VEL (M/SEC)	LUNG TYPE	1 YR LUNG DOSE - INH (REM/CI)	1 YR MARROW DOSE (REM/CI)
TH228	6.98E+02	3.30E-03	2.68E-04	2.6E+08	3.8E+05	0	0	0.01	3	4.5E+08	7.9E+07
U234	8.93E+07	1.73E-03	2.43E-05	1.3E+08	2.8E+05	0	0	0.01	3	1.2E+07	6.5E+04
U238	[illegible]	1.57E-03	1.92E-05	8.7E+08	2.5E+05	0	0	0.01	3	7.7E+07	6.1E+04
									1 - T1/2 LESS THAN 1 YR		
									2 - GAMMA AND BETA		
SOURCES:									3 - ALPHA		
B - ICRP 38											
C - ICRP 38											
D - DOE-0070											
E - DOE-0071											
F - DOE-0071											
G - RADTRAN MANUAL											
H - RADTRAN MANUAL											
I - RADTRAN MANUAL											
J - EMISSION TYPE											
K - DUNNING											
L - DUNNING											

7.3 HISTORICAL DOSE RATE DATA

Westinghouse Hanford Company **Internal Memo**

From: Sylvia Albertin
Phone: 373-2678 S5-60
Date: November 3, 1994
Subject: Dose Rates on Nitric Acid shipped to PUREX from UO3

To: Janet Green G2-02

cc: file

See attached Radiation Survey Report forms on Nitric Acid shipments from UO3 to PUREX. These forms are to help establish dose rate information on these shipments. The acid was shipped in batches of 2800 gallons in the UNH tanker.

Sylvia Albertin
PUREX/UO3 Radiological Control Manager

sma

see attachments

p. 1 of 2

Westinghouse Hanford Company

RADIATION SURVEY REPORT

Date	Time	Survey Number		Page
6/23/93	From 1300 to 1330	Nº 136951	HH	1 of 1

Area: 200 West — Room: N/A

RWP No.: HH-008 — Location: UNH Truck Pad

Description of Job: Survey of nitric acid truck for shipment to Purex

Check if appropriate: ☐ Personnel Contamination ☐ CAM Radiation Alarm ☐ Establish Dose Rates ☐ Radiation/Contamination Incident ☐ High Radiation Level Area ☐ "Special Survey" ☐ Property Release ☒ Road Shipment

Item No.	Description of Work Performed, Radiation Controls, and Measurements	Meter Deflection W/O	Meter Deflection W/C	Dist	CF	Dose Rate: beta (rads)	Dose Rate: gamma (rem)	Dose Rate: neutron	Direct beta	Direct alpha	Smear beta	Smear alpha	Smear
1	Cupola	N/A									<LD	<LD	N/A
2	Dockings & Mud Belts	N/A									<LD	<LD	N/A
3	Sides & Top of tank	N/A									<LD	<LD	N/A
4	Dose Rate Truck	<.5	<.5	C	1/1	<.5	<.5	N/A					
5	Cab Dose Rate	<.5	<.5	C	1/1	<.5	<.5	N/A					
6	Truck Pad	N/A									<LD	<LD	N/A
7	Truck Tires	N/A									<LD	<LD	N/A

☐ Continued on supplemental report form

Instrument(s) Used	☒ CP	☒ GM Pancake	☒ PAM
Serial No.(s)	6350	1553 / 1354	2319

Respiratory Protection Worn: ☐ Supplied Air ☐ Filter ☐ Other ☒ None

Estimated Personnel Dose Rates: Phase of Work / Based on Measurement(s) / Average Dose Rate / Limit Applying

RPT Exposure: N/A — Work Location Code: N/A

Did you ... job meeting for this work? ☒ N/A ☐ No ☐ Yes

Signature: [illegible] — HP No.: 0-2399

Reviewed By: [illegible signature] — Date: 6/24/93

BD 6000-816 (10-90)

RADIATION SURVEY REPORT (cont.)

Survey Number	F.C.	Team
№ 136951	N/A	N/A

Further Observations, Data, and Comments

N/A

DIAGRAMS OR SKETCHES

N/A

ADDITIONAL REPORTS COMPLETED

N/A

	Log No.		Log No.
Radiological Problem Report		Onsite Radioactive Shipment	
Skin Contamination Survey		Offsite Radioactive Shipment	
Personnel & Clothing Contamination Report		Routine Radioactive Shipment	
Radiation Survey Report		Sample Counter Log	

BD 6000-016 (10-94)

Westinghouse Hanford Company

RADIATION SURVEY REPORT

Date	Time	Survey Number	FC	Page
6-24-93	from 2320 to 2310	№ 136955	UU	1 of 2

Bldg	Area	Room
224 U	200 W	N/A

Description of Job: survey & release of Tanker Truck for shipment to Purex

RWP No.: UU-WHC-008 Location: UNH Truck Pad

Check if appropriate:
- [ ] Personnel Contamination
- [ ] CAM/Radiation Alarm
- [ ] Establish Dose Rates
- [ ] Radiological Contamination Incident
- [ ] High Radiation Level Area
- [ ] "Special Survey"
- [ ] Property Release
- [x] RAM Shipment

Item No.	P/S/R	Description of Work Performed, Radiation Controls, and Measurements	Meter Deflection W/O	Meter Deflection W/C	Dist	C/F	Dose Rate: beta (open) mrad/hr	Dose Rate: gamma (pen) mR/hr	Dose Rate: neutron mrem/hr	Contamination: Direct beta	Contamination: Direct alpha	Smear 100 cm²: beta (dpm)	Smear 100 cm²: alpha (dpm)	Smear: tritium
1		Cupola	N/A							→	→	<D	<D	N/A
2		sides & top of tank	N/A							→	→	<D	<D	N/A
3		Decking, hand rails, ladder	N/A							→	→	<D	<D	N/A
4		Dose rate Tank	<.5	<.5	c	1/1	<0.5	<0.5	N/A	→	→	→	→	→
5		Dose rate cab	<.5	<.5	c	1/1	<0.5	<0.5	N/A	→	→	→	→	→
6		Truck tires	N/A							→	→	<D	<D	N/A
N/A														

