APPENDIX H
LONG-TERM PERFORMANCE ASSESSMENT RESULTS

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A primary focus of the assessment of long-term performance[1] is estimation of human health impacts for the four alternatives proposed for remediation or closure of the site (Sitewide Removal, Sitewide Close-In-Place, Phased Decisionmaking, and No Action). This appendix presents details of the estimates of health impacts for both radiological and hazardous chemical constituents.

The first section of this appendix presents an introduction that first briefly recapitulates the definition of each alternative. The locations and activities associated with each receptor are also described. The second section presents the analysis of the Sitewide Removal Alternative. The third section describes analyses performed for alternatives for which radioactive materials remain onsite – the Sitewide Close-In-Place Alternative and the No Action Alternative. The information is presented in three subsections.

- *Impacts given indefinite continuation of institutional controls*: These impacts take credit for institutional controls to prevent access to the waste management areas, to maintain the integrity of structures such as the Main Plant Process Building, together with engineered features such as erosion control structures and engineered caps. See Section H.2.2.1 for further definition of indefinite continuation of institutional controls.

- *Impacts assuming loss of institutional controls*: In this case it is assumed that institutional controls will be lost after 100 years. (This assumption is conservatively adapted from U.S. Department of Energy (DOE) Manual 435.1-1, which states that for performance assessments prepared by DOE for low-level radioactive waste disposal facilities, "institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure" [DOE 1999]). In particular, it is assumed that there are no more efforts to contain radionuclides and hazardous chemicals within the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farms. Conservatively, these are assumed to fail as soon as institutional controls fail. This subsection reexamines the analysis for the offsite receptors and also considers failure of institutional controls that would allow intruders to enter the Western New York Nuclear Service Center (WNYNSC) and various waste management areas. See Section H.2.2.2 for further definition of loss of institutional controls.

- *Loss of institutional controls leading to unmitigated erosion*: The offsite receptors are again reanalyzed. In addition, this section considers onsite receptors on the banks of Franks Creek and Erdman Brook who would be exposed to direct radiation shine from eroded surfaces. See Section H.2.2.2.6 for further discussion of unmitigated erosion.

Finally, there is a section that presents the results of sensitivity analyses related to human health impacts.

Note that this appendix is intended only to present the results of the long-term performance assessment. Interpretations, comparisons with regulatory guidelines, and comments on acceptability are provided in Appendix L.

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[1] *"Long-term" means until after peak dose or risks have occurred and ranges up to 100,000 years. Note that the analysis assumes that radioactive decay continues to occur throughout this period.*

H.1 Introduction

A set of four alternatives has been proposed to investigate the effects of a range of site closure plans. In addition, a set of potential human receptors has been selected as the basis for estimation of health impacts. The alternatives and receptors are described in the following paragraphs.

H.1.1 The Waste Management Areas

For the convenience of the reader, and to facilitate the discussion of alternatives and receptors, a brief description of the Waste Management Areas (WMAs) is included in **Table H–1** and the locations of WMAs 1-10 are plotted in **Figure H–1**.[2] A detailed description of the WMAs is provided in Appendix C, Section C.2.

Table H–1 Description of Waste Management Areas

Area	*Description*
WMA 1	Main Plant Process Building and Vitrification Area
WMA 2	Low-Level Waste Treatment Facility Area
WMA 3	Waste Tank Farm Area, including High-Level Waste Tanks 8D-1, 8D-2, 8D-3, and 8D-4.
WMA 4	Construction and Demolition Debris Landfill [a]
WMA 5	Waste Storage Area [a]
WMA 6	Central Project Premises [a]
WMA 7	NRC-licensed Disposal Area (NDA) and Associated Facilities
WMA 8	State-licensed Disposal Area (SDA) and Associated Facilities
WMA 9	Radwaste Treatment System Drum Cell [a]
WMA 10	Support and Services Area [a]
WMA 11	Bulk Storage Warehouse and Hydrofracture Test Well Area [a]
WMA 12	Balance of Site [a] (includes steam sediment)
North Plateau Groundwater Plume	A zone of groundwater contamination that extends across WMAs 1, 2, 3, 4, and 5. See Appendix C, Figure C–12, of the EIS.
Cesium Prong	An area of surface soil contamination extending from the Main Plant Process Building in WMA 1 northwest to a distance of 6.0 kilometers (3.7 miles) beyond the boundary of the West Valley Demonstration Project. See Appendix C, Figure C–14, of the EIS.

WMA = Waste Management Area.

[a] These areas do not appear explicitly in any of the results below because they have either already been remediated or do not contain sufficient inventories of radioactive materials or hazardous chemicals to contribute to risks above the noise level.

[2] *WMA 11 is not shown in Figure H–1. It contains two self-contained areas in the southeast corner of WNYNSC outside the 84 hectares (200 acres) of the Project Premises and the SDA. And outside the area shown in Figure H–1. WMA 12 is not explicitly shown: it is the balance of the site.*

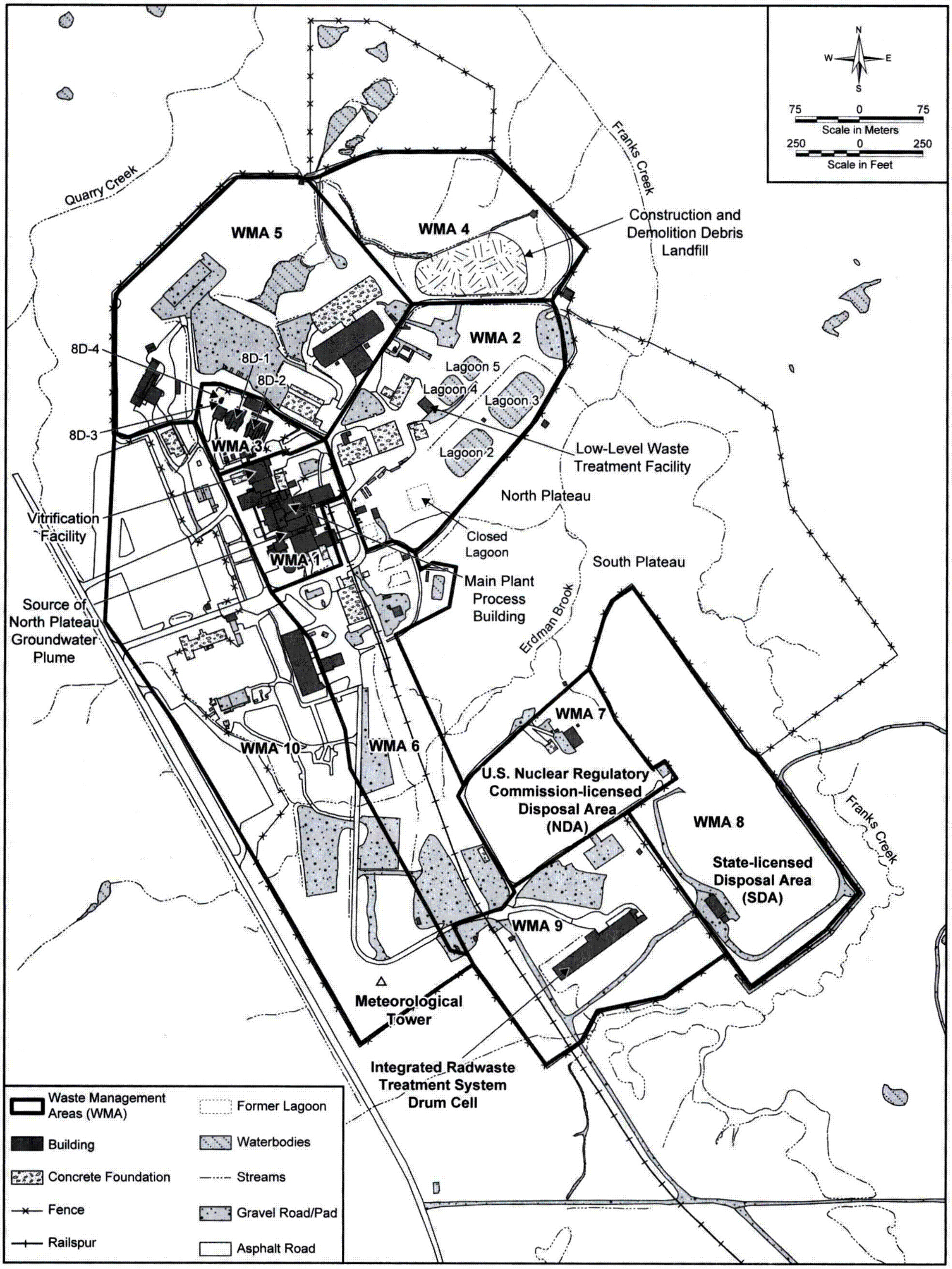

Figure H–1 Location of Waste Management Areas

H.1.2 The Four Alternatives

The alternatives analyzed in this environmental impact statement (EIS) are discussed in detail in Chapter 2 and in Appendix C. In summary, these alternatives are:

- **Sitewide Removal** – all site facilities (see Table 2–2) would be removed. Soils, waters, etc. would be removed or remediated. All radioactive, hazardous, and mixed waste would be characterized, packaged as necessary, and shipped offsite for disposal. The Sitewide Removal Alternative requires temporary onsite storage for the vitrified high-level radioactive waste canisters while waiting for a Federal waste repository to open. Since this alternative is estimated to require approximately 60 years to be completed, it is anticipated that the canisters would be shipped offsite as part of this alternative. The entire WNYNSC would be available for release for unrestricted use. The Sitewide Removal Alternative is one type of bounding alternative that would remove facilities and contamination so that the site could be reused with no restrictions.

  The U.S. Nuclear Regulatory Commission (NRC)-licensed portion of the site would meet the NRC License Termination Rule (10 *Code of Federal Regulations* [CFR] 20.1402). The State-licensed portion of the site (the SDA) would meet similar State criteria. Residual hazardous contaminants would meet applicable State and Federal standards. A final status survey performed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) and the Resource Conservation and Recovery Act (RCRA) guidance would demonstrate that the remediated site meets the standards for unrestricted release, which would be confirmed by independent verification surveys.

- **Sitewide Close-In-Place** – key site facilities (see Table 2–2 and Section 2.4.1.1) would be closed in place. The residual radioactivity in facilities with larger inventories of long-lived radionuclides would be isolated by specially-designed closure structures and engineered barriers. The Sitewide Close-In-Place Alternative is another type of bounding alternative where the major facilities and sources of contamination would be managed at its current location.

- **Phased Decisionmaking (Preferred Alternative)** – the decommissioning would be completed in two phases:

  - Phase 1 decisions would include removal of all WMA 1 facilities (Main Plant Process Building, Vitrification Facility, and 01-14 Building), the lagoons in WMA 2, and the source area of the North Plateau Groundwater Plume. No decommissioning or long-term management decisions would be made for the Waste Tank Farm and its support facilities, the Construction and Demolition Debris Landfill (CDDL), the nonsource area of the North Plateau Groundwater Plume, or the NRC-licensed Disposal Area (NDA). The State-licensed Disposal Area (SDA) would continue under active management consistent with its New York State Department of Health (NYSDOH) license and a New York State Department of Environmental Conservation (NYSDEC) permit for up to 30 years. Phase 1 activities would also include additional characterization of site contamination and studies to provide information to support additional evaluations to determine the approach to be used to complete the decommissioning.

  - Phase 2 would complete the decommissioning or long-term management decisionmaking, following the approach determined through the additional evaluations to be the most appropriate.

- **No Action**—no actions toward decommissioning would be taken. The No Action Alternative would involve the continued management and oversight of the remaining portion of the WNYNSC and all facilities located on the WNYNSC property as of the starting point of this EIS.

Table H–2 summarizes the important features of the alternatives that are analyzed in the EIS.

H.1.3 The Receptors

The approach used for estimation of health impacts is development and analysis of a set of scenarios comprising sources of hazardous material, facility closure designs, environmental transport pathways, and human receptor locations and activities. A detailed description of this approach is presented in Appendix D. This section summarizes the selection of receptors, and describes the locations and activities that are the primary attributes contributing to potential impacts on receptors.

H.1.3.1 Summary List – Receptor Locations

Receptor locations are selected based on comparison of environmental transport pathways, current demography, and regulatory guidance. Receptor locations considered in the analysis include those located outside the boundaries of the WNYNSC (offsite) and those located within the boundaries proposed for control under a given alternative (onsite). The reasons for the choice of receptors are given in Appendix D, Section D.3.1.3, which also contains a more detailed description of those receptors than does the summary below. Table D–4 contains a summary of receptor exposure modes. Offsite receptors would be affected for both assumed continuation of institutional controls and assumed loss of institutional controls. Onsite receptors are considered under assumed loss of institutional controls. Offsite receptor locations are:

- Cattaraugus Creek – just downstream of Franks Creek
- Cattaraugus Creek – Seneca Nation of Indians Cattaraugus Reservation
- Drinkers of water from municipal water system intakes at Sturgeon Point near Derby, New York and in the Niagara River. These receptors do not necessarily live on the shores of Lake Erie or the Niagara River.

The locations of offsite receptors and one onsite receptor (Buttermilk Creek) are shown in **Figure H–2.**

Onsite receptor locations are selected based on the location of existing contamination in the environment, the location and function of engineered barriers for closure systems, and regulatory guidance. Locations selected for the North and South Plateaus include:

- Onsite North Plateau
  - Main Plant Process Building (WMA 1)
  - Vitrification Facility (WMA 1)
  - Low-Level Waste Treatment Facility (WMA 2)
  - Waste Tank Farm (WMA 3)
  - North Plateau Groundwater Plume
  - Cesium Prong

Table H–2 Summary of Alternatives

	Sitewide Removal	*Sitewide Close-In-Place*	*Phased Decisionmaking Phase 1 Activities (up to 30 years)* [a]	*No Action*
Canisters	Storage in new Interim Storage Facility until they can be shipped offsite	Storage in new Interim Storage Facility until they can be shipped offsite.	Storage in new Interim Storage Facility until they can be shipped offsite	No decommissioning action
Process Building	Decontamination, demolition without containment and removal from site	Decontamination, demolition without containment. Rubble used to backfill underground portions of the Main Plant Process Building and Vitrification Facility, and to form the foundation of a cap.	Decontamination, demolition without containment and removal from site	No decommissioning action
High-Level Waste Tanks	Removal, including associated contaminated soil and groundwater in WMA 3	Backfilled with controlled, low-strength material. Strong grout placed between the tank tops and in the tank risers. Underground piping to remain in place and filled with grout. Closed in an integrated manner with the Main Plant Process Building, Vitrification Facility, and North Plateau Groundwater Plume source with a common circumferential hydraulic barrier and beneath a common multi-layer cap.	Remain in-place, monitored and maintained with the Tank and Vault Drying system operating as necessary	No decommissioning action
NRC-licensed Disposal Area (NDA)	Removal	Removal offsite of liquid pretreatment system. Trenches, and holes emptied of leachate and grouted. Buried leachate transfer line to remain in place. Existing NDA geomembrane cover replaced with a robust multi-layer cap.	Continued monitoring and maintenance	No decommissioning action
State-licensed Disposal Area (SDA)	Removal	Leachate removed from disposal trenches and replaced with grout. Waste Storage Facility removed to grade. Existing SDA geomembrane cover replaced with robust multi-layer cap. Hydraulic barrier installed.	Active management for up to 30 years	No decommissioning action
North Plateau Groundwater Plume	Removal	Plume source area closed in an integrated manner with the Main Plant Process Building, Vitrification Facility and Waste Tank Farm within a common circumferential barrier. Permeable treatment wall installed before decommissioning would remain in place. Nonsource area allowed to decay in place.	Removal of source area	No decommissioning action
Cesium Prong	Removal	Restrictions on use until sufficient decay has taken place.	Managed in place	No decommissioning action

WMA = Waste Management Area.

[a] Up to 30 years is the period for all Phase 1 activities. Decommissioning activities will be completed within 8 years.

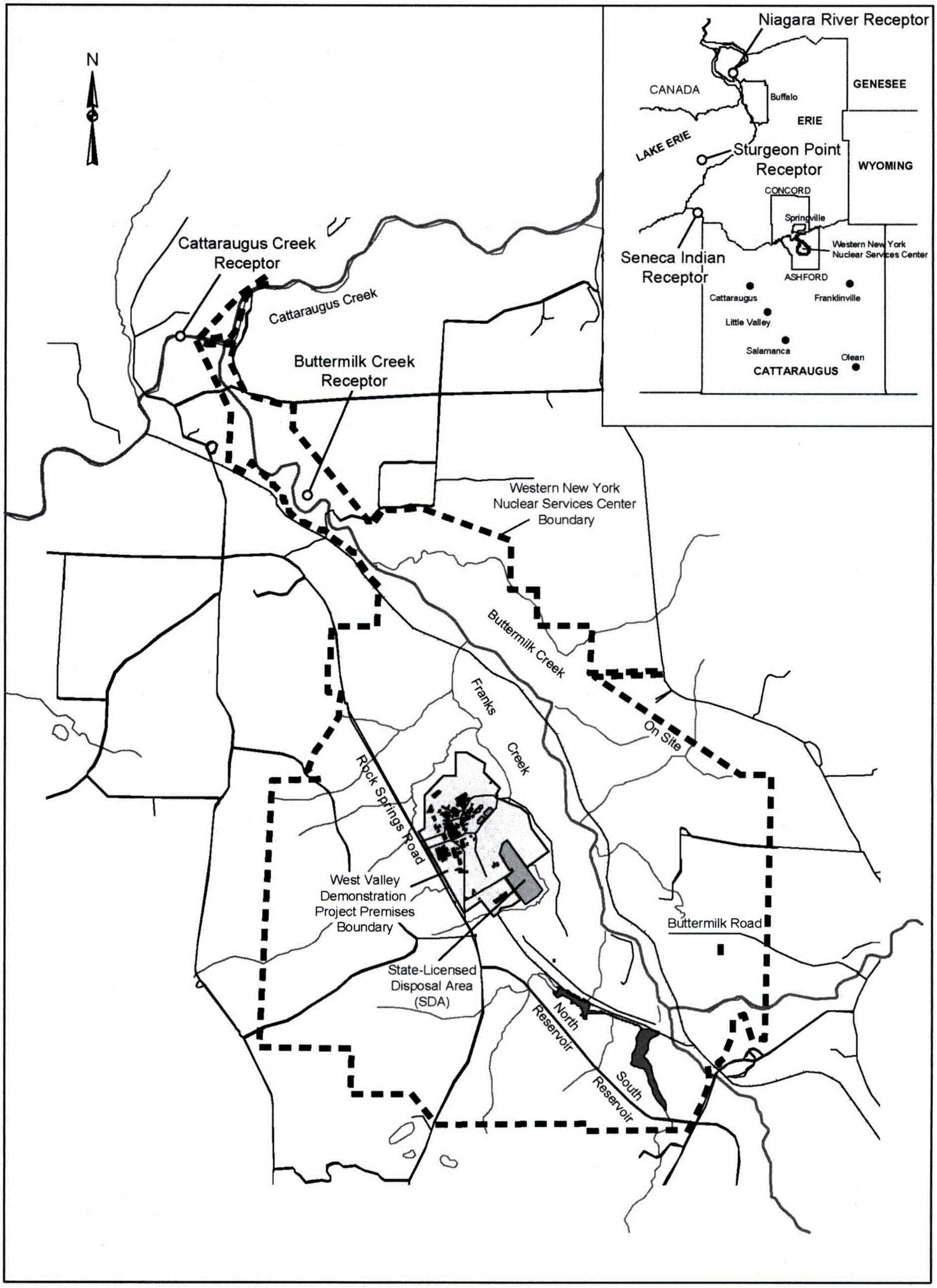

Figure H–2 Location of Offsite Receptors and Buttermilk Creek Receptor

- Onsite South Plateau
  - NDA (WMA 7)
  - SDA (WMA 8)
- Onsite adjacent to Buttermilk Creek.[3]
- On the East bank of Franks Creek opposite the SDA, on the West bank of Erdman Brook opposite the NDA, and in the area of the Low-Level Waste Treatment Facility (receptors for the erosion analysis)

Figure H–3 shows the locations of the receptors for the erosion analysis. It also shows the assumed location of wells that are used in subsequent calculations involving the use or consumption of contaminated groundwater.

Table H–3 Values of Parameters for the Home Construction Scenario

Parameter	*Value*	*Source*
Excavation Length and Width	23 meters	Oztunali and Roles 1986
Excavation Depth	3 meters	Oztunali and Roles 1986
Dust Mass Loading for Inhalation	0.538 milligrams per cubic meters	Beyeler et al. 1999
Duration of Construction Work	500 hours	Oztunali and Roles 1986
Inhalation Rate	8,400 cubic meters per year	Beyeler et al. 1999

H.1.3.2 Types of Receptors

Types of receptors selected to provide a basis for EIS analysis are individuals involved in home construction, well drilling, recreational hiking, maintaining a home and garden (resident farmer), and a non-farming resident. In the cases of home construction and well drilling the receptors are workers directly contacting contaminated material during activities that intrude into the waste.

For *home construction*, worker exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and exposure to external radiation from the walls of an excavation for the foundation of a home. Assumed locations for home construction are directly on top of facilities such as the Main Plant Process Building, Vitrification Facility, lagoons, Waste Tank Farm, or within areas such as the NDA and SDA for the No Action Alternative (see Figure H–1). Values of parameters for the home construction worker receptor and scenario are summarized in Table H–3.

For *well drilling*, worker exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and direct exposure to external radiation from contaminated water in a cuttings pond. Assumed locations for well drilling are directly on top of facilities such as the Main Plant Process Building, Vitrification Facility, lagoons, Waste Tank Farm, or within areas such as the NDA and SDA for the No Action Alternative and the Low-Level Waste Treatment Facility for the Sitewide Close-In-Place Alternative (see Figure H–1). Values of parameters characterizing this receptor and scenario are summarized in **Table H–4**. Because all waste at the West Valley Site is within thirty meters of the ground surface, depth to waste is not a constraint that limits occurrence of the well-drilling scenario.

[3] *This receptor is located below the Franks Creek discharge into Buttermilk Creek and above the Buttermilk Creek discharge into Cattaraugus Creek. The predicted radiation dose to such as receptor would be the same anywhere along this entire length because there is very little dilution of the flow until Cattaraugus Creek is reached.*

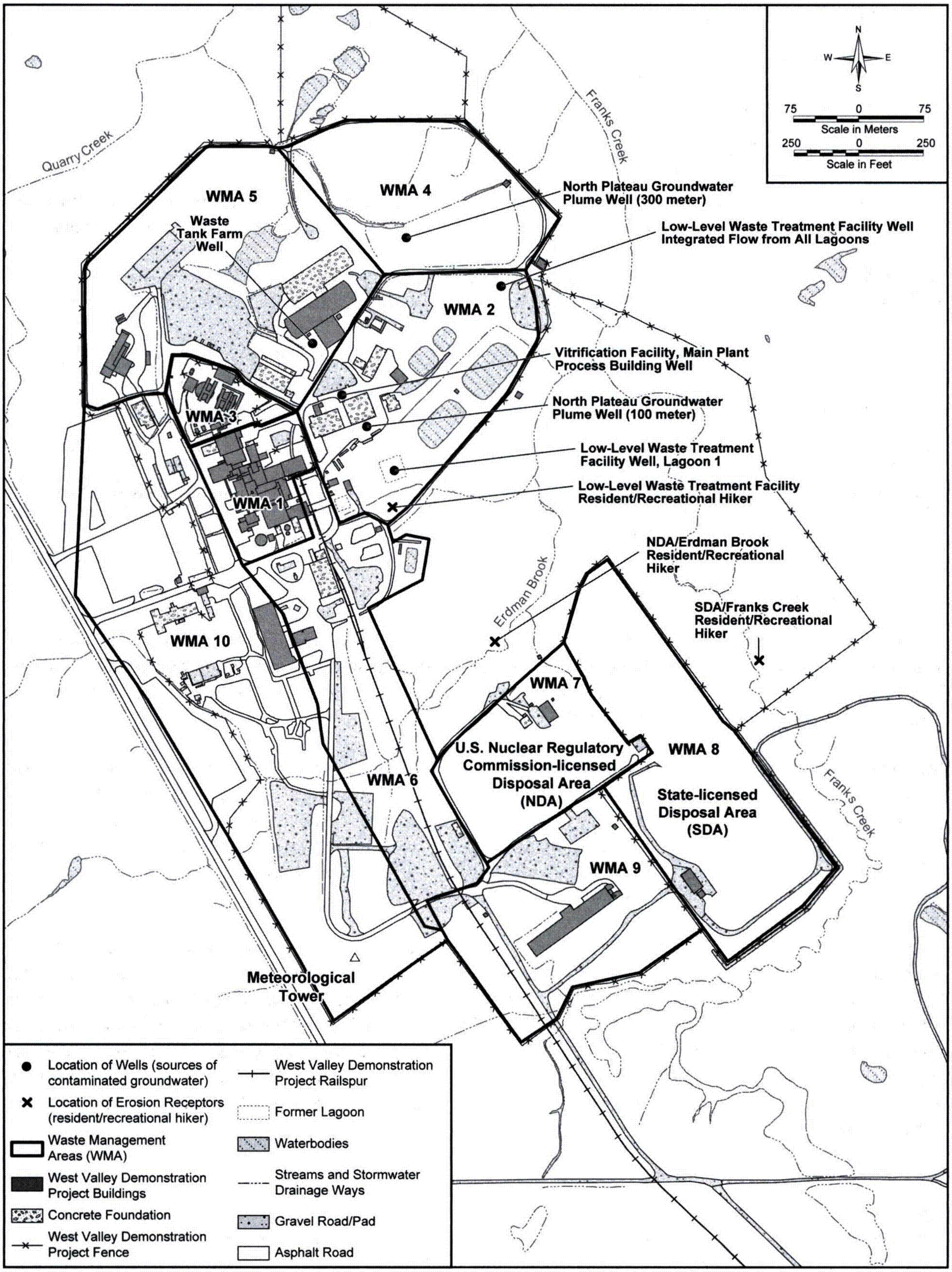

Figure H–3 Location of Wells and Resident/Recreational Hikers

Table H–4 Values of Parameters for the Well Drilling Scenario

Parameter	*Value*	*Source*
Drill Hole Diameter	20 centimeters	Oztunali and Roles 1986
Maximum Hole Depth	61 meters	Oztunali and Roles 1986
Well Completion Time	6 hours	Oztunali and Roles 1986
Cuttings Pond Length	2.7 meters	Oztunali and Roles 1986
Cuttings Pond Width	2.4 meters	Oztunali and Roles 1986
Cuttings Pond Depth	1.2 meters	Oztunali and Roles 1986
Cuttings Pond Water Shielding Layer Depth	0.6 meters [a]	Oztunali and Roles 1986
Inhalation Rate	8,400 cubic meters per year	Beyeler et al. 1999

[a] The analysis takes credit for the shielding provided by a 2-foot (0.6-meter) layer of water, consistent with the discussion of this scenario in NUREG/CR-4370 (Oztunali and Roles 1986).

Exposure modes for *recreational hiking* are inadvertent ingestion of soil and inhalation of fugitive dust for both radionuclides and hazardous chemicals and exposure to direct radiation for radionuclides. For radionuclides, values of parameters for these pathways are summarized in Tables H–9 and H–10. For hazardous chemicals, values of parameters are those presented in Table H–15 for the inadvertent soil ingestion and inhalation of fugitive dust pathways. For both radionuclides and hazardous chemicals, exposure time for recreational hiking is determined by time spent in the contaminated area. Parameters determining exposure time for the recreational hiker exposure pathway are length of the contaminated area, rate of hiking through the area, and frequency and duration of exposure. Values for these parameters are summarized in **Table H–5**. These parameters are based on the known dimensions of the Process Building, high-level waste tanks, SDA, and NDA. Exposure modes for a hiker include inadvertent ingestion of soil, inhalation of fugitive dust, and exposure to direct radiation. Exposure through recreational hiking pathways is evaluated for onsite receptors for both groundwater and erosion-release scenarios. Results for erosion-release scenarios are presented in Table H–62 and associated text, where hiking along an active erosion front is considered to be the bounding scenario. This EIS does not analyze the less conservative scenario of a downstream hiker coming into contact with contaminated creek-bank sediments. For groundwater release scenarios, exposure through the recreational hiking pathways contributes a small fraction of the total impact. The method for calculating the dose for the recreational hiking pathways is described in Appendix G, Section G.4.2.4.

Table H–5 Values of Parameters for Exposure Time in Recreational Hiking

Parameter	*Value*	*Source*
Length of Contaminated Area		
Process Building	10 to 40 meters	Site Specific
Vitrification Facility	7 to 10 meters	Site Specific
High-level waste tanks 8D-1 and 8D-2	30 meters	Site Specific
High-level waste tanks 8D-3 and 8D-4	6 meters	Site Specific
NDA	60 meters	Site Specific
SDA	400 meters	Site Specific
Velocity of hiking	1.6 kilometers per hour	A conservative hiking speed of 1.6 kilometers (approximately 1 mile) per hour
Exposure frequency	365 days per year	EPA 1999
Exposure duration	30 years	EPA 1999

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

Exposure pathways for the *resident farmer* are based on contact with surface soil and involves a set of activities including living in a home, maintaining a garden, harvesting fish and deer, and recreational hiking. The scenario may be initiated by existing residual contamination of surface soil, by irrigation with contaminated groundwater or surface water, by deposition of contaminated soil from the home construction excavation on the ground surface, by deposition of contaminated soil from the well drilling cuttings pond on the ground surface, or by exposure of contaminated material during erosion. The locations of wells that could potentially supply contaminated groundwater are shown in Figure H–3. The locations of the farmer's gardens are not explicitly located in Figure H–3. It is simply assumed that those gardens are somewhere nearby and that they are contaminated by water piped from one of the wells or by contaminated waste deposited after home construction or well drilling.

For both radionuclides and hazardous chemicals, maintenance of a home and garden involves inadvertent ingestion of soil, inhalation of fugitive dust, and consumption of crops and animal products. For radionuclides, there is an additional pathway, exposure to external radiation.

The location and mode of transport of contaminated material and the nature and location of the receptor determine the degree of exposure to each of the exposure pathways of the resident farmer scenario. General assumptions connecting exposure modes and receptor locations and activities are:

- Exposure pathways related to maintenance of a home and garden apply to both onsite and offsite receptors.
- When surface soil is contaminated by irrigation with groundwater or surface water, exposure by drinking water involves consumption of the primary source of groundwater or surface water rather than by consumption of water infiltrating through the contaminated soil. The pathways other than consumption of drinking water are termed water independent pathways.
- When the source of contamination is residue on surface soil rather than irrigation water, infiltration through the soil is the source of drinking water. The combined pathways are termed water dependent pathways.
- Consumption of fish occurs for the Buttermilk Creek onsite receptor and for offsite receptors.
- Discharge of contaminated groundwater to surface water contaminates soils and plants along onsite creek banks, initiating the deer consumption and recreational hiking pathways. Therefore, these two pathways apply for onsite receptors.

Because human health impacts related to radionuclides and hazardous chemicals involve differing physiological mechanisms, differing sets of parameters characterize receptors for these two classes of materials. Sets of parameters used to estimate health impact due to exposure to radionuclides during residence in a home and maintenance of a garden are presented in **Tables H–6 through H–11** and the exposure pathways for residing in a home and maintaining a garden are summarized in **Table H–12**. Unit dose and risk factors for these pathways, calculated using the RESRAD, Version 6.1 computer code (Yu et al. 1993) are presented in **Tables H–13** and **H–14** for the water dependent and water independent pathways, respectively.

Table H–6 Data Values for Residential and Garden Exposure Pathways for Radionuclides on the North and South Plateaus: Contaminated Zone Data

Parameter	*Parameter Value* [a]	*Source*
Area	6,850 square meters	NUREG/CR-5512 [b]
Thickness	1 meter	Site specific
Length parallel to aquifer flow	85 meters	Site specific
Bulk density	1.7 grams per cubic meter	WVNS 1993d, 1993c
Erosion rate	1×10^{-5} meters per year	WVNS 1993a
Total porosity	0.36 (for both North and South Plateaus)	WVNS 1993c
Field Capacity	0.20	WVNS 1993c
Hydraulic conductivity	3,500 meters per year (North Plateau) 0.01 meters per year (South Plateau)	WVNS 1993b
b Parameter [c]	1.4	NUREG/CR-5512 [b]
Evapotranspiration coefficient	0.78	WVNS 1993c
Wind speed	2.6 meters per second	WVNS 1993c
Precipitation	1.16 meters per year	WVNS 1993e
Irrigation rate	0.47 meters per year (water dependent) 0.0 meters per year (water independent)	NUREG/CR-5512 [d]
Irrigation mode	Overhead	Site specific
Runoff coefficient	0.41	WVNS 1993c

[a] Parameter values are the same for the North and South plateaus with the exception of total porosity and hydraulic conductivity.
[b] NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).
[c] Value for loamy sand (based onsite conditions).
[d] The authors have been unable to find a referenceable basis for site-specific irrigation rates.

Table H–7 Data Values for Residential and Garden Exposure Pathways for Radionuclides on the North and South Plateaus: Saturated Zone Hydrologic Data

Parameter	*Parameter Value* [a]	*Source*
Bulk density	1.7 grams per cubic meter	WVNS 1993d, 1993c
Total porosity	0.36 (for both North and South Plateaus)	WVNS 1993c
Field capacity	0.20	WVNS 1993c
Effective porosity	0.25	WVNS 1993c
Hydraulic conductivity	3,500 meters per year (North Plateau) 0.01 meters per year (South Plateau)	WVNS 1993b
Hydraulic gradient	0.03	WVNS 1993b
Water table drop rate	0 meters per year	Site Specific
Well pump intake depth	2 meters (below water table)	Site specific
Mixing model	Non-dispersion	Site specific
Well pumping rate	3,300 cubic meters per year (water dependent) 0 cubic meters per year (water independent)	NUREG/CR-5512 [b, c]

[a] Parameter values are the same for the North and South plateaus with the exception of total porosity and hydraulic conductivity.
[b] NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).
[c] Sum of domestic use and irrigation rate.

Table H–8 Data Values for Residential and Garden Exposure Pathways for Radionuclides on the North and South Plateaus: Uncontaminated and Unsaturated Zone Hydrologic Data

Parameter	***Parameter Value*** [a]	***Source***
Number of strata	1	Site specific
Thickness	2 meters	Site specific
Bulk density	1.7 grams per cubic meter	WVNS 1993d, 1993c
Total porosity	0.36 (for both North and South Plateaus)	WVNS 1993c
Effective porosity	0.25	WVNS 1993c
Hydraulic conductivity	3,500 meters per year (North Plateau) 0.01 meters per year (South Plateau)	WVNS 1993b
b Parameter [b]	1.4	NUREG/CR-5512 [c]

[a] Parameter values are the same for the North and South plateaus with the exception of total porosity and hydraulic conductivity.
[b] Value for loamy sand (based onsite conditions).
[c] NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).

Table H–9 Data Values for Residential and Garden Exposure Pathways for Radionuclides: Dust Inhalation and External Gamma Data

Parameter	***Parameter Value***	***Source***
Inhalation rate	8,400 cubic meters per year	NUREG/CR-5512 [a]
Mass loading for inhalation	4.5×10^{-6} grams per cubic meter	NUREG/CR-5512 [b]
Exposure duration	1 year	NUREG/CR-5512
Indoor dust filtration factor	1	NUREG/CR-5512
Shielding factor, external gamma	0.59	NUREG/CR-5512 [c]
Fraction of time indoors, onsite	0.66	NUREG/CR-5512
Fraction of time outdoors, onsite	0.12	NUREG/CR-5512
Shape factor, external gamma	1	RESRAD [d]

[a] NUREG/CR-5512, Vol 3 (Beyeler et al. 1999).
[b] Activity and time average of NUREG/CR-5512 values.
[c] Sum of products of the means of the fraction of time and shielding factors for indoor and outdoor exposure.
[d] RESRAD (Yu et al. 1993).

Table H–10 Data Values for Residential and Garden Exposure Pathways for Radionuclides: Dietary Data

Parameter	*Parameter Value*	*Source*
Fruit, vegetable and grain consumption rate	112 kilograms per year	NUREG/CR-5512 [a, b]
Leafy vegetable consumption rate	21 kilograms per year	NUREG/CR-5512
Milk consumption	233 liters per year	NUREG/CR-5512
Meat and poultry consumption	65 kilograms per year	NUREG/CR-5512 [c]
Soil ingestion rate	43.8 grams per year	EPA/540-R-00-007 [d] NUREG/CR-5512
Drinking water intake rate	730 liters per year (water dependent) 0 liters per year (water independent)	NUREG/CR-5512
Fraction contaminated drinking water	1	NUREG/CR-5512
Fraction contaminated livestock water	1	NUREG/CR-5512
Fraction contaminated irrigation water	1	NUREG/CR-5512
Fraction contaminated plant food	1	NUREG/CR-5512
Fraction contaminated meat	1	NUREG/CR-5512
Fraction contaminated milk	1	NUREG/CR-5512

[a] NUREG/CR-5512, Vol 3 (Beyeler et al. 1999).
[b] Sum of individual means for other vegetables, fruit and grain.
[c] Sum of individual means for meat and poultry.
[d] Soil Screening Guidance for Radionuclides.

Table H–11 Data Values for Residential and Garden Exposure Pathways for Radionuclides: Nondietary Data, North Plateau

Parameter	*Parameter Value*	*Source*
Livestock fodder intake for meat	27.3 kilograms per day	NUREG/CR-5512 [a]
Livestock fodder intake for milk	64.2 kilograms per day	NUREG/CR-5512 [b]
Livestock water intake for meat	50 liters per day	NUREG/CR-5512
Livestock water intake for milk	60 liters per day	NUREG/CR-5512
Livestock intake of soil	0.5 kilograms per day	RESRAD [c]
Mass loading for foliar deposition	4×10^{-4} grams per cubic meter	NUREG/CR-5512 [d]
Depth of soil mixing layer	0.15 meters	NUREG/CR-5512
Depth of roots	0.9 meters	RESRAD
Fraction of drinking water from groundwater	1	NUREG/CR-5512
Fraction of livestock water from groundwater	1	NUREG/CR-5512
Fraction of irrigation water from groundwater	1	NUREG/CR-5512

[a] NUREG/CR-5512, Vol 3 (Beyeler et al. 1999).
[b] Sum of individual medians for forage, hay and grain.
[c] Default parameter value from RESRAD (Yu et al. 1993).
[d] Value for gardening.

Table H–12 Summary of Exposure Modes for Residential and Garden Exposure to Radionuclides

Exposure Mode	*Water-Dependent Pathways*	*Water-Independent Pathways*
External gamma	Active	Active
Inhalation	Active	Active
Plant ingestion	Active	Active
Meat ingestion	Active	Active
Milk ingestion	Active	Active
Drinking water ingestion	Active	Inactive
Soil ingestion	Active	Active

Table H–13 RESRAD Unit Dose Factors for Water-Dependent Pathways

Nuclide	*Distribution Coefficient* [a] *(milliliters per gram)*	*Unit Dose Factor [(rem per year / (picocuries per gram)]*	*Unit Risk Factor (1 per year)*
Tritium	1	2.4×10^{-5}	2.2×10^{-8}
Carbon-14	20.9	1.1×10^{-3}	9.4×10^{-7}
Cobalt-60	1,000	7.4×10^{-3}	5.9×10^{-6}
Nickel-63	37.2	1.4×10^{-5}	2.3×10^{-8}
Selenium-79	115	5.4×10^{-4}	4.9×10^{-7}
Strontium-90	5	6.0×10^{-3}	5.0×10^{-6}
Technetium-99	7.4	1.7×10^{-3}	3.0×10^{-6}
Antimony-125	174	1.0×10^{-3}	7.6×10^{-7}
Iodine-129	4.6	1.5×10^{-2}	2.3×10^{-6}
Cesium-137	447	2.3×10^{-3}	1.7×10^{-6}
Promethium-147	5,010	4.0×10^{-7}	9.8×10^{-10}
Samarium-151	993	1.6×10^{-7}	3.6×10^{-10}
Europium-154	955	3.5×10^{-3}	2.7×10^{-6}
Lead-210	2,400	1.0×10^{-2}	5.0×10^{-6}
Radium-226	3,550	2.1×10^{-2}	1.2×10^{-5}
Radium-228	3,550	1.8×10^{-2}	1.1×10^{-5}
Actinium-227	1,740	2.6×10^{-3}	9.3×10^{-7}
Thorium-228	5,890	4.1×10^{-3}	3.2×10^{-6}
Thorium-229	5,890	1.2×10^{-3}	6.8×10^{-7}
Thorium-230	5,890	1.7×10^{-2}	9.1×10^{-6}
Thorium-232	5,890	2.4×10^{-2}	1.5×10^{-5}
Protactinium-231	2,040	6.9×10^{-3}	1.4×10^{-6}
Uranium-232	10	4.5×10^{-3}	3.2×10^{-6}
Uranium-233	10	1.7×10^{-3}	5.6×10^{-7}
Uranium-234	10	1.6×10^{-3}	5.5×10^{-7}
Uranium-235	10	1.7×10^{-3}	6.1×10^{-7}
Uranium-236	10	1.6×10^{-3}	5.2×10^{-7}
Uranium-238	10	1.6×10^{-3}	7.0×10^{-7}
Neptunium-237	7.1	5.3×10^{-3}	6.3×10^{-7}
Plutonium-238	955	1.5×10^{-4}	2.9×10^{-8}
Plutonium-239	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-240	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-241	955	4.5×10^{-6}	1.1×10^{-9}
Americium-241	1,450	1.5×10^{-4}	3.6×10^{-8}
Curium-243	6,760	3.7×10^{-4}	2.2×10^{-7}
Curium-244	6,760	7.5×10^{-5}	1.8×10^{-8}

[a] Site-specific data for strontium and uranium (Dames and Moore 1995a, 1995b), balance of data from NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).