[ ] Check for personnel dose rate [ ] Continued on supplemental report form

Instrument(s) Used	[x] Tb	[x] E-140/Pancake	[x] PAM	[ ]	[ ] N/A	[ ]
Serial No.(s)	6350	1167 / 1898	2280			

ESTIMATED PERSONNEL DOSE RATES

Phase of Work	Based on Measurement(s)	Average Dose Rate	Limit Applying
N/A			WBP

Respiratory Protection Worn:
- [ ] Supplied Air
- [ ] Filter
- [ ] Other
- [x] None

RPT Exposure: N/A

Work Location Code: N/A

Did you attend a pre-job meeting for this work? [x] N/A [ ] No [ ] Yes

Signed: Laura Baumgartner
PR No. 83815

Reviewed By: [signature] Date: 7/6/93

BD-6000-070 (10-90)

RADIATION SURVEY REPORT (cont.) | Survey Number: № 136955 | FC: VU | Page 2 of 2

Further Descriptions, Data, and Comments

N/A

DIAGRAMS OR SKETCHES

N/A

ADDITIONAL REPORTS COMPLETED

Report	Log No.	Report	Log No.
Radiological Problem Report	N/A	Onsite Radioactive Shipment	N/A
Skin Contamination Survey	↓	Offsite Radioactive Shipment	↓
Personnel & Hosts Contamination Report	↓	Routine Radioactive Shipment	↓
Radiation Survey Report	↓	Sample Counter Log	↓

Westinghouse Hanford Company

RADIATION SURVEY REPORT

Date	Time	Survey Number	FY	Page
7-6-93	from 1920 to 2010	№ 136968	UU	1 of 2

Bldg	Area	Room
224U	200 W	N/A

RWP No. UU-WHC-008 | Location UNH Truck Pad

Description of Job: Survey of Nitric Acid Truck for shipment to Purex

Check if appropriate:
- ☐ Personnel Contamination
- ☐ CAM Radiation Alarm
- ☐ Establish Dose Rates
- ☐ Radiation/Contamination Incident
- ☐ High Radiation Level Area
- ☐ "Spot of Survey"
- ☐ Property Release
- ☑ RAM Shipment

Item No.	P E R (1)	Description of Work Performed, Radiation Controls, and Measurements	Meter Deflection WO	Meter Deflection WC	Dist	CF	Dose Rate: beta (non-pen) mrad/hr	Dose Rate: gamma (pen) mR/hr	Dose Rate: neutron mrem/hr	Direct (dpm): beta	Direct (dpm): alpha	Smear 100 cm²: beta (dpm)	Smear 100 cm²: alpha (dpm)	Smear 100 cm²: [illegible]
1		Cupola	N/A	N/A	—	/	—	—	—	—	→	<D	<D	N/A
2		Decking, rails, ladder	N/A	N/A	—	/	—	—	—	—	→	<D	<D	N/A
3		sides & top of Tank	N/A	N/A	—	/	—	—	—	—	→	<D	<D	N/A
4		sides of Truck	N/A	N/A	—	/	—	—	—	—	→	<D	<D	N/A
5		Tires	N/A	N/A	—	/	—	—	—	—	→	<D	<D	N/A
6		Dose Rate Truck	<.5	<.5	c	1/1	<.5	<.5	N/A	—	—	—	—	→
7		Dose Rate Cab	<.5	<.5	c	1/1	<.5	<.5	N/A	—	—	—	—	→
	N/A	—				/								→

1 Check for personnel dose rate ☐ Continued on supplemental report form

Instrument(s) Used	☑ CP	☑ G M [illegible]	☑ PAM	☐	☐ N/A	☐
Serial No.(s)	6312	1992 / 802	2895	←	N/A	→

Respiratory Protection Worn:
- ☐ Supplied Air
- ☐ Other
- ☐ Other ____
- ☑ None

ESTIMATED PERSONNEL DOSE RATES

Phase of Work	Based on Measurement(s)	Average Dose Rate	Limit Applying
←	N/A	→	WBP $ $
			WBP $ →
			WBP $ $

RPT Estimate: N/A | Work Location Code: N/A

Signature: Laura Baumgartner | Payroll No. 83915

Did you receive all Procedure R/P requirements for this work? ☑ Yes ☐ No (explain on reverse side)

Did you attend a pre-job meeting for this work? ☑ N/A ☐ No ☐ Yes

Reviewed By: [illegible signature] | Date: 7/9/93

[illegible form number]

RADIATION SURVEY REPORT (cont.)	Survey Number № 136968	TC UU	Page 2 of 2

Further Descriptions, Data, and Comment

N/A

DIAGRAMS OR SKETCHES

N/A

ADDITIONAL REPORTS COMPLETED

	Log No.		Log No.
Radiological Problem Report	N/A	Onsite Radioactive Shipment	N/A
Skin Contamination Survey	↓	Offsite Radioactive Shipment	↓
Personnel Effects Contamination Report	↓	Receive Radioactive Shipment	↓
Radiation Survey Report	↓	Sample Counter Log	↓

BD-6000-018R (10/90)

Westinghouse Hanford Company

RADIATION SURVEY REPORT

Date	Time	Survey Number		Rev
7-8-93	from 1715 to 1815	№ 136976	UU	1 of 2

Bldg	Area	Room
224 U	200 W	N/A

Description of Job: survey of Nitric Acid Truck for Shipment to Purex

RWP No. UU-WIIC-008 | Location: UNH Truck Pad

Check if appropriate:
- ☐ Personnel Contamination
- ☐ CAM Radiation Alarm
- ☐ Establish Dose Rates
- ☐ Radiological Contamination Incident
- ☐ High Rad Area Level Meter
- ☐ "Special Survey"
- ☐ Property Release
- ☒ Shipment

Item No.		Description of Work Performed & Radiation Control, and Measurements	Meter Distance WO	Meter Distance W/C	Dist	CF	DOSE RATE: beta-gamma reading	DOSE RATE: gamma (mR)	DOSE RATE: neutron	CONTAMINATION LEVELS: Direct: beta	CONTAMINATION LEVELS: Direct: alpha	Smear: beta-gamma	Smear: alpha	Smear: other
1		Cupola	N/A							→		<D	<D	N/A
2		Decking, rails, ladder	N/A							→		<D	<D	N/A
3		sides & top of tank	N/A							→		<D	<D	N/A
4		sides of truck	N/A							→		<D	<D	N/A
5		Tires	N/A							→		<D	<D	N/A
6		Dose Rate Truck	<.5	<.5	c.	1/1	<.5	<.5	N/A	→				
7		Dose Rate Cab	<.5	<.5	c	1/1	<.5	<.5	N/A	→				
		N/A →												

1 Check for personnel dose rate ☐ Continued on supplemental report form

Instrument(s) Used	☒	☒	☒	☐	☐	☐
Serial No.	6350	1397 / 811	2895	←	N/A	→

ESTIMATED PERSONNEL DOSE RATES

Phase of Work	Based on Measurement(s)	Average Dose Rate	Limit Applying
			WRP
←	N/A	→	WRP
			WRP

Respiratory Protection Worn
- ☐ Supplied Air
- ☐ Other
- ☐ Other
- ☒ None

Comments: N/A

Work Location Time: N/A

Did you attend a pre-job meeting for this work? ☒ N/A ☐ No ☐ Yes

Surveyor: Laura Bumgarner
HPT No. 83815

Reviewed By: [signature] Date: 7-14-93

BD 6000 016 (10)

7-22

RADIATION SURVEY REPORT (cont.)	Survey Number №136976	FC VU	Page 2 of 2

Further Description, Data, and Comment

N/A

DIAGRAMS OR SKETCHES

N/A

ADDITIONAL REPORTS COMPLETED

	Log No.		Log No.
Radiological Problem Report	N/A	Onsite Radioactive Shipment	N/A
Skin Contamination Survey	↓	Offsite Radioactive Shipment	↓
Personnel Effects Contamination Report	↓	Routine Radioactive Shipment	↓
Radiation Survey Report	↓	Sample Counter Log	

Westinghouse Hanford Company

RADIATION SURVEY REPORT

Date: 7-14-93
Time: From 2200 to 2230
Survey Number: № 137000
Page 1 of 2
Bldg: 224-4
Area: 200-West
Room: N/A
Description of Job: Survey and Release of a Full Tanker Truck Back To PUREX
N/A
RWP No: ... 008
Location: 224-4 Truck Pad

- [ ] Personnel Contamination
- [ ] CAM Radiation Alarm
- [ ] Establish Dose Rates
- [ ] Radiation/Contamination Incident
- [ ] High Radiation Level Area
- [ ] "Special Survey"
- [ ] Property Release
- [x] RAM Shipment

Item No.		Description of Work Performed, Radiation Controls, and Measurements	Meter Deflection W/O	Meter Deflection W/	Dist		Beta (non pen)	Gamma	Neutron	Direct beta	Direct alpha	Smear beta	Smear alpha	
1	N/A	Survey of Tanker Truck	<0.5	<0.5	1"		<0.5	<0.5	N/A	→	→	<50	<50	N/A
N/A		N/A	N/A	N/A	N/A		N/A	N/A		N/A	N/A	N/A	N/A	N/A

Instrument(s) Used: [x] CP; [x] GM Pancake; [x] PAM
Serial No(s): 6350; 1934 / 1995; 2895; N/A

ESTIMATED PERSONNEL DOSE RATES

Phase of Work	Based on Measurement(s)	Average Dose Rate	Time Applying
N/A			
N/A			
N/A			

Respiratory Protection Worn: [ ] Supplied Air [ ] Filter [ ] Other ______ [x] None

RPT Exposure: N/A
Work Location Code: N/A
Did you attend a pre-job meeting for the work? [x] N/A [ ] No [ ] Yes
Signed: D Richardson 96022
Reviewed By: [illegible] Date: 7/18/93

RADIATION SURVEY REPORT (cont.)	Survey Number № 137000	FC 44	Page 2 of 2

Further Description, Data, and Comment

N/A

DIAGRAMS OR SKETCHES

N/A

ADDITIONAL REPORTS COMPLETED

	Log No.		Log No.
Radiological Problem Report	N/A	Onsite Radioactive Shipment	200-EAST-10-Ankey
Skin Contamination Survey		Offsite Radioactive Shipment	N/A
Personnel Effects Contamination Report		Routine Radioactive Shipment	
Radiation Survey Report		Sample Counter Log	

Westinghouse Hanford Company

RADIATION SURVEY REPORT

Date	Time	Survey Number		Page
7-19-93	from 2200 to 2300	№ 129214	UU	1 of 2

Bldg	Area	Room
224U	200W	N/A

Description of Job: survey of Tanker Truck for Shipment to Purex

RWP No: UU-WHC-008

Location: Truck Pad

Check if appropriate:

- [ ] Personnel Contamination
- [ ] CAM Radiation Alarm
- [ ] Establish Dose Rates
- [ ] Radiation/Contamination Incident
- [ ] High Radiation Level Work
- [ ] "Special Survey"
- [ ] Property Release
- [x] RAM Shipment

Item No.	PER (1)	Description of Work Performed, Radiation Controls, and Measurements	Meter Deflection W/O	Meter Deflection W/C	Dist	CI	Dose Rate: beta	Dose Rate: gamma	Dose Rate: neutron	Direct: beta	Direct: alpha	Smear: beta	Smear: alpha	Smear: tritium
1		cupola	N/A							→	N/A	<D	<D	N/A
2		truck tank	N/A							→	N/A	<D	<D	N/A
3		sides of truck	N/A							→	N/A	<D	<D	N/A
4		rails, decking & ladder	N/A							→	N/A	<D	<D	N/A
5		Dose rate truck cab	N/A	<.5	c	1	N/A	<0.5	N/A	→				N/A
6		Dose rate tank	N/A	<.5	c	1	N/A	<0.5	N/A	→				N/A
7		wheels	N/A							→	N/A	<D	<D	N/A
	N/A													