Table H–14 RESRAD Unit Dose Factors for Water-Independent Pathways

Nuclide	*Distribution Coefficient* [a] *(milliliters per gram)*	*Unit Dose Factor [(rem per year)/ (picocuries per gram)]*	*Unit Risk Factor (1 per year)*
Tritium	1	4.2×10^{-6}	3.9×10^{-8}
Carbon-14	20.9	1.1×10^{-3}	9.4×10^{-7}
Cobalt-60	1,000	7.4×10^{-3}	5.9×10^{-6}
Nickel-63	37.2	1.4×10^{-5}	2.3×10^{-8}
Selenium-79	115	5.4×10^{-4}	4.9×10^{-7}
Strontium-90	5	6.0×10^{-3}	5.0×10^{-6}
Technetium-99	7.4	1.8×10^{-3}	3.0×10^{-6}
Antimony-125	174	1.0×10^{-3}	7.6×10^{-7}
Iodine-129	4.6	3.0×10^{-3}	2.4×10^{-6}
Cesium-137	447	2.3×10^{-3}	1.7×10^{-6}
Promethium-147	5,010	4.0×10^{-7}	9.8×10^{-10}
Samarium-151	993	1.6×10^{-7}	3.6×10^{-10}
Europium-154	955	3.5×10^{-3}	2.7×10^{-6}
Lead-210	2,400	1.0×10^{-2}	5.0×10^{-6}
Radium-226	3,550	2.1×10^{-2}	1.2×10^{-5}
Radium-228	3,550	1.8×10^{-2}	1.1×10^{-5}
Actinium-227	1,740	2.6×10^{-3}	9.3×10^{-7}
Thorium-228	5,890	4.1×10^{-3}	3.2×10^{-6}
Thorium-229	5,890	1.2×10^{-3}	6.8×10^{-7}
Thorium-230	5,890	7.7×10^{-3}	4.2×10^{-6}
Thorium-232	5,890	2.4×10^{-2}	1.5×10^{-5}
Protactinium-231	2,040	6.9×10^{-3}	1.4×10^{-6}
Uranium-232	10	4.6×10^{-3}	3.3×10^{-6}
Uranium-233	10	9.0×10^{-5}	4.6×10^{-8}
Uranium-234	10	8.6×10^{-5}	4.5×10^{-8}
Uranium-235	10	4.4×10^{-4}	3.1×10^{-7}
Uranium-236	10	8.2×10^{-5}	4.3×10^{-8}
Uranium-238	10	1.5×10^{-4}	1.1×10^{-7}
Neptunium-237	7.1	1.7×10^{-3}	6.3×10^{-7}
Plutonium-238	955	1.5×10^{-4}	3.3×10^{-8}
Plutonium-239	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-240	955	1.6×10^{-4}	3.0×10^{-8}
Plutonium-241	955	4.5×10^{-6}	4.2×10^{-10}
Americium-241	1,450	1.5×10^{-4}	3.6×10^{-8}
Curium-243	6,760	3.7×10^{-4}	2.2×10^{-7}
Curium-244	6,760	7.5×10^{-5}	1.8×10^{-8}

[a] Site-specific data for strontium and uranium (Dames and Moore 1995a, 1995b), balance of data from NUREG/CR-5512, Vol. 3 (Beyeler et al. 1999).

Table H–15 Values of Parameters for Exposure to Hazardous Chemicals

Parameter	*Value*	*Source*
Drinking Water Ingestion		
Ingestion Rate	2.35 liters per day	EPA/600/C-99/001
Exposure Frequency	365 days per year	EPA/600/C-99/001
Exposure Duration	30 years	EPA/600/C-99/001
Inadvertent Soil Ingestion		
Ingestion Rate	120 milligrams per day	EPA/540-R-00-007
Exposure Frequency	365 days per year	EPA/540-R-00-007
Exposure Duration	30 year	EPA/540-R-00-007
Fugitive Dust Inhalation		
Particulate emission factor	1.32×10^9 cubic meters per kilogram	EPA/540-R-00-007
Inhalation Rate	20 cubic meters per day	EPA/540-R-00-007
Exposure Frequency	365 days per year	EPA/540-R-00-007
Exposure Duration	30 years	EPA/540-R-00-007
Outdoor exposure time fraction	0.073	EPA/540-R-00-007
Indoor exposure time fraction	0.683	EPA/540-R-00-007
Dilution factor for indoor inhalation	0.4	EPA/540-R-00-007
Crop Ingestion		
Vegetable and fruit ingestion rate	112 kilograms per year	NUREG/CR-5512
Leafy vegetables ingestion rate	21 kilograms per year	NUREG/CR-5512
Exposure duration	30 years	EPA/540-R-00-007
Meat Ingestion		
Ingestion Rate	65 kilograms per year	NUREG/CR-5512
Exposure Duration	30 years	EPA/600/C-99/001
Milk Ingestion		
Ingestion Rate	233 liters per year	NUREG/CR-5512
Exposure Duration	30 years	EPA/600/C-99/001

The degree of contamination for the deer consumption pathway involves consideration of the portion of deer diet obtained in the contaminated area and the amount of deer meat consumed. Values for these parameters are presented in **Table H–16**. The amount of deer consumed (65 kilograms per year) is the difference between the 95th percentile estimate for meat consumption during a year (EPA 1999) and the estimate of home production meat and poultry (Beyeler et al. 1999) used in the RESRAD simulation of the residential and garden pathways. Note that in practice the deer pathway contributes only a very small fraction of predicted doses.

Table H–16 Values for the Deer Ingestion Pathway

Parameter	*Value*	*Source*
Ingestion Rate	65 kilograms per year	EPA 1999; Beyeler et al. 1999
Length of Contaminated Area		
Process Building	10 to 40 meters	Site Specific
Vitrification Facility	7 to 10 meters	Site Specific
High-level waste tanks 8D-1 and 8D-2	30 meters	Site Specific
High-level waste tanks 8D-3 and 8D-4	6 meters	Site Specific
NDA	60 meters	Site Specific
SDA	400 meters	Site Specific
Deer range area	2.5 square kilometers	State of Missouri 2004
Deer rate of consumption of vegetation	2.25 kilograms per day	State of North Carolina 2004
Exposure frequency	365 days per year	EPA 1999
Exposure duration	30 years	EPA 1999

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

In addition to the residential and garden exposure pathways, offsite receptors may harvest fish from surface water downstream of the WNYNSC. Exposure pathways data for offsite receptors are summarized in **Table H–17.**

Table H–17 Exposure Pathway Data for Offsite Receptors [a]

Receptor Location	*Scenario*	*Consumption of Drinking water (liters per day)*	*Consumption of Impacted Fish (kilograms per year)*	*Use of Water for Garden Irrigation*
Cattaraugus Creek, downstream of confluence with Buttermilk Creek	Resident farmer	2.35 [b]	9.0 [b]	Yes
Cattaraugus Creek at Seneca Nation of Indian reservation	Resident farmer	2.35	62.0 [b]	Yes
Sturgeon Point water user	Drinking water user, fish consumer	2.35	0.1 [c]	Yes
Niagara River water user	Drinking water user, fish consumer	2.35	0.1 [c]	Yes

[a] In the long-term performance assessment, offsite receptors are not exposed via the deer pathway or as recreational hikers. This is not because the predicted radiation dose from such activities is exactly zero. It is because, if calculated, it would only be a very small fraction of the dose accumulated via other pathways.

[b] These values for water and fish consumption are taken from EPA's *Exposure Factors Handbook* (EPA 1999). The 9 kilograms per year is the 95th percentile fish consumption for recreational anglers. The 62 kilograms per year is the 95th percentile fish consumption for subsistence fishermen.

[c] The population dose for each alternative is that for the population using the water from Sturgeon Point and several intakes in the East Channel of the Niagara River along with the assumption that each member of this population consumes 0.1 kilograms per year of fish that has been contaminated due to releases from the West Valley Site. The 0.1-kilogram per year is based on a five-year average New York fish yield from Lake Erie (102,000 kilograms) distributed over the population that uses the water.

Finally, as noted previously, there is a receptor on the East bank of Franks Creek (opposite the SDA), one on the North bank of Erdman Brook (opposite the NDA), and one in the vicinity of the Low-Level Waste Treatment Facility and lagoons to model radiation dose from exposure to contaminated ground water and soils uncovered by *erosion* of the stream's banks. This receptor is assumed to live in a house on the opposite side of the eroded bank and so is exposed to direct shine. This receptor does not keep a garden on the eroding bank and does not consume deer. In addition, the receptor is assumed to be affected by the inhalation and inadvertent ingestion pathways of the recreational hiking exposure pathway.

H.2 Long-Term Impacts

The purpose of this section is to present estimates of long-term impacts for each of the alternatives. The organization of this section closely parallels that of Section 4.1.10, but more detail is provided.

H.2.1 Sitewide Removal

The Sitewide Removal Alternative is addressed separately because it would require decontamination of the entire site so it is available for unrestricted use. This means that the radiation dose to any reasonably foreseeable onsite receptor would be less than 25 millirem per year. The precise residual contamination is not known with enough precision to warrant an offsite dose analysis, but it is expected that offsite dose consequences would be substantially below that for the Sitewide Close-In-Place Alternative or the No Action Alternative. Estimates of soil removal volumes are provided in the technical reports and are based on available characterization information and the estimated precision of the removal equipment.

Radioactive Contamination

Under this alternative, WNYNSC would be decontaminated during the Decommissioning Period so that any remaining residual radiological contamination would be below the unrestricted use dose criteria of 10 CFR 20.1402. To demonstrate that decontamination is adequate would require analysis of a number of representative, reasonably conservative scenarios to ensure that none of the range of potential human activities on the site would lead to the accumulation of individual radiation doses exceeding the unrestricted use dose criteria. One possible way of achieving this would be to use the analysis of the scenarios to estimate derived concentration guideline levels (DCGLs) that could be used as decontamination targets in various parts of the site. Examples of how this could be done are provided below. In practice, official DCGLS will be developed through the Decommissioning Plan process.

Two exposure scenarios have been identified for the illustrative determination of DCGLs; a resident farmer scenario and a recreational hiker scenario. Estimates of the radionuclide-specific DCGLs for these two scenarios are presented in **Tables H–18** and **H–19**. See Appendix G, Section G.2.1 for further details.

Table H–18 Examples of Radionuclide Derived Concentration Guideline Levels that will Result in Total Effective Dose Equivalent of 25 Millirem per Year for the Residential Agriculture Scenario: Water-Dependent Pathways

Nuclide	*Derived Concentration Guidelines (picocuries per gram)*	*Nuclide*	*Derived Concentration Guidelines (picocuries per gram)*
Tritium	1.04×10^3	Thorium-229	2.16×10^1
Carbon-14	2.33×10^1	Thorium-230	1.51
Cobalt-60	3.38	Thorium-232	1.06
Nickel-63	1.84×10^3	Protactinium-231	3.64
Selenium-79	4.62×10^1	Uranium-232	5.51
Strontium-90	4.19	Uranium-233	1.46×10^1
Technetium-99	1.44×10^1	Uranium-234	1.52×10^1
Antimony-125	2.43×10^1	Uranium-235	1.49×10^1
Iodine-129	1.67	Uranium-236	1.59×10^1
Cesium-137	1.11×10^1	Uranium-238	1.53×10^1
Promethium-147	6.30×10^4	Neptunium-237	4.73
Samarium-151	1.55×10^5	Plutonium-238	1.70×10^2
Europium-154	7.14	Plutonium-239	1.56×10^2
Lead-210	2.44	Plutonium-240	1.56×10^2
Radium-226	1.20	Plutonium-241	5.53×10^3
Radium-228	1.37	Americium-241	1.68×10^2
Actinium-227	9.66	Curium-243	6.76×10^1
Thorium-228	6.04	Curium-244	3.35×10^2

Table H–19 Examples of Radionuclide Derived Concentration Guidelines that will Result in Total Effective Dose Equivalent of 25 Millirem per Year for the Recreational Scenario

Nuclide	*Derived Concentration Guidelines (picocuries per gram)*	*Nuclide*	*Derived Concentration Guidelines (picocuries per gram)*
Tritium	2.72×10^4	Thorium-229	1.58×10^1
Carbon-14	3.16×10^5	Thorium-230	2.91
Cobalt-60	11.4	Thorium-232	1.21
Nickel-63	1.03×10^6	Protactinium-231	1.07×10^1
Selenium-79	5.13×10^4	Uranium-232	3.09
Strontium-90	9.23×10^2	Uranium-233	1.53×10^3
Technetium-99	1.13×10^5	Uranium-234	2.95×10^3
Antimony-125	1.26×10^1	Uranium-235	3.50×10^1
Iodine-129	8.29×10^2	Uranium-236	3.14×10^3
Cesium-137	8.23	Uranium-238	1.69×10^2
Promethium-147	3.18×10^5	Neptunium-237	2.42×10^1
Samarium-151	1.48×10^6	Plutonium-238	6.33×10^2
Europium-154	11.70	Plutonium-239	5.78×10^2
Lead-210	8.13×10^1	Plutonium-240	5.80×10^1
Radium-226	2.40	Plutonium-241	1.10×10^4
Radium-228	2.78	Americium-241	3.30×10^2
Actinium-227	1.22×10^1	Curium-243	4.43×10^1
Thorium-228	3.15	Curium-244	1.23×10^3

For mixtures of radionuclides a DCGL referenced to a single radionuclide was calculated using the formula:

$$DCGL_j = 1 / \Sigma (f_i / DCGL_i) \qquad (H\text{-}1)$$

where:

$DCGL_j$ is the mixture DCGL referenced to radionuclide j,
$DCGL_i$ is the DCGL for individual radionuclide i, and
f_i is the ratio of the concentration of individual radionuclide i to that of the reference radionuclide j, and the summation is taken over all radionuclides in the mixture.

The meaning of $DCGL_j$ is that, if a sufficient percentage of the mixture is removed such that the concentration of radionuclide j is less than $DCGL_j$, then the concentration of all other radionuclides will be such that the area containing the mixture has been sufficiently decontaminated to meet unrestricted use dose criteria, assuming an equal percentage removal of all radionuclides.

Hazardous Chemical Contamination

Under this alternative, WNYNSC would be decontaminated during the Decommissioning Period so that residual hazardous material contamination would not result in a situation where the concentration would exceed criteria for clean closure. The criteria could include NYSDEC TAGM-4046, *Determination of Soil Cleanup Objectives and Cleanup Levels* and NYSDEC Division of Water, Technical and Operational Guidance Series 1.1.1, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* or other agency-approved cleanup objectives that are protective of human health and the environment (e.g., risk-based action levels).

H.2.2 Sitewide Close-In-Place and No Action Alternatives

The remainder of this analysis addresses the impacts that would be expected to result from implementing the Sitewide Close-In-Place Alternative and the No Action Alternative, respectively.[4] These two alternatives would have some amount of hazardous and radioactive material remaining onsite. The analysis addresses the impacts to a spectrum of individual and population receptors located outside the current WNYNSC boundary as a result of releases to the local groundwater that then discharges to the onsite streams (Erdman Brook, Franks Creek and Buttermilk Creek). It also addresses the effects of radionuclide releases on individual receptors and the local population, and the effect of both radionuclide and hazardous chemical releases on the two closest offsite individual receptors. The analysis of the Sitewide Close-in-Place and No Action Alternatives is organized as follows:

Section H.2.2.1 presents a summary description of parameters used in the impact analysis. Values of parameters characterizing receptor behavior are those already summarized in Section H.1.3.

Section H.2.2.2 deals with impacts given assumed indefinite continuation of institutional controls. These impacts take credit for institutional controls to prevent access to the waste management areas, to maintain the integrity of structures such as the Main Plant Process Building, together with engineered features such as erosion control structures and engineered caps.

Section H.2.2.3 deals with impacts assuming loss of institutional controls. In this case it is assumed that institutional controls will be lost after 100 years. In particular, it is assumed that there are no more efforts to contain radionuclides and hazardous chemicals within the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farms. Conservatively, these are assumed to fail as soon as institutional controls fail. This subsection reexamines the analysis for the offsite receptors and also considers failure of institutional controls that would allow intruders to enter the WNYNSC and various waste management areas.

Section H.2.2.3 considers failure of institutional controls leading to unmitigated erosion. The offsite receptors are again reanalyzed. In addition, this section considers onsite receptors on the banks of Franks Creek and Erdman Brook who would be exposed to direct radiation shine from eroded surfaces.[5] A summary of other sources of radiation to which these receptors would be exposed is given in Section H.2.2.2.7.

The analytical results presented here are from deterministic runs that are considered to be conservative,[6] except for those that include unmitigated erosion, in which case an "intermediate" estimate is presented corresponding to the case in which the site becomes partly forested and partly grassland. More details on both the deterministic and sensitivity/uncertainty analyses are presented in Section H.3.

H.2.2.1 Parameters Used in the Impact Analysis

A primary set of information used in impact analysis consists of the conditions of groundwater flow. The sitewide and near-field flow models used to develop this description of groundwater flow conditions are described in Appendix E. In that appendix, results of solute transport simulations with three-dimensional models indicated that plumes originating from given locations on the North Plateau followed nearly direct paths to points of discharge (Figures E–38 and E–39). In addition, one-dimensional simulation of

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[4] *There is no quantitative long-term performance assessment for the preferred alternative, Phased Decisionmaking, because the long-term impact depends on the final condition, which is yet to be defined. There is a qualitative discussion of long-term impacts for the preferred alternative in Section H.2.3.*

[5] *In this appendix, calculations of dose from external irradiation are performed using the Microshield computer model and include both direct shine from eroded surfaces and skyshine. However, the modeling did not consider ground shine from radioactive materials deposited directly onto creek banks.*

[6] *The major assumptions that contribute to the assessment that the estimates of dose are conservative are listed in section 4.3.5.*

concentration of strontium-90 in the North Plateau Groundwater Plume provided a reasonable match with the results of three-dimensional transport simulation and with measured concentrations along the centerline of the plume. On this basis, one-dimensional groundwater flow models were selected for human health impacts analysis. In each case, the width of the flow tube is the width of the source. The value of longitudinal dispersivity is 1/10 of the distance from the source to the nearest point at which a receptor contacts the groundwater for all sources except for the North Plateau Groundwater Plume for which the value of 5 meters determined by comparison to data (see Appendix E) is used.

Values of groundwater flow velocities extracted from the three-dimensional model results for use in one-dimensional models are summarized in **Table H–20**. In addition to this flow information, estimation of concentrations of contaminants in the North Plateau Groundwater Plume at the initiation time (calendar year 2020) of long-term performance assessment is required. The approach taken to the development of this information was to use the inventory estimate for the North Plateau Groundwater Plume presented in Appendix C and the one-dimensional flow model to estimate the concentration of contaminants in the plume in calendar year 2020 given a release in calendar year 1968. The results of this calculation, assumed applicable for both the No Action and Sitewide Close-In-Place Alternatives, are presented in **Table H–21**. Consistent with the relatively rapid movement of groundwater in the thick-bedded unit and the slack-water sequence on the North Plateau, relatively mobile radionuclides such as tritium-3, technetium-99 and iodine-129 would have discharged from the aquifer prior to calendar year 2020.

Table H–20 Groundwater Flow Velocities for Human Health Impact Analysis

Facility	*Geohydrologic Unit*	*Average Linear Velocity (meters per year)*	
		Sitewide Close-In-Place Alternative	*No Action Alternative*
North Plateau			
Main Plant Process Building	Slack-water Sequence	97	115
Vitrification Facility	Slack-water Sequence	97	115
Waste Tank Farm	Thick-bedded Unit	65	75
Low-Level Waste Treatment Facility	Thick-bedded Unit	98	120
South Plateau			
NDA [a]			
Horizontal	Weathered Lavery Till	0.70(P),0.30(H),0.66(W)	0.85(P),0.36(H),0.77(W)
Vertical	Unweathered Lavery Till	0.077(P),0.176(H),0.096(W)	0.074(P),0.176(H),0.096(W)
SDA			
Horizontal	Weathered Lavery Till	0.76	0.79
Vertical	Unweathered Lavery Till	0.071	0.071

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

[a] The parenthetical labels P and H denote the Nuclear Fuel Services process and hulls disposal areas of the NDA while the label W denotes the West Valley Demonstration Project disposal area of the NDA.

Table H–21 Estimated Concentrations in the North Plateau Groundwater Plume for Calendar Year 2020

Distance [a] (meters)	*Concentration (picocuries per liter)*				
	Carbon-14	*Strontium-90*	*Uranium-238*	*Neptunium-237*	*Plutonium-239*
0	0	0.4	0	0	0.01
50	0.1	4,790	0.15	0.02	35.0
100	2.3	106,000	0.39	0.44	90.0
150	6.6	294,000	0.02	1.20	5.0
200	2.6	118,000	0	0.50	0.007
250	0.16	6,910	0	0.03	0
300	0.001	60	0	0	0

[a] Coordinates for the source initially located at distance of 20 meters.

Engineered barriers and natural materials considered in this performance assessment include the ability to divert or control flow. The flow control structures considered in the analysis include the drainage and underlying clay layers of engineered caps, the subsurface slurry walls on the North and South Plateaus, the Controlled Low Strength Material (a form of grout) used to fill the tanks of the Waste Tank Farm, and the grout used to stabilize sediments at lagoons 1, 2, and 3 of the Low-Level Waste Treatment Facility. The values of hydraulic conductivity that control the functional capacities of these barriers are well defined by design at the time of installation but may degrade over time. Because the rate of degradation would be difficult to predict, *degraded values of hydraulic conductivity are assumed to apply over the entire time period of the long-term performance assessment, irrespective of whether institutional controls are maintained or fail.*

Literature review of the performance of drainage layers identified particulate plugging and biofilm growth as the primary modes of degradation (Rowe et al. 2004). However, it is also reported that proper choice of gravel size and with quality assurance for installation, coarse gravel can maintain high hydraulic conductivity in operation (Rowe et al. 2004). Based on these considerations and in order to provide a conservative assessment of performance, a value of hydraulic conductivity of 0.03 centimeters pre second was adopted for drainage layers in the engineered caps. This value is two orders of magnitude less than the design value of the gravel and at the upper end of the range of values reported for sand (Meyer and Gee 1999).

Literature review of performance of clay layers identified dessication as the primary failure mechanism for this type of barrier (Rowe et al. 2004). The study also reported excellent performance when the layers were maintained in the saturated state. On this basis, a degraded valued of hydraulic conductivity of clay layers in the center of engineered caps of 5×10^{-8} centimeters per second was adopted. This value is one order of magnitude higher than the design value.

Also based on these considerations, additional degradation of performance is assumed for slurry walls extending to the ground surface. Although the offset in hydraulic conductivity between the slurry wall and the surrounding natural material is large and would be expected to maintain near saturated conditions in a humid environment such as West Valley, a two-order of magnitude degradation in design value of hydraulic conductivity was assumed for this analysis. The value adopted for hydraulic conductivity of slurry walls was 1×10^{-6} centimeters per second. Values of hydraulic conductivity reported for intact concrete range from 1×10^{-10} to 1×10^{-8} centimeters per second (Clifton and Knab 1989). In order to account for degradation and potential effectiveness of placement, a value of 1×10^{-5} centimeters per second was used for Controlled Low Strength Material and grout in the long-term performance assessment.

The above cited values of hydraulic properties are used in the near-field groundwater flow models to estimate rates of flow through waste materials. The results of these calculations for facilities on the North Plateau are presented in **Tables H–22** and **H–23** for the No Action and Sitewide Close-In-Place Alternatives, respectively. Differences in volumetric flow rates reported in these two tables are related to placement of engineered barriers while differences in waste volume are related to decontamination and closure activities. On the South Plateau, waste is simulated as mixed with soil in holes and trenches and groundwater velocities through the waste are those reported in Table H–20 for the geohydrologic unit in which the waste is located. Flow areas and waste volumes used in simulation of the South Plateau facilities are presented in **Table H–24**. Estimates of radiological and chemical constituent inventories are presented in Appendix C.

Table H–22 Flow Rates Through Waste Disposal Volumes for North Plateau Facilities for the No Action Alternative

Facility	*Flow Area Through Waste (square meters)*	*Disposal Volume (cubic meters)*	*Flow Direction*	*Volumetric Flow Rate Through Waste (cubic meters per year)*
Main Plant Process Building				
General Purpose Cell	3	42	Horizontal	78
Liquid Waste Cell	102	102	Vertical	26
Fuel Receiving and Storage Pool	12	240	Horizontal	310
Rubble Pile	3,200	14,000	Vertical	835
Vitrification Facility	79	340	Vertical	21
Waste Tank Farm				
Tank 8D-1	19	357	Horizontal	66
Tank 8D-2	38	357	Horizontal	181
Tank 8D-3	3	10	Horizontal	16
Tank 8D-4	3	10	Horizontal	16
Low-Level Waste Treatment Facility				
Lagoon 1	35	605	Horizontal	940
Lagoon 2	1.4	84	Horizontal	38
Lagoon 3	1.7	102	Horizontal	46
Lagoon 4	1.1	29	Horizontal	30
Lagoon 5	1.1	29	Horizontal	30

Table H–23 Flow Rates Through Waste Disposal Volumes for North Plateau Facilities for the Sitewide Close-In-Place Alternative

Facility	*Flow Area Through Waste (square meters)*	*Disposal Volume (cubic meters)*	*Flow Direction*	*Volumetric Flow Rate Through Waste (cubic meters per year)*
Main Plant Process Building				
General Purpose Cell	45	40	Vertical	2.3
Liquid Waste Cell	102	245	Vertical	2.2
Fuel Receiving and Storage Pool	260	40	Vertical	13.3
Rubble Pile	12,000	12,000	Vertical	194
Vitrification Facility	79	12	Vertical	1.7
Waste Tank Farm				
Tank 8D-1	357	357	Vertical	10.6
Tank 8D-2	357	357	Vertical	10.6
Tank 8D-3	13	13	Vertical	0.21
Tank 8D-4	13	13	Vertical	0.21
Low-Level Waste Treatment Facility				
Lagoon 1	35	605	Horizontal	0.52
Lagoon 2	4.2	252	Horizontal	2.0
Lagoon 3	5.1	306	Horizontal	1.2
Lagoon 4	3.3	86	Horizontal	48
Lagoon 5	3.3	86	Horizontal	58

Table H–24 Flow Areas and Disposal Area Volumes for Facilities on the South Plateau

Facility	*Disposal/Waste Area Volume (cubic meters)*	*Flow Area (square meters)*	
		Horizontal Flow Path	*Vertical Flow Path*
NDA			
Nuclear Fuel Services Process	5,500	220	2,200
Nuclear Fuel Services Hulls	3,000	40	200
West Valley Demonstration Project	12,800	160	1,600
SDA	120,000	1,200	20,000

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

Values of distribution coefficient characterizing retention in natural and engineered materials are also applied for analysis of transport of solutes. Values of distribution coefficient used for aquifer soils, concrete and Controlled Low Strength Material are presented in **Table H–25**. The approach taken for these selections is to use values for un-degraded material for short-lived constituents expected to decay during the expected life of the engineered material, such as strontium-90 and cesium-137, and degraded values for those elements expected to remain for long periods of time. The expected lifetimes of the engineered grouts are on the order of 500 years (Clifton and Knab 1989, Atkinson and Hearn 1984). While decrease in retention of elements on cement with degradation has been reported (Bradbury and Sarott 1995), high retention of actinide elements is reported for even for degraded cements.

The Controlled Low Strength Material is a grout-based mixture that is expected to include zeolite and apatite minerals as aggregates. Characterization of grouted materials has established that cesium and strontium are retained primary on the aggregates used in the concrete while other elements are retained both on the aggregate and on the calcium silicate hydrogel matrix of the concrete (Stinton et al. 1984). High retention of cesium on zeolite (Lonin and Krasnopyorova 2004) and of strontium and heavier elements on apatite (Krejzler and Narbutt 2003) has been documented.

For high-density concrete as used in contaminated portions of site facilities, retention of strontium and cesium is expected to occur on the sand ballast while retention of actinides is expected to occur on the degraded cement material. On the basis of the above considerations, the values of Table H–20 primarily characteristic of sand (Sheppard and Thibault 1990) are proposed for cement materials. The increased value for neptunium in Controlled Low Strength Material is related to presence of apatite. For aquifer soils, the values are derived from site specific measurements for strontium and uranium (Dames and Moore 1995a, 1995b) and from national survey data for sand (Sheppard and Thibault 1990). These values are applied to both the sandy units of the North Plateau and the silt-clay soils underlying both the North and South Plateaus.

Table H–25 Values of Distribution Coefficient for Long-term Impact Analysis

Element	***Distribution Coefficient (milliliters per gram)***		
	Aquifer	***Concrete***	***Controlled Low Strength Material***
Hydrogen	0	1.0	1.0
Carbon	5	5	5
Strontium	5	15	15
Technetium	0.1	1.0	1.0
Iodine	1	1	1
Cesium	280	280	280
Uranium	10	10	35
Neptunium	5	5	60
Plutonium	550	550	550
Americium	1,900	1,900	1,900

H.2.2.2 Indefinite Continuation of Institutional Controls

This section presents long-term radiological dose and long-term radiological and hazardous chemical risk to offsite receptors and populations. Assuming that institutional controls continue indefinitely is clearly optimistic. The results of the calculations represent a lower bound on potential health impacts. The section is organized by receptor beginning with the nearest offsite receptor and progressing to the farthest and discusses the impacts to these receptors following releases to the local groundwater, discharges to the onsite streams (Erdman Brook, Franks Creek and Buttermilk Creek), and flow into Cattaraugus Creek.

In this case of indefinite continuation of institutional controls, it is assumed that maintenance actions for the Main Plant Process Building, the Vitrification Facility, and the Waste Tank farm would keep engineered systems (e.g., drying systems, and roofs) operating indefinitely. The doses from these units would be minimal as long as the engineered systems function as originally designed and institutional controls prevent releases. These maintenance actions and their associated costs are described in the No Action technical report, which is a primary reference for this EIS.

H.2.2.2.1 Cattaraugus Creek Receptor

This sub-section focuses on the Cattaraugus Creek receptor (just outside the site boundary) and first considers exposures to radionuclides, followed by a discussion of exposures to chemicals. The Cattaraugus Creek receptor is a postulated offsite receptor who is closest to the site boundary and receives the impact of liquid release from all portions of the site. This receptor is conservatively assumed to drink water from Cattaraugus Creek, eat fish and deer, and irrigate his garden, also with water from Cattaraugus Creek.

Radiological Dose and Risk

This section covers total effective dose equivalent (TEDE), dominant doses and pathways, and radiological risk.

Total Effective Dose Equivalent

Figures H–4 and **H–5** present the annual TEDE as a function of time to a Cattaraugus Creek receptor located just outside the WNYNSC boundary. This hypothetical individual is postulated to drink water from Cattaraugus Creek, use the water for irrigation and consume fish raised in the Cattaraugus Creek. Detailed information on the timing and magnitude of peak dose is presented in Tables H–26 and H–27. For each alternative and for both the NDA and SDA, the time series of dose represents the combined effect of horizontal transport through the weathered Lavery till and vertical and horizontal flow through the unweathered Lavery till and Kent Recessional Sequence. The models used to predict the doses and risks presented in Figures H–3 and H–4 and in many of the subsequent tables and figures are described in Appendix G. The analyses were performed consistent with the general approach outlined in Appendix D.

For the Sitewide Close-In-Place Alternative, Figure H–4 shows that the SDA contributes by far the majority of the annual TEDE, with the peak clearly occurring after 30,000-40,000 years. There is an earlier, subsidiary SDA peak occurring at about 1,000 years, and a few minor peaks associated with the. These peaks arrive at different times because different radionuclides leach from the SDA at different rates and percolate through the ground at different rates.

Figure H–5 provides the same information for the No Action Alternative. The figures are virtually identical. This is a consequence of the conservative assumptions about the behavior of engineered barriers as described in Section H.2.2.1, which means that the rates of groundwater flow through areas such as the NDA and SDA are nearly the same for both alternatives for the period for which analysis was performed.

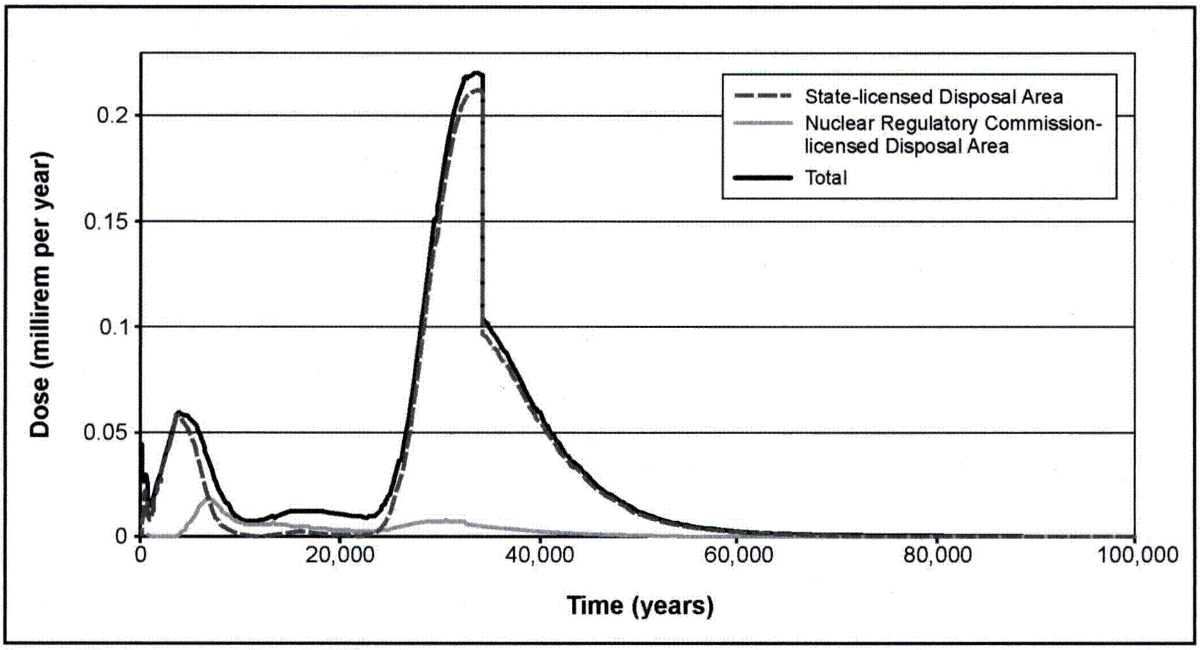

Figure H–4 Annual Total Effective Dose Equivalent for the Cattaraugus Creek Receptor with the Sitewide Close-In-Place Alternative and Indefinite Continuation of Institutional Controls

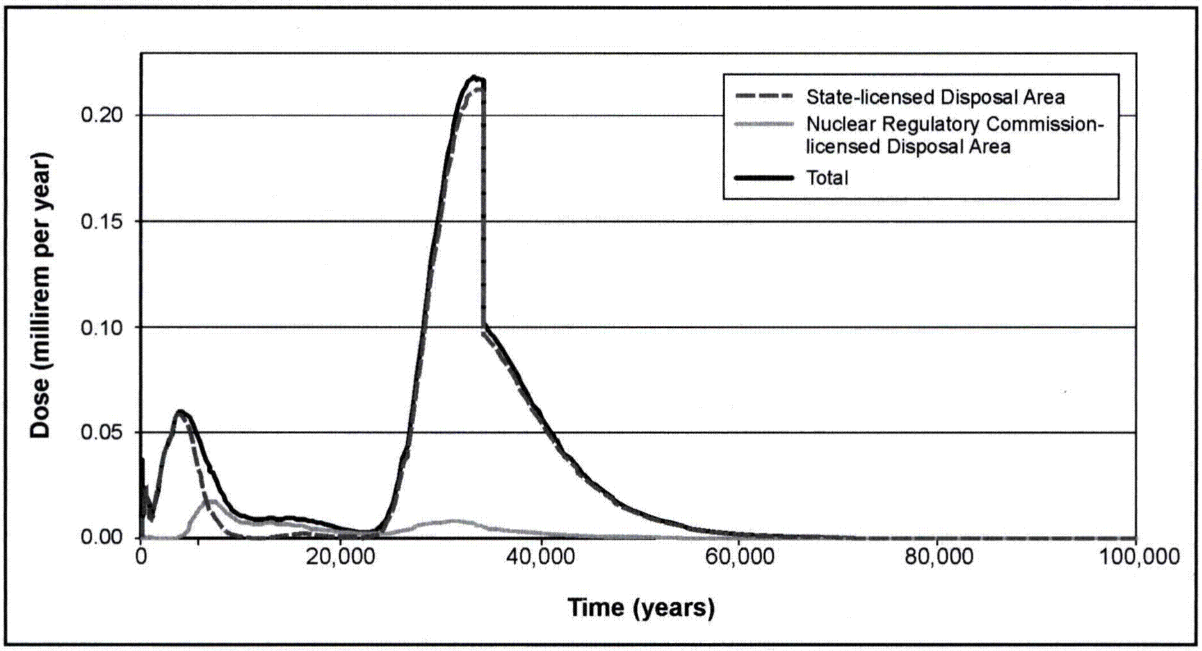

Figure H–5 Annual Total Effective Dose Equivalent for the Cattaraugus Creek Receptor with the No Action Alternative Indefinite Continuation of Institutional Controls

Table H–26 breaks down the predicted peak TEDE arising from radionuclides leaching from each WMA, and the predicted years until peak TEDE for each alternative. This displays the smaller contributors which would not be visible if plotted in Figures H–4 and H–5. In this and other tables the years to peak total dose do not match the years to peak individual WMA dose because, in general, the peak total dose is the sum of doses from individual WMAs that do not coincide with their peaks.

Table H–26 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.019 (200)	0 [b]
Vitrification Facility – WMA 1	0.000082 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.00015 (100)	0.0092(100)
Waste Tank Farm – WMA 3	0.0029 (200)	0 [b]
NDA – WMA 7	0.018 (6,800) [c]	0.018 (6,800) [c]
SDA – WMA 8	0.21 (33,800) [c]	0.21 (33,800) [c]
North Plateau Groundwater Plume	0.072 (79)	0.11 (68)
Total	0.22 (33,700)	0.22 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Detailed Analysis of Total Effective Dose Equivalent

Table H–27 provides further detailed breakdown of Table H–26 organized by components. The SDA is broken into two components, which consist of different pathways whereby radionuclides migrate through the groundwater and eventually end up in Cattaraugus Creek. The first of these is horizontal groundwater flow through the disposal area, and the second is vertical flow through the SDA into a lower-lying horizontally flowing aquifer. Aspects of this are further described in Appendices D, E, and G. The NDA also exhibits the two flowpaths (horizontal and vertical/horizontal) and is further broken down into three components of the waste disposal area, the Nuclear Fuel Services, Inc. (NFS) process, NFS hulls, and WVDP. These are three distinct components of the NDA containing different mixes of hazardous materials and radionuclides. Their geometry also differs (e.g., depth). Radionuclide releases from the hulls provide the largest contribution to the portion of the peak TEDE stemming from the NDA.

Table H–27 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor Broken Down by Waste Management Area Components (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	1.4×10^{-3} (800)	b
	General Purpose Cell	6.8×10^{-3} (19,700)	b
	Liquid Waste Cell	1.4×10^{-2} (200)	b
	Fuel Receiving Storage Pad	3.3×10^{-4} (19,800)	b
	Total Main Plant Process Building	1.9×10^{-2} (200)	b
Vitrification Facility – WMA 1		8.2×10^{-5} (500)	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	1.0×10^{-4} (500)	6.9×10^{-3} (100)
	Lagoon 2	5.5×10^{-5} (100)	2.3×10^{-3} (100)
	Lagoon 3	1.5×10^{-7} (500)	5.0×10^{-6} (100)
	Lagoon 4	6.2×10^{-7} (100)	6.8×10^{-7} (100)
	Lagoon 5	2.0×10^{-7} (200)	2.3×10^{-7} (200)
	Total Low-Level Waste Treatment Facility	1.5×10^{-4} (100)	9.2×10^{-3} (100)
Waste Tank Farm – WMA 3	8D-1	1.6×10^{-3} (200)	b
	8D-2	1.4×10^{-3} (200)	b
	8D-3	6.4×10^{-7} (400)	b
	8D-4	2.5×10^{-5} (400)	b
	Total Waste Tank Farm	2.9×10^{-3} (200)	b
NDA – WMA 7 Horizontal	Process	1.7×10^{-3} (18,500)	2.0×10^{-3} (15,400)
	Hulls	2.8×10^{-4} (12,500)	4.2×10^{-4} (10,700)
	West Valley Demonstration Project	1.4×10^{-5} (16,900)	1.5×10^{-5} (14,700)
	Total NDA – Horizontal	2.0×10^{-3} (18,300)	2.3×10^{-3} (14,900)
NDA – WMA 7 Vertical/Horizontal	Process	7.1×10^{-3} (30,900)	7.1×10^{-3} (31,700)
	Hulls	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
	West Valley Demonstration Project	1.2×10^{-4} (21,300)	1.2×10^{-4} (21,300)
	Total NDA – Vertical/ Horizontal	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
Total NDA	Total NDA [c]	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
SDA – WMA 8	Horizontal	4.6×10^{-2} (4,700)	4.6×10^{-2} (4,500)
	Vertical/Horizontal	2.1×10^{-1} (33,700)	2.1×10^{-1} (33,700)
	Total SDA [c]	2.1×10^{-1} (33,800)	2.1×10^{-1} (33,800)
North Plateau Groundwater Plume		7.2×10^{-2} (79)	1.1×10^{-1} (68)
Total Site		2.2×10^{-1} (33,700)	2.2×10^{-1} (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Controlling Nuclides and Pathways

It is of interest to understand the controlling nuclides and pathways at the years of peak TEDE. **Table H–28** provides this information. As noted above, the SDA provides the largest peak for both alternatives, with both the vertical and horizontal pathways contributing. Table H–28 shows that ingestion of uranium-234 via fish is the dominant contributor for the SDA, and hence is also the dominant contributor for the total dose.

Table H–28 Controlling Nuclides and Pathways for the Cattaraugus Creek Receptor Broken Down by Waste Management Area Components at Year of Peak Annual Total Effective Dose Equivalent – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Controlling Nuclide/Pathway*	
		Sitewide Close-In-Place Alternative	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	b
	General Purpose Cell	Plutonium-239/Fish	b
	Liquid Waste Cell	Iodine-129/Fish	b
	Fuel Receiving Storage Pad	Plutonium-239/Fish	b
Vitrification Facility – WMA 1		Neptunium-237/Fish	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Strontium-90/DW
	Lagoon 2	Strontium-90/DW	Strontium-90/DW
	Lagoon 3	Uranium-234/DW	Uranium-234/DW
	Lagoon 4	Uranium-234/DW	Uranium-234/DW
	Lagoon 5	Uranium-234/DW	Uranium-234/DW
Waste Tank Farm – WMA 3	8D-1	Technetium-99/RF [c]	b
	8D-2	Technetium-99/RF	b
	8D-3	Technetium-99/RF [c]	b
	8D-4	Iodine-129/Fish	b
NDA – WMA 7 Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	West Valley Demonstration Project	Uranium-233/DW	Uranium-233/DW
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	West Valley Demonstration Project	Uranium-233/DW	Uranium-233/DW
SDA – WMA 8	Horizontal	Uranium-234/Fish	Uranium-234/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/DW	Strontium-90/DW

WMA = Waste Management Area, RF = resident farmer, DW = drinking water, NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] RF means resident farmer and includes a number of pathways such as eating contaminated vegetables, inhalation, etc.