1 Check for personnel dose rate [ ] Continued on supplemental report form

Instrument(s) Used	[x] CP	[x] Cutie Pie/Rate	[x] PAM	[ ]	[ ]	[ ]
Serial No.(s)	635D	1593 / 1358	2423	←	N/A	→

ESTIMATED PERSONNEL DOSE RATES

Phase of Work	Based on Measurement(s)	Average Dose Rate	Limit Applying
←		N/A	→

Respiratory Protection Worn:

- [ ] Supplied Air
- [ ] Filter
- [ ] Other
- [x] None

RPT Comments: N/A

Work Location Code: N/A

Signed: Laura Bumgarner
Payroll No.: 83815

Do you increase or reduce RWP requirements for this work? [x] No [ ] Yes Explain on reverse side

Did you attend a pre-job meeting for this work? [x] N/A [ ] No [ ] Yes

Reviewed By: [signature] Date: 7/27/93

RADIATION SURVEY REPORT (cont.)	Survey Number № 129214	FC UU	Page 2 of 2

Further Description, Data, and Comment

N/A

DIAGRAMS OR SKETCHES

N/A

ADDITIONAL REPORTS COMPLETED

	Log No.		Log No.
Radiological Problem Report	N/A	Onsite Radioactive Shipment	N/A
Skin Contamination Survey	↓	Offsite Radioactive Shipment	↓
Personnel Effects Contamination Report	↓	Routine Radioactive Shipment	↓
Radiation Survey Report	↓	Sample Counter Log	↓

[illegible] (10/90)

7.4 PUREX NITRIC ACID SHIPPING CATEGORY

Westinghouse Hanford Company — **Internal Memo**

From: Packaging Safety Engineering — 84100-94-JEM-056
Phone: 376-0298 G2-02
Date: January 4, 1994
Subject: PUREX NITRIC ACID SHIPPING CATEGORY

To: R. J. Thompson S6-17

cc:	R. W. Barker	G2-03
	K. S. Drivdahl	S6-18
	J. G. Field	G2-02
	D. G. Hamrick	S6-15
	D. G. Harlow	S6-17
	J. E. Maxwell	G2-03
	W. A. Peiffer	S6-18
	J. H. Portsmouth	G2-03
	R. J. Smith	G2-02
	J. W. Thornton	G2-03
	JEM Files/PSE Route/LB	

References:

(1) 49 CFR 173, Subpart I, "Radioactive Materials", 1992, *Code of Federal Regulations*, as amended.

(2) IAEA Safety Series, No. 6, Regulations for the Safe Transport of Radioactive Material, 1985 Edition (amended 1990), pp 5-6.

Background:

Transportation and Packaging is supporting the effort to ship 200,000 gallons of uranium-contaminated nitric acid from the Hanford Site as product. The shipment may involve marine transport. In order to identify the applicable hazardous material transportation requirements, calculations were performed to determine the radioactive shipping category of the acid.

Source term:

The concentrations of the radionuclides in the liquid were provided by PUREX Process Shutdown Projects (Attachment 1). The isotopic distributions for Uranium and Plutonium and the solution densities were also provided by PUREX Process Shutdown Projects. In order to be conservative, the calculations assume that ^{90}Sr is responsible for the total beta contribution. Values that were provided as "less than" were used in the calculations as if they were actual measured values. No precipation or separation of the solution is anticipated.

Hanford Operations and Engineering Contractor for the US Department of Energy

R. J. Thompson
Page 2
January 4, 1994

84100-94-JEM-056

Calculations:

Two sets of calculations were performed for each of four tanks: P2, P3, U1, and U2. The measured concentrations were compared to the DOT and IAEA limits for Low Specific Activity (LSA) radioactive material [49 CFR 173.403(n) and IAEA SS #6, Paragraph #131]. The calculations are documented in Attachments 2-9.

Results:

The calculations verified that the acid in each tank falls within the LSA limits.

The acid is excepted from fissile material requirements per 49 CFR 173.453 (e) and IAEA SS #6, Paragraph 560 (d) because the material does not contain more than 5 grams of fissile radionuclides per 10 liter volume. Fissile radionuclides are ^{238}Pu, ^{239}Pu, ^{241}Pu, ^{233}U and ^{235}U.

Very truly yours,

J. E. Mercado, Engineer
Packaging Safety Engineering

dmr

Attachments 9

84100-94-JEM-056
ATTACHMENT 1

PUREX LSA NITRIC ACID SAMPLE ANALYSES

	TANK P2	TANK P3	TANK U1	TANK U2
APPR/OTR	<1% SOLIDS, CLEAR, COLORLESS, <0.5 MR	<1% SOLIDS, CLEAR, YELLOW, <0.5 MR	<1% SOLIDS, CLEAR, LT BROWN, <0.5 MR *	<1% SOLIDS, COLORLESS
H+	7.0 M	9.4 M	INCOMPLETE	10.46 M
Pu	<[illegible] G/L	<1.34E-07 G/L	1.70E-06 G/L	1.77E-06 G/L
U	14.85 G/L	10.4 G/L	1.79E-04 G/L	1.21E-04 G/L
SpG	1.30	1.29	1.29	1.31
TOC	616 uG C/ML	490 uG C/ML	INCOMPLETE	1050 uG C/ML
TB	10.7 uCi/L	9.14 uCi/L	18.4 uCi/L	28.1 uCi/L
AT	8.87 uCi/L	7.31 uCi/L	2.46-02 uCi/L	2.40-02 uCi/L
CePr-144	<2.[illegible]E-01 uCi/L	<2.08E-01 uCi/L	[illegible]E-01 uCi/L	[illegible]E-01 uCi/L
Co-60	<2.78E-02 uCi/L	<4.[illegible]E-02 uCi/L	<1.08E-02 uCi/L	<4.08E-02 uCi/L
Cs-134	<2.01E-02 uCi/L	<2.14E-02 uCi/L	4.7E-02 uCi/L	8.1E-02 uCi/L
Cs-137	3.01E-02 uCi/L	4.25E-02 uCi/L	4.08 uCi/L	8.02 uCi/L
Nb-95	2.79E-02 uCi/L	<2.07E-02 uCi/L	<[illegible]E-02 uCi/L	<1.31E-02 uCi/L
Ru-103	<1.74E-02 uCi/L	<1.41E-02 uCi/L	<2.12E-02 uCi/L	<[illegible]E-02 uCi/L
RuRh-106	<2.5E-01 uCi/L	<3.11E-01 uCi/L	<[illegible]E-01 uCi/L	<7.79E-01 uCi/L
Zr-95	<[illegible]E-02 uCi/L	<2.40E-02 uCi/L	<1.37E-02 uCi/L	<[illegible]E-02 uCi/L
Th-228/Pb	1.[illegible] uCi/L	NONE DETECTED	<1.22E-04 uCi/L	NONE DETECTED
U-235	2.0[illegible]E-01 uCi/L	1.[illegible]E-01 uCi/L	NONE DETECTED	NONE DETECTED
F-	<2.12E03 uG/ML	<2.12E02 uG/ML	<2.09E02 uG/ML	<2.12E02 uG/ML
CL-	<4.24E03 uG/ML	<4.24E02 uG/ML	<4.19E02 uG/ML	<4.24E02 uG/ML
PO_4-	<2.12E03 uG/ML	<2.12E03 uG/ML	<2.09E03 uG/ML	<2.12E03 uG/ML
SO_4-	<2.12E03 uG/ML	<2.12E03 uG/ML	<2.09E03 uG/ML	<2.12E03 uG/ML
Am-241	<1.7E-05 uCi/ML	<1.7E-05 uCi/ML *	4.71E-05 uCi/ML *	4.41E-05 uCi/ML *
NP-237	[illegible]E-05 uCi/ML	[illegible]E-05 uCi/ML	4.2E-05 uCi/ML	<2.09E-05 uCi/ML
As	1.4E-02 uG/ML	8.0E-03 uG/ML	INCOMPLETE	INCOMPLETE
Se	INCOMPLETE	INCOMPLETE	INCOMPLETE	INCOMPLETE
Hg LIQ	10.4 uG/L	33.6 uG/L	INCOMPLETE	13.7 uG/L
Fe	86 uG/ML	43.3 uG/ML	INCOMPLETE	79.1 uG/ML
Ca	14 uG/ML	2.44 uG/ML	INCOMPLETE	10 uG/ML
Cr	12 uG/ML	8.40 uG/ML	INCOMPLETE	22.6 uG/ML
P	27.7 uG/ML	3.50 uG/ML	INCOMPLETE	34 uG/ML
Mg	1.4 uG/ML	NONE DETECTED	INCOMPLETE	5.0E-01 uG/ML
Na	34.2 uG/ML	3.38 uG/ML	INCOMPLETE	8.06 uG/ML
K	36.4 uG/ML	3.24 uG/ML	INCOMPLETE	NONE DETECTED
Ni	7.4 uG/ML	54.30 uG/ML	INCOMPLETE	12.4 uG/ML

* PER TELECON WITH [illegible] THOMPSON 12/22/93

Calculations by: J.E Mercado 12/20/93
Checked by: RJ Smith 12/27/93

NITRICP2.XLS
84100-94-JEM-056
ATTACHMENT 2

tank:	P2		density:	1.2571	g/ml		
nuclide	data	units	mCi/g	LSA limit	aggregat/limit		
Sr-90	10.7	uCi/L	8.51E-06	0.006	1.70E-03		
Ce/Pr-144	2.56E-01	uCi/L	2.04E-07	0.3	6.78E-07		
Co-60	2.75E-03	uCi/L	2.19E-09	0.3	7.29E-09		
Cs-134	2.81E-02	uCi/L	2.24E-08	0.3	7.48E-08		
Cs-137	3.01E-02	uCi/L	2.39E-08	0.3	7.98E-08		
Nb-95	2.78E-02	uCi/L	2.21E-08	0.3	7.37E-08		
Ru-103	1.74E-02	uCi/L	1.38E-08	0.3	4.61E-08		
Ru/Rh-106	2.50E-01	uCi/L	1.99E-07	0.3	6.63E-07		
Zr-95	3.63E-02	uCi/L	2.89E-08	0.3	9.63E-08		
Th-228	1.58	uCi/L	1.26E-06	0.0001	1.26E-02		
Am-241	1.70E-05	uCi/ml	1.35E-08	0.0001	1.35E-04		
Np-237	6.90E-05	uCi/ml	5.49E-08	0.0001	5.49E-04		
Pu	8.33E-08	g/l					
Pu-238 (fissile)	2.20E-11	g/l (calc)	3.79E-10	0.0001	3.79E-06		
Pu-239 (fissile)	8.71E-08	g/l (calc)	4.30E-09	0.0001	4.30E-05		
Pu-240	6.62E-09	g/l (calc)	1.03E-09	0.0001	1.03E-05		
Pu-241 (fissile)	5.06E-10	g/l (calc)	4.43E-08	0.005	8.85E-06		
Pu-242	3.27E-11	g/l (calc)	1.02E-13	0.0001	1.02E-09		
Uranium	14.88	g/l					
U-234	1.64E-03	g/l (calc)	8.11E-09	0.005	1.62E-06		
U-235 (fissile)	1.38E-01	g/l (calc)	2.30E-07	0.005	4.60E-05		
U-236	1.29E-02	g/l (calc)	6.44E-07	0.005	1.29E-04		
U-238	1.48E+01	g/l (calc)	3.88E-08	0.3	1.29E-06		
					1.68E-02	<1 ==> LSA	