Excess Cancer Risk

A complementary measure is the peak lifetime risk (excess risk of morbidity, or risk of contracting cancer, both fatal and non-fatal) to the Cattaraugus Creek receptor arising from radiological discharges. This risk is calculated assuming a lifetime exposure at the peak predicted dose rate. This introduces an element of conservatism. Note also that the risk is not calculated by the simple method of taking the peak TEDE and multiplying by 6×10^{-4}. The risks are calculated by summing the risks for individual radionuclides using data from FGR-13. **Table H–29** shows how this risk varies from different WMAs and what it is for the entire WNYNSC for each alternative. Since the doses from which the latent cancer morbidity risk is calculated differ little between the alternatives, neither do the risks.

Table H–29 Peak Lifetime Radiological Risk (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	3.6×10^{-7} (200)	0 [b]
Vitrification Facility – WMA 1	5.0×10^{-10} (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	3.9×10^{-9} (100)	2.0×10^{-7} (100)
Waste Tank Farm – WMA 3	1.3×10^{-7} (200)	0 [b]
NDA – WMA 7	4.7×10^{-7} (6,800) [c]	4.7×10^{-7} (6,800) [c]
SDA – WMA 8	2.7×10^{-6} (33,700) [c]	2.7×10^{-6} (33,700) [c]
North Plateau Groundwater Plume	1.6×10^{-6} (79)	2.4×10^{-6} (68)
Total	2.7×10^{-6} (33,700)	2.7×10^{-6} (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

Estimates of the risk to the Cattaraugus Creek receptor from hazardous chemicals have also been prepared. Three measures are used: lifetime cancer risk, hazard index and comparison to maximum contaminant levels (MCLs) for drinking water that have been issued under the Clean Water Act. A listing of the hazardous chemicals that were included in the risk analysis is presented in Appendix C.

Lifetime Cancer Risk

Table H–30 shows the peak lifetime cancer risk from chemical exposure broken down by WMA.

Table H–30 shows that, for both alternatives, the SDA is by far the dominant contributor. The NDA peaks are less than 10 percent of those from the SDA. The NDA peak occurs much later because the dominant chemical constituent in the NDA is much less mobile than that in the SDA. Comparing the radiological risk information in Table H–29 with the chemical risk information in Table H–30, it can be seen that the peak lifetime cancer risk to the Cattaraugus Creek receptor is dominated by radionuclides rather than hazardous chemicals. The peak radiological risk is on the order of 100 times greater than the peak chemical risk.

Table H–30 Peak Lifetime Risk from Hazardous Chemicals (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.3×10^{-10} (6,000)	0 [b]
Vitrification Facility – WMA 1	5.9×10^{-11} (7,400)	0 [b]
Waste Tank Farm – WMA 3	3.1×10^{-10} (9,000)	0 [b]
NDA – WMA 7	1.3×10^{-9} (86,400)	1.3×10^{-9} (88,700)
SDA – WMA 8	2.0×10^{-8} (100)	2.1×10^{-8} (100)
Total	2.0×10^{-8} (100)	2.1×10^{-8} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals. There is no hazardous chemical inventory available for the Construction and Demolition Debris Landfill in WMA 4.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

This comparison of lifetime cancer risk from radionuclides and chemicals for the Cattaraugus Creek receptor is also shown in **Figures H–6 and H–7**, which confirm that the greatest risk is from the radionuclides except far into the future when both risks are very small. The slight increase in chemical risk far into the future is due to the presence of arsenic, an element whose movement through the groundwater is strongly retarded.

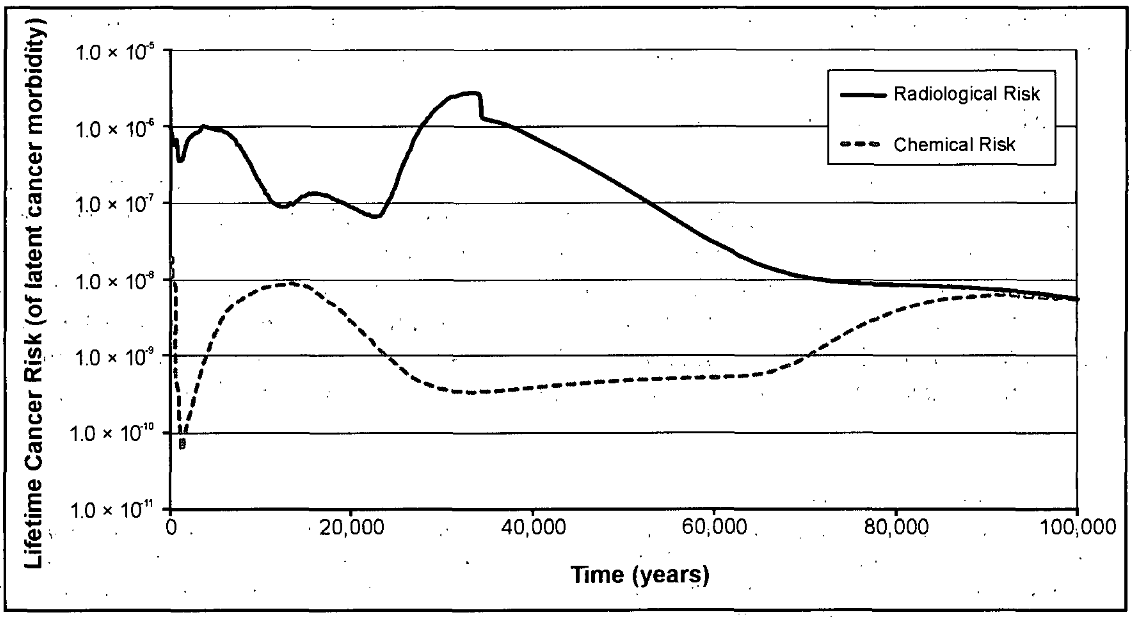

Figure H–6 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Cattaraugus Creek Receptor with the Sitewide Close-In-Place Alternative and Indefinite Continuation of institutional Controls

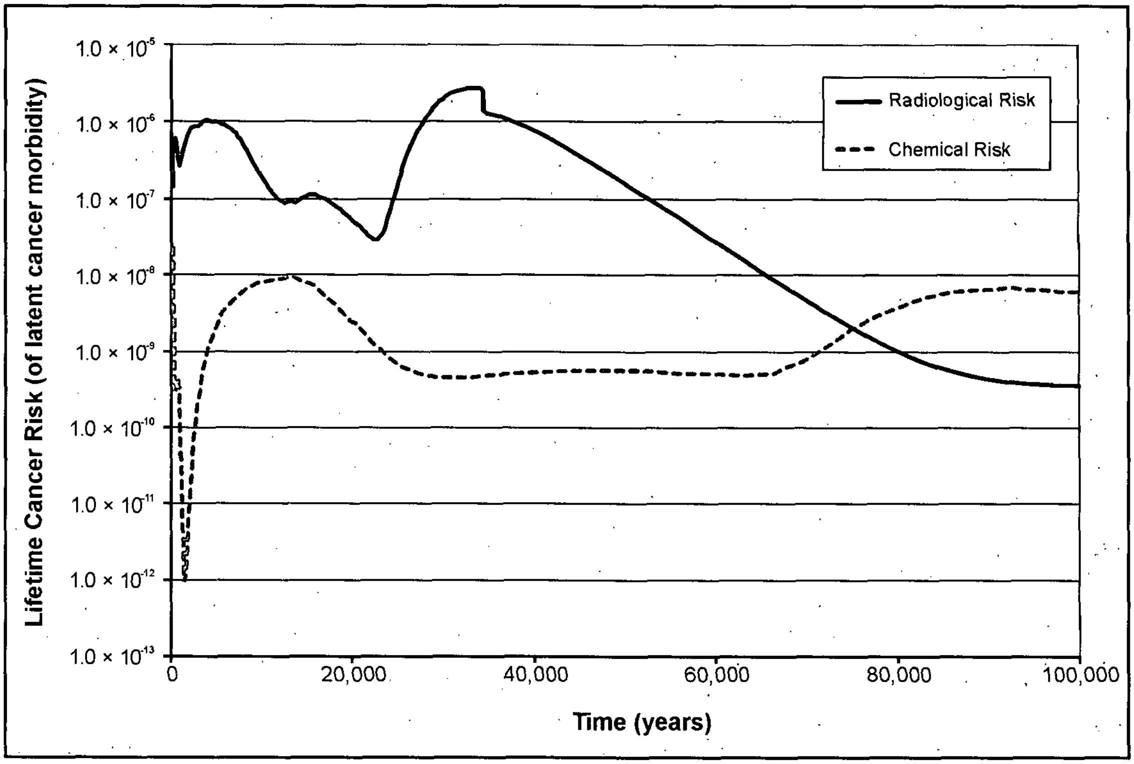

Figure H–7 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Cattaraugus Creek Receptor with the No Action Alternative and Indefinite Continuation of Institutional Controls

Hazard Index

Another measure of chemical risk that is appropriate for non-carcinogenic chemicals is the hazard index[7] for an individual receptor. If the hazard index is greater than 1, an observable non-carcinogenic health effect may occur. **Table H–31** presents the hazard index peaks for the Cattaraugus Creek receptor in expected conditions. As can be seen, the hazard index peaks are much less than one for both alternatives.

Fraction of Maximum Concentration in Liquid

There are some hazardous chemicals for which there is no carcinogenic slope factor or a reference dose, but they are recognized as hazardous materials and MCLs have been issued under the Clean Water Act. A primary example that is relevant to WNYNSC is lead. When the inventory for a known hazardous material could be estimated, but there was no slope factor or reference dose for the material, an analysis was conducted to determine the maximum concentration of the hazardous material in the years until peak risk and the years until peak hazard index. **Table H–32** shows the results of this analysis. This ratio of peak concentration to MCL would always be less than one and for most elements it would be far less than one (less than 1×10^{-3}).

[7] *The Hazard Index is defined as the sum of the hazard quotients for substances that affect the same target organ or organ system. The Hazard Quotient for a specific chemical is the ratio of the exposure to the hazardous chemical (e.g., amount ingested over a given period) to a reference value regarded as corresponding to a threshold of toxicity, or a threshold at which some recognizable health impact would appear. If the hazard quotient for an individual chemical or the hazard quotient for a group of chemicals exceeds unity, the chemical(s) may produce and adverse effect, but normally this will require a hazard index or quotient of several times unity. A hazard index or quotient of less than unity indicates that no adverse effects are expected over the period of exposure.*

Table H–31 Peak Chemical Hazard Index for the Cattaraugus Creek Receptor (year of peak hazard index in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	6.7×10^{-6} (8,100)	0 [b]
Vitrification Facility – WMA 1	2.5×10^{-6} (10,100)	0 [b]
Waste Tank Farm – WMA 3	2.0×10^{-4} (12,400)	0 [b]
NDA – WMA 7	1.4×10^{-5} (30,100) [c]	1.5×10^{-5} (30,900) [c]
SDA – WMA 8	2.8×10^{-3} (4,700) [c]	2.9×10^{-3} (4,500) [c]
Total	2.9×10^{-3} (4,700)	2.9×10^{-3} (4,500)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted hazard index and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–32 Chemicals with Largest Fraction of Maximum Concentration Levels in Cattaraugus Creek at Year of Peak Risk and Year of Peak Hazard Index – Indefinite Continuation of Institutional Controls [a]

Waste Management Areas [b]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
	Year of Peak Risk in Parentheses	
Main Plant Process Building – WMA 1	9.7×10^{-6} (55,100) Pb [d]	– [c]
Vitrification Facility – WMA 1	6.7×10^{-3} (40,500) Pb [d]	– [c]
Waste Tank Farm – WMA 3	2.0×10^{-6} (9,000) Tl [e]	– [c]
NDA – WMA 7	1.3×10^{-6} (86,700) As [f,h]	1.3×10^{-6} (89,200) As [f,h]
SDA – WMA 8	8.3×10^{-5} (200) Usol [g]	9.0×10^{-5} (100) Usol [g,h]
	Year of Peak Hazard Index in Parentheses	
Main Plant Process Building – WMA 1	9.6×10^{-6} (8,100) Pb [d]	– [c]
Vitrification Facility – WMA 1	6.7×10^{-3} (26,000) Pb [d]	– [c]
Waste Tank Farm – WMA 3	2.1×10^{-6} (12,400) Tl [e]	– [c]
NDA – WMA 7	3.4×10^{-5} (30,200) Usol [f,h]	3.4×10^{-5} (31,000) Usol [f,h]
SDA – WMA 8	7.5×10^{-3} (4,700) Usol [g,h]	7.8×10^{-3} (4,500) Usol [g,h]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] Presented as fraction of the applicable MCL / (years until peak exposure) / chemical.

[b] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[c] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[d] Pb = lead, MCL (Action Level) =0.015 milligrams per liter.

[e] Tl= thallium, MCL = 0.002 milligrams per liter.

[f] As = arsenic, MCL = 0.01 milligrams per liter.

[g] Usol = soluble uranium, MCL = 0.03 milligrams per liter.

[h] The reason why the predicted hazard index and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

H.2.2.2.2 Seneca Nation of Indians Receptor

Another receptor of interest for the WNYNSC is an individual who may engage in subsistence fishing along Cattaraugus Creek. A Seneca Nation of Indian receptor is postulated to use Cattaraugus Creek new Gowanda for drinking water and irrigation of a garden and is also postulated to consume elevated quantities of fish raised in these waters. This sub-section first considers exposure to radionuclides, followed by a discussion of exposure to chemicals. The timing of peaks from individual WMAs presented below are in many respects similar to those for the Cattaraugus Creek receptor although the peak doses themselves are slightly higher.

Radiological Dose and Risk

Total Effective Dose Equivalent

Figures H–8 and H–9 present the annual TEDE as a function of time to a Seneca Nation of Indians receptor located just outside the WNYNSC boundary. This hypothetical individual is postulated to drink water from Cattaraugus Creek, use the water for irrigation and consume fish raised in the Cattaraugus Creek. The principal difference from the Cattaraugus Creek receptor is that the Seneca Nation of Indians receptor consumes more fish. Just as was the case for the Cattaraugus Creek receptor, the SDA is the dominant contributor. However, the peak annual TEDE is about 2.5 times larger than the corresponding peak for the Cattaraugus Creek receptor. As was the case for the Cattaraugus Creek receptor, the figure for the No Action Alternative is almost the same as the figure for the Sitewide Close-In-Place Alternative.

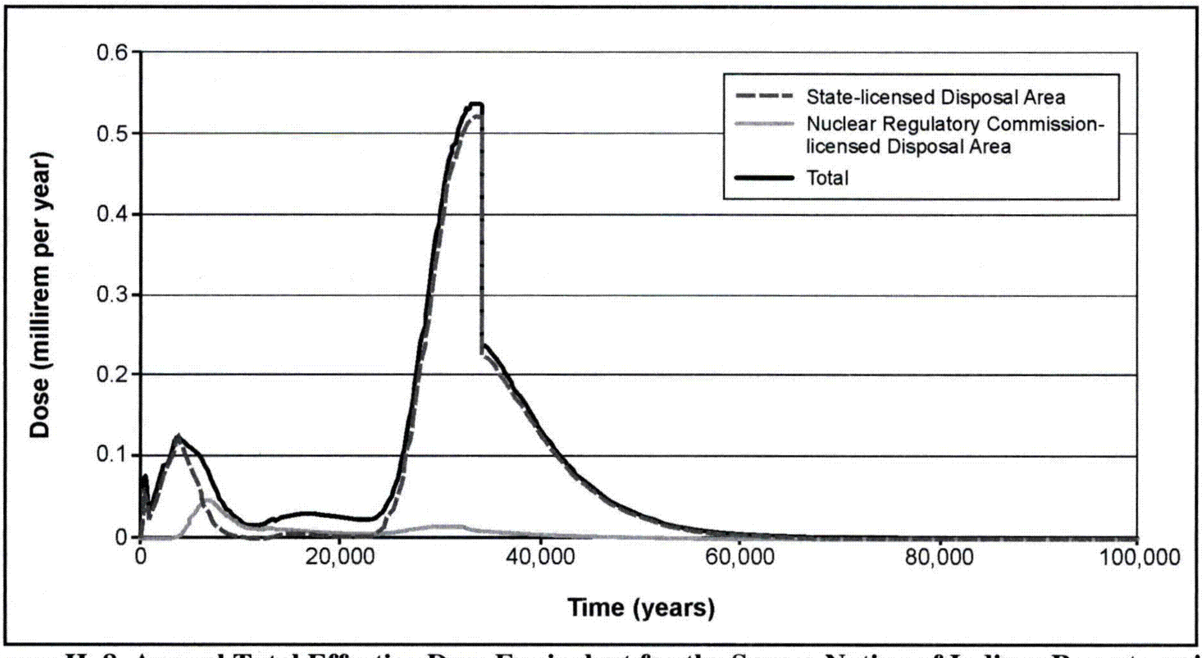

Figure H–8 Annual Total Effective Dose Equivalent for the Seneca Nation of Indians Receptor with the Sitewide Close-In-Place Alternative and Indefinite Continuation of Institutional Controls

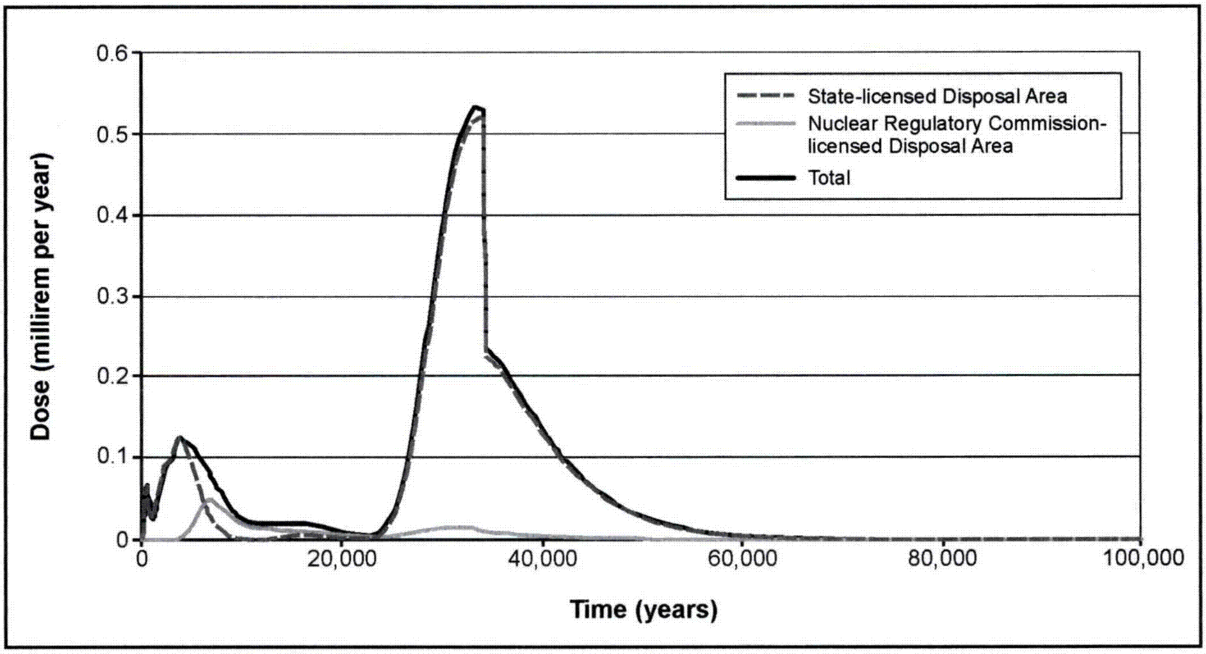

Figure H–9 Annual Total Effective Dose Equivalent for the Seneca Nation of Indians Receptor with the No Action Alternative and Indefinite Continuation of Institutional Controls

The magnitude and the year of the peak contribution are shown in **Table H–33**.

Table H–33 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.052 (200)	0 [b]
Vitrification Facility – WMA 1	0.00020 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.00029 (100)	0.015 (100)
Waste Tank Farm – WMA 3	0.0027 (200)	0 [b]
NDA – WMA 7	0.048 [c] (6,800)	0.049 [c] (6,800)
SDA – WMA 8	0.52 [c] (33,800)	0.52 [c] (33,800)
North Plateau Groundwater Plume	0.093 (78)	0.15 (67)
Total	0.54 (33,700)	0.53 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

The doses for the Seneca Nation of Indians receptor are 2-3 times higher than those for the Cattaraugus Creek receptor. This is due of the large amount of locally raised fish that is postulated to be consumed by this receptor. Table H–33 and Figures H–8 and H–9 show similar patterns to those for the Cattaraugus Creek receptor (Table H–26 and Figures H–4 and H–5) in terms of timing of dose peaks for individual WMAs. **Table H–34** provides further detailed breakdown of Table H–33 organized by components of each WMA. Table H–34 presents information for the Seneca Nation of Indians receptor this is of the type of information presented in Table H–27 for the Cattaraugus Creek receptor.

Controlling Nuclides and Pathways

As for the Cattaraugus Creek receptor, it is of interest to understand the controlling nuclides and pathways at the years until peak TEDE for the Seneca Nation of Indians receptor. **Table H–35** provides this information. As noted above, the SDA provides the largest peak for both alternatives. Table H–35 shows that ingestion of carbon-14, uranium-233, and uranium-234 via fish are important pathways. Table H–28 shows that, for the Cattaraugus Creek receptor, the drinking water pathway is important for releases from some WMA components, and that technetium-99 is a prominent radionuclide. For the Seneca Nation of Indians receptor, fish consumption dominates doses originating from all WMA components, technetium-99 is no longer important, and iodine-129 becomes prominent.

Excess Lifetime Cancer Risk

A complementary measure is the peak lifetime risk to the Seneca Nation of Indians receptor from radiological discharges. **Table H–36** shows how this risk varies from different WMAs and what it is for the entire WNYNSC for each alternative. The lifetime radiological cancer risk to the postulated Seneca Nation of Indians receptor is 2-3 times higher than, the risk to the Cattaraugus Creek receptor as presented in Table H–29. The higher risk is the result of the postulated higher fish consumption. The SDA is the largest contributor to risk.

Hazardous Chemical Risk

Estimates of the risk to the Seneca Nation of Indians receptor from hazardous chemicals in the burial grounds, the Main Plant Process Building and the high-level waste tanks have also been prepared. As for the Cattaraugus Creek receptor, three measures are used: lifetime cancer risk, hazard index and comparison to MCLs for drinking water.

Lifetime Cancer Risk

Table H–37 shows the lifetime excess cancer morbidity risk from exposure to chemicals. As was the case for the Cattaraugus Creek receptor, the SDA dominates the risk. Comparing with Table H–36, the radiological risk is at least two orders of magnitude higher.

The comparison of lifetime cancer risk from radionuclides and chemicals for the Seneca Nation of Indians receptor is also shown in **Figures H–10 and H–11**. These figures for the Seneca Nation of Indians receptor are quite similar to, and can be interpreted in the same way as, Figures H–6 and H–7 for the Cattaraugus Creek receptor.

As was the case for TEDEs (Table H–34), it is possible to break the information in Table H–37 down to more detailed levels. These are available on request, as tables or figures.

Table H–34 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor Broken Down by Waste Management Area Components (year of peak exposure in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	3.5×10^{-3} (800)	b
	General Purpose Cell	1.7×10^{-2} (19,500)	b
	Liquid Waste Cell	3.8×10^{-2} (200)	b
	Fuel Receiving Storage Pad	8.0×10^{-4} (19,800)	b
	Total Main Plant Process Building	5.2×10^{-2} (200)	b
Vitrification Facility – WMA 1		2.0×10^{-4} (500)	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	1.0×10^{-4} (500)	1.2×10^{-2} (100)
	Lagoon 2	5.5×10^{-5} (100)	2.8×10^{-3} (100)
	Lagoon 3	1.5×10^{-7} (500)	7.1×10^{-6} (100)
	Lagoon 4	6.2×10^{-7} (100)	1.0×10^{-6} (100)
	Lagoon 5	2.9×10^{-7} (200)	3.4×10^{-7} (200)
	Total LLWTF	2.9×10^{-4} (100)	1.5×10^{-2} (100)
Waste Tank Farm – WMA 3	8D-1	1.4×10^{-3} (200)	b
	8D-2	1.3×10^{-3} (200)	b
	8D-3	6.0×10^{-7} (400)	b
	8D-4	5.1×10^{-5} (400)	b
	Total Waste Tank Farm	2.7×10^{-3} (200)	b
NDA – WMA 7 Horizontal	Process	3.2×10^{-3} (18,500)	3.6×10^{-3} (15,400)
	Hulls	7.4×10^{-4} (12,300)	1.1×10^{-3} (10,600)
	WVDP	2.6×10^{-5} (17,100)	2.8×10^{-5} (14,800)
	Total NDA – Horizontal	3.8×10^{-3} (18,000)	4.5×10^{-3} (14,600)
NDA – WMA 7 Vertical/ Horizontal	Process	1.3×10^{-2} (30,900)	1.3×10^{-2} (31,700)
	Hulls	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
	WVDP	2.3×10^{-4} (21,300)	2.3×10^{-4} (21,300)
	Total NDA – Vertical/ Horizontal	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
Total NDA	Total NDA	4.8×10^{-2} (6,800) [c]	4.9×10^{-2} (6,800) [c]
SDA – WMA 8	Horizontal	9.2×10^{-2} (2,900)	9.5×10^{-2} (2,700)
	Vertical/Horizontal	5.2×10^{-1} (33,800)	5.2×10^{-1} (33,800)
	Total SDA	5.2×10^{-1} (33,800) [c]	5.2×10^{-1} (33,800) [c]
North Plateau Groundwater Plume		9.3×10^{-2} (78)	1.5×10^{-1} (67)
Total Site		5.4×10^{-1} (33,700)	5.3×10^{-1} (33,4000)

LLWTF = Low-Level Waste Treatment Facility, NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–35 Controlling Nuclides and Pathways for the Seneca Nation of Indians Receptor Broken Down by Waste Management Area Components at Year of Peak Total Effective Dose Equivalent – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	b
	General Purpose Cell	Plutonium-239/Fish	b
	Liquid Waste Cell	Iodine-129/Fish	b
	Fuel Receiving Storage Pad	Plutonium-239/Fish	b
Vitrification Facility – WMA 1		Neptunium-237/Fish	b
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Iodine-129/Fish
	Lagoon 2	Strontium-90/Fish	Strontium-90/Fish
	Lagoon 3	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 4	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 5	Uranium-234/Fish	Uranium-234/Fish
Waste Tank Farm – WMA 3	8D-1	Iodine-129/Fish	b
	8D-2	Iodine-129/Fish	b
	8D-3	Iodine-129/Fish	b
	8D-4	Iodine-129/Fish	b
NDA – WMA 7 Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
SDA – WMA 8	Horizontal	Carbon-14/Fish	Carbon-14/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/Fish	Strontium-90/Fish

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

Table H–36 Peak Lifetime Radiological Risk (risk of latent cancer morbidity) for the Seneca Nation of Indians Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.0×10^{-6} (200)	0 [b]
Vitrification Facility – WMA 1	1.3×10^{-9} (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	7.2×10^{-9} (100)	3.4×10^{-7} (100)
Waste Tank Farm – WMA 3	9.6×10^{-8} (200)	0 [b]
NDA – WMA 7	1.3×10^{-6} (6,800)	1.3×10^{-6} (6,800)
SDA – WMA 8	7.5×10^{-6} (33,800)	7.5×10^{-6} (33,800)
North Plateau Groundwater Plume	2.1×10^{-6} (78)	3.4×10^{-6} (67)
Total	7.6×10^{-6} (33,700)	7.6×10^{-6} (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

Table H–37 Peak Lifetime Risk from Hazardous Chemicals (risk of latent cancer morbidity) for the Seneca Nation of Indians Receptor (year of peak risk in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	2.6×10^{-10} (5,800)	0 [b]
Vitrification Facility – WMA 1	1.2×10^{-10} (5,800)	0 [b]
Waste Tank Farm – WMA 3	6.3×10^{-10} (8,900)	0 [b]
NDA – WMA 7	3.4×10^{-9} (85,800) [c]	3.2×10^{-9} (88,800) [c]
SDA – WMA 8	2.1×10^{-8} (13,400) [c]	2.2×10^{-8} (12,900) [c]
Total	2.1×10^{-8} (13,400)	2.2×10^{-8} (12,900)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

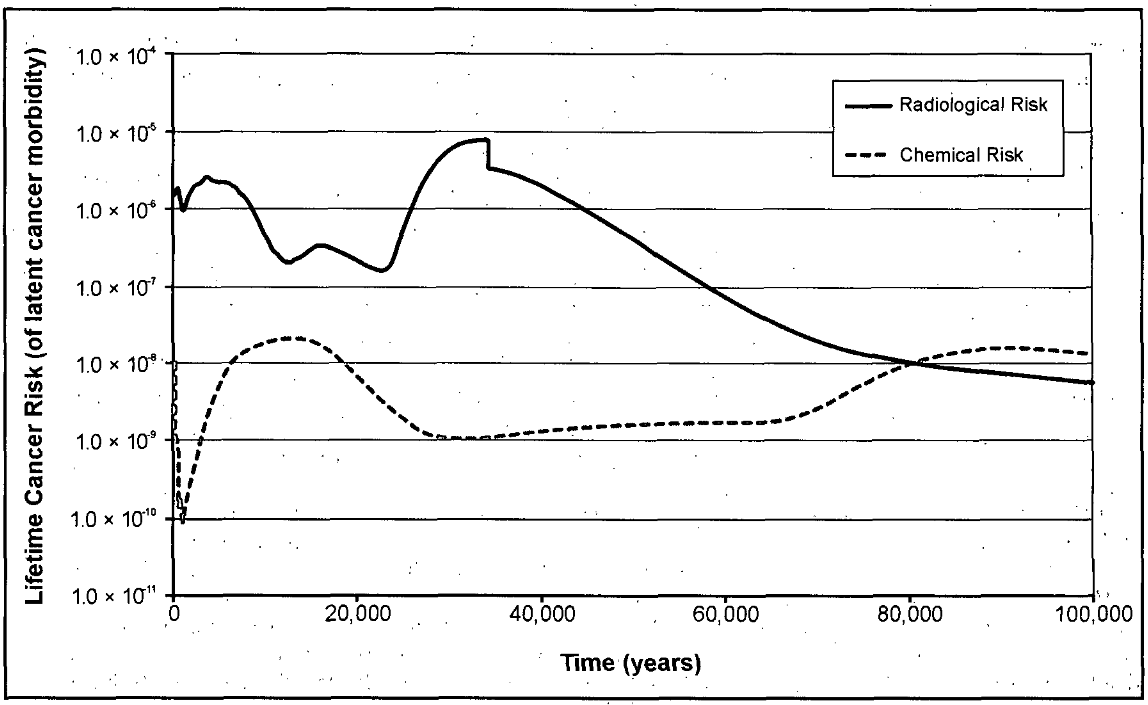

Figure H–10 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Seneca Nation of Indians Receptor with the Sitewide Closure-In-Place Alternative and Indefinite Continuation of Institutional Controls

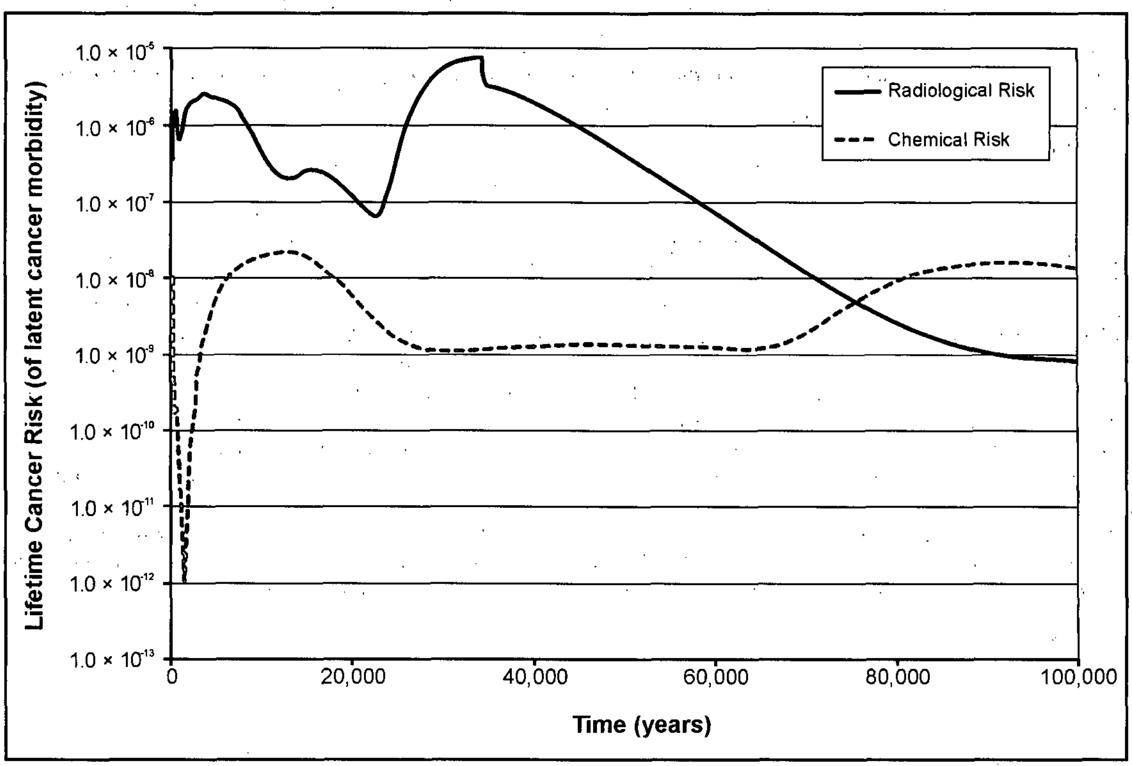

Figure H–11 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Seneca Nation of Indians Receptor with the No Action Alternative and Indefinite Continuation of Institutional Controls

Hazard Index

Another measure of chemical risk that is appropriate for non-carcinogenic chemicals is the hazard index for an individual receptor. If the hazard index is greater than 1, an observable non-carcinogenic health effect may occur. **Table H–38** presents the hazard index peaks for the Seneca Nation of Indians receptor for indefinite continuation of institutional controls.

The peak annual hazard index for the postulated Seneca Nation of Indians receptor is similar to, and sometimes slightly higher than, the peak annual hazard index for the Cattaraugus Creek receptor. The peak index in no case exceeds 1 percent. This confirms that the risk from non-carcinogenic hazardous chemicals is small.

Table H–38 Peak Chemical Hazard Index for the Seneca Nation of Indians Receptor (year of peak hazard index in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.6×10^{-5} (7,200)	0 [b]
Vitrification Facility – WMA 1	7.0×10^{-6} (17,100)	0 [b]
Waste Tank Farm – WMA 3	6.2×10^{-4} (12,400)	0 [b]
NDA – WMA 7	1.8×10^{-5} (85,900) [c]	1.7×10^{-5} (88,600) [c]
SDA – WMA 8	2.1×10^{-3} (4,700) [c]	2.2×10^{-3} (4,500) [c]
Total	2.4×10^{-3} (4,800)	2.2×10^{-3} (4,500)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted hazard index and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Fraction of Maximum Concentration in Liquid

The MCL is inversely proportional to the flow rate, which, at the Seneca Nation of Indians receptor, is twice that at the Cattaraugus Creek receptor. It follows that fractions of MCL for the Seneca Nation of Indians receptor are half those shown in Table H–34 for the Cattaraugus Creek receptor.

H.2.2.2.3 Lake Erie/Niagara Water River Users

This section discusses population dose, and individual exposures to radioactive materials and chemicals.

Population Dose

In addition to the Cattaraugus Creek and Seneca Nation of Indians individuals, peak annual and time-integrated population dose estimates have been prepared. These are summarized in **Tables H–39** and **H–40**, respectively. Lake Erie water users consume water taken from Sturgeon Point and several structures in the eastern channel of the Niagara River. They are assumed to drink water from Lake Erie or the Niagara River, to eat fish from Lake Erie, and (conservatively) to all be resident farmers.

Table H–39 Peak Annual Total Effective Population Dose Equivalent in person-rem per year for the Lake Erie Water Users (year of peak dose in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.2 (200)	0 [b]
Vitrification Facility – WMA 1	0.0065 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.0205(100)	1.5 (100)
Waste Tank Farm – WMA 3	0.66 (200)	0 [b]
NDA – WMA 7	1.1 (30,600) [c]	1.0 (31,500) [c]
SDA – WMA 8	16.9 (33,700) [c]	16.9 (33,700) [c]
North Plateau Groundwater Plume	13.7 (80)	21.5 (67)
Total	17.9 (33,600)	17.9 (33,400)

NDA = NRC-licensed Disposal Area; SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Most of the population dose shown in Table H–39 would be received by the users of water from Sturgeon Point and intake which would see higher radionuclide concentrations than the intake structures on the Niagara River. No credit is taken in dilution in the flow between the month of Cattaraugus Creek and the Sturgeon Point intake structure. Complete mixing in the flow of the Niagara River is assumed for water intake points in the Niagara River. The estimated annual background radiation dose for the Sturgeon Point group (565,000 people) would be approximately 200,000 person-rem. The peak annual dose of 18 person-rem for either alternative would be less than a 0.01 percent increase over the estimated annual background radiation dose received by this group.

Table 4–40 presents the time-integrated population dose over periods of 1,000 and 10,000 years. For both alternatives, the total population dose accumulated over 10,000 years (approximately 35,000 person-rem) would be less than the background dose accumulated by Sturgeon Point and Niagara River users in one year (200,000 person rem).

Individual Exposure to Radioactive Material

Tables H–41 and **H–42** contain the predicted peak individual TEDEs from radioactive exposure for Sturgeon Point and Niagara Falls respectively.

The total peak annual TEDEs in Table H–41 (Sturgeon Point) are all about a factor of 17 lower than those for the Seneca Nation of Indians receptor, and a factor of 7 lower than those for the Cattaraugus Creek receptor. The total peak annual TEDEs in Table H–42 (Niagara River) are still lower by more than a further factor of 100. Because the predicted values in Tables H–41 and H–42 are so low, it has been decided not to provide further information in the form of plots or detailed tables. This has already been done for the Cattaraugus Creek and Seneca Nation of Indians receptors: to do the same thing for the Sturgeon Point and Niagara River receptors would provide no new information. Similarly, predicted lifetime risks are comparably lower and are not further discussed here.

Table H–40 Time-Integrated Total Effective Population Dose Equivalent for Lake Erie Water Users (person-rem over 1,000 and 10,000 years) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Integration Over 1,000 Years		
Main Plant Process Building – WMA 1	510	0 [b]
Vitrification Facility – WMA 1	4	0 [b]
Low-Level Waste Treatment Facility – WMA 2	9	240
Waste Tank Farm – WMA 3	140	0 [b]
NDA – WMA 7	140 [c]	140 [c]
SDA – WMA 8	600 [c]	620 [c]
North Plateau Groundwater Plume	730	1,000
Total	2,100	2,000
Integration Over 10,000 Years		
Main Plant Process Building – WMA 1	1,000	0 [b]
Vitrification Facility – WMA 1	5	0 [b]
Low-Level Waste Treatment Facility – WMA 2	37	860
Waste Tank Farm – WMA 3	270	0 [b]
NDA – WMA 7	4,100 [c]	4,400 [c]
SDA – WMA 8	29,000 [c]	29,000 [c]
North Plateau Groundwater Plume	750	1,020
Total	35,000	35,000

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted population doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

For the Niagara River and Sturgeon Point users, the peak hazard index, the peak lifetime risk, and the ratio of concentration in water to the MCLs are all smaller than for Cattaraugus Creek or the Seneca Nation of Indians receptor and are not discussed further here.

Conclusions Given Continuation of Institutional Controls

For alternatives where waste would remain onsite, the overall assessment is that the dose and risk is small for both alternatives. The risk is dominated by the radiological hazards. The peak annual dose to offsite receptors is less than 25 millirem per year when considering all WMAs, regardless of the alternative.[8] The radiological hazard for both alternatives is dominated by the burial grounds with the SDA presenting the largest hazard over the longest time period.

[8] *The statement that the doses are less than 25 millirem is not intended to support any regulatory conclusions. Regulatory analysis is presented in Appendix L.*

Table H–41 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Sturgeon Point Receptor (year of peak dose in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.0021 (200)	0 [b]
Vitrification Facility – WMA 1	0.000011 (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	0.000036 (100)	0.0026 (100)
Waste Tank Farm – WMA 3	0.0012 (200)	0 [b]
NDA – WMA 7	0.0019 (30,600) [c]	0.0018 (31,500) [c]
SDA – WMA 8	0.030 (33,700) [c]	0.030 (33,700) [c]
North Plateau Groundwater Plume	0.024 (80) [d]	0.038 (67)
Total	0.032 (33,600)	0.032 (33,400)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–42 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Niagara River Receptor (year of peak dose in parentheses) – Indefinite Continuation of Institutional Controls

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	7.5×10^{-6} (200)	0 [b]
Vitrification Facility – WMA 1	4.1×10^{-8} (500)	0 [b]
Low-Level Waste Treatment Facility – WMA 2	1.3×10^{-7} (100)	9.5×10^{-6} (100)
Waste Tank Farm – WMA 3	4.2×10^{-6} (200)	0 [b]
NDA – WMA 7	7.0×10^{-6} (30,600) [c]	6.6×10^{-6} (31,400) [c]
SDA – WMA 8	1.1×10^{-4} (33,700) [c]	1.1×10^{-4} (33,700) [c]
North Plateau Groundwater Plume	8.66×10^{-5} (80)	1.4×10^{-4} (67)
Total	1.1×10^{-4} (33,400)	1.1×10^{-4} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that proactive maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational indefinitely. The doses from these units would be minimal as long as these engineered systems function as originally designed and institutional control prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

H.2.2.3 Conditions Assuming Loss of Institutional Control

The loss of institutional controls is assumed to take place after 100 years. In the case of the No Action Alternative, loss of institutional controls means that all maintenance activities cease and, in particular, no effort is made to keep radionuclides confined within the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm. Conservatively, failure of containment of these facilities is assumed to take place immediately upon loss of institutional controls. For the Sitewide Close-In-Place Alternative, however, it is expected that cessation of maintenance and other activities has little effect on the rate of release of radionuclides from areas that dominate dose in this case, such as the SDA and NDA. Finally, for both alternatives, loss of institutional controls means that intruders can enter the site.

The scenarios considered below are: (1) loss of institutional control leading to intruders on Buttermilk Creek; (2) loss of institutional controls leading to intruders on or adjacent to the north and south plateaus; (3) effect of loss of institutional controls on offsite receptors; and (4) loss of institutional control leading to an unmitigated erosion scenario.[9] All of these analyses focus on the impacts of radionuclides being released and coming in contact with human receptors. For radiological health impacts, the discussion is confined to dose impacts only (except for offsite receptors), because there are dose standards for situations following loss of institutional control, but not risk standards.

H.2.2.3.1 Loss of Institutional Controls Leading to Buttermilk Creek Intruder/Resident Farmer

Table H–43 presents the peak annual TEDE for the Buttermilk Creek resident farmer for each alternative, assuming failure of the active controls that would detect and mitigate releases from the process building, the high-level waste tank and the north plateau plume. See Figure H–2 for the location of this receptor.

Table H–43 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Buttermilk Creek Resident Farmer (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.15 (200)	9.9 (100)
Vitrification Facility – WMA 1	0.00062 (500)	1.7 (100)
Low-Level Waste Treatment Facility – WMA 2	0.00079 (100)	0.07 (100)
Waste Tank Farm – WMA 3	0.022 (200)	68 (100)
NDA – WMA 7	0.13 (6,800) [b]	0.14 (6,800) [b]
SDA – WMA 8	1.6 (33,800) [b]	1.6 (33,800) [b]
North Plateau Groundwater Plume	0.54 (79) [c]	0.86 (68) [c]
Total	1.7 (33,700)	80 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

[c] The predicted peak TEDE from the North Plateau Groundwater Plume is slightly less for the No Action Alternative than for the Sitewide Close-In-Place Alternative because mitigating features in the latter case (e.g., hydraulic barriers) slightly reduce the rate of groundwater flow to Cattaraugus Creek, thus resulting in slightly greater predicted concentration of radionuclides.

[9] *Cases 1-3 consider loss of institutional controls without erosion. Case 4 considers the case with erosion, see Section H.2.2.4. Section H.2.2.4 also contains a qualitative discussion of the combination of doses received as a result of both erosion and releases into groundwater.*

All of the predicted doses for the Sitewide Close-In-Place Alternative would be less than 25 millirem per year. The No Action Alternative would result in the highest peak annual dose to this receptor (80 millirem), dominated by the Waste Tank Farm (68 millirem). If the loss of institutional controls were to occur earlier (i.e., prior to year 100), the dose would be higher because radionuclides from facilities such as the Main Plant Process Building could then migrate towards receptors and reach them sooner with less radioactive decay having taken place. For the Sitewide Close-In-Place Alternative, the SDA is the largest contributor to the long-term dose, while for the No Action Alternative the Waste Tank Farms would dominate.

H.2.2.3.2 Loss of Institutional Controls Leading to North and South Plateau Intruders

This section presents the estimated doses to a spectrum of intruders that could enter the site in the event of failure of institutional controls designed to limit site access. These scenarios are considered to be reasonably conservative ones and useful for understanding the potential magnitude of impacts if intruders come onto the plateaus. The specific intruders evaluated are: (1) direct intruder workers, (2) a resident farmer who has waste material directly deposited in his garden as a result of well drilling or home construction, and (3) a resident farmer who uses contaminated groundwater. Direct intruders are assumed to be located directly above the waste in each WMA while contaminated groundwater is assumed to come from wells that are located approximately 100 meters downgradient from the edge of the waste, see Figure H–3. Additional information on these exposure scenarios is provided in Appendix D. For the purposes of analysis of the No Action alternative, the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm are assumed to have collapsed and lost their structural integrity after exactly 100 years.

Intruder Worker

Table H–44 presents the doses to the intruder worker. Two worker scenarios were considered, a well driller and a home constructor. For the well driller, exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and direct exposure to contaminated water in a cuttings pond. For home construction, exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and exposure to external radiation from the walls of an excavation for the foundation of a home. However, the home construction scenario is not considered credible when there is a thick engineered cap (e.g., the South Plateau burial grounds under the Sitewide Close-In-Place Alternative).

The results of this analysis are summarized in Table H–44, with the results presented for the scenario with the highest TEDE. The results presented assume the scenario occurs after 100 years of effective institutional controls.

Under the Sitewide Close-In-Place Alternative, none of the predicted doses would exceed 10 millirem per year.[10] However, the No Action Alternative peak annual doses could be substantial. For the No Action Alternative, the highest dose would be for the Low-Level Waste Treatment Facility from the home construction scenario. In all cases, the radionuclide contributing the greatest portion of dose is cesium-137.

This analysis shows the importance of the thick, multi-layered engineered barrier in limiting the extent of direct intrusion into the waste, and thereby limiting the dose under the Sitewide Close-In-Place Alternative.

[10] *This is merely an observation with no implied regulatory implications.*

Table H–44 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to Intruder Worker (well driller or home construction worker) – Intrusion After 100 Years

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Not applicable	3,890 [a,c]
Vitrification Facility – WMA 1	Not applicable	27,800 [a,c]
Low-Level Waste Treatment Facility – WMA 2	1.7 [d]	55,700 [a, c]
Waste Tank Farm – WMA 3	Not applicable	133 [d]
NDA – WMA 7	Not applicable	18,900 [a]
SDA – WMA 8	Not applicable	4,580 [a, c]
North Plateau Groundwater Plume	0 [b]	0 [b]
Cesium Prong Onsite	4.4 [c]	4.4 [c]
Cesium Prong Offsite	0.9 [c]	0.9 [c]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The doses for the No Action alternative are very high because, in this scenario, the well driller or home construction worker intrudes directly into volumes that contain high inventories of radionuclides. In the corresponding Sitewide Close-In-Place scenarios, the concentrated inventories have been covered by a cap that is thick enough to preclude a home construction worker from reaching the remaining inventories.

[b] There would be a dose to a well driller, but it is predicted to be less than 1 × 10^{-8} millirem per year.

[c] Peak impact due to home construction scenarios.

[d] Peak impact due to well-drilling scenarios.

Resident Farmer with Waste Material in His Garden

Table H–45 presents the doses to the resident farmer as a result of direct contact from contamination that would be brought to the surface and placed in a garden following a well drilling or home construction scenario. In all cases, the radionuclide contributing the greatest portion of dose is cesium-137.

Table H–45 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to Resident Farmer with a Garden Containing Contaminated Soil from Well Drilling or House Construction – Intrusion After 100 Years

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Not applicable	7,350 [a,c]
Vitrification Facility – WMA 1	Not applicable	71,800 [a,c]
Low-Level Waste Treatment Facility – WMA 2	12 [b,d]	111,000 [a,c,]
Waste Tank Farm – WMA 3	Not applicable	2,030 [a,c]
NDA – WMA 7	Not applicable	22,600 [a,d]
SDA – WMA 8	Not applicable	2,750 [a,c]
North Plateau Groundwater Plume	0 [d]	0 [d]
Cesium Prong – onsite	4.4 [c]	4.4 [c]
Cesium Prong – offsite	0.9 [c]	0.9 [c]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The doses for the No Action Alternative are very high because, in this scenario, the well driller or home construction worker intrudes directly into volumes that contain high inventories of radionuclides. In the corresponding Sitewide Close-In-Place scenarios, the concentrated inventories have been covered by a cap that is thick enough to preclude a home construction worker from reaching the remaining inventories.

[b] In the case of the Low-Level Waste Treatment Facility, it is possible for the well driller to penetrate soil contaminated with radioactive waste, and spread radioactive material over a farmer's garden. However, the amount of material brought to the surface by a well driller is much less than that spread around during house construction.

[c] Peak impact due to home construction scenarios

[d] Peak impact due to well-drilling scenarios.

Resident Farmer Using Contaminated Groundwater

Table H–46 presents the doses to the resident farmer whose contact with the waste would be through an indirect pathway – the use of contaminated water. The receptors for the North Plateau facilities (Main Plant Process Building, Low-Level Waste Treatment Facility, Waste Tank Farm, and North Plateau Groundwater Plume) have wells in the sand and gravel layer on the North Plateau. For the North Plateau Groundwater Plume, the peak dose for the Sitewide Close-In-Place Alternative exceeds that of the No Action Alternative because the plume moves more rapidly for the No Action Alternative. The scenario is inapplicable for the NDA and SDA receptor because of the low hydraulic conductivity of the unweathered Lavery until and the unsaturated conditions in the Kent Recessional Sequence.

Table H–46 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year to a Resident Farmer using Contaminated Groundwater – Intrusion After 100 Years

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	366	36,900[a]
Vitrification Facility – WMA 1	1.9	3,410[a]
Low-Level Waste Treatment Facility – WMA 2	110	3,000
Waste Tank Farm – WMA 3	556	1,500,000[a]
NDA – WMA 7	Not applicable	Not applicable
SDA – WMA 8	Not applicable	Not applicable
North Plateau Groundwater Plume	846	420
Cesium Prong – onsite	4.4	4.4
Cesium Prong – offsite	0.9	0.9

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] The doses for the No Action Alternative are very high because, in this scenario, the well intrudes directly into volumes that contain high inventories of radionuclides. In the Sitewide Close-In-Place scenario the cap prevents direct intrusion into the waste and the slurry wall and cap limit flow of water through the waste.

The results for the No Action Alternative clearly show that serious consequences are possible should facilities like the Main Plant Process Building or the Waste Tank Farm be abandoned. The results also show the high potential consequences for both alternatives in the event of intrusion over the North Plateau Groundwater Plume.

The time series of dose for the North Plateau plume under the Sitewide Close-In-Place Alternative is presented in **Figure H–12** for receptors at 100 and 300 meters from the source of the plume. The figure illustrates how sensitive the dose is to the time at which the intrusion occurs, and to where the intruder places his farm. The peak dose in Table H–46 for the North Plateau Groundwater Plume for the Sitewide Close-In-Place Alternative come from the receptor at 300 meters at 100 years. The distance of 100 meters is in the vicinity of the peak concentration of the plume at the first year of the period of analysis for both the No Action and Sitewide Close-In-Place Alternatives and just outside of the downgradient slurry wall for the Sitewide Close-In-Place Alternative. The distance of 300 meters is located just upgradient of the North Plateau drainage ditch, the first location of discharge of the plume to the surface. For each alternative, the peak onsite concentration would occur during the period of institutional control when a receptor could not access the contaminated groundwater. As time proceeds, concentration in the plume decreases at locations near the source and increases and then decreases at locations further removed from the source. This behavior explains the occurrence of peak dose at a location removed from the original source for an analysis time of 100 years.

Dose from Multiple Sources

The previous discussion presented information on the dose to various receptors from individual WMAs. There is the potential for receptors to come in contact with contamination from multiple areas and therefore see higher doses than one would see from a single WMA. The highest doses are home construction intruders for the No Action Alternative (Table H–44), a resident farmer with contamination from home construction for the No Action Alternative (Table H–45) and a resident farmer using contaminated groundwater under either the Sitewide Close-In-Place Alternative or the No Action Alternative (Table H–46).

The greatest potential for a dose from multiple sources for the No Action Alternative would be the combination of a garden contaminated with material from a home construction and irrigated with contaminated groundwater. These combinations could result in peak doses approaching 100,000 millirem or even higher if the well was located near the Waste Tank Farm.

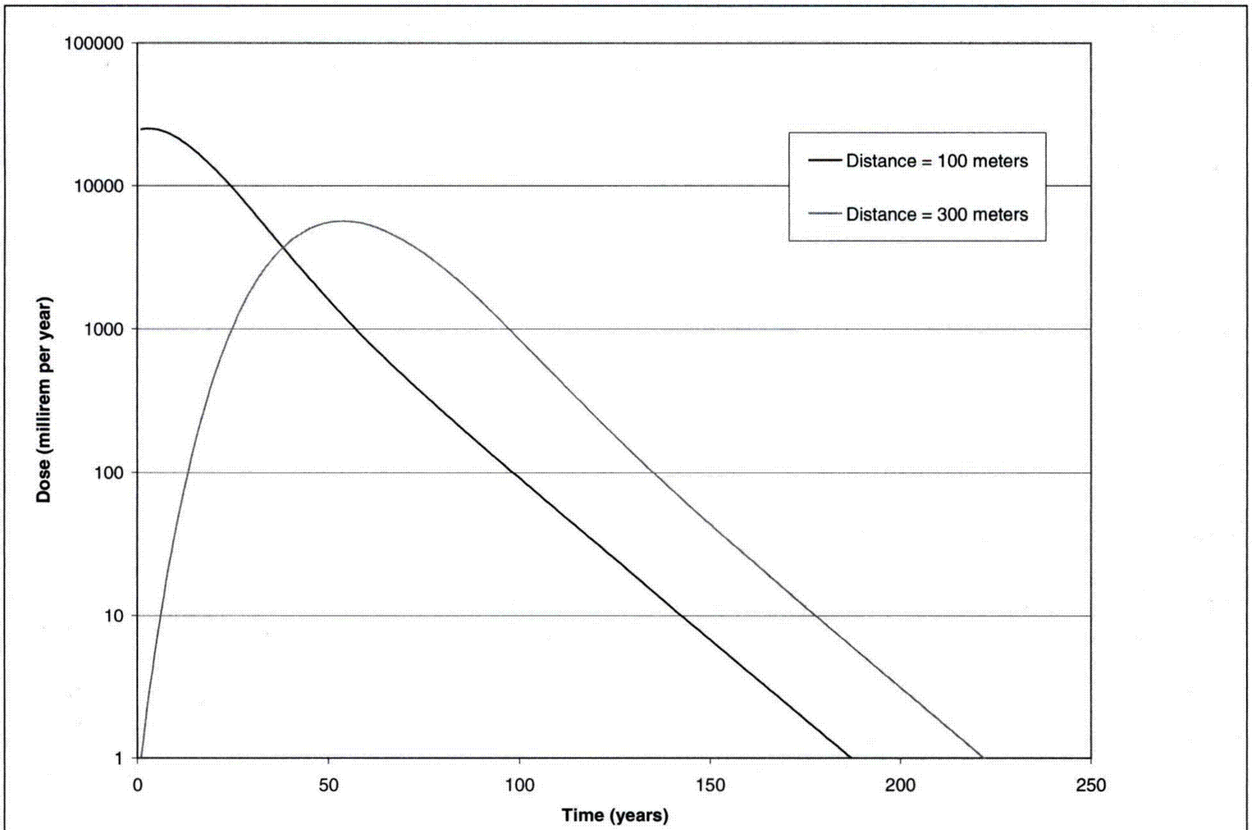

Figure H–12 Time Series of Dose for Onsite Receptors for North Plateau Groundwater Plume Under Sitewide Close-In-Place – Time Measured from Completion of Decommissioning

The greatest potential for the Sitewide Close-In-Place Alternative would appear to involve a water well on the North Plateau that would intercept the plume from both the Main Plant Process Building and the Waste Tank Farm. A conservative estimate of the combined dose from the Main Plant Process Building and the Waste Tank Farm would be about 900 millirem (366 from the Main Plant Process Building and 556 from Waste Tank Farm).

H.2.2.3.3 Effect of Loss of Institutional Controls on Offsite Receptors

This Section is parallel to Section H.2.2.2, which presented the results of the long-term performance assessment for offsite receptors assuming indefinite continuation of institutional controls (but with no erosion, which is considered in Section H.2.2.4). However, in this Section it is assumed that institutional controls will be lost after 100 years and maintenance activities will cease. In particular, it is assumed that there are no more efforts to contain radionuclides and hazardous chemicals within WMAs on the North and South Plateaus. Conservatively, these are assumed to fail as soon as institutional controls fail. This subsection reexamines the analysis for the offsite receptors.

The principal effect of allowing releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm is to considerably increase predicted doses and risks for the No Action Alternative. However, the predicted doses and risks for the Sitewide Close-In-Place Alternative are barely changed because the various engineered features that would be put in place around and above (for example) the NDA and SDA would be little affected by the cessation of maintenance. Therefore, the discussion in Section H.2.2.2.3 focuses on the No Action Alternative. Tabular results for the Sitewide Close-In-Place Alternative are included for comparison, but readers should turn to Section H.2.2.1 for discussions.

Cattaraugus Creek Receptor

As described previously, the Cattaraugus Creek receptor is a postulated offsite receptor who is closest to the site boundary and receives the impact of liquid release from all portions of the site. This receptor is conservatively assumed to drink water from Cattaraugus Creek, eat fish and deer, and irrigate his garden, also with water from Cattaraugus Creek.

Radiological Dose and Risk

This section covers TEDE, dominant doses and pathways, and radiological risk.

Total Effective Dose Equivalent

Figure H–13 present the annual TEDE as a function of time to the Cattaraugus Creek receptor for the No Action Alternative. See Figure H–4 for the comparable plot for the Sitewide Close-In-Place Alternative.

The figures show a number of peaks that correspond to the arrival of "pulses" of radionuclides from different areas on the site. This is further clarified by **Table H–47**, which, for each alternative, displays the WMA, the predicted peak annual TEDE arising from radionuclides leaching from the WMA, and the predicted years until peak annual TEDE.

The results presented in Table H–47 show that the total peak annual dose to the Cattaraugus Creek receptor due to groundwater releases would s be below 25 millirem per year for both alternatives. However, whereas in Table H–26 the predicted total doses for the two alternatives were about the same, the dose for the No Action Alternative is now 40 to 50 times larger. For the No Action Alternative, the peak annual dose would be dominated by the Waste Tank Farm and occurs at approximately 100 years. The dominant radionuclide from the Waste Tank Farm is strontium-90 in drinking water. The doses for the Sitewide Close-In-Place Alternative are much the same as they were for indefinite continuation of institutional controls, reflecting the fact that the conservative assumptions in the model mean that the maintenance or cessation of institutional controls make little difference to how rapidly, for example, nuclides enter groundwater in the SDA and are then transported to Franks Creek or Erdman Brook.

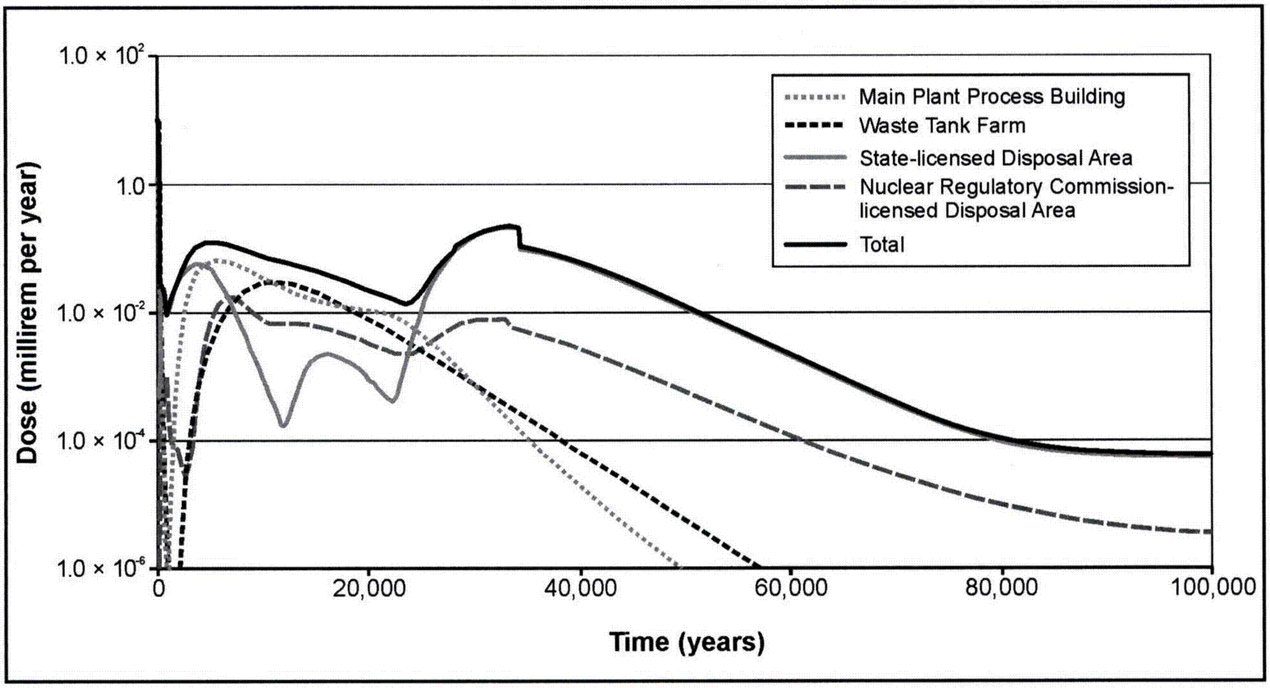

Figure H–13 Annual Total Effective Dose Equivalent for the Cattaraugus Creek Receptor with the No Action Alternative and Loss of Institutional Controls after 100 Years

Table H–47 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor (year of peak exposure in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.019 (200)	1.3 (100) [b]
Vitrification Facility – WMA 1	0.000082 (500)	0.23 (100) [b]
Low-Level Waste Treatment Facility – WMA 2	0.0092 (100)	0.026 (100)
Waste Tank Farm – WMA 3	0.0029 (200)	8.9 (100) [b]
NDA – WMA 7	0.018 (6,800) [c]	0.018 (6,800) [c]
SDA – WMA 8	0.21 (33,800) [c]	0.21 (33,800) [c]
North Plateau Groundwater Plume	0.072 (79)	0.11 (68)
Total	0.22 (33,700)	10 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Detailed Analysis of Total Effective Dose Equivalent

Table H–48 provides further detailed breakdown of Table H–47 organized by components. The parallel table in Section H.2.2.2 is Table H–27.

Table H–48 shows that the dominant contributor to the radiological dose for the No Action Alternative is Tank 8D-2

Table H–48 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor Broken Down by Waste Management Area Components (year of peak exposure in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	1.4×10^{-3} (800)	2.0×10^{-1} (100) [b]
	General Purpose Cell	6.8×10^{-3} (19,700)	6.0×10^{-1} (100) [b]
	Liquid Waste Cell	1.4×10^{-2} (200)	4.7×10^{-1} (100) [b]
	Fuel Receiving Storage Pad	3.3×10^{-4} (19,800)	2.6×10^{-2} (100) [b]
	Total Main Plant Process Building	1.9×10^{-2} (200)	1.3 (100) [b]
Vitrification Facility – WMA 1		8.2×10^{-5} (500)	2.3×10^{-1} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	1.0×10^{-4} (6,500)	6.9×10^{-3} (100)
	Lagoon 2	5.5×10^{-5} (100)	2.3×10^{-3} (100)
	Lagoon 3	1.5×10^{-7} (300)	5.0×10^{-6} (100)
	Lagoon 4	6.2×10^{-7} (100)	6.8×10^{-7} (100)
	Lagoon 5	2.0×10^{-7} (100)	2.3×10^{-7} (100)
	Total LLWTF	1.5×10^{-4} (100)	9.2×10^{-3} (100)
Waste Tank Farm – WMA 3	8D-1	1.6×10^{-3} (200)	4.1×10^{-1} (100) [b]
	8D-2	1.4×10^{-3} (200)	7.0 (100) [b]
	8D-3	6.4×10^{-7} (400)	2.5×10^{-4} (100) [b]
	8D-4	2.5×10^{-5} (400)	1.5 (100) [b]
	Total Waste Tank Farm	2.9×10^{-3} (200)	8.9 (100) [b]
NDA – WMA 7 Horizontal	Process	1.7×10^{-3} (18,500)	2.0×10^{-3} (15,400)
	Hulls	2.8×10^{-4} (12,500)	4.2×10^{-4} (10,700)
	WVDP	1.4×10^{-5} (16,900)	1.5×10^{-5} (14,700)
	Total NDA – Horizontal	2.0×10^{-3} (18,300)	2.3×10^{-3} (14,900)
NDA – WMA 7 Vertical/ Horizontal	Process	7.1×10^{-3} (30,900)	7.1×10^{-3} (31,700)
	Hulls	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
	WVDP	1.2×10^{-4} (21,300)	1.2×10^{-4} (21,300)
	Total NDA – Vertical/Horizontal	1.8×10^{-2} (6,800)	1.8×10^{-2} (6,800)
Total NDA	Total NDA	1.8×10^{-2} (6,800) [c]	1.8×10^{-2} (6,800) [c]
SDA – WMA 8	Horizontal	4.6×10^{-2} (4,700)	4.6×10^{-2} (4,500)
	Vertical/Horizontal	2.1×10^{-1} (33,700)	2.1×10^{-1} (33,700)
	Total SDA	2.1×10^{-1} (33,800) [c]	2.1×10^{-1} (33,800) [c]
North Plateau Groundwater Plume		7.2×10^{-2} (79)	1.1×10^{-1} (68)
Total Site		2.2×10^{-1} (33,700)	1.0×10^{1} (100)

WMA = Waste Management Area, LLWTF = Low-Level Waste Treatment Facility, NDA = NRC-licensed Disposal Area, WVDP = West Valley Demonstration Project, SDA = State-licensed Disposal Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted TEDEs and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Controlling Nuclides and Pathways

It is of interest to understand the controlling nuclides and pathways at the years until peak TEDE. **Table H–49** provides this information. For the No Action Alternative, also as noted above, the high-level waste tanks, particularly 8D-2 provide the largest peaks. These are dominated by the ingestion of strontium-90 in drinking water, whereas the Sitewide Close-In-Place Alternative is dominated by uranium and carbon isotopes from the SDA via fish.

Table H–49 Controlling Nuclides and Pathways for the Cattaraugus Creek Receptor, Broken Down by Waste Management Area Components at Year of Peak Annual Total Effective Dose Equivalent – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Controlling Nuclide/Pathway*	
		Sitewide Close-In-Place Alternative	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	Strontium-90/DW
	General Purpose Cell	Plutonium-239/Fish	Strontium-90/DW
	Liquid Waste Cell	Iodine-129/Fish	Strontium-90/DW
	Fuel Receiving Storage Pad	Plutonium-239/Fish	Strontium-90/DW
Vitrification Facility – WMA 1		Neptunium-237/Fish	Strontium-90/DW
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Strontium-90/DW
	Lagoon 2	Strontium-90/DW	Strontium-90/DW
	Lagoon 3	Uranium-234/DW	Uranium-234/DW
	Lagoon 4	Uranium-234/DW	Uranium-234/DW
	Lagoon 5	Uranium-234/DW	Uranium-234/DW
Waste Tank Farm – WMA 3	8D-1	Technetium-99/RF [b]	Strontium-90/DW
	8D-2	Technetium-99/Fish	Strontium-90/DW
	8D-3	Technetium-99/RF [b]	Strontium-90/DW
	8D-4	Iodine-129/Fish	Strontium-90/DW
NDA – WMA 7 Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/DW	Uranium-233/DW
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/DW	Uranium-233/DW
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/DW	Uranium-233/DW
SDA – WMA 8	Horizontal	Uranium-234/Fish	Uranium-234/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/DW	Strontium-90/DW

DW = drinking water, NDA = NRC-licensed Disposal Area, RF = resident farmer, SDA = State-licensed Disposal Area, WVDP = West Valley Demonstration Project, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] RF means resident farmer and includes a number of pathways such as eating contaminated vegetables, inhalation, etc.

Excess Cancer Risk

A complementary measure is the peak lifetime risk (excess cancer risk) to the Cattaraugus Creek receptor arising from radiological discharges. **Table H–50** shows how this risk varies from different WMAs and what it is for contributions from the entire WNYNSC for each alternative. As expected, this table closely parallels the dose table, Table H–47. Releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farms increase the predicted lifetime risk of cancer fatality by about a factor of 100 to ~ 10^{-4}.

Table H–50 Peak Lifetime Radiological Risk (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	3.6×10^{-7} (200)	2.8×10^{-5} (100) [b]
Vitrification Facility – WMA 1	5.0×10^{-10} (500)	5.0×10^{-6} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	3.9×10^{-9} (100)	2.0×10^{-7} (100)
Waste Tank Farm – WMA 3	1.3×10^{-7} (200)	1.9×10^{-4} (100) [b]
NDA – WMA 7	4.7×10^{-7} (6,800) [c]	4.7×10^{-7} (6,800) [c]
SDA – WMA 8	2.7×10^{-6} (33,700) [c]	2.7×10^{-6} (33,700) [c]
North Plateau Groundwater Plume	1.6×10^{-6} (79)	2.4×10^{-6} (68)
Total	2.7×10^{-6} (33,700)	2.3×10^{-4} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.
[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risks from these units would be minimal as long as these engineered systems function as originally designed.
[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

Estimates of the risk to the Cattaraugus Creek receptor from hazardous chemicals in the burial grounds, the process building and the high-level waste tank have also been prepared. Three measures are used: lifetime cancer risk, hazard index and comparison to MCLs for drinking water that have been issued under the Clean Water Act.

Lifetime Cancer Risk

Table H–51 shows the peak lifetime cancer risk from chemical exposure broken down by WMA. In contrast to the case for radiological doses, the additional releases from the Main Plant Process Building and Waste Tank Farm that occurring the case of the No Action Alternative do not cause a large increase in risk. This is because, when thinking purely of chemicals, inventories of hazardous chemicals are much larger and more mobile in the NDA and SDA than in the buildings and tanks.[11]

[11] Note that, in general, organic chemicals experience less retardation than radionuclides. The controlling constituent of the NDA impact is more strongly retarded than that for the SDA impact, which is why the SDA peak occurs much earlier than the NDA peak. Note also that degradation of organic compounds was not addressed.

Table H–51 Peak Lifetime Risk from Hazardous Chemicals (risk of latent cancer morbidity) for the Cattaraugus Creek Receptor (year of peak risk in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.3×10^{-10} (6,000)	2.9×10^{-9} (4,200) [b]
Vitrification Facility – WMA 1	5.9×10^{-11} (7,400)	1.0×10^{-9} (4,300) [b]
Waste Tank Farm – WMA 3	3.1×10^{-10} (9,000)	1.0×10^{-9} (2,600) [b]
NDA – WMA 7	1.3×10^{-9} (86,400) [c]	1.3×10^{-9} (88,700) [c]
SDA – WMA 8	2.0×10^{-8} (100) [c]	2.1×10^{-8} (100) [c]
Total	2.0×10^{-8} (100)	2.1×10^{-8} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risk from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

This comparison of lifetime cancer risk from radionuclides and chemicals for the Cattaraugus Creek receptor in the No Action Case is also shown in **Figure H–14**. The comparable figure for the No Action Alternative with indefinite continuation of institutional controls is given in Figure H–7. The two figures are similar.

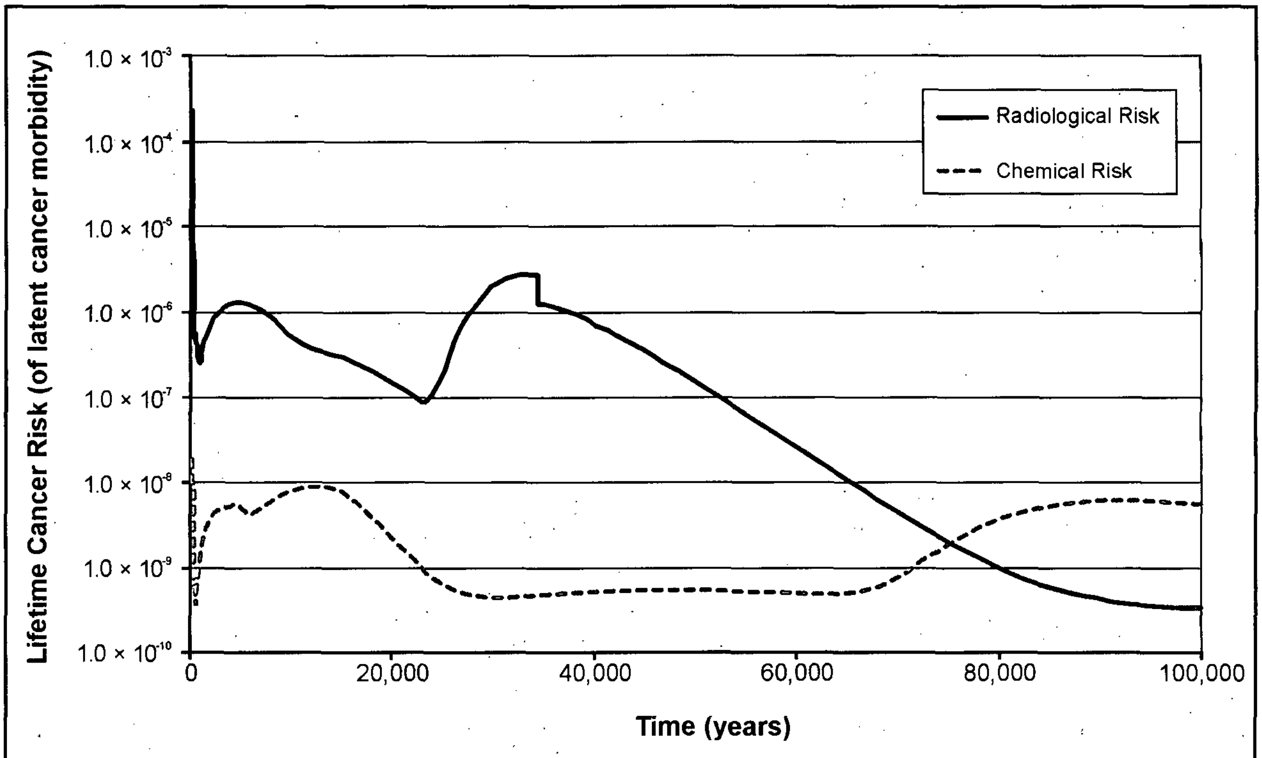

Figure H–14 Lifetime Cancer Risk from Radionuclides and Hazardous Chemicals for the Cattaraugus Creek Receptor with the No Action Alternative and Loss of Institutional Controls After 100 Years

As was the case for TEDEs (Table H–48), it is possible to break the information in Table H–51 down to more detailed levels. However, the contributions from all sources are so small that it is not worth breaking them down further. It is also possible to graphically represent how the excess cancer risks listed above behave as a function of time, broken down by each WMA. These detailed results are available upon request.

Hazard Index

Another measure of chemical risk that is appropriate for non-carcinogenic chemicals is the hazard index for an individual receptor. If the hazard index is greater than 1, an observable non-carcinogenic health effect may occur. **Table H–52** presents the hazard index peaks for the Cattaraugus Creek receptor in the case of loss of institutional controls after 100 years.

These hazard indices are all very small, with the totals being less than 1 percent. The Main Plant Process Building and the Vitrification Facility add only about 20 percent to the total hazard index. In principal, they can be broken down by WMA component. Their behavior as a function of time could also be plotted. However, this would not provide much useful information since the totals are so small. These breakdowns are available upon request.

Table H–52 Peak Chemical Hazard Index for the Cattaraugus Creek Receptor (year of peak hazard index in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	6.7×10^{-6} (8,100)	1.1×10^{-4} (3,300) [b]
Vitrification Facility – WMA 1	2.5×10^{-6} (10,100)	3.8×10^{-5} (4,400) [b]
Waste Tank Farm – WMA 3	2.0×10^{-4} (12,400)	6.7×10^{-4} (3,600) [b]
NDA – WMA 7	1.4×10^{-5} (30,100)	1.5×10^{-5} (30,900)
SDA – WMA 8	2.8×10^{-3} (4,700)	2.9×10^{-3} (4,500)
Total	2.9×10^{-3} (4,700)	3.6×10^{-3} (4,300)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.
[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The hazard indices from these units would be minimal as long as these engineered systems function as originally designed.

Fraction of Maximum Concentration in Liquid

Table H–53 shows the chemical that has the largest fraction of its MCL at the years until peak risk and the years until peak hazard index. The addition of releases from the Main Plant Process Building and the Waste Tank Farm for the No Action Alternative does not change the conclusion that the maximum ratios to the MCL are all less than one, nor does it introduce different chemicals.

Seneca Nation of Indians Receptor

As described previously, the Seneca Nation of Indians receptor is similar to the Cattaraugus Creek receptor but is postulated to consume a larger amount of fish (62 kilograms per year) raised in the lower reaches of Cattaraugus Creek or in Lake Erie near the point where Cattaraugus Creek discharges into the lake. The results presented below are in many respects similar to those for the Cattaraugus Creek receptor, so the discussion that follows is less detailed than for Cattaraugus Creek.

Table H–53 Chemicals with Largest Fraction of Maximum Concentration Levels in Cattaraugus Creek – Loss of Institutional Controls After 100 Years [a]

Waste Management Areas [b]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
	Year of Peak Risk in Parentheses	
Main Plant Process Building – WMA 1	9.7×10^{-6} (55,100) Pb [d]	1.9×10^{-4} (4,200) Pb [c,d]
Vitrification Facility – WMA 1	6.7×10^{-3} (40,500) Pb [d]	8.5×10^{-2} (4,300) Tl [c,e]
Waste Tank Farm – WMA 3	2.0×10^{-6} (9,000) Tl [e]	4.8×10^{-6} (2,600) Tl [c,e]
NDA – WMA 7	1.3×10^{-6} (86,700) As [f]	1.3×10^{-6} (89,200) As [f]
SDA – WMA 8	8.3×10^{-5} (200) Usol [g]	9.0×10^{-5} (100) Usol [g]
	Year of Peak Hazard Index in Parentheses	
Main Plant Process Building – WMA 1	9.6×10^{-6} (8,100) Pb [d]	1.5×10^{-4} (3,300) Pb [c,d]
Vitrification Facility – WMA 1	6.7×10^{-3} (26,000) Pb [d]	8.5×10^{-2} (4,300) Tl [c,e]
Waste Tank Farm – WMA 3	2.1×10^{-6} (12,400) Tl [e]	7.2×10^{-6} (3,600) Tl [c,e]
NDA – WMA 7	3.4×10^{-5} (30,200) Usol [f,h]	3.4×10^{-5} (31,000) Usol [f,h]
SDA – WMA 8	7.5×10^{-3} (4,700) Usol [g,h]	7.8×10^{-3} (4,500) Usol [g,h]

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] Presented as fraction of the applicable MCL / (years until peak exposure) / chemical.

[b] The limited information available on hazardous chemical inventories in the Low-Level Waste Treatment Facility suggest it will not make a noticeable contribution to the overall long-term risk from hazardous chemicals.

[c] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational indefinitely. The health impacts of hazardous chemicals released from these units would be minimal as long as these engineered systems function as originally designed and institutional controls prevents releases from the Main Plant Process Building, the Vitrification Facility, and the Waste Tank Farm.

[d] Pb = lead, MCL (Action Level) = 0.015 milligrams per liter.

[e] Tl= thallium, MCL = 0.002 milligrams per liter.

[f] As = arsenic, MCL = 0.01 milligrams per liter.

[g] Usol = soluble uranium, MCL = 0.03 milligrams per liter.

[h] The reason why the predicted MCL and years until peak exposure are almost the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Radiological Dose and Risk

Total Effective Dose Equivalent

Figure H–15 presents the annual TEDE as a function of time to a Seneca Nation of Indians receptor located just outside the WNYNSC boundary. This hypothetical individual is postulated to drink water from Cattaraugus Creek, use the water for irrigation and consume fish raised in the Cattaraugus Creek. The principal difference from the Cattaraugus Creek receptor is that the Seneca Nation of Indians receptor consumes more fish. The figures show the relative contributions of the four WMAs that are the largest contributors to the predicted dose (the Main Plant Process Building, the Waste Tank Farm, the NDA, and the SDA). This figure is much the same as the comparable one for Cattaraugus Creek (H–13) except that the curves are somewhat higher due to the aforementioned consumption of fish.

The magnitude and the year of the peak contribution are shown in **Table H–54.**

Comparing with Table H–47, the predicted TEDEs would be higher than those of the Cattaraugus Creek receptor for both alternatives, again due to the aforementioned consumption of fish; the ratio of the dose received by the Seneca Nation of Indians receptor to that received by the Cattaraugus Creek Receptor is 2.5 for the Sitewide Close-In-Place Alternative and 1.3 for the No Action Alternative. These peak doses would occur at approximately the same time as do those for the Cattaraugus Creek receptor, and would be dominated by the SDA for the Sitewide Close-In-Place Alternative, and by the Waste Tank Farm for the No Action Alternative.