Calculations by: J. E. Mercado
Checked by: [illegible] 12/27/93

NITRICP3.XLS
84100-94-JEM-056
ATTACHMENT 3

tank:	F3		density:	1.291	g/ml		
nuclide	data	units	mCi/g	DEA limit	equivalent/limit		
Sr-90	9.14	uCi/L	7.08E-06	0.005	1.42E-03		
Ce/Pr-144	2.06E-01	uCi/L	1.62E-07	0.3	5.40E-07		
Co-60	4.28E-02	uCi/L	3.30E-08	0.3	1.10E-07		
Cs-134	1.16E-02	uCi/L	1.07E-08	0.3	3.58E-08		
Cs-137	4.25E-02	uCi/L	3.29E-08	0.3	1.10E-07		
Nb-95	2.07E-02	uCi/L	1.60E-08	0.3	5.34E-08		
Ru-103	1.41E-02	uCi/L	1.09E-08	0.3	3.64E-08		
Ru/Rh-106	3.11E-01	uCi/L	2.41E-07	0.3	8.03E-07		
Zr-95	3.48E-02	uCi/L	2.70E-08	0.3	8.99E-08		
Th-228	0	uCi/L	0.00E+00	0.0001	0.00E+00		
Am-241	1.70E-05	uCi/ml	1.32E-08	0.0001	1.32E-04		
Np-237	6.08E-05	uCi/ml	4.69E-08	0.0001	4.69E-04		
Pu	1.34E-07	g/l					
Pu-238 (fissile)	4.02E-11	g/l (calc)	5.29E-10	0.0001	5.29E-06		
Pu-239 (fissile)	1.26E-07	g/l (calc)	6.01E-09	0.0001	6.01E-05		
Pu-240	8.07E-09	g/l (calc)	1.44E-09	0.0001	1.44E-05		
Pu-241 (fissile)	7.27E-10	g/l (calc)	6.19E-08	0.005	1.24E-05		
Pu-242	4.70E-11	g/l (calc)	1.42E-13	0.0001	1.42E-09		
Uranium	10.4	g/l					
U-234	1.14E-03	g/l (calc)	5.49E-06	0.005	1.10E-03		
U-235 (fissile)	1.98E-01	uCi/L	1.53E-07	0.005	3.07E-05		
U-236	8.34E-03	g/l (calc)	4.36E-07	0.005	8.73E-05		
U-238	1.03E+01	g/l (calc)	2.63E-08	0.3	8.77E-08		
					9.34E-03	<1 ==> 10A	

12/28/93

Calculations by: J.E. Mercado
Checked by: [signature] 12/29/93

NITRICU1.XLS
84100-94-JEM-056
ATTACHMENT 4

tank:	U1		density:	1.39	g/ml		
nuclide	data	units	mCi/g	LSA limit	amount/limit		
Sr-90	15.4	uCi/L	1.27E-05	0.005	2.54E-03		
Ce/Pr-144	3.90E-01	uCi/L	2.71E-07	0.3	9.04E-07		
Co-60	1.09E-02	uCi/L	8.45E-09	0.3	2.82E-08		
Cs-134	4.70E-02	uCi/L	3.64E-08	0.3	1.21E-07		
Cs-137	4.03E+00	uCi/L	3.12E-06	0.3	1.04E-05		
Nb-95	9.25E-03	uCi/L	7.17E-09	0.3	2.39E-08		
Ru-103	2.12E-02	uCi/L	1.64E-08	0.3	5.48E-08		
Ru/Rh-106	3.45E-01	uCi/L	2.67E-07	0.3	8.91E-07		
Zr-95	1.37E-02	uCi/L	1.06E-08	0.3	3.54E-08		
Th-228	1.22E-04	uCi/L	9.46E-11	0.0001	9.46E-07		
Am-241	4.71E-05	uCi/ml	3.65E-08	0.0001	3.65E-04		
Np-237	4.20E-05	uCi/ml	3.26E-08	0.0001	3.26E-04		
Pu	2.70E-06	g/l					
Pu-238 (fissile)	8.10E-10	g/l (calc)	1.07E-08	0.0001	1.07E-04		
Pu-239 (fissile)	2.52E-06	g/l (calc)	1.21E-07	0.0001	1.21E-03		
Pu-240	1.83E-07	g/l (calc)	2.90E-08	0.0001	2.90E-04		
Pu-241 (fissile)	1.46E-09	g/l (calc)	1.25E-08	0.005	2.50E-06		
Pu-242	8.48E-10	g/l (calc)	2.37E-12	0.0001	2.37E-08		
Uranium	1.15E-04	g/l					
U-234	1.27E-08	g/l (calc)	6.08E-11	0.005	1.22E-08		
U-235 (fissile)	1.08E-06	g/l (calc)	1.72E-12	0.005	3.45E-10		
U-236	9.29E-08	g/l (calc)	4.33E-12	0.005	8.66E-10		
U-238	1.14E-04	g/l (calc)	2.91E-11	0.3	9.71E-11		
					5.10E-03	<1 ==> LSA	

12/28/93

Calculations by: J. E. Mercado
Checked by: [signature] 12/29/93

NITRICU2.XLS
84100-94-JEM-056
ATTACHMENT 5

tank:	U2		density:	1.31	g/ml		
nuclide	data	units	mCi/g	LSA limit	[illegible]		
Sr-90	28.1	uCi/L	2.15E-05	0.005	4.30E-03		
Ce/Pr-144	6.50E-01	uCi/L	4.96E-07	0.3	1.65E-06		
Co-60	4.08E-02	uCi/L	3.11E-08	0.3	1.04E-07		
Cs-134	9.10E-02	uCi/L	6.95E-08	0.3	2.32E-07		
Cs-137	9.02E+00	uCi/L	6.89E-06	0.3	2.30E-05		
Nb-95	1.31E-02	uCi/L	1.00E-08	0.3	3.33E-08		
Ru-103	5.20E-02	uCi/L	3.97E-08	0.3	1.32E-07		
Ru/Rh-106	7.78E-01	uCi/L	5.94E-07	0.3	1.98E-06		
Zr-95	3.93E-02	uCi/L	3.00E-08	0.3	1.00E-07		
Th-228	0	uCi/L	0.00E+00	0.0001	0.00E+00		
Am-241	4.41E-05	uCi/ml	3.37E-08	0.0001	3.37E-04		
Np-237	2.06E-05	uCi/ml	1.57E-08	0.0001	1.57E-04		
Pu	1.77E-06	g/l					
Pu-238 (fissile)	5.31E-10	g/l (calc)	6.89E-09	0.0001	6.89E-05		
Pu-239 (fissile)	1.65E-06	g/l (calc)	7.82E-08	0.0001	7.82E-04		
Pu-240	1.07E-07	g/l (calc)	1.87E-08	0.0001	1.87E-04		
Pu-241 (fissile)	9.80E-09	g/l (calc)	9.06E-07	0.005	1.81E-04		
Pu-242	9.21E-10	g/l (calc)	1.85E-12	0.0001	1.85E-08		
Uranium	1.21E-04	g/l					
U-234	1.33E-08	g/l (calc)	6.30E-11	0.005	1.26E-08		
U-235 (fissile)	1.11E-06	g/l (calc)	1.79E-12	0.005	3.57E-10		
U-236	1.04E-07	g/l (calc)	5.00E-12	0.005	1.00E-09		
U-238	1.20E-04	g/l (calc)	3.02E-11	0.3	1.01E-10		
					6.01E-03	< 1 ==> LSA	

12/28/93

Calculations by: [illegible] 1/3/94
Checked by: [illegible] 1/3/94

NIAEAP3.XLS
84100-94-JEM-056
ATTACHMENT 7

tank:	[illegible]		density:	1.291	g/ml	
nuclide	conc.	units	mCi/g	NASA A2 (Ci)	NASA LSA limit mCi/g	actual/limit
Sr-90	9.14	uCi/L	7.08E-06	2	2.00E-02	3.54E-04
Ce/Pr-144	2.09E-01	uCi/L	1.62E-07	6	5.00E-02	3.24E-06
Co-60	4.28E-02	uCi/L	3.30E-08	10	1.00E-01	3.30E-07
Cs-134	2.16E-03	uCi/L	1.67E-09	10	1.00E-01	1.67E-07
Cs-137	4.28E-02	uCi/L	3.29E-08	10	1.00E-01	3.29E-07
Nb-95	2.07E-02	uCi/L	1.60E-08	20	2.00E-01	8.02E-08
Ru-103	1.41E-02	uCi/L	1.09E-08	20	2.00E-01	5.46E-08
Ru/Rh-106	3.11E-01	uCi/L	2.41E-07	6	5.00E-02	4.82E-06
Zr-95	3.48E-02	uCi/L	2.70E-08	20	2.00E-01	1.35E-07
Th-228	0	uCi/L	0.00E+00	1.00E-02	1.00E-04	0.00E+00
Am-241	1.70E-05	uCi/ml	1.32E-05	8.00E-03	8.00E-05	1.83E-04
Np-237	6.06E-05	uCi/ml	4.69E-05	5.00E-03	5.00E-05	9.38E-04
Pu	1.34E-07	g/l				
Pu-238 (fissile)	4.02E-11	g/l (calc)	8.29E-10	6.00E-03	6.00E-05	1.08E-08
Pu-239 (fissile)	1.25E-07	g/l (calc)	6.01E-06	6.00E-03	6.00E-05	1.20E-04
Pu-240	8.07E-09	g/l (calc)	1.44E-09	6.00E-03	6.00E-05	2.88E-06
Pu-241 (fissile)	7.27E-10	g/l (calc)	6.19E-08	2.00E-01	2.00E-03	3.10E-05
Pu-242	4.70E-11	g/l (calc)	1.42E-13	5.00E-03	6.00E-05	2.84E-09
Uranium	10.4	g/l				
U-234	1.14E-03	g/l (calc)	5.49E-06	2.00E-02	2.00E-04	2.75E-02
U-235 (fissile)	1.96E-01	uCi/L	1.53E-07	unlimited	n/a	0.00E+00
U-236	3.94E-03	g/l (calc)	4.36E-07	2.00E-02	2.00E-04	2.18E-03
U-238	1.02E+01	g/l (calc)	2.63E-08	unlimited	n/a	0.00E+00
						3.14E-02
						<1 ==> LSA

1/3/94

Calculations by: J.E. [illegible] 1/4/94
Checked by: [illegible] 1/5/94

NIAEAP3.XLS
84100-94-JEM-056
ATTACHMENT 7

tank:	P3		density:	1.291	g/ml	
nuclide	data	units	mCi/g	IAEA A2 (Ci)	IAEA LSA limit mCi/g	[illegible]
Sr-90	8.14	uCi/L	7.09E-06	2	2.00E-02	3.54E-04
Ce/Pr-144	2.09E-01	uCi/L	1.62E-07	6	6.00E-02	2.24E-06
Co-60	4.25E-02	uCi/L	3.30E-08	10	1.00E-01	3.30E-07
Cs-134	2.19E-02	uCi/L	1.57E-08	10	1.00E-01	1.47E-07
Cs-137	4.29E-02	uCi/L	3.29E-08	10	1.00E-01	3.29E-07
Nb-95	2.07E-02	uCi/L	1.60E-08	20	2.00E-01	8.02E-08
Ru-103	1.41E-02	uCi/L	1.09E-08	20	2.00E-01	5.46E-08
Ru/Rh-106	3.11E-01	uCi/L	2.41E-07	6	6.00E-02	4.02E-06
Zr-95	3.48E-02	uCi/L	2.70E-08	20	2.00E-01	1.35E-07
Th-228	0	uCi/L	0.00E+00	1.00E-02	1.00E-04	0.00E+00
Am-241	1.70E-05	uCi/ml	1.32E-08	6.00E-03	6.00E-05	2.20E-04
Np-237	6.08E-05	uCi/ml	4.88E-08	5.00E-03	5.00E-05	9.38E-04
Pu	1.34E-07	g/l				
Pu-238 (fissile)	4.02E-11	g/l (calc)	5.29E-10	5.00E-03	5.00E-05	1.06E-05
Pu-239 (fissile)	1.25E-07	g/l (calc)	6.01E-09	5.00E-03	5.00E-05	1.20E-04
Pu-240	8.07E-09	g/l (calc)	1.44E-09	5.00E-03	5.00E-05	2.88E-05
Pu-241 (fissile)	7.27E-10	g/l (calc)	6.19E-08	2.00E-01	2.00E-03	3.10E-05
Pu-242	4.70E-11	g/l (calc)	1.43E-12	5.00E-03	5.00E-05	2.84E-08
Uranium	10.4	g/l				
U-234	1.14E-03	g/l (calc)	5.49E-06	2.00E-02	2.00E-04	2.75E-02
U-235 (fissile)	1.93E-01	uCi/L	1.53E-07	unlimited	n/a	0.00E+00
U-236	2.94E-03	g/l (calc)	4.30E-07	2.00E-02	2.00E-04	2.15E-03
U-238	1.03E+01	g/l (calc)	2.83E-06	unlimited	n/a	0.00E+00
						3.14E-02
						<1 => LSA