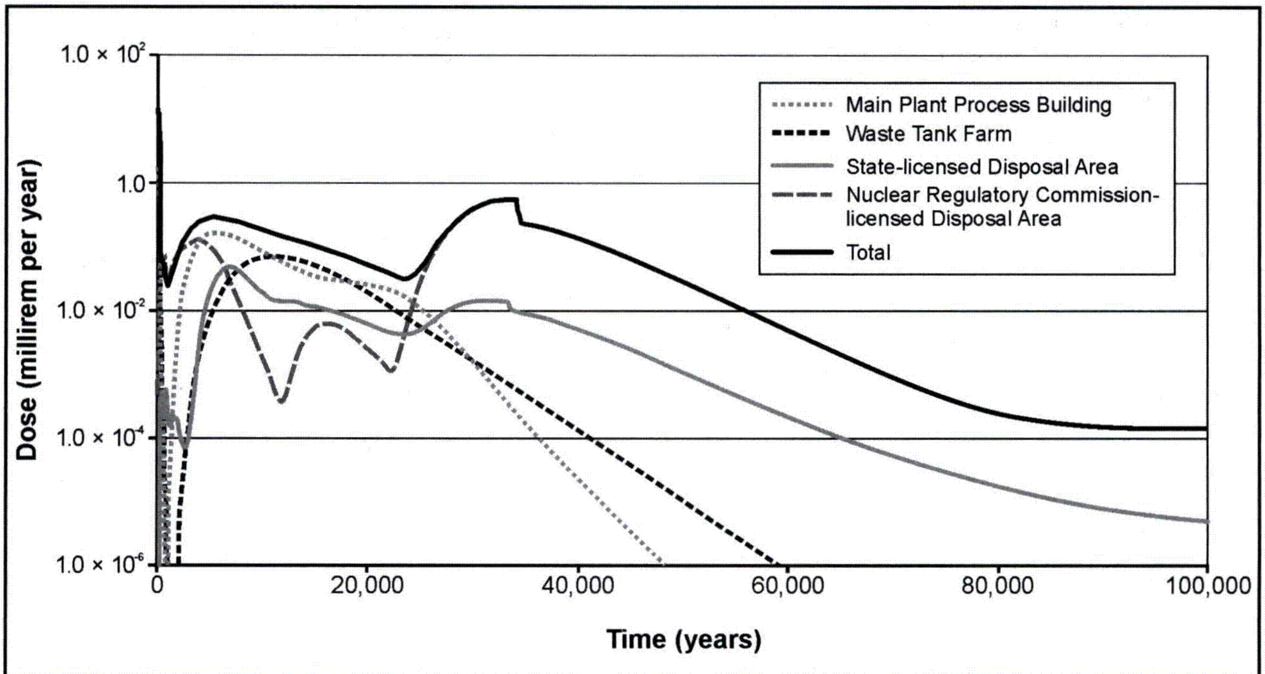

Figure H–15 Annual Total Effective Dose Equivalent for the Seneca Nation of Indians Receptor with the No Action Alternative and Loss Institutional Controls After 100 Years

Table H–54 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.052 (200)	1.8 (100) [b]
Vitrification Facility – WMA 1	0.00020 (500)	0.29 (100) [b]
Low-Level Waste Treatment Facility – WMA 2	0.00029 (100)	0.015 (100)
Waste Tank Farm – WMA 3	0.0027 (200)	11 (100) [b]
NDA – WMA 7	0.048 (6,800) [c]	0.049 (6,800) [c]
SDA – WMA 8	0.52 (33,800) [c]	0.52 (33,800) [c]
North Plateau Groundwater Plume	0.093 (78)	0.15 (67)
Total	0.54 (33,700)	13 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–55 provides further detailed breakdown of Table H–54 organized by components of each WMA. Table H–54 is similar to that for the Cattaraugus Creek receptor (Table H–48). Just as was the case for the Cattaraugus Creek receptor, Tank 8D-2 is the dominant contributor to the predicted dose for the No Action Alternative.

Table H–55 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Seneca Nation of Indians Receptor Broken down by Waste Management Area Components (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place*	*No Action*
Main Plant Process Building – WMA 1	Rubble Pile	3.5×10^{-3} (800)	2.6×10^{-1} (100) [b]
	General Purpose Cell	1.7×10^{-2} (19,500)	7.7×10^{-1} (100) [b]
	Liquid Waste Cell	3.8×10^{-2} (200)	7.2×10^{-1} (100) [b]
	Fuel Receiving Storage Pool	8.0×10^{-4} (19,800)	3.3×10^{-2} (100) [b]
	Total Main Plant Process Building	5.2×10^{-2} (200)	1.8 (100) [b]
Vitrification Facility – WMA 1		2.0×10^{-4} (500)	2.9×10^{-1} (100)
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	2.4×10^{-4} (6,500)	1.2×10^{-2} (100)
	Lagoon 2	6.9×10^{-5} (100)	2.8×10^{-3} (100)
	Lagoon 3	2.2×10^{-7} (300)	7.1×10^{-6} (100)
	Lagoon 4	9.1×10^{-7} (100)	1.0×10^{-6} (100)
	Lagoon 5	2.9×10^{-7} (100)	3.4×10^{-7} (100)
	Total Low-Level Waste Treatment Facility	2.9×10^{-4} (100)	1.5×10^{-2} (100)
Waste Tank Farm – WMA 3	8D-1	1.4×10^{-3} (200)	5.1×10^{-1} (100) [b]
	8D-2	1.3×10^{-3} (200)	8.8 (100) [b]
	8D-3	6.0×10^{-7} (400)	3.2×10^{-4} (100) [b]
	8D-4	5.1×10^{-5} (400)	1.9 (100) [b]
	Total Waste Tank Farm	2.7×10^{-3} (200)	1.1×10^{1} (100) [b]
NDA – WMA 7 Horizontal	Process	3.2×10^{-3} (18,500)	3.6×10^{-3} (15,400)
	Hulls	7.4×10^{-4} (12,300)	1.1×10^{-3} (10,600)
	WVDP	2.6×10^{-5} (17,100)	2.8×10^{-5} (14,800)
	Total NDA – Horizontal	3.8×10^{-3} (18,000)	4.5×10^{-3} (14,600)
NDA – WMA 7 Vertical/ Horizontal	Process	1.3×10^{-2} (30,900)	1.3×10^{-2} (31,700)
	Hulls	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
	WVDP	2.3×10^{-4} (21,300)	2.3×10^{-4} (21,300)
	Total NDA – Vertical/ Horizontal	4.8×10^{-2} (6,800)	4.8×10^{-2} (6,800)
Total NDA	Total NDA	4.8×10^{-2} (6,800) [c]	4.9×10^{-2} (6,800) [c]
SDA – WMA 8	Horizontal	9.2×10^{-2} (2,900)	9.5×10^{-2} (2,700)
	Vertical/Horizontal	5.2×10^{-1} (33,800)	5.2×10^{-1} (33,800)
	Total SDA	5.2×10^{-1} (33,800) [c]	5.2×10^{-1} (33,800) [c]
North Plateau Groundwater Plume		9.3×10^{-2} (78)	1.5×10^{-1} (67)
Total Site		5.4×10^{-1} (33,700)	1.3×10^{1} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA.. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Controlling Nuclides and Pathways

It is of interest to understand the controlling nuclides and pathways at the year of peak TEDE. **Table H–56** provides this information. For the No Action Alternative, also as noted above, the high-level waste tanks, particularly 8D-2 provide the largest peaks. These are dominated by the ingestion of strontium-90 in drinking water, whereas the Sitewide Close-In-Place Alternative is dominated by uranium and carbon isotopes from the SDA via fish ingestion.

Table H–56 Controlling Nuclides and Pathways for the Seneca Nation of Indians Receptor Broken Down by Waste Management Area Components at Year of Peak Total Effective Dose Equivalent – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Waste Management Area Components*	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	Rubble Pile	Iodine-129/Fish	Strontium-90/Fish
	General Purpose Cell	Plutonium-239/Fish	Strontium-90/Fish
	Liquid Waste Cell	Iodine-129/Fish	Strontium-90/Fish
	Fuel Receiving Storage Pool	Plutonium-239/Fish	Strontium-90/Fish
Vitrification Facility – WMA 1		Neptunium-237/Fish	Strontium-90/Fish
Low-Level Waste Treatment Facility – WMA 2	Lagoon 1	Iodine-129/Fish	Strontium-90/Fish
	Lagoon 2	Strontium-90/Fish	Strontium-90/Fish
	Lagoon 3	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 4	Uranium-234/Fish	Uranium-234/Fish
	Lagoon 5	Uranium-234/Fish	Uranium-234/Fish
Waste Tank Farm – WMA 3	8D-1	Iodine-129/Fish	Strontium-90/Fish
	8D-2	Iodine-129/Fish	Strontium-90/Fish
	8D-3	Iodine-129/Fish	Strontium-90/Fish
	8D-4	Iodine-129/Fish	Strontium-90/Fish
NDA – WMA 7 Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
NDA – WMA 7 Vertical/Horizontal	Process	Uranium-233/Fish	Uranium-233/Fish
	Hulls	Carbon-14/Fish	Carbon-14/Fish
	WVDP	Uranium-233/Fish	Uranium-233/Fish
SDA – WMA 8	Horizontal	Carbon-14/Fish	Carbon-14/Fish
	Vertical/Horizontal	Uranium-234/Fish	Uranium-234/Fish
North Plateau Groundwater Plume		Strontium-90/Fish	Strontium-90/Fish

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WVDP = West Valley Demonstration Project.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

For the No Action Alternative, the principal difference from Cattaraugus Creek is that the dominant nuclides and pathways for the principal contributor (the Waste Tank Farm) is now strontium-90 via fish rather than via drinking water.

Excess Lifetime Cancer Risk

A complementary measure is the peak lifetime risk to the Seneca Nation of Indians receptor from radiological discharges. **Table H–57** shows how this risk would be apportioned between different WMAs and what it would be for the entire WNYNSC for each alternative. The lifetime radiological cancer risk to the postulated Seneca Nation of Indians receptor is similar to, sometimes slightly higher than, the risk to the Cattaraugus Creek receptor as presented in Table H–50. The higher risk is the result of the postulated higher fish consumption. The radiological risk for the No Action Alternative is dominated by the high-level waste tanks.

Table H–57 Peak Lifetime Radiological Risk (risk of cancer morbidity) for the Seneca Nation of Indians Receptor (year of peak risk in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.0×10^{-6} (200)	4.1×10^{-5} (100) [b]
Vitrification Facility – WMA 1	1.3×10^{-9} (500)	6.6×10^{-6} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	7.2×10^{-9} (100)	3.4×10^{-7} (100)
Waste Tank Farm – WMA 3	9.6×10^{-8} (200)	2.6×10^{-4} (100) [b]
NDA – WMA 7	1.3×10^{-6} (6,800) [c]	1.3×10^{-6} (6,800) [c]
SDA – WMA 8	7.5×10^{-6} (33,800) [c]	7.5×10^{-6} (33,800) [c]
North Plateau Groundwater Plume	2.1×10^{-6} (78)	3.4×10^{-6} (67)
Total	7.6×10^{-6} (33,700)	3.0×10^{-4} (200)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risks from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted risks and years until peak exposure are the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

Tables H–46 through H–48 and Figure H–13 show that the lifetime cancer risk from hazardous chemicals, the hazard index, and the ratio of concentration in water to the MCL for the Cattaraugus Creek receptor differ by only about 20 percent whether or not institutional controls are lost. The same conclusion holds for the Seneca Nation of Indians receptor.

Lake Erie/Niagara River Water Users

This section discusses population dose, and individual exposures to radioactive materials and chemicals.

Population Dose

In addition to the Cattaraugus Creek and Seneca Nation of Indians individuals, peak annual and time-integrated population dose estimates have been prepared. These are summarized in **Tables H–58** and **H–59**, respectively. Lake Erie water users consume water taken from Sturgeon Point and several structures in the eastern channel of the Niagara River. They are assumed to drink water from Lake Erie or the Niagara River, to eat fish from Lake Erie, and (conservatively) to all be resident farmers.

Table H–58 Peak Annual Total Effective Population Dose Equivalent in person-rem per year for Lake Erie/Niagara River Water Users (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	1.2 (200)	238 (100) [b]
Vitrification Facility – WMA 1	0.0065 (500)	44.3 (100) [b]
Low-Level Waste Treatment Facility – WMA 2	0.02 (100)	1.5 (100)
Waste Tank Farm – WMA 3	0.66 (200)	1,726 (100) [b]
NDA – WMA 7	1.1 (30,600) [c]	1.0 (31,500) [c]
SDA – WMA 8	16.9 (33,700) [c]	16.9 (33,700) [c]
North Plateau Groundwater Plume	13.7 (80)	21.5 (67)
Total	17.9 (33,600)	2,020 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs, etc.) operational for 100 years. The risks from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted TEDEs and years until peak exposure are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–59 Time-Integrated Total Effective Population Dose Equivalent for Lake Erie/Niagara River Water Users (person-rem over 1,000 and 10,000 years) - Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Integration over 1,000 years		
Main Plant Process Building – WMA 1	510	25,000 [b]
Vitrification Facility – WMA 1	4	4,900 [b]
Low-Level Waste Treatment Facility – WMA 2	9	520
Waste Tank Farm – WMA 3	140	220,000 [b]
NDA – WMA 7	140 [c]	140 [c]
SDA – WMA 8	600 [c]	620 [c]
North Plateau Groundwater Plume	730	1,000
Total	2,100	252,000
Integration over 10,000 years		
Main Plant Process Building – WMA 1	1,000	130,000 [b]
Vitrification Facility – WMA 1	5	5,000 [b]
Low-Level Waste Treatment Facility – WMA 2	9	2,400
Waste Tank Farm – WMA 3	270	223,000 [b]
NDA – WMA 7	4,100 [c]	4,400 [c]
SDA – WMA 8	29,000 [c]	29,000 [c]
North Plateau Groundwater Plume	750	1,020
Total	35,000	395,000

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted population doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

As described previously, most of the population dose shown in Table H–58 would be received by the users of water from Sturgeon Point intake which would see higher radionuclide concentrations than the intake structures on the Niagara River. The estimated annual background radiation dose for this group (565,000 people) would be approximately 200,000 person-rem. The peak annual dose of 18 person-rem for the Sitewide Close-In-Place Alternative would be less than a 0.01 percent increase over the estimated annual background radiation dose received by this group, while the peak annual dose of 2,000 person-rem for the No Action Alternative would contribute about 1 percent.

Table H–59 presents the time-integrated population dose over periods of 1,000 and 10,000 years. For the Sitewide Close-In-Place Alternative, the total population dose accumulated over 10,000 years (35,000 person-rem) would be less than the background dose by Sturgeon Point users in one year (203,000 person rem).

The background radiation dose to Sturgeon Point water users over 10,000 years would be an estimated 2 billion person-rem compared to the maximum projected dose of 395,000 person-rem for the No Action Alternative.

Individual Exposure to Radioactive Material

Tables H–60 and **H–61** contain the predicted peak individual TEDEs from radioactive exposure for Sturgeon Point and Niagara River, respectively.

The total peak annual TEDE for the No Action Alternative in Table H–60 (Sturgeon Point) is about a factor of 4 lower than those for the Seneca Nation of Indians receptor, and a factor of 3 lower than those for the Cattaraugus Creek receptor. The total peak annual TEDEs in Table H–61 (Niagara River) are still lower by more than a further factor of 100.

Table H–60 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Sturgeon Point Receptor (year of peak dose in parentheses) – Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	0.0021 (200)	0.42 [b] (100)
Vitrification Facility – WMA 1	0.000011 (500)	0.078 [b] (100)
Low-Level Waste Treatment Facility – WMA 2	0.000036 (100)	0.0026 (100)
Waste Tank Farm – WMA 3	0.0012 (200)	3.0 (100) [b]
NDA – WMA 7	0.0019 (30,600) [c]	0.0018 (31,500) [c]
SDA – WMA 8	0.030 (33,700) [c]	0.030 (33,700) [c]
North Plateau Groundwater Plume	0.024 (80)	0.038 (67)
Total	0.032 (33,600)	3.6 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Table H–61 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Niagara River Receptor (year of peak dose in parentheses) - Loss of Institutional Controls After 100 Years

Waste Management Areas [a]	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
Main Plant Process Building – WMA 1	7.5×10^{-6} (200)	1.5×10^{-3} (100) [b]
Vitrification Facility – WMA 1	4.1×10^{-8} (500)	2.8×10^{-4} (100) [b]
Low-Level Waste Treatment Facility – WMA 2	4.2×10^{-8} (100)	9.5×10^{-6} (100)
Waste Tank Farm – WMA 3	4.2×10^{-6} (200)	1.1×10^{-2} [b] (100) [b]
NDA – WMA 7	7.0×10^{-6} (30,600) [c]	6.6×10^{-6} (31,400) [c]
SDA – WMA 8	1.1×10^{-4} (33,700) [c]	1.1×10^{-4} (33,700) [c]
North Plateau Groundwater Plume	8.66×10^{-5} (80)	1.4×10^{-4} (67)
Total	1.1×10^{-4} (33,400)	1.3×10^{-2} (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

[a] For WMAs 1 through 3, the contributions to dose are presented for the key facilities that contain almost all of the radioactive materials in the WMA. However, no single facility characterizes the burial grounds, so the NDA (WMA 7) and the SDA (WMA 8) are presented as entities in their own right. Other WMAs are not sources of radioactive materials.

[b] It is assumed that maintenance actions would keep engineered systems (caps, drying systems, roofs) operational for 100 years. The doses from these units would be minimal as long as these engineered systems function as originally designed.

[c] The reason why the predicted doses are approximately the same for the Sitewide Close-In-Place and No Action Alternatives is that it is assumed that the effectiveness of any caps and other mitigating features in the Sitewide Close-In-Place Alternative degrades immediately so that groundwater flow rates and leaching rates are essentially the same for both alternatives.

Hazardous Chemical Risk

For the Niagara River and Sturgeon Point users, the peak hazard index, the peak lifetime risk, and the ratios of the concentration in water to the MCLs are all smaller than for Cattaraugus Creek or the Seneca Nation of Indians receptor and are not discussed further here.

H.2.2.4 Loss of Institutional Controls Leading to Unmitigated Erosion

Erosion is recognized as a site phenomenon and so a bounding scenario of unmitigated erosion is analyzed to estimate the dose to various receptors. For the purposes of this analysis, unmitigated erosion is defined to mean that credit is not taken for the presence of erosion control structures or performance monitoring and maintenance of any kind. Predictions of unmitigated erosion for thousands of year into the future were developed with the help of landscape evolution models that were calibrated to reproduce both historical erosion rates and current topography, starting from the topography estimated to exist after the last glacial recession. The development of the unmitigated erosion estimate is discussed in Appendix F. The chosen erosion scenario for the landscape evolution model corresponds to a case in which the site becomes partly forested and partly grassland.

The modeling below considers only erosion of the Low-Level Waste Treatment Facility on the North Plateau and of the SDA and NDA on the South Plateau. The landscape evolution model predicts very little erosion in the region of the Main Plant Process Building, Vitrification Facility, and Waste Tank Farm, and also predicts that the only places where any serious erosion would be expected in the foreseeable future would be in the vicinities of the Low-Level Waste Treatment Facility, SDA or NDA. In order to establish an upper bound on the potential impacts, the simplified single gully model described in Appendix G was used to estimate rate of soil loss for the Low-Level Waste Treatment Facility, NDA and SDA. Conservative estimates of gully advance rate (0.7 meters per year for the North Plateau and 0.4 meters per year for the South Plateau), downcutting rate (0.058 meters per year) and stable slope angle (21 degrees) were used in the analysis. The results of the analysis indicate that, for both the No Action and Sitewide Close-In-Place Alternatives, waste is completely removed from the Low-Level Waste Treatment Facility, NDA, and SDA in approximately 200, 990, and 1,900 years respectively.

A spectrum of erosion-related receptors was examined: (a) three residents,[12] one on the west bank of Erdman Brook south of the Low-Level Waste Treatment Facility, one on the east bank of Franks Creek opposite the SDA and one on the west bank of Erdman Brook opposite the NDA, each of whom would be subject to direct shine from the eroded opposite bank and would spend some time hiking about the site; (b) a resident farmer along Buttermilk Creek; and (c) the same offsite receptors evaluated for the case of continuation of institutional controls (Section 4.1.10.3.1 – Cattaraugus Creek, Seneca Nation of Indians, and Lake Erie/Niagara River Water Users).

NDA/SDA Resident/Recreational Hiker

Table H–62 presents the peak annual TEDE for the resident/recreational hiker for the Low-Level Waste Treatment Facility, NDA and SDA for each alternative if unmitigated erosion of the site were allowed to take place. The table also shows the years until peak annual dose. The assumptions governing the behavior and exposure of the recreational hiker are given in Table H–5. Exposure modes as a hiker include inadvertent ingestion of soil, inhalation of fugitive dust, and exposure to direct radiation. This receptor does not ingest radionuclides through food and water pathways.

The predicted results are quite similar for the Sitewide Close-In-Place and the No Action Alternatives. Because of conservative assumptions in the erosion model, the engineered cap only slightly reduces the rate of erosion for the Sitewide Close-In-Place Alternative. No credit is taken for stream erosion controls and no credit is taken for the erosion resistance of the rock along the side of the engineered cap. Additional detail on the erosion release model is provided in Appendix G.

Table H–62 Peak Annual Total Effective Dose Equivalent in Millirem Per Year to a Resident/Recreational Hiker on the Low-Level Waste Treatment Facility, NDA and SDA (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	10 (500)	10 (325)
SDA – WMA 8	11 (375)	12 (375)
Low-Level Waste Treatment Facility – WMA 2	36 (122)	104 (100)
Total	36 (122)	104 (100)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

Buttermilk Creek Resident Farmer

Table H–63 presents the peak annual TEDE from the eroded Low-Level Waste Treatment Facility, NDA and SDA for the Buttermilk Creek resident farmer for the unmitigated erosion scenario. See Section H.1.3.1 for a discussion of the location of the Buttermilk Creek resident farmer. The table also shows the years until peak annual dose.

[12] *The onsite resident differs from the onsite resident farmer in that the former has no garden and does not drink contaminated water. See Figure H–3 for the locations of these three receptors.*

Table H–63 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Buttermilk Creek Resident Farmer (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	342 (725)	358 (650)
SDA – WMA 8	87 (625)	89 (600)
Low-Level Waste Treatment Facility – WMA 2	16 (156)	36 (103)
Total	421 (725)	443 (650)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.
[a] Years until peak exposure in parentheses.

The relationship between the doses for the Sitewide Close-In-Place Alternative and the No Action Alternative would be much the same as for the resident/farmer. However, the predicted doses would be higher because of the greater number of exposure pathways for a resident farmer as opposed to a resident only.

Cattaraugus Creek Receptor

Table H–64 presents the peak annual TEDE from the Low-Level Waste Treatment Facility, NDA and SDA for the Cattaraugus Creek resident farmer for the unmitigated erosion scenario.

Table H–64 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Cattaraugus Creek Receptor (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	45 (725)	47 (650)
SDA – WMA 8	12 (625)	12 (600)
Low-Level Waste Treatment Facility – WMA 2	2 (156)	5 (103)
Total	56 (725)	58 (650)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

The doses to the Cattaraugus Creek receptor, if unmitigated erosion were allowed to progress at WNYNSC, show a similar pattern to that seen for the Buttermilk Creek intruder, but the doses would be generally lower by a factor of 5 to 10.

An illustration of how the peak annual dose to the Cattaraugus Creek receptor would vary as a function of time for the Sitewide Close-In-Place Alternative is presented in **Figure H–16.** The variation for the No Action Alternative is almost identical. The variations for the Buttermilk Creek farmer (above) and the Seneca Nation of Indians receptor (below) have the same shape, although the peaks are not of the same magnitude. The plot cuts off at about 2,000 years because all of the available radioactive material has been eroded by that time.

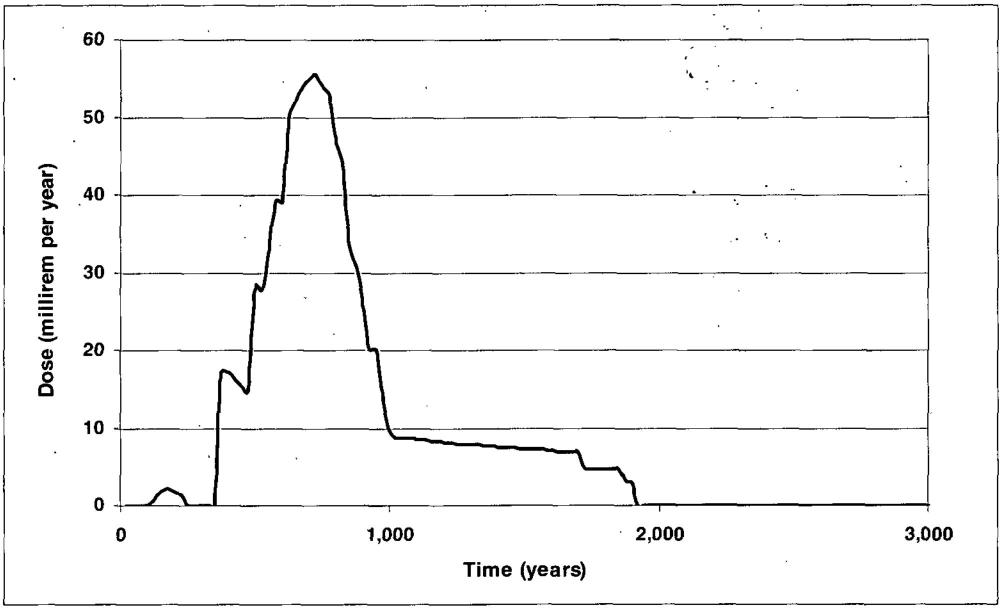

Figure H–16 Annual Total Effective Dose Equivalent (millirem per year) for the Cattaraugus Creek Receptor as a Function of Time with the Sitewide Close-In-Place Alternative and Unmitigated Erosion

Seneca Nation of Indians Receptor

A Seneca Nation of Indian receptor is postulated to use Cattaraugus Creek near Gowanda for drinking water and is also postulated to consume large quantities of fish raised in these waters. The peak annual dose for this receptor is presented in **Table H–65**.

The doses to the Seneca Nation of Indians receptor, in the event of unmitigated erosion at WNYNSC, show a similar pattern to that seen for the Cattaraugus Creek receptor, but the numerical values of the total doses would be higher by a factor of about 2 as a result of the higher assumed fish consumption.

Table H–65 Peak Annual Total Effective Dose Equivalent in Millirem Per Year to the Seneca Nation of Indians Receptor (year of peak exposure in parentheses) – Unmitigated Erosion

Waste Management Areas	*Sitewide Close-In-Place Alternative*	*No Action Alternative*
NDA – WMA 7	107 (725)	112 (650)
SDA – WMA 8	17 (625)	18 (375)
Low-Level Waste Treatment Facility – WMA 2	4 (156)	9 (103)
Total	122 (725)	129 (650)

NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area, WMA = Waste Management Area.

Lake Erie Water Users

In addition to the Cattaraugus Creek and Seneca Nation of Indians individuals, peak annual and time-integrated population dose estimates have been prepared for the unmitigated erosion release scenario. These are summarized in **Tables H–66** and **H–67**, respectively.

Table H–66 Peak Annual Total Effective Dose Equivalent Population Dose in Person-Rem per year to the Lake Erie Water Users (year of peak exposure in parentheses) – Unmitigated Erosion

	Sitewide Close-In-Place Alternative	*No Action Alternative*
Unmitigated Erosion	5,800 (725)	6,100 (650)

Table H–67 Time-integrated Total Effective Population Dose Equivalent in Person-Rem to the Lake Erie Water Users – Unmitigated Erosion

	Sitewide Close-In-Place Alternative	*No Action Alternative*
Integration over 1,000 years	2,200,000	2,300,000
Integration over 10,000 years	3,300,000	3,400,000

As described previously, most of this population dose would be received by the estimated 565,000 individuals using water from the Sturgeon Point intake. Using an average background dose rate of 360 millirem per year, the annual background population dose for this community would be approximately 200,000 person-rem. The peak annual population dose for the Sitewide Close-In-Place Alternative (5,800 person-rem per year) and the No Action Alternative (6,100 person-rem per year) would both be about 3 percent of the annual background dose.

Additional perspective is provided by the cumulative population dose to 1,000 and 10,000 years. For comparison, the background population dose accumulated by Sturgeon Point water users would be approximately 200 million person rem over 1,000 years and 2 billion person rem over 10,000 years. The additional population doses accumulated from WNYNSC would be relatively small.

Conclusions for Loss of Institutional Controls Leading to Unmitigated Erosion

The results for uncontrolled erosion of the SDA, NDA and Low-Level Waste Treatment Facility for the Sitewide Close-In-Place Alternative show TEDEs of up to about 36 millirem for the resident hiker, 421 millirem for the Buttermilk Creek resident farmer, 56 millirem for the Cattaraugus Creek receptor, and 122 millirem for the Seneca Nation of Indians receptor. For the two offsite receptors, these represent an increase by a factor of about 200 over the case of no erosion. The results for the No Action Alternative are only slightly higher than those for the Sitewide Close-in-Place Alternative because, under the conservative assumptions of the erosion model, the engineered safety cap only slightly reduces the rate of erosion for the Sitewide Close-In-Place Alternative.

Integrated Groundwater/Erosion Model

In the foregoing, groundwater releases and erosion releases (i.e. particulate matter washed into rivers and streams) are modeled separately. At the present time, integrated models of groundwater releases and erosion releases are beyond the state-of-the art. This question is addressed in sensitivity studies in the following section. However, as noted above, dose impacts to offsite receptors are about 200 times greater in the erosion scenarios than they are in the groundwater release scenarios. Therefore, intuitively, one would not expect the combined model to predict doses much greater than those already predicted by the stand-alone erosion model.

H.2.3 Some Observations on the Preferred Alternative

As previously discussed, it is not possible to do a long-term performance assessment for the Preferred Alternative, because the ultimate disposition of various areas of the site is not known. However, some general observations are possible.

Main Plant Process Building and Vitrification Facility – Waste Management Area 1

The plume source volume for the Main Plant Process Building and the Vitrification Facility will be completely removed. These actions most closely resemble those expected for these facilities under the Sitewide Removal alternative. Therefore, these two structures will contribute negligibly to potential health impacts under any final disposition of the site.

Low-Level Waste Treatment Facility and Lagoons – Waste Management Area 2

All facilities in WMA 2 would be removed except the permeable treatment wall, which would be periodically replaced. A hydraulic barrier wall would be installed northwest of Lagoons 1, 2, and 3 which would be removed with excavations extending 0.6 meter (2 feet) into the Lavery till. The liners and underlying berms for Lagoons 4 and 5 would be removed, as would the North Plateau Groundwater Recovery System associated with the North Plateau Groundwater Plume.

Underground lines within the excavated areas would be removed. Pipeline sections remaining at the face of the excavations would be characterized and the portion of the piping within WMA 2 removed as necessary depending on the characterization results.

These proposed actions would greatly reduce the inventory of radioactive materials and hazardous chemicals – in fact, the proposed removal of materials is greater than that proposed for the Sitewide Close-In-Place Alternative. Therefore, for groundwater releases, under any future disposition of the site, it would be expected that offsite doses and risks would be less than those already calculated for the Sitewide Close-In-Place Alternative. Dose to intruders (e.g., home constructors and well drillers) would depend on the amount of residual radioactive materials remaining after the actions described above, but would be much less than for the No Action Alternative.

Waste Tank Farms – Waste Management Area 3

The high-level radioactive waste mobilization and transfer pumps would be removed from the underground Waste Tanks. The Waste Tanks themselves would remain in place, as would the Permanent Ventilation System Building, STS Support Building, and underground piping in the area. The STS vessels and contents in Tank 8D-1 will remain in place. The Equipment Shelter and Condensers and Con-Ed Building would be removed. The Waste Tanks would continue to be monitored and maintained with the Tank and Vault Drying System operating as necessary.. The piping used to convey high-level radioactive waste in the High-Level Waste Transfer Trench would be removed and the trench would remain in place. Pipe removal would be conducted with soil removal with cutoffs of the piping occurring somewhere between the excavation and the tanks. The barrier wall would also extend westward across the piping runs.

If no further action were taken, this would be similar to the No Action Alternative. It would allow future selection of complete removal, Sitewide Close-in-Place, or No Action. Therefore, the range of health impacts already calculated for this WMA spans the possible range from future disposition possibilities for the Waste Tank Farm.

NDA – Waste Management Area 7 and SDA – Waste Management Area 8

The NDA and SDA would continue as at present, under monitoring and/or active management. Therefore the future possibilities include any of removal per the Sitewide Removal Alternative, Sitewide Close-In-Place, or No Action. Calculations already performed span the potential range of health impacts.

North Plateau Groundwater Plume

The source area of the North Plateau Groundwater Plume would be removed as in the Sitewide Removal Alternative. The nonsource area of the North Plateau Groundwater Plume would be contained by the permeable reactive barrier and permeable treatment wall installed for the Interim End State as in the No Action Alternative. The permeable treatment wall would require replacement on a periodic basis. The future possibilities include any of removal per the Sitewide Removal Alternative, Sitewide Close-In-Place, or No Action. Calculations already performed span the range of possible health impacts.

Cesium Prong

The cesium prong would be managed by continuing restrictions on use and access, exactly as for both the No Action and Sitewide Close-In-Place Alternatives.

Conclusion – Preferred Alternative

Initial decommissioning actions for this alternative would essentially remove the Main Plant Process Building, the Vitrification Facility, and the source for the North Plateau Groundwater Plume as potential sources of health impacts. The potential impact of the Low-Level Waste Treatment facility would be much reduced. Potential health impacts of the Waste Tank Farm, the NDA, the SDA, the non-source portion of the North Plateau Groundwater Plume, and the Cesium Prong span the ranges already calculated in the Sitewide Removal, the Sitewide Close-In-Place, and the No Action Alternatives.

H.3 Sensitivity Analysis

Estimation of human health impacts depends in a complex manner on geologic and environmental conditions, facility closure designs, the structure of models used to represent these conditions and features and the values of parameters used in the models to characterize the conditions and features. These conditions and features may not be well known or have variability over space and time that contributes to uncertainty in estimates of health impacts. In this section, deterministic sensitivity analysis is used to provide insight into the potential range of uncertainty in estimates of health impacts. Key conditions or parameters selected for sensitivity analysis include: amount of precipitation (wetter or dryer conditions), degree of degradation of engineered caps, ability to retain technetium in grout, rate of advance and downcutting of a single large gully, the impact of erosion on engineered structures designed to limit release to groundwater transport pathways, and the degree of degradation of the slurry wall on the North Plateau. The sensitivity analysis cases use the Sitewide Close-In-Place Alternative as the primary example but provide information relevant to all EIS alternatives.

H.3.1 Amount of Precipitation

Water reaching the ground surface as precipitation enters into estimation of human health impacts for both groundwater and erosion release scenarios. Precipitation infiltrating the ground surface influences rate of groundwater movement while run-off produced by precipitation influences rate of erosion. Rate of flow of creeks affects concentration of contaminants in the creek due to a given release and thereby influences estimates of health impacts. Available data characterizing the variability include annual rate of precipitation at Jamestown, NY reported by the National Climatic Data Center (NCDC 2008) for 28 years between calendar years 1979 and 2006 and annual average flow of Cattaraugus Creek at Gowanda, NY reported by the U.S. Geological Survey (USGS 2008) for 64 years between calendar years 1941 and 2006. Annual precipitation varied between 0.89 and 1.41 meters with and average of 1.13 meters. Ten percent of years had precipitation greater than 1.23 meters while ten percent of years had precipitation less than 0.98 meters. A similar range of moderate variability is found in the flow rate data for Cattaraugus Creek. Ten percent of years had annual flow less than 16.5 meters per second while ten per cent of years had annual flow greater than

26.3 meters per second with an annual average of 21.2 meters per second. The minimum and the maximum annual flows for the period of record were 15.1 and 29.2 meters per second, respectively.

Three-dimensional near-field groundwater flow models for both the North and South Plateaus for the Sitewide Close-In-Place Alternative are described in Appendix E of the EIS. Features of these models relevant for evaluation of the importance of variability of precipitation are presence of a slurry wall on the North Plateau that limits flow through the system and the low rate of infiltration predicted for the South Plateau due to low hydraulic conductivity of geohydrologic units in that location. For the North Plateau, the predicted rate of infiltration consistent with function of a degraded slurry wall is less than ten percent of the lowest value of precipitation reported for the period of record (see Table H–73). As a consequence of this condition, the rate of movement of groundwater and related rate of release of contaminants from the Main Plant Process Building and the Waste Tank Farm would not change greatly with variation in rate of precipitation. A similar situation would occur on the South Plateau where recharge is a small percentage of the lowest rate of precipitation reported for the period of record. For erosion scenarios, variation in rate of precipitation is implicitly incorporated into calibration of the landscape evolution model over a long period of time.

For the health impact models used in the EIS, variation in annual rate of flow of creeks produces an inverse but proportionate variation in estimate of impact. This behavior applies for both groundwater and erosion release scenarios. Thus, for only ten percent of years the estimates of impacts would be more that twenty-five percent higher than that reported for average conditions.

H.3.2 Degree of Degradation of Engineered Caps

For the Sitewide Close-In-Place Alternative, the Main Plant Process Building, the Low-Level Waste Treatment Facility, the Waste Tank Farm, the NDA and the SDA are located under engineered caps. The primary design features limiting infiltration of each cap are a gravel drainage layer and an underlying layer of clay. Additional layers that are not considered in the EIS infiltration model are geotextiles and soil that function to protect and support the major functional layers. More detailed description of the engineered caps is presented in Appendix C of the EIS. With respect to control of infiltration, the EIS model simulates diversion of water through the drainage layer and impedance of downward flow of water through the clay layer. The design values of hydraulic conductivity for the drainage and clay layers are 3.0 and 5×10^{-9} centimeters per second, respectively. The response of rate of infiltration through the cap to variation in these principal parameters was simulated using a two-dimensional representation implemented with the Subsurface Over Multiple Phases (STOMP) computer code. Results of this analysis are presented in **Table H–68**. As would be expected, the rate of infiltration increases in proportion to increase in hydraulic conductivity of the clay layer but increases in a non-linear manner as hydraulic conductivity of the drainage layer decreases.

Table H–68 Dependence of Infiltration through an Engineered Cap on Values of Hydraulic Parameters

Hydraulic Conductivity of the Drainage Layer (centimeters per second)	*Infiltration Rate (centimeters per year)*		
	Hydraulic Conductivity of the Clay Layer (centimeters per second)		
	5×10^{-9}	5×10^{-8}	5×10^{-7}
3.0	0.015	0.15	1.44
0.03	0.11	1.12	10.3
0.003	0.31	3.02	24.6

For the rubble pile, Liquid Waste Cell and General Purpose Cell of the Main Plant Process Building and the Vitrification Cell, the rate of movement through the contaminated material is equal to the rate of infiltration through the cap and estimates of health impacts would increase in proportion to this rate of infiltration. For the Waste Tank Farm, the rate of downward movement through the tanks is determined by the rate of downward movement through the unweathered Lavery till and would not increase in response to increase in infiltration through the cap. Thus, a minor dependence of estimate of dose on amount of precipitation is expected at the Waste Tank Farm.

H.3.3 Retention of Technetium

Analysis of base cases for groundwater release scenarios for tanks 8D-1 and 8D-2 of the Waste Tank Farm identified technetium-99 as a major contributor to human health impacts. Grouts designed for stabilization of the tanks include fly ash material that is expected to reduce the valence state of technetium producing a precipitate with low solubility as well as sorbents designed to retain radionuclides by physical and chemical bonding. The EIS release models do not simulate solubility release but relate rate of release to degree of partitioning between the liquid and solid phases of the waste form. For technetium, a conservative value of 1.0 milliliters per gram, consistent with retention on a natural clay material (Sheppard and Thibault 1990), has been adopted as the value of distribution coefficient for the base case. A plausible lower bound value of distribution coefficient for technetium in the waste form is the value of 0.1 milliliters per gram reported for sand in natural deposits (Sheppard and Thibault 1990). A plausible higher value is that recommended for surface soil in analysis of decommissioning scenarios, 7.4 milliliters per gram (Beyeler et al. 1999). Estimates of impact for a resident farmer receptor for releases from Tank 8D-1 are presented in **Table H–69**. The results show a strong dependence on the value of distribution coefficient for technetium. For the lower values of distribution coefficient of technetium, technetium-99 is the radionuclide dominating dose and the year of peak impact occurs within approximately 100 years. For the higher value of technetium distribution coefficient, isotopes of uranium dominate impacts, impacts occur in the distant future and peak dose due to technetium-99 peak is approximately 25 millirem per year after approximately 170 years.

Table H–69 Dependence of Onsite Resident Farmer Peak Annual Dose on the Value of Technetium Distribution Coefficient for Groundwater Release from Tank 8D-1

Distribution Coefficient of Technetium in Grout (milliliters per gram)	*Peak Annual Dose (millirem per year)*			*Years to Peak Dose*
	Drinking Water	*Garden*	*Total*	
0.1	609	274	883	28
1.0	78	145	223	116
7.4	104	10	114	1,200

H.3.4 Rate of Gully Erosion

The landscape evolution models described in Appendix F were calibrated to current conditions of the Buttermilk Creek watershed and predict low rates of erosion of plateau areas of the site near the project waste management areas. Estimates of rate of soil loss for a single large gully were used to develop estimates of human health impact. These results were developed using conservative estimates of stable slope angle (21 degrees), rate of advance (0.4 meters per year) and downcutting (0.058 meters per year) described in Appendix F that were assumed to occur for the entire period of analysis. The analysis did not take credit for the presence of erosion control structures or the performance of maintenance. Field surveys of gully behavior report an initial period of rapid growth followed by decrease in rate of growth, attainment of a maximum length and transition into an inactive state (Nachtergaele et al. 2002). The length, surface area and volume were reported to follow a negative exponential relation termed Graf's Law:

$$L_t = (L_f - L_0)\{1 - \exp[-b(t - t_0)]\} \qquad (H\text{-}2)$$

Where:

L_t	=	length of gully at time t, meters,
L_f	=	final equilibrium length of gully, meters,
L_0	=	length of gully at initial time, meters,
t	=	time, years,
t_0	=	initial time, years, and
b	=	rate parameter, 1/years.

The sensitivity of estimates of health impacts to the gully growth model were investigated using this relation. The hulls portion of the NDA was used as the case for this analysis. For this area, the distance between Erdman Brook, a reasonable candidate initiation point for the gully, and Franks Creek is approximately four hundred meters and the disposal area is approximately 150 meters from Erdman Brook. Assuming a maximum gully length of four hundred meters and an initial growth rate of 0.4 meters per year, the value of the parameter b in Equation H-2 is estimated as 0.001 per year. Using this value and applying Equation H-2 provides estimates of the time dependent rate of advance for use in the single gully erosion model. The value of stable angle of 21 degrees was retained for the sensitivity analysis but the rate of average downcutting of Buttermilk Creek consistent with the landscape evolution modeling of 0.018 meters per year was applied for the rate of downcutting of the gully. Results for this sensitivity analysis and the base case are summarized in **Table H–70**. The results indicate that the assumption of constant rate of downcutting of the gully provides conservatism in estimate of dose as large as a factor of approximately four.

Table H–70 Dependence of Single NRC-licensed Disposal Area Gully Impacts on Model Parameters

Parameter	*Value*	
	Base Case	*Sensitivity Case*
Time to Reach Top of Waste (years)	490	910
Time to Reach Bottom of Waste (years)	955	2,330
Time to Peak Dose (years)	717	2,330
Peal Dose (millirem per year)	170	45

H.3.5 Erosion Damage of Groundwater Flow Barriers

The near-field groundwater flow models described in Appendix E are used as a basis for estimation of human health impacts for groundwater release scenarios. In these analyses, the engineered barriers are assumed to degrade due to natural processes, such as, clogging of gravel in drainage layers and dessication of clay in slurry walls but to remain unaffected by erosion processes. The potential influence of erosion damage on estimates of dose is considered in this section through introduction of segments of elevated hydraulic conductivity in the upgradient slurry wall of the Sitewide Close-In-Place Alternative. In the two cases considered, separate twenty-meter high hydraulic conductivity segments of the slurry wall were placed in the vicinity of the Waste Tank Farm and the General Purpose Call of the Main Plant Process Building.

In the first case, damage to the slurry wall in the vicinity of the Waste Tank Farm, Tank 8D-1 was selected as the example case and the near-field flow model predicts increased rate of flow into the tank excavation, increased horizontal flow through the tank but limited increase of vertical flow through the tank itself. Results of the flow analysis are summarized in **Table H–71** while results of the dose analysis for a resident farmer receptor located on the North Plateau 100 meters downgradient of the tank are presented in **Table H–72**. Estimates of dose were developed for both horizontal and vertical flow through the tank and the contribution of the horizontal flow was a small fraction of the contribution from vertical flow.

Table H–71 Summary of Flow Conditions for Waste Tank Farm Slurry Wall Sensitivity Analysis

Condition	*Case*	
	No Erosion Damage to Slurry Wall	*Erosion Damage to Slurry Wall*
Rate of Groundwater flow into the Excavation (cubic meters per year)	963	1,622
Interstitial Velocity (meters per year)		
Vertical	0.132	0.137
Horizontal	0	0.153

Table H–72 Summary of Peak Annual Dose Estimates for Waste Tank Farm Slurry Wall Sensitivity Analysis

Condition	*Peak Annual Dose (millirem per year)*	
	Drinking Water	*Garden*
No Erosion Damage to Slurry Wall	78	145
Erosion Damage to Slurry Wall	119	149

For the case of damage to the slurry wall in the vicinity of the General Purpose Cell, interstitial velocity through the cell into the underlying slack-water sequence increases from 0.158 meters per year for the base case to 0.566 meters per year. The estimate of dose for a resident farmer receptor located on the North Plateau downgradient of the Main Plant Process Building due to releases from the General Purpose Cell increases from 188 millirem per year at year 100 for the base case with a degraded slurry wall to 6,960 millirem per year at year 180 for the case of damage to the slurry wall. Thus, the results indicate that local hydrologic conditions contribute to dependence of estimates of dose for below grade cells of the Main Plant Process Building on integrity of the slurry wall. Local damage to this hydraulic barrier could have a major impact on the amount of groundwater moving through the cells leading to the predicted strong sensitivity of the estimate of dose. Should the Sitewide Close-In-Place Alternative be chosen, it would be appropriate to consider the implications of this finding when designing groundwater flow barriers.

H.3.6 Degree of Degradation of Slurry Walls

For the Sitewide Close-In-Place Alternative, slurry walls are used on both the North and South Plateaus to limit the amount of groundwater reaching sub-surface waste. Because of greater offset in value of hydraulic conductivity between the slurry wall and the surrounding natural materials on the North Plateau than on the South Plateau, the slurry wall is more important to reduction of dose for facilities on the North Plateau. The closure design for the Main Plant Process Building and Waste Tank Farm on the North Plateau includes a circumferential slurry wall and additional slurry walls up- and downgradient of the circumferential slurry wall. The near-field flow model for the North Plateau includes only the upgradient slurry wall and analysis presented in this section investigates the sensitivity of estimates of dose for the General Purpose Cell of the Main Plant Process Building to variation in the value of hydraulic conductivity of this slurry wall.

For the base case for this EIS, the value of the hydraulic conductivity of the slurry wall for the long-term period is taken as 1×10^{-6} centimeters per second, two orders of magnitude greater than the design value of 1×10^{-8} centimeters per second. For comparison purposes, the average value of hydraulic conductivity of the thick-bedded unit intersected by the slurry wall is 2.5×10^{-3} centimeters per second. For this sensitivity analysis, the hydraulic conductivity of the slurry wall is increased by one order of magnitude in a first case and by an additional order of magnitude in a second case.

The analysis proceeds in two steps: the three-dimensional near-field groundwater model is used to establish the distribution of hydraulic head and groundwater flow velocities in the first step while the integrated dose model uses the results of the first step to estimate human health impacts in the second step. Because data are not available to calibrate conditions for the first step, infiltration rates upgradient of the slurry wall are iteratively varied to produce a water table near the ground surface at the slurry wall. For the base and sensitivity cases, total infiltration immediately upgradient of the slurry wall and the flow balance around the General Purpose Cell are summarized in **Tables H–73 and H–74**, respectively. Doses estimated for the base, first sensitivity and second sensitivity cases are 220, 285 and 11,090 millirem per year, respectively. The large difference in estimate of dose is related to a change in flow regime indicated in the flow estimates presented in Tables H–68 and H–69. The General Purpose Cell extends from the ground surface downward toward the underlying Slackwater Sequence and with an effective slurry wall the primary flow is low and in the vertical direction. For the case of less than a two order of magnitude difference in hydraulic conductivity between the slurry wall and thick-bedded unit, the flow direction transitions to horizontal and flow rate approaches the value estimated for the location in the absence of the slurry wall.

Table H–73 Predicted Conditions for the North Plateau Three-dimensional Near-field Groundwater Flow Model, Slurry Wall Sensitivity Analysis

Case	*Hydraulic Conductivity of the Slurry Wall (centimeters per second)*	*Rate of Infiltration Upgradient of the Slurry Wall*		*Average Linear Velocity in the Slackwater Sequence (meters per year)*
		Volumetric (cubic meters per year)	*Flux (centimeters per year)*	
Base	1×10^{-6}	3,314	0.07	97
First Sensitivity	1×10^{-5}	4,059	0.09	103
Second Sensitivity	1×10^{-4}	10,537	0.22	131

Table H–74 Flow Balance for the General Purpose Cell, Slurry Wall Sensitivity Analysis

Direction	*Volumetric Flow Rate (cubic meters per year)*		
	Base Case	*First Sensitivity Case*	*Second Sensitivity Case*
Inflow			
Top	5.933	5.933	5.933
South	8.539	14.032	215.88
East	0.017	0.017	59.153
Outflow			
Bottom	14.246	19.691	24.615
North	0.235	0.283	255.03
West	0.007	0.007	1.355

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APPENDIX I
DECOMMISSIONING RADIOLOGICAL AND HAZARDOUS CHEMICAL HUMAN HEALTH IMPACTS EVALUATION

APPENDIX I
DECOMMISSIONING RADIOLOGICAL AND HAZARDOUS CHEMICAL HUMAN HEALTH IMPACTS EVALUATION

I.1 Introduction

This appendix provides a brief general discussion on radiation and its health effects. It also describes the methodologies and assumptions used for estimating potential impacts on and risks to individuals and the general public from exposure to radioactive and hazardous chemical material releases during normal operations and hypothetical accidents during the short-term preparation for the decommissioning phase of the decommissioning alternatives. Long-term radioactive and hazardous chemical release consequences are presented in Appendix H.

This appendix presents numerical information using scientific, or exponential, notation. For example, the number 100,000 can also be expressed as 1×10^5. The number 0.001 can be expressed as 1×10^{-3}. The following chart defines the equivalent numerical notations that may be used in this appendix.

Fractions and Multiples of Units

Multiple	*Decimal Equivalent*	*Prefix*	*Symbol*
1×10^6	1,000,000	mega-	M
1×10^3	1,000	kilo-	k
1×10^2	100	hecto-	h
1×10	10	deka-	da
1×10^{-1}	0.1	deci-	d
1×10^{-2}	0.01	centi-	c
1×10^{-3}	0.001	milli-	m
1×10^{-6}	0.000001	micro-	μ

I.2 Human Health Radiological Impacts

Because radiation exposure and its consequences are of interest to the general public, this environmental impact statement (EIS) provides information about the nature of radiation, explains basic concepts used to evaluate radiation health effects, and presents radiation exposure consequences.

I.2.1 Nature of Radiation and Its Effects on Humans

What Is Radiation?

Radiation is energy transferred in the form of particles or waves. Globally, human beings are exposed constantly to radiation from the solar system and the Earth's rocks and soil. This radiation contributes to the natural background radiation that always surrounds us. Manmade sources of radiation also exist, including medical and dental x-rays and household smoke detectors.

All matter in the universe is composed of atoms. Radiation comes from the activity of tiny particles within an atom. An atom consists of a positively charged nucleus (central part of an atom) with a number of negatively charged electron particles in various orbits around the nucleus. There are two types of particles in the nucleus:

neutrons that are electrically neutral, and protons that are positively charged. Atoms are categorized as different stable elements based on the number of protons in the nucleus. There are more than 100 natural and manmade elements. An element has equal numbers of electrons and protons. When atoms of an element differ in their number of neutrons, they are called isotopes of that element. All elements have three or more isotopes, some or all of which could be unstable.

Unstable isotopes undergo spontaneous change, known as radioactive disintegration or radioactive decay. The process of continuously undergoing spontaneous disintegration is called radioactivity. The radioactivity of a material decreases with time. The time it takes a material to lose half of its original radioactivity is its half-life. An isotope's half-life is a measure of its decay rate. For example, an isotope with a half-life of 8 days will lose one-half of its radioactivity in that amount of time. In 8 more days, one-half of the remaining radioactivity will be lost, and so on. Each radioactive element has a characteristic half-life. The half-lives of various radioactive elements may vary from millionths of a second to billions of years.

As unstable isotopes change into more stable forms, they emit particles and/or energy. An emitted particle may be an alpha particle (a helium nucleus), a beta particle (an electron), or a neutron, with various levels of kinetic energy. Sometimes these particles are emitted in conjunction with gamma rays. The particles and gamma rays are referred to as "ionizing radiation." Ionizing radiation refers to the fact that the radiation can ionize, or electrically charge, an atom by stripping off one or more of its electrons. Gamma rays, even though they do not carry an electric charge, can ionize atoms as they pass through an element by ejecting electrons. Thus, they cause ionization indirectly. Ionizing radiation can cause a change in the chemical composition of many things, including living tissue (organs), which can affect the way they function.

When a radioactive isotope of an element emits a particle, it changes to an entirely different element or isotope, one that may or may not be radioactive. Eventually a stable element is formed. This transformation, which may take several steps, is known as a decay chain. For example, the isotope radium-226, which is a member of the radioactive decay chain of uranium, has a half-life of 1,622 years. It emits an alpha particle and becomes the isotope radon-222, a radioactive gas with a half-life of only 3.8 days. Radon decays first to polonium; then, through a series of further decay steps, to bismuth; and ultimately to a stable isotope of lead. Meanwhile, the decay products will build up and eventually die away as time progresses.

Characteristics of various forms of ionizing radiation are briefly described below and in the box to the right.

Radiation Type	***Typical Travel Distance in Air***	***Barrier***
α	Few centimeters	Sheet of paper or skin's surface
β	Few meters	Thin sheet of aluminum foil or glass
γ	Very large	Thick wall of concrete, lead, or steel
n	Very large	Water, paraffin, graphite

Alpha (α) – Alpha particles are the heaviest type of ionizing radiation consisting of two protons and two neutrons. They can travel only a few centimeters in air. Alpha particles lose their energy almost as soon as they collide with anything. They can be stopped easily by a sheet of paper or by the skin's surface.

Beta (β) – Beta particles, consisting of an electron, are much (7,330 times) lighter than alpha particles. They can travel a longer distance than alpha particles in the air. A high-energy beta particle can travel a few meters in the air. Beta particles can pass through a sheet of paper, but can be stopped by a thin sheet of aluminum foil or glass.

Gamma (γ) – Gamma rays (and x-rays), unlike alpha or beta particles, are waves of pure energy. Gamma rays travel at the speed of light. Gamma radiation is very penetrating and requires a large mass such as a thick wall of concrete, lead, or steel to stop it.

Neutrons (n) – The most prolific source of neutrons is a nuclear reactor. Neutrons produce ionizing radiation indirectly by collision with hydrogen nuclei (protons) and when gamma rays and alpha particles are emitted following neutron capture in matter. A neutron has about one-quarter the weight of an alpha particle. It will travel in the air until it is absorbed in another nucleus.

I.2.2 Radiation Measuring Units

During the early days of radiological experimentation, there was no precise unit for radiation measure. Therefore, a variety of units were used to measure radiation. These units determined the amount, type, and intensity of radiation. Just as heat can be measured in terms of its intensity or effects using units of calories or degrees, amounts of radiation or its effects can be measured in units of curies, radiation absorbed dose (rad), or dose equivalent (roentgen equivalent man, or rem). The following summarizes these units.

Curie— The curie, named after French scientists Marie and Pierre Curie, describes the "intensity" of a sample of radioactive material. The decay rate of 1 gram of radium was the basis of this unit of measure. Because the measured decay rate kept changing slightly as measurement techniques became more accurate, the curie was subsequently defined as exactly 3.7×10^{10} disintegrations (decays) per second.

Rad—The rad is the unit of measurement for the physical absorption of radiation. The total energy absorbed per unit quantity of tissue is referred to as "absorbed dose" (or simply dose). As sunlight heats pavement by giving up an amount of energy to it, radiation similarly gives up energy to objects in its path. One rad is equal to the amount of radiation that leads to the deposition of 0.01 joule of energy per kilogram of absorbing material.

Radiation Units and Conversions to International System of Units

1 curie	= 3.7×10^{10} disintegrations per second
	= 3.7×10^{10} becquerels
1 becquerel	= 1 disintegration per second
1 rad	= 0.01 gray
1 rem	= 0.01 sievert
1 gray	= 1 joule per kilogram

Rem—The rem is a measurement of the dose equivalent from radiation based on its biological effects. The rem is used in measuring effects of radiation on the body. One rem of one type of radiation is presumed to have the same biological effects as 1 rem of any other kind of radiation. This allows comparison of the biological effects of radionuclides that emit different types of radiation. One-thousandth of a rem is called a millirem.

Person-rem—The term used for reporting the collective dose, the sum of individual doses received in a given time period by a specified population from exposure to a specified radiation source.

The units of radiation measure in the International System of Units are: becquerel (a measure of source intensity [activity]), gray (a measure of absorbed dose), and sievert (a measure of dose equivalent). In accordance with U.S. Department of Energy (DOE) convention, all units presented in this EIS are in terms of curies, rad, rem, and person-rem.

An individual may be exposed to ionizing radiation externally (from a radioactive source outside the body) or internally (from ingesting or inhaling radioactive material). The external dose is different from the internal dose because an external dose is delivered only during the actual time of exposure to the external radiation source, while an internal dose continues to be delivered as long as the radioactive source is in the body. The dose from internal exposure is calculated over 50 years following the initial exposure. Both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time.

I.2.3 Radiation Sources

The average American receives a total of approximately 360 millirem per year from all radiation sources, both natural and manmade, of which approximately 300 millirem per year are from natural sources. Radiation sources can be divided into six different categories: (1) cosmic radiation, (2) terrestrial radiation, (3) internal radiation, (4) consumer products, (5) medical diagnosis and therapy, and (6) other sources (NCRP 1987). These categories are discussed in the following paragraphs.

Cosmic Radiation – Cosmic radiation is ionizing radiation resulting from energetic charged particles from space continuously hitting Earth's atmosphere where they create secondary particles and protons. These particles and the secondary particles and photons they create compose cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with the altitude above sea level. The average dose to people in the United States from this source is approximately 27 millirem per year.

External Terrestrial Radiation – External terrestrial radiation is radiation emitted from radioactive materials in Earth's rocks and soils. The average individual dose from external terrestrial radiation is approximately 28 millirem per year.

Internal Radiation – Internal radiation results from the human body metabolizing natural radioactive material that has entered the body by inhalation or ingestion. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, potassium, rubidium, and carbon. The major contributors to the annual dose equivalent for internal radioactivity are the short-lived decay products of radon, which contribute approximately 200 millirem per year. The average individual dose from other internal radionuclides is approximately 39 millirem per year.

Consumer Products – Consumer products also contain sources of ionizing radiation. In some products, such as smoke detectors and airport x-ray machines, the radiation source is essential to the product's operation. In other products, such as televisions and tobacco, radiation occurs as the products function. The average dose from consumer products is approximately 10 millirem per year.

Medical Diagnosis and Therapy – Radiation is an important diagnostic medical tool and cancer treatment. Diagnostic x-rays result in an average exposure of 39 millirem per year. Nuclear medical procedures result in an average exposure of 14 millirem per year.

Other Sources – There are a few additional sources of radiation that contribute minor doses to individuals in the United States. The average dose from nuclear fuel cycle facilities (e.g., uranium mines, mills, and fuel processing plants) and nuclear power plants has been estimated to be less than 1 millirem per year. Radioactive fallout from atmospheric atomic bomb tests, emissions from certain mineral extraction facilities, and transportation of radioactive materials contribute less than 1 millirem per year to the average dose to an individual. Air travel contributes approximately 1 millirem per year to the average dose.

I.2.4 Exposure Pathways

As stated earlier, an individual may be exposed to ionizing radiation both externally and internally. The different ways that could result in radiation exposure to an individual are called exposure pathways. Each type of exposure is discussed separately in the following paragraphs.

External Exposure—External radiation exposure can result from several different pathways, including exposure to a cloud of radioactive particles passing over the receptor (an exposed individual), standing on ground contaminated with radioactivity, and swimming or boating in contaminated water. If the receptor leaves the source of radiation exposure, the dose rate will be reduced if not eliminated. Dose from external radiation is based on time spent exposed to a radiation source. The appropriate dose measure is called the effective dose equivalent.

Internal Exposure—Internal exposure results from a radiation source entering the human body through either inhalation of contaminated air or ingestion of contaminated food or water. In contrast to external exposure, once a radiation source enters the body, it remains there for a period of time that varies, depending on decay and biological half-life.[1] The absorbed dose to each organ of the body is calculated for a period of 50 years following intake, in accordance with DOE safety analysis application guidance. The calculated absorbed dose is called the committed dose equivalent. Various organs have different susceptibilities to damage from radiation. The committed effective dose equivalent takes these different susceptibilities into account and provides a broad indicator of the health risk to an individual from radiation. The committed effective dose equivalent is a weighted sum of the committed dose equivalent in each major organ or tissue. The concept of committed effective dose equivalent applies only to internal pathways.

I.2.5 Radiation Protection Guides

Several organizations have issued radiation protection guides. Responsibilities of the main radiation safety organizations, particularly those that affect policies in the United States, are summarized below.

International Commission on Radiological Protection (ICRP)—ICRP has responsibility for providing guidance in matters of radiation safety. ICRP's operating policy is to prepare recommendations to address basic principles of radiation protection, leaving the various national protection committees to introduce detailed technical regulations, recommendations, or codes of practice best suited to the needs of their countries.

National Council on Radiation Protection and Measurements—In the United States, this Council has responsibility for adapting and providing detailed technical guidelines for implementing ICRP recommendations. The Council consists of expert radiation protection specialists and scientists.

National Research Council/National Academy of Sciences—The National Research Council, which provides science and policy research supporting the National Academy of Sciences, associates the broad science and technology community with the Academy's purposes of furthering knowledge and advising the Federal Government. The Council's Nuclear Radiation Studies Board prepares reports to advise the Federal Government on issues related to radiation protection and radioactive materials. The Committee on the Biological Effects of Ionizing Radiation (BEIR), which has issued a number of studies on radiation exposure health conveyances, operates under the Nuclear Radiation Studies Board.

U.S. Environmental Protection Agency (EPA)—EPA has published a series of documents, *Radiation Protection Guidance to Federal Agencies,* used as a regulatory benchmark by a number of Federal agencies, including DOE, to limit public and occupational workforce exposures to the greatest extent possible.

The Interagency Steering Committee on Radiation Standards (ISCORS)—ISCORS technical reports serve as guidance to Federal agencies to assist them in preparing and reporting analyses results and implementing radiation protection standards in a consistent and uniform manner. ISCORS issued a technical report entitled *A Method for Estimating Radiation Risk from TEDE* (DOE 2002). This report provides dose-to-risk conversion factors using total effective dose equivalent (TEDE) to estimate dose. It is recommended for use by DOE personnel and contractors when computing potential radiation risk from calculated radiation dose for comparison purposes. However, for radiation risk assessments required in risk management decisions, the

[1] *Biological half-life is the time for one-half of a radioactive source that has entered the body to be removed from the body by natural processes.*

radionuclide-specific risk coefficients in EPA's Federal Guidance Report No. 13, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides* (EPA 1999b), should be used.

I.2.6 Radiation Exposure Limits

Exposure limits for members of the public and radiation workers are generally consistent with ICRP recommendations. EPA also considers National Council on Radiation Protection and Measurements and ICRP recommendations and sets specific annual exposure limits (usually less than those specified by ICRP) in *Radiation Protection Guidance to Federal Agencies* documents. Each regulatory organization then establishes its own set of radiation standards. Examples of exposure limits set by DOE, EPA and the U.S. Nuclear Regulatory Commission (NRC) for radiation workers and members of the public are shown in **Table I–1**.

Table I–1 Exposure Limits for Members of the Public and Radiation Workers

Guidance Criteria (Organization)	*Public Exposure Limits at the Site Boundary*	*Worker Exposure Limits*
10 CFR 835.202 (DOE)	–	5 rem per year [a]
10 CFR 835.1002 (DOE)	–	1 rem per year [b]
40 CFR 61 (EPA)	0.01 rem per year (all air pathways)	–
40 CFR 141 (EPA)	0.004 rem per year (drinking water pathways)	–
DOE Order 5400.5 (DOE) [c]	0.01 rem per year (all air pathways) 0.004 rem per year (drinking water pathway) 0.1 rem per year (all pathway)	–
10 CFR 20.1301 (NRC)	0.1 rem per year (all pathways)	–
10 CFR 20.1201 (NRC)	–	5 rem per year
New York State Department of Environmental Conservation DSHM-RAD-05-01	0.01 rem per year after cleanup (all pathways)	–

CFR = *Code of Federal Regulations*, EPA = U.S. Environmental Protection Agency, NRC = U.S. Nuclear Regulatory Commission.

[a] Although this is a limit (or level) enforced by DOE, worker doses must be managed in accordance with as low as is reasonably achievable principles. See footnote b.

[b] This is an objective by DOE for the design of new facilities or modifications of existing facilities, to control personnel exposures from external sources of radiation. DOE recommends that facilities adopt an Administrative Control Level for occupational doses that should not exceed 2 rem per year, although DOE believes that an Administrative Control Level of 0.5 rem per year would be achievable for most facilities (DOE 1999b). Reasonable attempts must be made by the site to maintain individual worker doses below these levels.

[c] Derived from 40 CFR Part 61, 40 CFR Part 141, and 10 CFR Part 20.

I.3 Health Effects

To provide background information for discussions of radiation exposure impacts, this section explains basic concepts used to evaluate radiation effects.

Radiation can cause a variety of damaging health effects in humans. The most significant effects are induced cancer fatalities. These effects are referred to as "latent cancer fatalities" because the cancer may take many years to develop. In the discussions that follow, all fatal cancers are considered latent; therefore, the term "latent cancer fatalities" and "fatal cancers" are used interchangeably in this appendix.

The National Research Council's Committee on the BEIR has prepared a series of reports to advise the Federal Government on radiation exposure health consequences. *Health Effects of Exposure to Low Levels of Ionizing Radiation*, BEIR V (National Research Council 1990), provides current estimates for excess mortality from leukemia and other cancers expected to result from exposure to ionizing radiation. BEIR V provides estimates consistently higher than those in its predecessor, BEIR III. This increase is attributed to several factors, including use of a linear dose response model for cancers other than leukemia, revised dosimetry for the Japanese atomic bomb survivors, and additional followup studies of the atomic bomb survivors and associated others. BEIR III employs constant, relative, and absolute risk models, with separate coefficients for each of several sex and age-at-exposure groups. Absolute risks are total population fatal cancer risks directly related to radiation dose. Relative risks account for differences in risk between the different age and sex of exposure groups. BEIR V develops models in which excess relative risk is expressed as a function of age at exposure, time after exposure, and sex for each of several cancer categories. The BEIR III models were based on the assumption that absolute risks are comparable between the atomic bomb survivors and the U.S. population. BEIR V models were based on the assumption that the relative risks are comparable. For a disease such as lung cancer, where baseline risks in the United States are much larger than those in Japan, the BEIR V approach leads to larger risk estimates than the BEIR III approach. The BEIR VII report, issued three years ago, is still being studied and incorporated into U.S. regulations and guidance. At this point, it appears that the BEIR VII report will not result in a change in mortality estimates. Therefore, fatal cancer estimates based on BEIR V are expected to remain valid. However, the BEIR VII report does result in an increase in morbidity estimates. Therefore, morbidity estimates, which are presented in Appendix H, are expected to increase when BEIR VII is incorporated into U.S. regulations and guidance.

Models and risk coefficients in BEIR V were derived through analyses of relevant epidemiologic data that included the Japanese atomic bomb survivors, ankylosis spondylitis patients, Canadian and Massachusetts fluoroscopy (breast cancer) patients, New York postpartum mastitis (breast cancer) patients, Israeli tinea capitis (thyroid cancer) patients, and Rochester thymus (thyroid cancer) patients. Models for leukemia, respiratory cancer, digestive cancer, and other cancers used only the atomic bomb survivor data, although the ankylosis spondylitis patient analysis results were considered. Atomic bomb survivor analyses were based on revised dosimetry, with an assumed relative biological effectiveness of 20 for neutrons, and were restricted to doses less than 400 rad. Estimates of fatal cancer (other than leukemia) risks were obtained by totaling estimates for breast, respiratory, digestive, and other cancers.

The National Council on Radiation Protection and Measurements, based on radiation risk estimates provided in BEIR V and ICRP Publication 60 recommendations (ICRP 1991), estimated the total detriment resulting from low-dose or low-dose rate exposure to ionizing radiation to be 0.00056 per rem for the working population and 0.00073 per rem for the general population (NCRP 1993). The total detriment includes fatal and nonfatal cancers, as well as severe hereditary (genetic) effects. The major contribution to the total detriment is from fatal cancer, estimated to be 0.0004 and 0.0005 per rem for radiation workers and the general population, respectively. The difference in radiation risk between workers and the public is due to the age of workers as compared to the population which includes children and elderly who are more sensitive to radiation. The risk estimator breakdowns for both workers and the general population are shown in **Table I–2**. Nonfatal cancers and genetic effects are less probable radiation exposure consequences.

Table I–2 Nominal Health Risk Estimators Associated with Exposure to 1 rem of Ionizing Radiation

Exposed Individual	*Fatal Cancer* [a, b]	*Nonfatal Cancer* [c]	*Genetic Disorders* [c]	*Total*
Worker	0.0004	0.00008	0.00008	0.00056
Public	0.0005	0.0001	0.00013	0.00073

[a] For fatal cancer, the health effect coefficient is the same as the probability coefficient. When applied to an individual, the unit is the lifetime probability of a cancer fatality per rem of radiation dose. When applied to a population of individuals, the unit is the excess number of fatal cancers per person-rem of radiation dose.

[b] For high individual exposures (greater than or equal to 20 rem) over a time period of up to one year, the health factors are multiplied by a factor of 2.

[c] In determining a means of assessing radiation exposure health effects, the ICRP has developed a weighting method for nonfatal cancers and genetic effects.

Source: NCRP 1993.

The EPA, in coordination with other Federal agencies involved in radiation protection, issued the September 1999 Federal Guidance Report No. 13: *Cancer Risk Coefficients for Environmental Exposure to Radionuclides* (EPA 1999b). This document is a compilation of risk factors for doses from external gamma radiation and internal intake of radionuclides. Federal Guidance Report No. 13 is the basis of radionuclide risk coefficients used in the EPA *Health Effects Assessment Summary Tables* (EPA 2001a) and in computer dose codes such as the DOE Argonne Residual Radiation (RESRAD) code. However, DOE and other agencies regularly conduct dose assessments with models and codes that calculate radiation dose from exposure or intake using dose conversion factors and do not compute risk directly. In these cases, where it is necessary or desirable to estimate risk for comparative purposes (e.g., comparing risk associated with alternative actions), it is common practice to simply multiply the calculated TEDE by a risk-to-dose factor. DOE previously recommended TEDE-to-fatal-cancer risk factors of 5×10^{-4} per rem for the public and 4×10^{-4} per rem for working-age populations. These values were based upon former Committee on Interagency Radiation Research and Policy Coordination 1992 recommendations, which were superceded by ISCORS guidance. ISCORS recommends that agencies use a conversion factor of 6×10^{-4} fatal cancers per TEDE (rem) for mortality and 8×10^{-4} cancers per rem for morbidity when making qualitative or semi-quantitative estimates of radiation exposure risk to members of the general public[2] (DOE 2002).

The TEDE-to-risk factor provided in *Estimating Radiation Risk from Total Effective Dose Equivalent (TEDE)*, ISCORS Technical Report No. 1, is based upon a static population with characteristics consistent with the U.S. population. There are no separate ISCORS recommendations for workers, but the report does specify the use of the same fatal cancer risk factor as for the general population. For workers (adults), a fatal cancer risk of 5×10^{-4} per rem and a morbidity risk of 7×10^{-4} per rem may be used. However, given the risk estimate uncertainties, for most estimates the value for the general population of 6×10^{-4} per rem could be used for workers (DOE 2002). The DOE Office of Environmental Policy and Guidance recommends these values, but it should be emphasized that they are principally suited for comparative analyses and where it would be impractical to calculate risk using Federal Guidance Report No. 13. If risk estimates for specific radionuclides are needed, cancer risk coefficients in Federal Guidance Report No. 13 should be used (DOE 2002).

The ISCORS report notes that the recommended risk coefficients used with TEDE dose estimates generally produce conservative radiation risk estimates (i.e., they overestimate risk).[3] For the ingestion pathway of 11 radionuclides compared, risks would be overestimated compared with Federal Guidance Report No. 13 values for about 8 radionuclides, and significantly overestimated (by up to a factor of 6) for 4 of these. The DOE Office of Environmental Policy and Guidance also compared the risks obtained using the risk conversion factor with the risks in Federal Guidance Report No. 13 for the inhalation pathway, and found a bias toward overestimation of risk, although it was not as severe as for ingestion. For 16 radionuclides/chemical states evaluated, 7 were significantly overestimated (by more than a factor of 2), 5 were significantly underestimated, and the remainder agreed within about a factor of 2. Generally, these differences are within the uncertainty of transport and uptake portions of dose or risk modeling and, therefore, the approach recommended is fully acceptable for comparative assessments. That notwithstanding, it is strongly recommended that, wherever possible, the more rigorous approach with Federal Guidance Report No. 13 cancer risk coefficients be used (DOE 2002).

The values in Table I–2 are "nominal" cancer and genetic disorder probability coefficients. They are based on an idealized population receiving a uniform whole-body dose. Recent EPA studies, based on age-dependent dose coefficients for members of the public, indicate that the product of the effective dose and the probability coefficient could over- or underestimate radiological risk (EPA 1999b). In support of risk results provided in Federal Guidance Report No. 13, EPA performed an uncertainty analysis on uniform whole-body exposure

[2] *Such estimates should not be stated with more than 1 significant digit.*
[3] *This statement presumes that using the radionuclide-specific risk factors in Federal Guidance Report No. 13 would be a more accurate measure of potential risk than multiplying the TEDE by a single average risk factor.*

effects. The analysis resulted in an estimated nominal risk coefficient increase from 0.051 fatal cancers per gray (0.00051 fatal cancers per rad) to 0.0575 fatal cancers per gray (0.000575 fatal cancers per rad) (EPA 1999a). This result indicates a nominal risk coefficient increase of about 20 percent over that provided in *Risk Estimates for Radiation Protection* (NCRP 1993) for the public.

Based on review of recent EPA reports, ISCORS recommended that a risk factor of 0.06 fatal cancers per sievert (0.0006 fatal cancers per rem) be used for estimating risks when using calculated dose (DOE 2002). DOE recommended that 0.0006 fatal cancers per rem be used for both workers and members of the public (DOE 2003a).

Numerical fatal cancer estimates presented in this EIS were obtained using a linear no-threshold extrapolation from the nominal risk estimated for lifetime total cancer mortality that results from a dose of 0.1 gray (10 rad). Other methods of extrapolation to the low-dose region could yield higher or lower numerical fatal cancer estimates. Studies of human populations exposed to low doses are inadequate to demonstrate the actual risk level. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation, and the possibility of no risk cannot be excluded (CIRRPC 1992). The risk factor of 0.0006 fatal cancers per rem was used as the conversion factor for all radiological exposures due to accidents, including those in the low-dose region. For normal operations radiological exposure, lifetime fatal cancer risk was calculated using radionuclide-specific risk factors.

EIS Health Effect Risk Estimators

Health impacts of radiation exposure, whether from external or internal sources, generally are identified as "somatic" (i.e., affecting the exposed individual) or "genetic" (i.e., affecting descendants of the exposed individual). Radiation is more likely to produce somatic than genetic effects. The somatic risks of most importance are induced cancers. Except for leukemia, which can have an induction period (time between exposure to carcinogen and cancer diagnosis) of as little as 2 to 7 years, most cancers have an induction period of more than 20 years.

For uniform irradiation of the body, cancer incidence varies among organs and tissues; the thyroid and skin demonstrate a greater sensitivity than other organs. Such cancers, however, also produce relatively low mortality rates because they are relatively amenable to medical treatment. Because fatal cancer is the most serious effect of environmental and occupational radiation exposures, estimates of cancer fatalities rather than cancer incidence are presented in this appendix. The numbers of fatal cancers can be used to compare risks among the various alternatives. (Note that cancer incidence [latent cancer morbidity] is analyzed in Appendix H, Long-Term Performance Assessment Results, to enable comparison of the potential long-term impacts for the alternatives with the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] risk range.)

Based on the preceding discussion, the number of fatal cancers to workers and the general public for postulated accidents in which individual doses are less than 20 rem, is calculated using a health risk estimator of 0.0006 per person-rem. (Risk estimators are lifetime probabilities that an individual would develop a fatal cancer per rem of radiation received.) Risk estimators associated with total cancer incidence among the public is 0.0008 per person-rem (DOE 2002). Federal Guidance Report No. 13 individual radioisotope risk factors are used to calculate lifetime fatal cancer risk for normal operations.

Recent EPA analyses (EPA 1999a, 1999b) addressed the effects of low-dose and low-dose-rate exposure to ionizing radiation. Consistent with the conclusion in *Risk Estimates for Radiation Protection* (NCRP 1993), the risk to individuals receiving doses of 20 rem or more is double that associated with doses of less than 20 rem.

The fatal cancer estimators are used to calculate the statistical expectation of the effects of exposing a population to radiation. For example, if 100,000 people were each exposed to a one-time radiation dose of 100 millirem (0.1 rem), the collective dose would be 10,000 person-rem. The exposed population would then be expected to experience 6 additional cancer fatalities from the radiation (10,000 person-rem × 0.0006 lifetime probability of cancer fatalities per person-rem = 6 cancer fatalities).

Calculations of the number of excess fatal cancers associated with radiation exposure do not always yield whole numbers. These calculations may yield numbers less than one, especially in environmental impact applications. For example, if a population of 100,000 was exposed to a total dose of only 0.001 rem per person, the collective dose would be 100 person-rem (100,000 persons × 0.001 rem = 100 person-rem). The corresponding estimated number of cancer fatalities would be 0.06 (100 person-rem × 0.0006 cancer fatalities per person-rem = 0.06 cancer fatalities). The 0.06 means that there is 1 chance in 16.6 that the exposed population would experience 1 fatal cancer. In other words, 0.06 cancer fatalities are the *expected* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. In most groups, no person would incur a fatal cancer from the 0.001 rem dose each member received. In a small fraction of the groups, 1 cancer fatality would result; in exceptionally few groups, 2 or more cancer fatalities would occur. The *average* expected number of deaths over all the groups would be 0.06 cancer fatalities (just as the average of 0, 0, and 0, added to 1 is ¼, or 0.25). The most likely outcome is no cancer fatalities.

The same concept is applied to estimate radiation exposure effects on an individual member of the public. Consider the effects of an individual's exposure to a 360-millirem (0.36 rem) annual dose from all radiation sources. The probability that the individual would develop a fatal cancer from continuous exposure to this radiation over an average life of 72 years (presumed) is 0.016 (one person × 0.36 rem per year × 72 years × 0.0006 cancer fatalities per person-rem = 0.016). This corresponds to 1 chance in 64.

I.4 Normal Operations Radiological Impacts During Implementation of Alternatives

Normal operations involving release of radionuclides to the environment were analyzed with the GENII computer code.

I.4.1 GENII Computer Code Generic Description

Radiological impacts of releases during normal operations were calculated using Version 2 of the GENII computer code (PNNL 2007). GENII is designed to model long-term atmospheric and liquid releases of radionuclides are their human health consequences. Site-specific input data were used, including location, meteorology, population, and source terms. This section briefly describes GENII, and outlines the approach used for normal operations.

Code Description

The GENII computer model, developed by Pacific Northwest National Laboratory, is an integrated system of computer modules that analyzes environmental contamination resulting from acute or chronic releases to, or initial contamination in, air, water, or soil. The model calculates radiation doses to individuals and populations. The GENII computer model is well documented for assumptions, technical approach, method, and quality assurance issues. The GENII computer model has gone through extensive quality assurance and quality control steps, including comparing results from model computations with those from hand calculations and performing internal and external peer reviews (PNNL 2007).

Available release scenarios include chronic and acute releases to water or to air (ground level or elevated sources), and initial contamination of soil or surfaces. GENII implements NRC models in LADTAP for surface water doses. Exposure pathways include direct exposure via water (swimming, boating, and fishing), soil, air, inhalation, and ingestion pathways. GENII Version 1 implemented dosimetry models recommended by the ICRP in Publications 26, 30, and 48, and approved for use by DOE Order 5400.5. GENII Version 2 implements these models plus those of ICRP Publications 56 through 72, and the related risk factors published in Federal Guidance Report No. 13. Risk factors in the form of EPA developed "slope factors" are also included (these are a special subset of the Federal Guidance Report No. 13 values). These dosimetry and risk models are considered to be "state of the art" by the international radiation protection community and have been adopted by most national and international organizations as their standard dosimetry methodology (PNNL 2007).

GENII Version 2 consists of four independent atmospheric models, one surface water model, three independent environmental accumulation models, one exposure module, and one dose/risk module, each with a specific user interface code. The computer programs are of several types: user interfaces (i.e., interactive, menu-driven programs to assist the user with scenario generation and data input), internal and external dose factor libraries, environmental dosimetry programs, and file-viewing routines. The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) program serves as the interface for operating GENII. For maximum flexibility, the code has been divided into several interrelated, but separate, exposure and dose calculations (PNNL 2007).

I.4.2 GENII Input Data

To perform dose assessments for this EIS, different types of data were collected and generated. This section discusses the various data, along with assumptions made for performing the dose assessments.

Dose assessments were performed for members of the general public at the West Valley Demonstration Project (WVDP) to determine incremental doses that would be associated with the alternatives addressed in this EIS. Incremental doses for members of the public were calculated (via GENII) for two different types of receptors:

- Maximally exposed individual (MEI) – The MEI for air releases was assumed to be an individual member of the public located at a position on the site boundary, including public roads inside the site, that would yield the highest impacts during normal operations. For this EIS, the MEI for air releases is located approximately 1.3 kilometers (0.8 miles) in the north-northwest direction. For liquid releases, there are two MEI locations on Cattaraugus Creek near the site and on the lower reaches of Cattaraugus Creek for a member of the Seneca Nation of Indians. These MEI locations are presented in **Figure I–1**.

- Population – The general population living within 80 kilometers (50 miles) of the facility (approximately 1.7 million for this EIS). An average dose to a member of this population was also calculated.

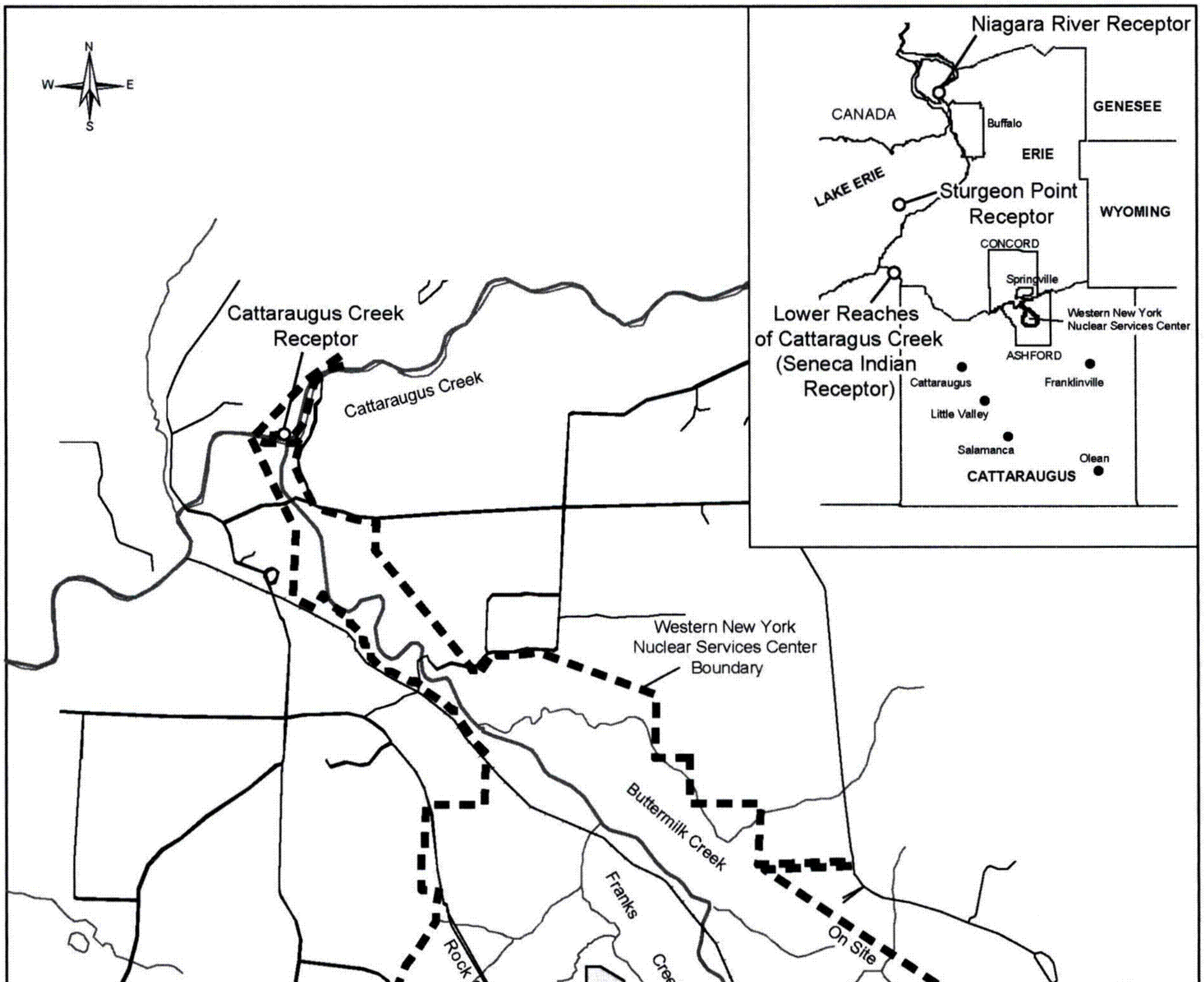

Figure I–1 Location of Maximally Exposed Individual for Normal Operations

I.4.3 Meteorological Data

The meteorological data used for all normal operational scenarios discussed in this EIS were in the form of joint frequency data files. A joint frequency data file is a table listing the fractions of time the wind blows in a certain direction, at a certain speed, and within a certain atmospheric stability class. The joint frequency data files were based on measurements taken over a period of 5 years (1998 to 2002) at WVDP.