1/3/94

Calculations by: J.E. Menard 1/3/94 NIAEAU1.XLS
Checked by: R.J. Smith 1/3/94

84100-94-JEM-056
ATTACHMENT 8

tank:	U1		density:	1.39	g/ml	
nuclide	conc	units	mCi/g	IAEA A2 (Ci)	IAEA LSA limit mCi/g	actual/limit
Sr-90	16.4	uCi/L	1.27E-05	2	0.02	6.36E-04
Ce/Pr-144	3.50E-01	uCi/L	2.71E-07	5	0.05	5.43E-06
Co-60	1.08E-02	uCi/L	8.45E-09	10	0.1	8.45E-08
Cs-134	4.70E-02	uCi/L	3.84E-08	10	0.1	3.84E-07
Cs-137	4.03E+00	uCi/L	3.12E-06	10	0.1	3.12E-05
Nb-95	9.25E-03	uCi/L	7.17E-09	20	0.2	3.59E-08
Ru-103	2.13E-02	uCi/L	1.64E-08	20	0.2	8.22E-08
Ru/Rh-106	3.45E-01	uCi/L	2.67E-07	5	0.05	5.35E-06
Zr-95	1.37E-02	uCi/L	1.06E-08	20	0.2	5.31E-08
Th-228	1.22E-04	uCi/L	9.46E-11	1.00E-02	0.0001	9.46E-07
Am-241	4.71E-06	uCi/ml	3.65E-09	5.00E-03	0.00005	7.30E-04
Np-237	4.20E-06	uCi/ml	3.26E-09	5.00E-03	0.00005	6.51E-04
Pu	3.70E-08	g/l				
Pu-238 (fissile)	8.10E-10	g/l (calc)	1.07E-08	2.00E-03	0.00005	2.13E-04
Pu-239 (fissile)	2.63E-05	g/l (calc)	1.21E-07	5.00E-03	0.00005	2.42E-03
Pu-240	3.63E-07	g/l (calc)	2.90E-08	5.00E-03	0.00005	5.80E-04
Pu-241 (fissile)	1.45E-08	g/l (calc)	1.25E-06	2.00E-01	0.002	6.24E-04
Pu-242	8.48E-10	g/l (calc)	2.87E-12	5.00E-03	0.00005	5.73E-08
Uranium	1.16E-04	g/l				
U-234	1.27E-08	g/l (calc)	6.09E-11	2.00E-02	0.0002	3.04E-07
U-235 (fissile)	1.06E-06	g/l (calc)	1.72E-12	unlimited	n/a	0.00E+00
U-236	9.89E-08	g/l (calc)	4.83E-12	2.00E-02	2.00E-04	2.42E-08
U-238	1.14E-04	g/l (calc)	2.91E-11	unlimited	n/a	0.00E+00
						5.90E-03
						<1 ==> LSA

1/3/94

Calculations by: E-Mussl 1/3/94
Checked by: [illegible] 1/3/94

MIAEAU2.XLS
84100-94-JEH-056
ATTACHMENT 9

tank:	U2		density:	1.31	g/ml	
nuclide	conc.	units	mCi/g	IAEA A2 (Ci)	IAEA LSA limit mCi/g	conc/limit
Sr-90	22.1	uCi/L	2.15E-05	2	2.00E-02	1.07E-03
Ce/Pr-144	6.30E-01	uCi/L	4.96E-07	9	5.00E-02	9.92E-06
Co-60	4.08E-02	uCi/L	3.11E-08	10	1.00E-01	3.11E-07
Cs-134	9.10E-02	uCi/L	6.95E-08	10	1.00E-01	6.95E-07
Cs-137	8.02E+00	uCi/L	6.12E-06	10	1.00E-01	6.12E-05
Nb-95	1.31E-02	uCi/L	1.00E-08	20	2.00E-01	5.00E-08
Ru-103	5.20E-02	uCi/L	3.97E-08	20	2.00E-01	1.98E-07
Ru/Rh-106	7.78E-01	uCi/L	5.94E-07	5	5.00E-02	1.19E-05
Zr-95	2.62E-02	uCi/L	2.00E-08	20	2.00E-01	1.00E-07
Th-228	0	uCi/L	0.00E+00	1.00E-02	1.00E-04	0.00E+00
Am-241	4.41E-05	uCi/ml	3.37E-08	5.00E-03	5.00E-05	6.73E-04
Np-237	2.06E-05	uCi/ml	1.57E-08	5.00E-03	5.00E-05	3.15E-04
Pu	1.77E-06	g/l				
Pu-238 (fissile)	9.31E-10	g/l (calc)	6.69E-09	5.00E-03	5.00E-05	1.34E-04
Pu-239 (fissile)	1.65E-06	g/l (calc)	7.82E-08	5.00E-03	5.00E-05	1.56E-03
Pu-240	1.07E-07	g/l (calc)	1.37E-08	5.00E-03	5.00E-05	2.74E-04
Pu-241 (fissile)	5.90E-09	g/l (calc)	5.06E-07	2.00E-01	2.00E-03	4.03E-04
Pu-242	6.21E-10	g/l (calc)	1.85E-12	5.00E-03	5.00E-05	3.70E-08
Uranium	1.21E-04	g/l				
U-234	1.35E-08	g/l (calc)	6.30E-11	2.00E-02	2.00E-04	3.15E-07
U-235 (fissile)	1.11E-06	g/l (calc)	1.79E-12	unlimited	n/a	0.00E+00
U-236	1.04E-07	g/l (calc)	5.00E-12	2.00E-02	2.00E-04	2.50E-08
U-238	1.20E-04	g/l (calc)	3.07E-11	unlimited	n/a	0.00E+00
						4.83E-03
						<1 ==> LSA

1/3/94