I.4.3.1 Population Data

Population distributions were based on U.S. Department of Commerce state population census numbers and Canadian population census data (DOC 2008, ESRI 2008, Statistics Canada 2008). Area population trends have shown a decreasing population over time. Therefore, for conservatism, the 2000 U.S. census (supplemented by the 2001 Canadian census) site-specific population was used in the impact assessments. The population was spatially distributed on a circular grid with 16 directions and 10 radial distances up to 80 kilometers (50 miles). The grid was centered at the location from which the radionuclides were assumed to be released. The 2000/2001 census total population from the WVDP out to 80 kilometers (50 miles) is approximately 1.7 million.

I.4.3.2 Source Term Data

Source term(s) (that is, the quantities of radioactive material released to the environment over a given period) for the No Action Alternative normal operational releases were based on release quantities identified in Annual Site Environmental Reports, which can be found on the Internet at www.wv.doe.gov and are summarized in a technical report (WSMS 2008e). These reports identified both airborne and liquid lifetime radiological releases. Source terms for each of the three decommissioning alternatives (Sitewide Removal, Sitewide Close-In-Place, and Phased Decisionmaking) were developed based on specific activities provided in the technical reports for these alternatives and their concomitant airborne and liquid radiological releases (WSMS 2008b, 2008c, 2008d). Projected airborne radiological releases for each alternative are presented in **Table I–3**, and liquid releases are provided in **Table I–4**. Tables I–3 and I–4 also present the estimated peak annual releases. The peak annual airborne and liquid releases were determined by evaluating annual releases for each radionuclide. The peak annual release for each radionuclide did not occur during the same year for some alternatives. Therefore, the year when the annual radiological release would result in the highest calculated population dose was selected. In some cases, this year does not result in the highest annual radiological release rate for every radionuclide.

Source terms used to calculate impacts of postulated accidents are provided in Section I.7.

I.4.3.3 Food Production and Consumption Data

Generic food consumption rates are available as default values in GENII. The default values are comparable to those established in NRC Regulatory Guide 1.109 (NRC 1977). This Regulatory Guide provides guidance for evaluating ingestion doses from consuming contaminated plant and animal food products using a standard set of assumptions for crop and livestock growth and harvesting characteristics.

Food consumption parameters used to evaluate each alternative are presented in **Tables I–5** and **I–6**.

Table I–3 Airborne Radiological Releases by Alternative

Alternative (duration in years)	*Tritium*	*Cobalt-60*	*Strontium-90*	*Iodine-129*	*Cesium-137*	*Transuranic* [a]	*Total* [b]
Average Airborne Radiological Releases (curies per year)							
Sitewide Removal (64)	3.3×10^{-2}	2.6×10^{-4}	1.0×10^{-2}	1.5×10^{-3}	2.3×10^{-3}	4.2×10^{-4}	4.7×10^{-2}
Sitewide Close-In-Place (7)	1.0×10^{-5}	9.0×10^{-5}	5.5×10^{-3}	1.9×10^{-6}	5.0×10^{-3}	2.5×10^{-4}	1.1×10^{-2}
Phased Decisionmaking (8)	2.7×10^{-4}	1.6×10^{-4}	1.7×10^{-2}	4.7×10^{-5}	1.5×10^{-2}	6.5×10^{-3}	3.9×10^{-2}
No Action [c] (100)	2.0×10^{-4}	1.4×10^{-9}	7.2×10^{-7}	3.3×10^{-6}	1.3×10^{-6}	2.7×10^{-8}	2.1×10^{-4}
Peak Annual Airborne Radiological Releases (curies per year)							
Sitewide Removal	7×10^{-2}	3×10^{-4}	1×10^{-1}	1×10^{-5}	3×10^{-3}	9×10^{-4}	1.7×10^{-1}
Sitewide Close-In-Place	1.4×10^{-5}	4.0×10^{-4}	1×10^{-2}	1.3×10^{-5}	1×10^{-2}	6×10^{-4}	2.1×10^{-2}
Phased Decisionmaking	8×10^{-5}	3×10^{-4}	3×10^{-2}	1.2×10^{-5}	3×10^{-2}	1.2×10^{-2}	7.2×10^{-2}
No Action [d]	4.1×10^{-1}	2.0×10^{-6}	4.8×10^{-4}	7.4×10^{-3}	8.6×10^{-4}	4.8×10^{-6}	4.2×10^{-1}

[a] Transuranic radioisotopes were represented by using plutonium-239.
[b] Yearly total presented. The activity released over the life of the alternative is the total (curies per year) times the duration (year).
[c] Also includes 6.1×10^{-8} curies of americium-241, 5.1×10^{-9} curies of europium-154, 7.5×10^{-9} curies of uranium isotopes represented by uranium-238, and 2×10^{-8} curies of plutonium-238.
[d] Also includes 2.8×10^{-6} curies of americium-241, 4.7×10^{-4} curies of europium-154, 3×10^{-7} curies of uranium isotopes represented by uranium-238, and 8.7×10^{-7} curies of plutonium-238.
Note: Alternative durations are presented in years. There is no decommissioning for the No Action Alternative; for this alternative, a 100-year period of site monitoring and maintenance is analyzed as adapted from the recommendations in DOE Manual 435.1-1 regarding analytical assumptions for institutional controls (DOE 1999c).
Sources: Steiner 2008; WSMS 2008b, 2008c, 2008d, 2008e.

Table I–4 Total Liquid Radiological Releases by Alternative

Alternative (duration in years)	*Tritium*	*Cobalt-60*	*Strontium-90*	*Cesium-137*	*Transuranic* [a]	*Total* [b]
Average Liquid Radiological Releases (curies per year)						
Sitewide Removal (64)	4.5	4.3×10^{-7}	6.1×10^{-3}	7.6×10^{-4}	6.5×10^{-6}	4.5
Sitewide Close-In-Place (7)	4.1×10^{1}	3.6×10^{-7}	4.3×10^{-2}	2.2×10^{-3}	4.9×10^{-5}	4.1×10^{1}
Phased Decisionmaking (8)	7.5×10^{-3}	1.3×10^{-9}	2.4×10^{-4}	4.1×10^{-7}	7.8×10^{-10}	7.7×10^{-3}
No Action (100) [c]	8.8×10^{-3}	4.3×10^{-6}	5.4×10^{-4}	2.7×10^{-4}	6.0×10^{-7}	9.6×10^{-3}
Peak Annual Liquid Radiological Releases (curies per year)						
Sitewide Removal	9×10^{-2}	5×10^{-6}	1.1×10^{-2}	1×10^{-3}	8×10^{-6}	1×10^{-1}
Sitewide Close-In-Place	7.2×10^{2}	6.3×10^{-7}	7.5×10^{-2}	3.8×10^{-3}	8.5×10^{-5}	7.2×10^{2}
Phased Decisionmaking	1.3×10^{-2}	2.6×10^{-9}	6.0×10^{-5}	9×10^{-7}	1.6×10^{-9}	1.3×10^{-2}
No Action [d]	7.2	2.3×10^{-3}	9.9×10^{-3}	6.6×10^{-2}	5.2×10^{-5}	7.3

[a] Transuranic radioisotopes were represented by using plutonium-239.
[b] Yearly total presented. The activity released over the life of the alternative is the total (curies per year) times the duration (year).
[c] Also includes: 3.6×10^{-5} curies of carbon-14, 7.4×10^{-5} curies of potassium-40, 1.1×10^{-4} curies of technetium-99, 8.1×10^{-6} curies of iodine-129, and 8.2×10^{-5} curies of uranium isotopes (represented by uranium-238).
[d] Also includes: 1.9×10^{-2} curies of carbon-14, 1.3×10^{-2} curies of potassium-40, 9.6×10^{-2} curies of technetium-99, 1.7×10^{-3} curies of iodine-129, and 1.1×10^{-2} curies of uranium isotopes (represented by uranium-238).
Note: Alternative durations are presented in years. There is no decommissioning for the No Action Alternative; for this alternative, a 100-year period of site monitoring and maintenance is analyzed as adapted from the recommendations in DOE Manual 435.1-1 regarding analytical assumptions for institutional controls (DOE 1999c).
Sources: Steiner 2008; WSMS 2008b, 2008c, 2008d, 2008e.

Table I–5 GENII Usage Parameters for Consumption of Plant Food (Normal Operations)

Food Type	*Agriculture Characteristics*		*Maximally Exposed Individual*		*General Population*	
	Growing Time (Days)	*Yield (kilograms per square meter)*	*Holdup Time (days)*	*Consumption Rate (kilograms per year)*	*Holdup Time (days)*	*Consumption Rate (kilograms per year)*
Leafy Vegetables	90	1.5	1	30	14	15
Root Vegetables	90	4	5	220	14	140
Fruit	90	2	5	330	14	64
Grains/Cereals	90	0.8	180	80	180	72

Note: To convert kilograms to pounds, multiply by 2.2046; square meters to square feet, multiply by 10.8.
Source: PNNL 2007.

Table I–6 GENII Usage Parameters for Consumption of Animal Products (Normal Operations)

Food Type	*Stored Feed*				*Fresh Forage*			
	Diet Fraction	*Growing Time (days)*	*Yield (kilograms per square meter)*	*Storage Time (days)*	*Diet Fraction*	*Growing Time (days)*	*Yield (kilograms per square meter)*	*Storage Time (days)*
Beef	0.25	90	0.8	180	0.75	45	2	100
Poultry	1	90	0.8	180	—	—	—	—
Milk	0.25	45	2	100	0.75	30	1.5	0
Eggs	1	90	0.8	180	—	—	—	—

Food Type	*Maximally Exposed Individual*		*General Population*	
	Consumption Rate (kilograms per year)	*Holdup Time (days)*	*Consumption Rate (kilograms per year)*	*Holdup Time (days)*
Beef	80	15	70	34
Poultry	18	1	8.5	34
Milk	270	1	230	3
Eggs	30	1	20	18

Note: To convert kilograms to pounds, multiply by 2.2046; square meters to square feet, multiply by 10.8.
Source: PNNL 2007.

Calculations of the population and MEI doses from liquid releases into the local streams and creeks (eventually reaching Buttermilk Creek, Cattaraugus Creek, and Lake Erie) included doses resulting from use of the creek water as a source of drinking water and from the ingestion of fish taken from the creek. (These waters are not a source of irrigation for local crops.) All receptors were assumed to drink 730 liters (193 gallons) of water per year. The populations considered in estimating the doses from drinking water were the customers of Lake Erie Water Treatment Plants Downstream of Cattaraugus Creek (565,000 individuals) and the Niagara River Water Treatment Plants (386,000 individuals). Fish consumption for the general population was determined to be approximately 0.1 kilograms per year (0.2 pounds per year) based upon estimates of the quantity of fish harvested from local waters, and the MEI was assumed to consume 9 kilograms per year (20 pounds per year). An additional receptor, a member of the Seneca Nations of Indians, was identified who could consume a greater quantity of fish than that identified for the MEI. This receptor was assumed to consume 62 kilograms per year (137 pounds per year) of fish harvested from local waters.

I.4.3.4 GENII Basic Assumptions

Other key assumptions used in GENII are delineated below:

- Public population distribution of an 80-kilometer (50-mile) radius in all 16 compass directions for specific distance rings (0 to 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 10, 10 to 20, 20 to 30, 30 to 40, and 40 to 50 miles) based on 2000 U.S. and 2001 Canadian census data.

- MEI location at the WVDP Site for all 16 azimuthal compass directions, which constitutes the closest public boundary to the site in each of these directions.

- Agricultural and food consumption data for the land within 80 kilometers (50 miles) and the population residing within 80 kilometers (50 miles) of the WVDP Site.

- Radiological airborne emissions were released to the atmosphere at a height of either 0 or 24 meters (0 or 79 feet) to represent the range of structure heights for decommissioning operations. The largest height is that of the Main Plant Process Building in Waste Management Area (WMA) 1. This range of lowest and highest airborne emission height results in enveloping public radiation dose calculation results.

- For normal operations calculations, emission of the plume was assumed to continue throughout the year. Plume and ground deposition exposure parameters used in the GENII model for the exposed offsite individual and the general population are provided in **Table I–7**.

- The exposed individual or population was assumed to have adult human characteristics and habits.

- No evacuation or sheltering was assumed, though individuals were assumed to spend some time indoors.

- A Pasquill-Gifford plume model was used for the air immersion doses.

Table I–7 GENII Parameters for Exposure to Plumes (Normal Operations)

Maximally Exposed Individual				*General Population*			
External Exposure		*Inhalation of Plume*		*External Exposure*		*Inhalation of Plume*	
Plume (hours) [a]	*Ground Contamination (hours)* [b]	*Exposure Time (hours)*	*Breathing Rate (cubic centimeters per second)*	*Plume (hours)*	*Ground Contamination (hours)* [b]	*Exposure Time (hours)*	*Breathing Rate (cubic centimeters per second)*
6,132	8,760	8,760	270	4,383	8,760	8,760	270

[a] Assumes 70 percent outdoor exposure, with the balance indoors.
[b] Assumes 70 percent shielding for time indoors.
Note: To convert cubic centimeters to cubic inches, multiply by 0.061024.
Sources: PNNL 2007, NRC 1977.

I.4.3.5 Radiological Consequences from Normal Operations

The following tables provide the impacts, in terms of dose (person-rem) and increased risk of latent cancer fatalities (LCFs), to the public from radiological releases associated with normal operations for each of the four alternatives. **Table I–8** provides the yearly average, peak annual and total population impacts associated with airborne radiological releases from normal operations for the duration of the implementation of each alternative. **Table I–9** provides this information for liquid radiological releases. The peak annual population doses presented in Tables I–8 and I–9 are based on the peak annual releases that are presented in Tables I–3 and I–4. The basis for these peak annual releases is also discussed in Section I.4.3.2.

Table I–8 Population Impacts from Normal Operational Airborne Radiological Releases

Alternative	*Yearly Average*		*Peak Annual*		*Duration Total*	
	Population Dose [a] (person-rem)	*Increased Risk of LCF [b]*	*Population Dose [a] (person-rem)*	*Increased Risk of LCF [b]*	*Population Dose [a] (person-rem)*	*Increased Risk of LCF [b]*
Sitewide Removal	6.1×10^{-1}	9.1×10^{-5}	1.8	5.0×10^{-4}	3.9×10^{1}	5.8×10^{-3}
Sitewide Close-In-Place	3.3×10^{-1}	7.3×10^{-5}	7.2×10^{-1}	1.5×10^{-4}	2.3	5.1×10^{-4}
Phased Decisionmaking (Phase 1)	5.2	7.0×10^{-4}	9.7	1.3×10^{-3}	4.2×10^{1}	5.6×10^{-3}
No Action	4.3×10^{-4}	2.0×10^{-8}	7.9×10^{-1}	2.5×10^{-5}	4.3×10^{-2} [c]	2.0×10^{-6} [c]

LCF = latent cancer fatality.
[a] Based on population of 1,704,000.
[b] Federal Guidance Report No. 13 individual radioisotope risk factors are used to calculate lifetime fatal cancer risk for normal operations.
[c] Although the duration of the No Action Alternative is in perpetuity, a 100-year time period is analyzed for this table. The 100-year period was adapted from the recommendations in DOE Manual 435.1-1 regarding analytical assumptions for institutional controls (DOE 1999c). The radionuclides that contribute to the majority of the calculated airborne and liquid release doses (tritium, cobalt-60, strontium-90, and cesium-137) would have decayed by a factor of 10 to 500,000 after 100 years.
Note: All population results for air releases are obtained directly from GENII 2 output.

Table I–9 Population Impacts from Normal Operational Liquid Radiological Releases

Alternative	*Yearly Average*		*Peak Annual*		*Duration Total*	
	Population Dose [a] (person-rem)	*Increased Risk of LCF [b]*	*Population Dose [a] (person-rem)*	*Increased Risk of LCF [b]*	*Population Dose [a] (person-rem)*	*Increased Risk of LCF [b]*
Lake Erie Downstream of Cattaraugus Creek Water Consumer [a]						
Sitewide Removal	5.1×10^{-1}	1.8×10^{-4}	6.7×10^{-1}	2.5×10^{-4}	3.3×10^{1}	1.2×10^{-2}
Sitewide Close-In-Place	3.4	1.2×10^{-3}	2.2×10^{1}	7.4×10^{-3}	2.4×10^{1}	8.7×10^{-3}
Phased Decisionmaking (Phase 1)	1.2×10^{-2}	4.6×10^{-6}	3.4×10^{-3}	1.3×10^{-6}	9.6×10^{-2}	3.7×10^{-5}
No Action	7.5×10^{-2}	2.4×10^{-5}	1.3×10^{1}	4.1×10^{-3}	7.5 [c]	2.4×10^{-3} [c]
Niagara River Water Consumer [a]						
Sitewide Removal	8.4×10^{-3}	3.0×10^{-6}	1.1×10^{-2}	4.1×10^{-6}	5.4×10^{-1}	1.9×10^{-4}
Sitewide Close-In-Place	5.6×10^{-2}	2.0×10^{-5}	3.7×10^{-1}	1.2×10^{-4}	4.0×10^{-1}	1.4×10^{-4}
Phased Decisionmaking (Phase 1)	2.0×10^{-4}	7.5×10^{-8}	5.5×10^{-5}	2.1×10^{-8}	1.6×10^{-3}	6.0×10^{-7}
No Action	1.2×10^{-3}	3.9×10^{-7}	2.1×10^{-1}	6.7×10^{-5}	1.2×10^{-1} [c]	3.9×10^{-5} [c]

LCF = latent cancer fatality.
[a] Affected populations: Lake Erie Treatment Plants Downstream of Cattaraugus Creek, 565,000; Niagara River Treatment Plants 386,000.
[b] Federal Guidance Report No. 13 individual radioisotope risk factors are used to calculate lifetime fatal cancer risk for normal operations.
[c] Although the duration of the No Action Alternative is in perpetuity, a 100-year time period is analyzed for this table. The 100-year period was adapted from the recommendations in DOE Manual 435.1-1 regarding analytical assumptions for institutional controls (DOE 1999c). The radionuclides that contribute to the majority of the calculated airborne and liquid release doses (tritium, cobalt-60, strontium-90, and cesium-137) would have decayed by a factor of 10 to 500,000 after 100 years.

The following tables provide the individual impacts, in terms of individual yearly dose (in millirem) and increased risk of an LCF, associated with radiological releases associated with normal operations for the implementation phase of each alternative. Three individuals have been identified for analysis. Typically the MEI would be a person at the site boundary (closest location to the point of release) in the direction that yields the highest individual dose from an airborne release, a result of a combination of distance and meteorological conditions. However, this is not the individual who could be the MEI from liquid releases. Therefore, two additional individuals were identified. One lives near the site; the second, a member of the Seneca Nation of Indians, has a significantly higher consumption of fish taken from local waters. **Table I–10** provides the yearly average, peak annual, and the total individual impacts associated with airborne radiological releases from normal operations for the duration of the implementation of each alternative. **Table I–11** provides this information for liquid radiological releases.

Table I–10 Individual Impacts from Normal Operational Airborne Radiological Releases

Alternative	*Yearly Average*		*Peak Annual*		*Duration Total*	
	Dose Rate (millirem per year)	*Increased Risk of LCF* [a]	*Total Rate (millirem)*	*Increased Risk of LCF* [a]	*Total Dose (millirem)*	*Increased Risk of LCF per Year* [a]
Maximally Exposed Individual (WVDP Site Boundary)						
Sitewide Removal	7.6×10^{-2}	1.3×10^{-8}	2.6×10^{-1}	8.4×10^{-8}	4.9	8.3×10^{-7}
Sitewide Close-In-Place	4.0×10^{-2}	1.1×10^{-8}	8.4×10^{-2}	2.1×10^{-8}	2.8×10^{-1}	7.7×10^{-8}
Phased Decisionmaking (Phase 1)	4.8×10^{-1}	7.1×10^{-8}	8.4×10^{-1}	1.1×10^{-7}	3.8	5.7×10^{-7}
No Action	6.6×10^{-5}	3.7×10^{-12}	1.3×10^{-1}	4.0×10^{-9}	6.6×10^{-3} [b]	3.7×10^{-10} [b]
Individual on Cattaraugus Creek Near Site						
Sitewide Removal	4.5×10^{-2}	6.8×10^{-9}	1.4×10^{-1}	3.9×10^{-8}	2.9	4.0×10^{-7}
Sitewide Close-In-Place	2.4×10^{-2}	5.6×10^{-9}	5.2×10^{-2}	1.1×10^{-8}	1.7×10^{-1}	3.9×10^{-8}
Phased Decisionmaking (Phase 1)	3.5×10^{-1}	4.8×10^{-8}	6.5×10^{-1}	8.9×10^{-8}	2.8	3.8×10^{-7}
No Action	3.3×10^{-5}	1.5×10^{-12}	6.4×10^{-2}	2.0×10^{-9}	3.3×10^{-3} [b]	1.5×10^{-10} [b]
Individual on Lower Reaches of Cattaraugus Creek						
Sitewide Removal	1.2×10^{-3}	1.8×10^{-10}	3.5×10^{-3}	9.4×10^{-10}	7.7×10^{-2}	1.2×10^{-8}
Sitewide Close-In-Place	6.6×10^{-4}	1.4×10^{-10}	1.4×10^{-3}	2.9×10^{-10}	4.6×10^{-3}	9.8×10^{-10}
Phased Decisionmaking (Phase 1)	1.1×10^{-2}	1.4×10^{-9}	2.0×10^{-2}	2.7×10^{-9}	8.8×10^{-2}	1.1×10^{-8}
No Action	8.0×10^{-7}	3.8×10^{-14}	1.5×10^{-3}	4.7×10^{-11}	8.0×10^{-5} [b]	3.8×10^{-12} [b]

LCF = latent cancer fatality, WVDP = West Valley Demonstration Project.

[a] Federal Guidance Report No. 13 individual radioisotope risk factors are used to calculate lifetime fatal cancer risk for normal operations.

[b] Although the duration of the No Action Alternative is in perpetuity, a 100-year time period is analyzed for this table. The 100-year period was adapted from the recommendations in DOE Manual 435.1-1 regarding analytical assumptions for institutional controls (DOE 1999c). The radionuclides that contribute to the majority of the calculated airborne and liquid release doses (tritium, cobalt-60, strontium-90, and cesium-137) would have decayed by a factor of 10 to 500,000 after 100 years.

Table I–11 Individual Impacts from Normal Operational Liquid Radiological Releases

Alternative	*Yearly Average*		*Peak Annual*		*Duration Total*	
	Individual Dose (millirem)	***Increased Risk of LCF*** [a]	***Individual Dose (millirem)***	***Increased Risk of LCF*** [a]	***Individual Dose (millirem)***	***Increased Risk of LCF*** [a]
Individual on Cattaraugus Creek Near Site						
Sitewide Removal	3.7×10^{-3}	1.3×10^{-9}	5.4×10^{-3}	2.0×10^{-9}	2.4×10^{-1}	8.6×10^{-8}
Sitewide Close-In-Place	2.1×10^{-2}	7.8×10^{-9}	8.8×10^{-2}	3.0×10^{-8}	1.5×10^{-1}	5.4×10^{-8}
Phased Decisionmaking (Phase 1)	8.0×10^{-5}	3.0×10^{-11}	2.2×10^{-5}	8.4×10^{-12}	6.4×10^{-4}	2.4×10^{-10}
No Action	7.4×10^{-4}	2.5×10^{-10}	1.7×10^{-1}	5.7×10^{-8}	7.4×10^{-2} [b]	2.5×10^{-8} [b]
Individual on Lower Reaches of Cattaraugus Creek						
Sitewide Removal	8.7×10^{-3}	3.2×10^{-9}	1.3×10^{-2}	4.7×10^{-9}	5.6×10^{-1}	2.0×10^{-7}
Sitewide Close-In-Place	4.1×10^{-2}	1.5×10^{-8}	1.1×10^{-1}	3.8×10^{-8}	2.9×10^{-1}	1.1×10^{-7}
Phased Decisionmaking (Phase 1)	1.4×10^{-4}	5.2×10^{-11}	4.0×10^{-5}	1.5×10^{-11}	1.1×10^{-3}	4.2×10^{-10}
No Action	2.3×10^{-3}	7.9×10^{-10}	6.1×10^{-1}	2.1×10^{-7}	2.3×10^{-1} [b]	7.9×10^{-8} [b]

LCF = latent cancer fatality.

[a] Federal Guidance Report No. 13 individual radioisotope risk factors are used to calculate lifetime fatal cancer risk for normal operations.

[b] Although the duration of the No Action Alternative is in perpetuity, a 100-year time period is analyzed for this table. The 100-year period was adapted from the recommendations in DOE Manual 435.1-1 regarding analytical assumptions for institutional controls (DOE 1999c). The radionuclides that contribute to the majority of the calculated airborne and liquid release doses (tritium, cobalt-60, strontium-90, and cesium-137) would have decayed by a factor of 10 to 500,000 after 100 years.

I.4.3.6 Analysis Uncertainties

The sequence of analyses performed to generate normal operations radiological impact estimates includes selection of normal operational modes, estimation of source terms, estimation of environmental transport and uptake of radionuclides, calculation of radiation doses to exposed individuals, and estimation of health effects. Uncertainties are associated with each of these steps. Uncertainties exist in the way the physical systems being analyzed are represented by the computational models and in the data required to exercise the models (due to measurement, sampling, or natural variability).

In principle, one can estimate the uncertainty associated with each source and predict the remaining uncertainty in the results of each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final results. However, conducting such a full-scale quantitative uncertainty analysis is neither practical nor standard practice for this type of study. Instead, the analysis is designed to ensure—through judicious selection of release scenarios, models, and parameters—that the results conservatively represent the potential risks. This is accomplished by making conservative assumptions in the calculations at each step. The models, parameters, and release scenarios used in the calculations are selected in such a way that most intermediate results and, consequently, final impact estimates are greater than expected. As a result, even though the range of uncertainty in a quantity might be large, the value calculated for the quantity would be close to one of the extremes in the range of possible values, so the chance of the actual quantity being greater than the calculated value would be low. Conservative assumptions in this analysis bound all uncertainties. Key conservative assumptions in this analysis that bound all uncertainties include:

1. Inhalation population radiological exposure continuously for 365 days and 24 hours per day causing the highest possible inhalation radiation dose;

2. A range of the lowest (i.e. ground-level) and highest (i.e. existing ventilation stack) possible airborne release plume heights resulting in the largest possible radionuclide air concentration from atmospheric dispersion;

3. Use of the 2000 Census population data causing the highest population dose since census data for all counties within 80 kilometers (50 miles) of the Western New York Nuclear Service Center (WNYNSC) shows a decrease in population since 2000;

4. Location of the MEI at the closest public boundary during all radiological releases resulting in the largest possible MEI radiation doses;

5. The annual airborne release rate of radionuclides was not reduced to account for the radioactive decay of relatively short half-life radionuclides such as cobalt-60, tritium, cesium-137, and strontium-90, which would significantly reduce the release rates and calculated dose especially for the longer time periods of the Sitewide Removal and No Action Alternatives.

Routine normal activities may have different human health impacts on specific populations such as American Indians or Hispanics whose cultural heritage can result in special exposure pathways that are different than those modeled to evaluate doses to the general population and MEI. The analyses performed to evaluate public impacts of the alternatives did include normally significant pathways and were designed to be conservative. Higher fish consumption for a member of the Seneca Nation of Indians was analyzed to calculate impacts on this population group. A qualitative evaluation of potential impacts on other specific population groups was performed based on the radionuclides emitted and an understanding of the most significant pathways.

Parameter selection and population and MEI practices were chosen to be conservative. For example, it was assumed that the population breathed contaminated air all the time (spent no time away from the local area) and that all food was produced in the potentially affected area (no food from outside the local area). The dose to a member of the public was dominated by internal exposures from inhalation and ingestion. Typically, about one-third of the dose was from inhalation and two-thirds was from ingestion. Inhalation of ambient air and the resulting dose would be about the same for all members of the population surrounding the locations of interest.

I.5 Impacts of Accidents During Alternative Implementation

I.5.1 Accident Relationship to Environmental Impact Statement Alternative

Each alternative considered in this EIS has specific aspects that may affect which accidents are analyzed for that alternative. This section evaluates the alternatives in terms of their applicable accident scenarios. Accident scenarios have been identified for radioactive waste packages, the radioactive waste tanks in WMA 3, the Main Plant Process Building in WMA 1, the NRC-licensed Disposal Area (NDA) in WMA 7, and the State-licensed Disposal Area (SDA) in WMA 8. **Table I–12** lists those aspects of the four alternatives that affect accident analyses.

Table I–12 shows that accidents involving the Main Plant Process Building, radioactive waste tanks, and the Low-Level Waste Treatment Facility could occur under all alternatives, and that the same radioactive waste packages would not be transported under each alternative. The No Action Alternative monitoring of facility and structure residual radioactivity does not preclude an accident in which this radioactivity could be released to the environment.

Based on the preparation for decommissioning actions and affected facilities for each alternative described in Table I–12, **Table I–13** was developed to correlate the accident scenarios with each specific alternative. The greatest difference, for accidents, between the alternatives is that the No Action Alternative does not have any remote-handled transuranic, Greater-Than-Class C, or high-integrity container (HIC) package accident scenarios.

Table I–12 Environmental Impact Statement Alternative Parameters Affecting Accident Analysis Scenarios

Alternative	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Main Plant Process Building	Demolish and exhume	Demolish to floor slab	Demolish and exhume	Monitor and maintain
Radioactive Waste Tanks in the Waste Tank Farms	Demolish and exhume	Fill and cap	Monitor and maintain	Monitor and maintain
Radioactive Waste Package Transportation	Yes	Yes	Yes	Yes
Low-Level Waste Treatment Facility	Demolish and exhume	Demolish and exhume	Demolish and exhume	Monitor and maintain
Lagoons, trenches, groundwater plume, Cesium Prong	Exhume	Manage in place	Remove lagoons, monitor others	Monitor and maintain
NRC-licensed Disposal Area	Exhume	Remove leachate and fill	Monitor and maintain	Monitor and maintain
State-licensed Disposal Area	Exhume	Remove leachate and fill	Monitor and maintain	Monitor and maintain

Table I–13 Accident Scenarios Applicable to Each Alternative

Accident Category	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Main Plant Process Building	Yes	Yes	Yes	Yes
Radioactive Waste Tanks	Yes	Yes	Yes	Yes
Radioactive Waste Package Transportation	Yes (most)	Yes	Yes	Yes (least)
NRC-licensed Disposal Area Exhumation	Yes	No	No	No
State-licensed Disposal Area Exhumation	Yes	No	No	No

I.5.2 Radiological Source Term Methodology

The accident source term is the amount of respirable radioactive material released to the air or particles released to the water, in terms of curies or grams, assuming the occurrence of a postulated accident. The airborne source term is typically estimated by the following equation:

$$\text{Source term} = MAR \times DR \times ARF \times RF \times LPF$$

where:

MAR = material at risk
DR = damage ratio
ARF = airborne release fraction
RF = respirable fraction
LPF = leak path factor

The MAR is the amount of radionuclides (in curies of activity or grams for each radionuclide) available for release when acted upon by a given physical stress or accident. The MAR is specific to a given process in the facility of interest. It is not necessarily the total quantity of material present, but is that amount of material in the scenario of interest postulated to be available for release.

The DR is the fraction of material exposed to the effects of the energy, force, or stress generated by the postulated event. For the accident scenarios discussed in this analysis, the DR value varies from 0.1 to 1.0.

The ARF is the fraction of material that becomes airborne due to the accident. In this analysis, ARFs were obtained from the *WVDP Waste Management EIS* (DOE 2003c), *Plutonium Residue EIS* (DOE 1998), or *DOE Handbook* on ARFs (DOE 1994).

The RF is the fraction of material with a 10-micrometer (0.0004 inches) or less aerodynamic-equivalent-diameter particle size that could be retained in the respiratory system following inhalation. The RF values are also taken from the *WVDP Waste Management EIS* (DOE 2003c), *Plutonium Residue EIS* (DOE 1998), or *DOE Handbook* on ARFs (DOE 1994).

The LPF accounts for the action of removal mechanisms – for example, containment systems, filtration, and deposition – to reduce the amount of airborne radioactivity ultimately released to occupied spaces in the facility or environment. An LPF of 1.0 (no reduction) is assigned in accident scenarios involving a major failure of confinement barriers. LPFs were obtained from the *WVDP Waste Management EIS* (DOE 2003c), *Plutonium Residue EIS* (DOE 1998), and site-specific evaluations.

I.5.3 Accident Scenario Development Methodology

The methodology used to develop accident scenarios and their associated parameters involved several steps. First, other relevant EISs and the *DOE Handbook* on ARFs (DOE 1994) were evaluated to develop a list of likely accident scenarios. This evaluation examined the types of structures and equipment at the WVDP expected to contain any significant residual radioactivity in the form of fixed or mobile chemical or physical forms of radionuclides. Experience from previous EISs involving nonreactor facilities was also used to establish accident scenarios. This first step led to the conclusion that accidents at a facility like the WVDP could fall into one of the following categories:

- Drops
- Punctures
- Spills
- Leaks
- Seismic induced structural failures
- Fires
- Explosions
- Seismic induced structural failures followed by fires and/or explosions
- Nuclear criticality events
- Chemical reactions

Evaluation of systems, components, and facilities at the WVDP that would be subject to decommissioning activities resulted in elimination of explosion, nuclear criticality, and chemical reaction as accident event scenarios. No explosive materials exist at the WVDP, and explosives would not be used for decommissioning activities. Any fissionable radionuclides at the WVDP are in quantities and concentrations too small to constitute any nuclear criticality risk or cause any nuclear criticality accident. Chemicals at the WVDP or intended for decommissioning activities are not capable of reaction with chemicals already at the WVDP or with each other in such a way that could initiate any accident releasing radionuclides. However, it was determined that drops, punctures, spills, leaks, seismic-induced structural failures, fires, and seismic-induced structural failures followed by fires are all possible accident scenarios during decommissioning activities at the WVDP. Further evaluation of fires eliminated them for large structures because of the absence of combustible materials and the distributed nature of radioactive contamination over large surface areas and room volumes. Although it would be possible for a fire to occur in an individual room or cell, the lack of combustible materials throughout a facility such as the Main Plant Process Building would preclude a facility-wide fire and would therefore limit the release of radionuclides to one room. Fires are still considered for radioactive waste package handling.

Several accidents were postulated at the WVDP during decommissioning activities. These involve the high-level radioactive waste tanks, which contain both mobile and fixed residual radionuclide contamination, and the Main Plant Process Building, which contains both mobile and fixed residual radionuclide contamination, because these structures appear to contain the largest residual radioactivity available for release to the environment during an accident.

The seismic-induced structural failure of one high-level radioactive waste tank is another accident analyzed for this EIS. In this accident, a seismic event occurs, which causes failure of tank supports or other tank structures, thereby resulting in direct exposure of the tank radionuclide inventory to the environment. The seismic event is also assumed to fail any isolating or confinement covers around the high-level radioactive waste tanks. Fires in and around the radioactive waste tanks in the Waste Tank Farm were dismissed because of lack of combustible material, thereby resulting in an extremely low probability (i.e., less than the screening limit of 1.0×10^{-6} per year). Although this postulated accident would result in both an airborne and liquid release, the relatively slow dispersion of a liquid, the ability to contain a liquid release, and the relatively longer timeframe which allows for emergency response would result in protection of the public from radiation doses due to liquids. The risk and consequence dominant release from this accident scenario is the airborne release.

The Main Plant Process Building consists of a number of cells and other enclosed areas. Five accidents were postulated for this structure, which involve either the single cell having the largest residual radionuclide contamination inventory or the entire Main Plant Process Building and its concomitant total residual radionuclide contamination inventory. As in the case of the high-level radioactive waste tanks, these accidents involve either a fire or seismic structural collapse of either the hottest cell or the entire Main Plant Process Building, with failure of any confinement enclosure. The fifth accident assumes a seismic event that causes both structural collapse and a fire in the Main Plant Process Building. As in the case of the radioactive waste tanks, this last accident scenario was dismissed from detailed analysis because its estimated frequency of occurrence is less than the screening limit of 1×10^{-6} per year. Furthermore, as the Main Plant Process Building, as a whole, contains the bounding radionuclide inventory (i.e., MAR), accidents involving the hottest process cell were eliminated from analysis. Lack of combustible material in and around the Main Plant Process Building eliminated the fire accident scenario. The Main Plant Process Building accident scenario that was analyzed is the seismic induced complete collapse of the entire Main Plant Process Building.

Ten different types of radioactive waste transportation packages were identified as being used under one or more of the four alternatives considered in this EIS. As in the WVDP Waste Management EIS (DOE 2003c), drops and/or fires resulting in package confinement failure were postulated for each of these packages. Eleven accident scenarios involving all 10 of these packages were analyzed for this EIS and are described in Sections I.5.4 and I.5.5.

The exhumation, removal, and backfill of contaminated areas such as the lagoons in WMA 2; NRC-licensed trenches, holes, and lagoons in WMA 7; State-licensed disposal area trenches and lagoons in WMA 8; the

North Plateau Groundwater Plume; and the Cesium Prong involve handling large quantities of soil, sediment, and other solid materials and their subsequent shipment offsite to a suitable waste facility. The magnitude of contamination per unit mass or volume for these areas is much smaller than that of the high-level radioactive waste tanks, radioactive waste shipping packages, and Main Plant Process Building.

Two accident scenarios were postulated to occur during exhumation of the waste in the NDA and the SDA. The radioactive waste in these areas consists of a wide range of materials including solvents, soil, filters, fuel rod segments, and clothing. Each scenario involves the ignition of flammable solvent or diesel fuel spill from exhumation equipment. The fire affects 0.3 cubic meters (11 cubic feet) of exposed contaminated waste. This release fraction is based on a conservative assumption that the waste consists of uncontained combustible material that contains radioactive contamination. For the NDA, combination waste is assumed for the radioisotope composition; and, for the SDA, Trench 10 was assumed for the accident scenario. Both the NDA and SDA scenarios use the largest respirable radioisotope inventory of all the buried waste categories and trenches. These scenarios were analyzed as either a plume with no energy or one with the energy associated with a postulated concomitant fire.

An accident scenario involving any liquid releases (e.g., leachate from transfer piping, used to transfer groundwater from the NDA interceptor trench sump) would involve smaller quantities of radionuclides and, being in a liquid form, would pose a much smaller risk to the public and workers. All accidental liquid releases are amenable to mitigation because public and worker radiation doses are dependent upon ingestion or immersion in the liquid. Emergency response to such a liquid release would preclude contaminated water ingestion or exposure in a timeframe sufficient to avoid radiological doses. The timing and nature of airborne releases from a postulated accident make it more difficult to mitigate and preclude radiation doses to workers and the public. Hence, the near-term consequences and risks of postulated accidents involving liquid releases are bounded by accidents that were analyzed involving the airborne release of radionuclides.

Accidents to workers involving exposure to radiologically contaminated liquids and volatile compounds could result in significant health impacts due to external exposure, inhalation, and ingestion. However, the EIS does not calculate any specific impacts to workers with regard to an accident scenario because of the wide range of locations and actions of such workers. All accident consequences and risks are calculated for the MEI and population. The most severe consequences may occur to workers for some of the accidents already analyzed in the EIS. For example, seismic collapse of the waste tank or main plant process building could be postulated to lead to fatalities of nearby workers due the seismic event and associated structural collapse. No liquid release or volatile chemical exposure can result in a higher worker consequence than a fatality. Furthermore, worker exposure to radiologically contaminated liquids, volatile chemicals and other hazardous or chemical substances are considered as part of the category of occupational hazards (Occupational Safety and Health Administration regulations) and not a lower probability accident as is analyzed in this appendix. In any industrial or waste cleanup situation, there are numerous possible opportunities for spills or mishaps that are not considered bounding conservative accidents.

A postulated accident involving a drop, puncture, or fire involving packages containing vitrified high-level radioactive waste would not release respirable particles of radioactive material. The physical properties of vitrified high-level radioactive waste preclude the generation of respirable size particles under these accident conditions. Moreover, the vitrified high-level radioactive waste packaging design provides a greater confinement than the packagings used for smaller quantities of radioactive materials. Therefore, although considered, no accident involving vitrified high-level radioactive waste packaging was analyzed because no release of respirable particles would occur under postulated accident conditions (DOE 1994).

The MEI location for postulated accident scenarios is based on the closest location to the accident scene at which a member of the public could be present. The MEI location for each accident scenario is: 183 meters (600 feet) for radioactive waste packages, 259 meters (850 feet) for the radioactive waste tanks, 244 meters

(800 feet) for the Main Plant Process Building, 366 meters (1,200 feet) for the NDA, and 549 meters (1,800 feet) for the SDA. Analysis of the maximum public individual dose rate for each accident scenario using the MACCS computer code showed that the NDA and SDA exhumation fire accident scenarios resulted in a higher MEI dose at a distance of 2,500 meters (8,200 feet) than at the nearest geographically determined distance. This greater distance is due to the plume rise associated with fire energy postulated for these two accidents. The highest MEI dose, regardless of location outside the site, was presented for all accident scenarios.

I.5.4 Accident Source Term

To calculate accident source terms, the MAR was first determined for key facilities at the WVDP, which contains significant residual radioactive contamination inventories. These were identified as the radioactive waste tanks in the Waste Tank Farm and Main Plant Process Building. Their respective radionuclide inventories are presented in **Tables I–14** and **I–15** (WSMS 2005a, WVNSCO 2005). Waste tanks have mobile and fixed inventories. Mobile inventories at the starting point of this EIS as described in Chapter 2 are physically present in the remaining liquid heel in these tanks. Fixed inventories are radionuclides physically attached to surfaces inside the tanks. The peak residual inventory varies between Tanks 8D-1 and -2 for individual radioisotopes and is delineated below for the conservative case. A bounding tank was synthesized from the two highest inventory tanks to represent the highest total inventory of any one tank and assigned the designation of Bounding Tank 8D-B. Bounding Tank 8D-B is now the MAR for accidents involving the Waste Tank Farm area at West Valley based on the highest individual radionuclide value for either Tank 8D-1 or -2.

Table I–14 Waste Management Area 3 High-Level Radioactive Waste Tank Material at Risk [a]

Radionuclide	*Tank 8D-1 (curies)*	*Tank 8D-2 (curies)*	*Bounding Tank 8D-B (curies)*
Carbon-14	2.0×10^{-2}	2.7×10^{-3}	2.0×10^{-2}
Strontium-90	2.3×10^{3}	3.0×10^{4}	3.4×10^{4}
Technetium-99	5.4	2.9	5.4
Iodine-129	6.8×10^{-3}	3.8×10^{-3}	6.8×10^{-3}
Cesium-137	2.5×10^{5}	8.6×10^{4}	2.5×10^{5}
Uranium-232	6.0×10^{-1}	1.2×10^{-1}	6.0×10^{-1}
Uranium-233	2.6×10^{-1}	5.9×10^{-2}	2.6×10^{-1}
Uranium-234	1.0×10^{-1}	2.2×10^{-2}	1.0×10^{-1}
Uranium-235	3.4×10^{-3}	1.1×10^{-3}	3.4×10^{-3}
Uranium-238	3.1×10^{-2}	5.2×10^{-3}	3.1×10^{-2}
Neptunium-237	2.3×10^{-2}	5.0×10^{-1}	5.0×10^{-1}
Plutonium-238	5.6	1.5×10^{2}	1.5×10^{2}
Plutonium-239	1.5	3.6×10^{1}	3.6×10^{1}
Plutonium-240	1.1	2.6×10^{1}	2.6×10^{1}
Plutonium-241	4.4×10^{1}	7.4×10^{2}	7.4×10^{2}
Americium-241	3.8×10^{-1}	3.8×10^{2}	3.8×10^{2}
Curium-243	1.1×10^{-3}	3.6	3.6
Curium-244	5.0×10^{-2}	8.0×10^{1}	8.0×10^{1}

[a] Consistent with the starting point of this EIS as defined in Chapter 2.
Source: WVNSCO 2005.

Table I–15 Main Plant Process Building Total Residual Radioactivity Material at Risk

Radionuclide	*Total Process Building Residual Activity (curies)*	*Radionuclide*	*Total Process Building Residual Activity (curies)*
Carbon-14	1.3×10^{1}	Neptunium-237	5.7×10^{-1}
Strontium-90	2.4×10^{3}	Uranium-238	9.0×10^{-2}
Technetium-99	5.0	Plutonium-238	2.1×10^{2}
Iodine-129	6.3×10^{-1}	Plutonium-239	6.4×10^{1}
Cesium-137	3.2×10^{3}	Plutonium-240	4.7×10^{1}
Uranium-232	8.1×10^{-1}	Plutonium-241	1.5×10^{3}
Uranium-233	4.2×10^{-1}	Americium-241	2.7×10^{2}
Uranium-234	2.0×10^{-1}	Curium-243	3.4×10^{-1}
Uranium-235	3.0×10^{-1}	Curium-244	8.4

Source: WSMS 2008a.

Numerous waste packages would be transported offsite under each alternative. Accidents are postulated to occur with these packages, including drops, punctures, and fires. The MAR for each type of waste package is presented in **Table I–16**.

Table I–16 Waste Package [a] Material at Risk (curies)

Isotope	*Truck Class B/C (HIC)*	*GTCC Cat-2 (Drum)*	*TRU (RH) (Drum)*	*LSA Container per cubic meters (7.306 each)*	*Fuel and Hardware (Drum)*	*Class A Drum*	*Class C-R-D Drum*	*Class B/C Box*	*Class A Box*
Tritium	73.5	2.00	0.0	0.0284	3.11	0.0114	0.0	37.2	0.124
Carbon-14	0.545	0.0148	1.6×10^{-6}	0.00163	0.425	8.44×10^{-5}	1.42×10^{-6}	0.276	9.18×10^{-4}
Iron-55	0.330	0.00898	0.0	0.0	0.0	5.12×10^{-5}	0.0	0.167	5.57×10^{-4}
Cobalt-60	9.49	0.258	0.0	0.0	27.3	0.00147	0.0	4.8	0.016
Nickel-63	36.7	0.999	0.0	0.0	0.0	0.00569	0.0	18.6	0.062
Strontium-90	0.403	1.85	49.3	9.2×10^{-4}	1,330	4.12×10^{-4}	2.16	0.204	4.49×10^{-3}
Yttrium-90	0.403	1.85	49.3	9.2×10^{-4}	1,330	4.12×10^{-4}	2.16	0.204	4.49×10^{-3}
Cesium-137	26.0	2.35	88.2	0.00152	1,730	0.00403	640	13.2	0.0439
Thorium-234	0.341	0.0268	8.93×10^{-6}	0.0	0.131	5.29×10^{-5}	2.85×10^{-5}	0.173	5.76×10^{-4}
Neptunium-237	0.0	0.0	6.64×10^{-4}	0.0	0.00794	0.0	2.79×10^{-5}	0.0	0.0
Uranium-238	0.341	0.00928	8.93×10^{-6}	0.0	0.131	5.29×10^{-5}	2.85×10^{-5}	0.173	5.76×10^{-4}
Plutonium-238	0.200	26.7	0.183	1.1×10^{-6}	10.5	3.09×10^{-5}	0.00401	0.101	3.73×10^{-4}
Plutonium-239	0.328	0.0363	0.0458	1.1×10^{-6}	41.2	5.08×10^{-5}	7.59×10^{-4}	0.166	5.53×10^{-4}
Plutonium-240	0.195	0.188	0.0332	1.1×10^{-6}	22.1	3.02×10^{-5}	5.46×10^{-4}	0.0985	3.28×10^{-4}
Plutonium-241	69.1	10.5	0.985	1.1×10^{-6}	671.0	0.00107	0.0451	3.5	0.0117
Americium-241	0.780	0.116	0.481	1.1×10^{-6}	79.9	1.21×10^{-4}	0.0115	0.395	1.23×10^{-3}
Curium-244	0.0	0.0	0.0997	0.0	0.626	0.0	0.00202	0.0	0.0

HIC = high-integrity container, GTCC = Greater-Than-Class C waste, Cat. = Category, TRU = transuranic (waste), RH = remote-handled, LSA = low specific activity, Class C-R-D = remote-handled Class C (waste).

[a] Vitrified high-level waste canisters were not included because their physical form would preclude the release of respirable particles in the event of a postulated accident.

Note: To convert cubic meters to cubic feet, multiply by 35.3.

Source: Karimi 2005.

The MAR for the SDA and NDA is presented in **Table I-17**.

Table I–17 NRC-licensed Disposal Area and State-licensed Disposal Area Material at Risk

Radionuclide	***NRC-licensed Disposal Area Material At Risk (curies per cubic foot)***	***Radionuclide***	***State-licensed Disposal Area Material At Risk (curies per cubic foot)***
Tritium	4.1×10^{-4}	Tritium	2.0×10^{-2}
Cobalt-60	1.2×10^{-4}	Carbon-14	1.2×10^{-4}
Nickel-63	3.4×10^{-4}	Cobalt-60	4.5×10^{-5}
Strontium-90	1.8×10^{-1}	Nickel-63	2.4×10^{-5}
Cesium-137	2.2×10^{-1}	Strontium-90	3.9×10^{-5}
Promethium-147	4.2×10^{-4}	Cesium-137	1.8×10^{-4}
Samarium-151	2.5×10^{-3}	Thorium-234	4.0×10^{-5}
Europium-154	1.5×10^{-3}	Protactinium-234m	4.0×10^{-5}
Europium-155	2.2×10^{-4}	Uranium-234	2.2×10^{-5}
Plutonium-238	2.2×10^{-3}	Uranium-238	4.0×10^{-5}
Plutonium-239	3.0×10^{-3}	Plutonium-238	3.5×10^{-2}
Plutonium-240	2.1×10^{-3}	Plutonium-239	8.2×10^{-6}
Plutonium-241	9.0×10^{-2}	Plutonium-241	9.6×10^{-6}
Americium-241	9.7×10^{-3}	Americium-241	3.2×10^{-5}

Note: To convert cubic feet to cubic meters, multiply by 0.028317.
Sources: URS 2000, 2002.

In two other EISs, the nature and form of radionuclide source term available for release during an accident scenario were found to be similar to that of this EIS. These are the *Plutonium Residue EIS* (DOE 1998) and the *WVDP Waste Management EIS* (DOE 2003c). Further guidance on airborne source terms was also found in the *DOE Handbook on ARFs* (DOE 1994). After the spectrum of accidents was identified, it was necessary to estimate a release fraction for each of the accidents. Release fraction estimates were developed based on review of available information on facility design and operation, as well as information in the *DOE Handbook on ARFs* (DOE 1994), relevant EISs (DOE 1998, 2003c), and Safety Analysis Reports (DOE 2006; WVNSCO 2004, 2007). The release fractions selected were also reviewed against each other to ensure that the relative magnitude was considered reasonable. Based on evaluation of the nature of contamination present in WVDP, the following **Table I–18** lists values of the DR, ARF, RF, and LPF developed from the aforementioned references and used in this EIS. These values are based on the discussion and references in **Table I–19**.

The release fraction is the fraction of the material at risk which become airborne and can be inhaled by humans causing a radiation dose. It is calculated by multiplying the four factors DR, ARS, RF, and LPF. Table I–19 summarizes release fractions considered appropriate for the identified severe accidents and the rationale for their selection.

Table I–18 Accident Scenario Damage Ratio, Respirable Fraction, Airborne Release Fraction, and Leak Path Factor

Accident Scenario	*Damage Ratio (DR)*	*Leak Path Factor (LPF)*	*Airborne Release Fraction (ARF)*	*Respirable Fraction (RF)*	*DR × LPF × ARF × RF*
Main Plant Process Building					
Main Plant Process Building seismic collapse	1.0	0.1	1.0×10^{-3}	1.0×10^{-2}	1.0×10^{-6}
High-Level Waste Tanks					
High-level waste tank seismic collapse	1.0	1.0	$\sim 3.0 \times 10^{-5}$	$\sim 3.0 \times 10^{-3}$	1.0×10^{-7}
Radioactive Waste Package					
Transuranic remote-handled drum puncture	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
Greater-Than-Class Class 2 drum puncture	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
High-integrity container fire	1.0	1.0	6.0×10^{-3}	1.0×10^{-2}	6.0×10^{-5}
High-integrity container puncture	1.0	1.0	4.0×10^{-5}	1.0	4.0×10^{-5}
Class A box puncture	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
Class A pallet drop	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
Low specific activity container puncture	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
Fuel and hardware drum puncture [a]	0.1	1.0	1.0×10^{-3}	1.0×10^{-2}	1.0×10^{-6}
Class A drum puncture	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
Class C-R-D drum puncture [a]	0.1	1.0	1.0×10^{-3}	1.0×10^{-2}	1.0×10^{-6}
Class B/C box puncture	0.1	1.0	1.0×10^{-3}	1.0	1.0×10^{-4}
NRC-licensed Disposal Area					
Exhumation plume release	1.0	1.0	1.0×10^{-4}	1.0	1.0×10^{-4}
State-licensed Disposal Area					
Exhumation plume release	1.0	1.0	1.0×10^{-4}	1.0	1.0×10^{-4}

[a] Radioactive waste in these packages is in the form of grout and has different dispersion properties during an accident.

Table I–19 Basis for Specific Accident Radionuclide Release Fraction

Accident	*Release Fraction (DR × RF × ARF × LPF)*	*Basis*
Main Plant Process Building collapse due to seismic event	1.0×10^{-6}	The *Plutonium Residue EIS* (DOE 1998) assumed a release fraction of 5×10^{-6} for release of material being processed through a canyon building. In the WVDP Main Plant Process Building, there is less material and it is not located in large quantities in process equipment. In many cases, easily removed material has already been removed. The largest inventories are in the lower cells of the facility and would have a much longer leak path than material from the actual process cells. A factor of 5 reduction in overall release fraction appears reasonable.
High-level radioactive waste tank collapse due to seismic event	1.0×10^{-7}	Factors similar to this were used in the *WVDP WM EIS* (DOE 2003c). Much of the inventory is fixed (not easily removed), and such a low release fraction appears reasonable.
Waste package puncture or drop, nonsolidified waste	1.0×10^{-4}	This release fraction has been used in the *WVDP WM EIS* and WVDP Safety Analysis Report (WVNSCO 2004) and is considered reasonable for contaminated material.
High-integrity container drop and puncture	4.0×10^{-5}	Factors similar to this were used in the *WVDP WM EIS* (DOE 2003c). Much of the inventory is fixed (not easily removed), and such a low release fraction appears reasonable. Also recommended in *DOE Handbook* (DOE 1994).

Accident	***Release Fraction (DR × RF × ARF × LPF)***	***Basis***
High-integrity container fire	6.0×10^{-5}	Factors similar to this were used in the *WVDP WM EIS* (DOE 2003c). Much of the inventory is fixed (not easily removed), and such a low release fraction appears reasonable. Also recommended in *DOE Handbook* (DOE 1994).
Waste package puncture or drop, solidified waste	1.0×10^{-6}	This number was used in the *WVDP WM EIS* (DOE 2003c), and a similar number was used in the WVDP Safety Analysis Report (WVNSCO 2004) for a dropped high-level radioactive waste canister.
NDA or SDA exhumation plume release	1.0×10^{-4}	The measured combustible contaminated waste ARF from experiments recommended in DOE Airborne Release Handbook (DOE 1994).

Puncture and high-integrity container drop accident source terms for all containers are listed in **Table I–20**. Pallet drop accident source terms are listed in **Table I–21**. The high-level radioactive waste tank and Main Plant Process Building accident source terms are presented in **Table I–22**. The NDA and SDA accident source terms are presented in **Table I–23**.

Table I–20 Waste Package Puncture and High-Integrity Container Drop Accident Source Terms (curies)

Isotope	***Truck Class B/C (HIC Drop)***	***GTCC Cat 2 (Drum)***	***TRU (RH) (Drum)***	***LSA Container***	***Fuel and Hardware (Drum)***	***Class A Drum***	***Class C-R-D Drum***	***Class B/C Box***	***Class A Box***
Tritium	2.9×10^{-3}	2.0×10^{-4}	0.0	2.1×10^{-5}	3.1×10^{-6}	1.1×10^{-6}	0.0	3.7×10^{-3}	1.2×10^{-5}
Carbon-14	2.2×10^{-5}	1.5×10^{-6}	1.6×10^{-10}	1.2×10^{-6}	4.2×10^{-7}	8.4×10^{-9}	1.4×10^{-12}	2.8×10^{-5}	9.2×10^{-8}
Iron-55	1.3×10^{-5}	9.0×10^{-7}	0.0	0.0	0.0	5.1×10^{-9}	0.0	1.7×10^{-5}	5.6×10^{-8}
Cobalt-60	3.8×10^{-4}	2.6×10^{-5}	0.0	0.0	2.7×10^{-5}	1.5×10^{-7}	0.0	4.8×10^{-4}	1.6×10^{-6}
Nickel-63	1.5×10^{-3}	1.0×10^{-4}	0.0	0.0	0.0	5.7×10^{-7}	0.0	1.9×10^{-3}	6.2×10^{-6}
Strontium-90	1.6×10^{-5}	1.8×10^{-4}	4.9×10^{-3}	6.7×10^{-7}	1.3×10^{-3}	4.1×10^{-8}	2.2×10^{-6}	2.0×10^{-5}	4.5×10^{-7}
Yttrium-90	1.6×10^{-5}	1.8×10^{-4}	4.9×10^{-3}	6.7×10^{-7}	1.3×10^{-3}	4.1×10^{-8}	2.2×10^{-6}	2.0×10^{-5}	4.5×10^{-7}
Cesium-137	1.0×10^{-3}	2.4×10^{-4}	8.8×10^{-3}	1.1×10^{-6}	1.7×10^{-3}	4.0×10^{-7}	6.4×10^{-4}	1.3×10^{-3}	4.4×10^{-6}
Thorium-234	1.4×10^{-5}	2.7×10^{-6}	8.9×10^{-10}	0.0	1.3×10^{-7}	5.3×10^{-9}	2.8×10^{-11}	1.7×10^{-5}	5.8×10^{-8}
Neptunium-237	0.0	0.0	6.6×10^{-8}	0.0	7.94×10^{-9}	0.0	2.8×10^{-11}	0.0	0.0
Uranium-238	1.4×10^{-5}	9.3×10^{-7}	8.9×10^{-10}	0.0	1.3×10^{-7}	5.3×10^{-9}	2.8×10^{-11}	1.7×10^{-5}	5.8×10^{-8}
Plutonium-238	8.0×10^{-6}	2.7×10^{-3}	1.8×10^{-5}	8.0×10^{-10}	1.0×10^{-5}	3.1×10^{-9}	4.0×10^{-9}	1.0×10^{-5}	3.7×10^{-8}
Plutonium-239	1.3×10^{-5}	3.6×10^{-6}	4.6×10^{-6}	8.0×10^{-10}	4.1×10^{-5}	5.1×10^{-9}	7.6×10^{-10}	1.7×10^{-5}	5.5×10^{-8}
Plutonium-240	7.8×10^{-6}	1.9×10^{-6}	3.3×10^{-6}	8.0×10^{-10}	2.2×10^{-5}	3.0×10^{-9}	5.5×10^{-10}	9.8×10^{-6}	3.3×10^{-8}
Plutonium-241	2.8×10^{-3}	1.0×10^{-3}	9.8×10^{-5}	8.0×10^{-10}	6.7×10^{-4}	1.1×10^{-7}	4.5×10^{-8}	3.5×10^{-4}	1.2×10^{-6}
Americium-241	3.1×10^{-5}	1.2×10^{-5}	4.8×10^{-5}	8.0×10^{-10}	8.0×10^{-5}	1.2×10^{-8}	1.2×10^{-8}	4.0×10^{-5}	1.2×10^{-7}
Curium-244	0.0	0.0	1.0×10^{-5}	0.0	6.3×10^{-7}	0.0	2.0×10^{-9}	0.0	0.0

HIC = high-integrity container, GTCC = Greater-Than-Class C waste, TRU = transuranic (waste), RH = remote-handled, LSA = low specific activity.

Table I–21 Waste Pallet High-integrity Container Drop Accident Source Terms (curies)

Isotope	*Class A Pallet Drop*	*Isotope*	*Class A Pallet Drop*
Tritium	6.84×10^{-6}	Uranium-238	3.17×10^{-8}
Carbon-14	5.06×10^{-8}	Plutonium-238	1.85×10^{-8}
Iron-55	3.07×10^{-8}	Plutonium-239	3.05×10^{-8}
Cobalt-60	8.82×10^{-7}	Plutonium-240	1.81×10^{-8}
Nickel-63	3.41×10^{-6}	Plutonium-241	6.42×10^{-7}
Strontium-90	2.47×10^{-7}	Americium-241	7.26×10^{-8}
Yttrium-90	2.47×10^{-7}	Neptunium-237	0.0
Cesium-137	2.42×10^{-6}	Curium-244	0.0
Thorium-234	3.17×10^{-8}		

Table I–22 High-level Radioactive Waste Tank and Main Plant Process Building Accident Source Terms

Radionuclide	*Tank Total Inventory or Material at Risk (curies)*	*Accident Source Term (curies)*	*Radionuclide*	*Main Plant Process Building Residual Activity or Material at Risk (curies)*	*Accident Source Term (curies)*
Carbon-14	2.0×10^{-2}	2.0×10^{-9}	Americium-241	2.7×10^{2}	2.7×10^{-4}
Strontium-90	3.4×10^{4}	3.4×10^{-3}	Carbon-14	1.3×10^{1}	1.3×10^{-5}
Technetium-99	5.4	5.4×10^{-7}	Curium-243	3.4×10^{-1}	3.4×10^{-7}
Iodine-129	6.8×10^{-3}	6.8×10^{-10}	Curium-244	8.4	8.4×10^{-6}
Cesium-137	2.5×10^{5}	2.5×10^{-2}	Cesium-137	3.2×10^{3}	3.2×10^{-3}
Uranium-232	6.0×10^{-1}	6.0×10^{-8}	Iodine-129	6.3×10^{-1}	6.3×10^{-7}
Uranium-233	2.6×10^{-1}	2.6×10^{-8}	Neptunium-237	5.7×10^{-1}	5.7×10^{-7}
Uranium-234	1.0×10^{-1}	1.0×10^{-8}	Plutonium-238	2.1×10^{2}	2.1×10^{-4}
Uranium-235	3.4×10^{-3}	3.4×10^{-10}	Plutonium-239	6.4×10^{1}	6.4×10^{-5}
Uranium-238	3.1×10^{-2}	3.1×10^{-9}	Plutonium-240	4.7×10^{1}	4.7×10^{-5}
Neptunium-237	5.0×10^{-1}	5.0×10^{-8}	Plutonium-241	1.5×10^{3}	1.5×10^{-3}
Plutonium-238	1.5×10^{2}	1.5×10^{-5}	Strontium-90	2.4×10^{3}	2.4×10^{-3}
Plutonium-239	3.6×10^{1}	3.6×10^{-6}	Technetium-99	5	5×10^{-6}
Plutonium-240	2.6×10^{1}	2.6×10^{-6}	Uranium-232	8.1×10^{-1}	8.1×10^{-7}
Plutonium-241	7.4×10^{2}	7.4×10^{-5}	Uranium-233	4.2×10^{-1}	4.2×10^{-7}
Americium-241	3.8×10^{2}	3.8×10^{-5}	Uranium-234	2×10^{-1}	2×10^{-7}
Curium-243	3.6	3.6×10^{-7}	Uranium-235	3×10^{-2}	3×10^{-8}
Curium-244	8.0×10^{1}	8.0×10^{-6}	Uranium-238	9×10^{-2}	9×10^{-8}

Table I–23 NRC-licensed Disposal Area and State-licensed Disposal Area Accident Source Terms

Radionuclide	*NRC-licensed Disposal Area (curies)*	*State-licensed Disposal Area Trench 10 (curies)*
Tritium	4.5×10^{-7}	2.2×10^{-5}
Carbon-14	1.7×10^{-9}	1.3×10^{-7}
Cobalt-60	1.3×10^{-7}	4.9×10^{-8}
Nickel-63	3.8×10^{-7}	2.7×10^{-8}
Strontium-90	1.9×10^{-4}	4.3×10^{-8}
Yttrium-90	1.9×10^{-4}	4.3×10^{-8}
Cesium-137	2.5×10^{-4}	2.0×10^{-7}
Samarium-151	2.8×10^{-6}	Not reported
Thorium-234	8.0×10^{-9}	4.4×10^{-8}
Uranium-233	7.4×10^{-8}	5.5×10^{-10}
Uranium-234	3.7×10^{-9}	2.5×10^{-8}
Uranium-235	7.1×10^{-10}	7.4×10^{-10}
Uranium-238	8.0×10^{-9}	4.4×10^{-8}
Plutonium-238	2.4×10^{-6}	3.9×10^{-5}
Plutonium-239	3.3×10^{-6}	9.0×10^{-9}
Plutonium-240	2.4×10^{-6}	1.8×10^{-10}
Plutonium-241	9.9×10^{-5}	1.1×10^{-8}
Americium-241	1.1×10^{-5}	3.5×10^{-8}

I.5.5 Accident Frequency

The annual frequency of each accident is used to calculate the annual risk of a fatal latent cancer associated with each accident. The annual accident risk is calculated by multiplying the accident risk of a fatal latent cancer by the annual frequency of the accident. Each specific accident's annual frequency is determined by data from operational experience or an analysis of the sequence of events necessary for the accident to occur. Accidents with an annual frequency of less than 1×10^{-6} per year or 1 in 1 million are not analyzed in this appendix because they are so unlikely to occur that their risks are extremely small. However, the consequences of intentional destructive acts, which have a lower frequency than 1×10^{-6} per year, are analyzed in Appendix N.

Radioactive waste accidents analyzed in the *WVDP Waste Management EIS* (DOE 2003c) and their frequencies are:

- Class A low-level radioactive waste drum puncture (0.1 to 0.01 per year)
- Class A low-level radioactive waste pallet drop (0.1 to 0.01 per year)
- Class A low-level radioactive waste box puncture (0.1 to 0.01 per year)
- Drum cell drop (0.1 to 0.01 per year)
- Class C low-level radioactive waste drum puncture (0.1 to 0.01 per year)
- Class C low-level radioactive waste pallet drop (0.1 to 0.01 per year)
- Class C low-level radioactive waste box puncture (0.1 to 0.01 per year)
- HIC drop (0.1 to 0.01 per year)
- Remote-handled transuranic waste drum puncture (0.1 to 0.01 per year)
- Loadout bay fire (1×10^{-4} to 1×10^{-6} per year).

The *WVDP Waste Management EIS* (DOE 2003c) addressed the shipment of 46,839 radioactive waste packages over a 10-year time period for both its alternatives. Using the annual frequency value range of 0.1 to 0.01 per year for all waste package mishandling drop and puncture accidents, the accident frequency for handling each individual package is 2.1×10^{-5} to 2.1×10^{-6} per year. The larger value of 2.1×10^{-5} per package year was used with the individual alternative average annual radioactive waste package rate to calculate an annual frequency for each accident scenario which is delineated in **Table I–24**. For comparison purposes, a separate radioactive waste handling accident analysis performed for the Waste Isolation Pilot Plant resulted in a calculation of 7×10^{-6} per year for radioactive waste package puncture and drop accidents, which is within the range of 2.1×10^{-5} and 2.1×10^{-6} per year (DOE 2006). The accident frequency for the high-level radioactive waste tank, Main Plant Process Building, and HIC fire were all assumed at the identical value for all alternatives because package handling rate is not a factor. In all cases, the largest value of the range of possible accident frequencies was conservatively used for this EIS. Accident scenarios developed for the WVDP decommissioning activities are listed, along with their annual frequency, for each alternative in Table I–24.

Table I–24 Accident Scenario Annual Frequency

West Valley Demonstration Project Location and Accident Scenario	*Accident Initiator*	*Sitewide Removal Alternative Annual Frequency*	*Sitewide Close-In-Place Alternative Annual Frequency*	*Phased Decisionmaking Alternative (Phase 1) Annual Frequency*	*No Action Alternative Annual Frequency*
Radioactive waste tank collapse	Seismic event	0.0001	0.0001	0.0001	0.0001
Main Plant Process Building collapse	Seismic event	0.0001	0.0001	0.0001	0.0001
Transuranic (remote-handled) drum puncture	Mishandling or drop	0.08	0.008	0.1	Not applicable
Greater-Than-Class C Class 2 drum puncture	Mishandling or drop	0.08	Not applicable	0.1	Not applicable
High-integrity container fire	Human error	0.0001	0.0001	0.0001	Not applicable
High-integrity container puncture	Mishandling or drop	0.08	0.008	0.1	Not applicable
Class A box puncture	Mishandling or drop	0.08	0.008	0.1	0.003
Class A pallet drop	Mishandling or drop	0.08	0.008	0.1	0.003
Low specific activity container puncture	Mishandling or drop	0.08	0.008	0.1	0.003
Fuel and hardware drum puncture	Mishandling or drop	0.08	0.008	0.1	Not applicable
Class A drum puncture	Mishandling or drop	0.08	0.008	0.1	0.003
Class C-R-D drum puncture	Mishandling or drop	0.08	0.008	0.1	Not applicable
Class B/C box puncture	Mishandling or drop	0.08	0.008	0.1	Not applicable
NRC-licensed Disposal Area Exhumation Fire	Human error	0.0001	Not applicable	Not applicable	Not applicable
State-licensed Disposal Area Exhumation Fire	Human error	0.0001	Not applicable	Not applicable	Not applicable

Not applicable = these radioactive waste packages or decommissioning actions are not part of the alternative.

I.5.6 MACCS2 Code Description

The MACCS2 computer code V.1.13.1 (Chanin and Young 1997) is used to estimate the radiological doses and health effects that could result from postulated accidental releases of radioactive materials to the atmosphere. MACCS was used to analyze health impacts of postulated accidents instead of GENII due to the following factors:

- MACCS uses actual hourly meteorological data (i.e., wind speed, wind direction, rainfall, atmospheric dispersion stability) from the site whereas GENII uses a statistically interpreted joint frequency distribution that averages this data. The use of actual hourly data is more accurate in calculating the probabilistic dose distribution for accident analyses;

- The GENII tritium model assumes equilibrium between tritium concentrations in the air and vegetation, which is a good assumption for long-term releases, but may over-predict short-duration releases (DOE 2003b);

- MACCS has the capability to model the effects of population evacuation or relocation during or after an accident. This capability is not in GENII; and

- GENII cannot be used to calculate 95th percentile radiation dose according to DOE Standard 3009-94 Appendix A (DOE 2003b) whereas MACCS can calculate this dose;

Conversely, GENII was used to analyze human health impacts from normal operations because:

- GENII can model liquid radiological releases whereas MACCS does not have this capability;

- GENII can model long-term radiological releases whereas MACCS is limited to a maximum plume release time of 24 hours

The specification of the release characteristics, designated a "source term," can consist of up to four Gaussian plumes that are often referred to simply as "plumes."

The radioactive materials released are modeled as being dispersed in the atmosphere while being transported by the prevailing wind. During transport, particulate material can be modeled as being deposited on the ground. The extent of this deposition can depend on precipitation. If contamination levels exceed a user-specified criterion, mitigating actions can be triggered to limit radiation exposures.

Atmospheric conditions during an accident scenario's release and subsequent plume transport are taken from the annual sequential hourly meteorological data file. Scenario initiation is assumed to be equally likely during any hour contained in the file's dataset, with plume transport governed by the succeeding hours. The model was applied by calculating the exposure to each receptor for accident initiation during each hour of the 8,760-hour dataset. The mean results of these samples, which include contributions from all meteorological conditions, are presented in this EIS.

Two aspects of the code's structure are important to understanding its calculations: (1) the calculations are divided into modules and phases; and (2) the region surrounding the facility is divided into a polar-coordinate grid. These concepts are described in the following sections.

MACCS2 is divided into three primary modules: ATMOS, EARLY, and CHRONC. Three phases are defined as the emergency, intermediate, and long-term phases. The relationship among the code's three modules and the three phases of exposure are summarized below.

The ATMOS module performs all of the calculations pertaining to atmospheric transport, dispersion, and deposition, as well as the radioactive decay that occurs before release and while the material is in the atmosphere. It uses a Gaussian plume model with Pasquill-Gifford dispersion parameters. The phenomena treated include building wake effects, buoyant plume rise, plume dispersion during transport, wet and dry deposition, and radioactive decay and in-growth. Local topography is not modeled for calculating atmospheric dispersion which results in conservatively higher plume concentrations, doses, and risks to the public. The results of the calculations are stored for subsequent use by EARLY and CHRONC. In addition to the air and ground concentrations, ATMOS stores information on wind direction, arrival and departure times, and plume dimensions.

It is noted that dispersion calculations such as used in MACCS2 are generally recognized to be less applicable within 100 meters (328 feet) of a release than they are to further downwind distances (DOE 2004); such close-in results frequently over-predict the atmospheric concentrations because they do not account for the initial momentum or size of the release, or for the impacts of structures and other obstacles on plume dispersion. Most of the results presented in this EIS are for distances at least 100 meters (328 feet) downwind from a hypothesized release source.

The EARLY module models the period immediately following a radioactive release. This period is commonly referred to as the emergency phase. The emergency phase begins at each successive downwind distance point when the first plume of the release arrives. The duration of the emergency phase is specified by the user, and it can range between 1 and 7 days. The exposure pathways considered during this period are direct external exposure to radioactive material in the plume (cloud shine), exposure from inhalation of radionuclides in the cloud (cloud inhalation), exposure to radioactive material deposited on the ground (ground shine), inhalation of resuspended material (resuspension inhalation), and skin dose from material deposited on the skin. Mitigating actions that can be specified for the emergency phase include evacuation, sheltering, and dose-dependent relocation.

The CHRONC module performs all of the calculations pertaining to the intermediate and long-term phases. CHRONC calculates the individual health effects that result from both direct exposures to contaminated ground and from inhalation of resuspended materials.

The intermediate phase begins at each successive downwind distance point upon conclusion of the emergency phase. The user can configure the calculations with an intermediate phase that has a duration as short as 0 or as long as 1 year. In the zero-duration case, there is essentially no intermediate phase, and a long-term phase begins immediately upon conclusion of the emergency phase.

Intermediate models are implemented on the assumption that the radioactive plume has passed and the only exposure sources (ground shine and resuspension inhalation) are from ground-deposited material.

The mitigating action model for the intermediate phase is very simple. If the intermediate phase dose criterion is satisfied, the resident population is assumed to be present and subject to radiation exposure from ground shine and resuspension for the entire intermediate phase. If the intermediate phase exposure exceeds the dose criterion, then the population is assumed to be relocated to uncontaminated areas for the entire intermediate phase.

The long-term phase begins at each successive downwind distance point upon conclusion of the intermediate phase. The exposure pathways considered during this period are ground shine and resuspension inhalation. The exposure pathways considered are those resulting from ground-deposited material. A number of protective measures, such as decontamination, temporary interdiction, and condemnation, can be modeled in the long-term phase to reduce doses to user-specified levels.

The decisions on mitigating action in the long-term phase are based on two sets of independent actions: (1) decisions related to whether land at a specific location and time is suitable for human habitation (habitability), and (2) decisions related to whether land at a specific location and time is suitable for agricultural production (ability to farm). For the EIS, no mitigation or special protective measures were assumed for the exposure calculations.

All of the calculations of MACCS2 are stored based on a polar-coordinate spatial grid with a treatment that differs somewhat between calculations of the emergency phase and calculations of the intermediate and long-term phases. The region potentially affected by a release is represented with a (r, Θ) grid system centered on the location of the release. Downwind distance is represented by the radius "r." The angle, "Θ", is the angular offset from the north, going clockwise.

The user specifies the number of radial divisions as well as their endpoint distances. The angular divisions used to define the spatial grid are fixed in the code. They correspond to the 16 points of the compass, each being 22.5 degrees wide. The 16 points of the compass are used in the United States to express wind direction. The compass sectors are referred to as the coarse grid.

Since emergency phase calculations use dose-response models for early fatalities and early injuries that can be highly nonlinear, these calculations are performed on a finer grid basis than the calculations of the intermediate and long-term phases. For this reason, the calculations of the emergency phase are performed with the 16 compass sectors divided into 3, 5, or 7 equal angular subdivisions. The subdivided compass sectors are referred to as the fine grid.

Lifetime doses are the conventional measure of detriment used for radiological protection. These are 50-year dose commitments to a weighted sum of tissue doses defined by the ICRP and referred to as "effective dose equivalent." Lifetime doses may be used to calculate the stochastic health effect risk resulting from exposure to radiation. The calculated lifetime dose was used in cancer risk calculations.

I.5.7 Radiological Accident Results

The MACCS-calculated results for all 15 analyzed accident scenarios are presented in **Table I–25**. Results are presented in terms of 80-kilometer (50-mile) radius population and MEI radiation dose, LCF, and annual risk. The LCF for all accidents was calculated using the 0.0006 LCF per rem risk factor discussed in Section I.3. Although the Main Plant Process Building and high-level radioactive waste tank accidents apply to all four alternatives, not all the radioactive waste package handling accidents are relevant to each alternative because the actions under each alternative do not necessarily require all the package types. In addition, the NDA and SDA exhumation accidents only apply to the Sitewide Removal Alternative. Therefore, the term, "Not Applicable" is placed under alternatives where a specific package, NDA, or SDA accident is not relevant.

Table I–25 MACCS Calculated Accident Risk and Consequences for Each Alternative

Bounding Accident	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Main Plant Process Building				
Main Plant Process Building Seismic Collapse				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.68 person-rem 0.046 rem 4.1×10^{-8} 2.7×10^{-9}	0.68 person-rem 0.046 rem 4.1×10^{-8} 2.7×10^{-9}	0.68 person-rem 0.046 rem 4.1×10^{-8} 2.7×10^{-9}	**0.68 person-rem** **0.046 rem** **4.1×10^{-8}** **2.7×10^{-9}**
Radioactive Waste Tanks				
High Level Waste Tank Seismic Collapse				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.59 person-rem 0.014 rem 3.6×10^{-8} 8.3×10^{-10}	0.59 person-rem 0.014 rem 3.6×10^{-8} 8.3×10^{-10}	0.59 person-rem 0.014 rem 3.6×10^{-8} 8.3×10^{-10}	0.59 person-rem 0.014 rem 3.6×10^{-8} 8.3×10^{-10}
Radwaste Package				
Transuranic (remote-handled) Drum Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.27 person-rem 0.029 rem 1.3×10^{-5} 1.4×10^{-6}	0.27 person-rem 0.029 rem **1.3×10^{-6}** **1.4×10^{-7}**	0.27 person-rem 0.029 rem **1.6×10^{-5}** **1.7×10^{-6}**	Not Applicable
GTCC Drum Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	1.9 person-rem **0.68 rem** **9.1×10^{-5}** **3.3×10^{-5}**	Not Applicable	Not Applicable	Not Applicable
HIC Fire				
-Population dose -MEI dose -Population annual risk -MEI annual risk	**3.4 person-rem** 0.053 rem 2.0×10^{-7} 3.2×10^{-9}	**3.4 person-rem** **0.053 rem** 2.0×10^{-7} 3.2×10^{-9}	**3.4 person-rem** **0.053 rem** 2.0×10^{-7} 3.2×10^{-9}	Not Applicable
HIC Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.12 person-rem 0.033 rem 5.8×10^{-6} 1.6×10^{-6}	0.12 person-rem 0.033 rem 5.8×10^{-7} 1.6×10^{-7}	0.12 person-rem 0.033 rem 7.2×10^{-6} 2.0×10^{-6}	Not Applicable
Class A Box Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.00038 person-rem 9.1×10^{-5} rem 1.8×10^{-8} 4.4×10^{-9}	0.00038 person-rem 9.1×10^{-5} rem 1.8×10^{-9} 4.4×10^{-10}	0.00038 person-rem 9.1×10^{-5} rem 2.3×10^{-8} 5.5×10^{-9}	.00038 person-rem 9.1×10^{-5} rem 6.8×10^{-10} 1.6×10^{-10}
Class A Pallet Drop				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.00013 person-rem 2.1×10^{-5} rem 6.2×10^{-9} 1.0×10^{-9}	0.00013 person-rem 2.1×10^{-5} rem 6.2×10^{-10} 1.0×10^{-10}	0.00013 person-rem 2.1×10^{-5} rem 7.8×10^{-9} 1.3×10^{-9}	0.00013 person-rem 2.1×10^{-5} rem 2.3×10^{-10} 3.8×10^{-11}
LSA Container Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	2.8×10^{-5} person-rem 1.1×10^{-6} rem 1.3×10^{-9} 5.3×10^{-11}	2.8×10^{-5} person-rem 1.1×10^{-6} rem 1.3×10^{-10} 5.3×10^{-12}	2.8×10^{-5} person-rem 1.1×10^{-6} rem 1.7×10^{-9} 6.6×10^{-11}	2.8×10^{-5} person-rem 1.1×10^{-6} rem 5.0×10^{-11} 2.0×10^{-12}

Bounding Accident	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Fuel and Hardware Drum Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.19 person-rem 0.054 rem 9.4×10^{-6} 2.6×10^{-6}	Not Applicable	Not Applicable	Not Applicable
Class A Drum Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	3.5×10^{-5} person-rem 8.6×10^{-6} rem 1.7×10^{-9} 4.1×10^{-10}	3.5×10^{-5} person-rem 8.6×10^{-6} rem 1.7×10^{-10} 4.1×10^{-11}	3.5×10^{-5} person-rem 8.6×10^{-6} rem 2.1×10^{-9} 5.2×10^{-10}	3.5×10^{-5} person-rem 8.6×10^{-6} rem 6.3×10^{-11} 1.5×10^{-11}
Class C-R-D Drum Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.013 person-rem 2.5×10^{-5} rem 6.2×10^{-7} 1.2×10^{-9}	0.013 person-rem 2.5×10^{-5} rem 6.2×10^{-8} 1.2×10^{-10}	0.013 person-rem 2.5×10^{-5} rem 7.8×10^{-7} 1.5×10^{-9}	Not Applicable
Class B/C Box Puncture				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.12 person-rem 0.028 rem 5.8×10^{-6} 1.3×10^{-6}	0.12 person-rem 0.028 rem 5.8×10^{-7} 1.3×10^{-7}	0.12 person-rem 0.028 rem 7.2×10^{-6} 1.7×10^{-6}	Not Applicable
NDA and SDA				
NDA Exhumation Release				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.038 person-rem 0.0023 rem 2.3×10^{-9} 1.4×10^{-10}	Not Applicable	Not Applicable	Not Applicable
SDA Exhumation Release				
-Population dose -MEI dose -Population annual risk -MEI annual risk	0.041 person-rem 0.0018 rem 2.5×10^{-9} 1.1×10^{-10}	Not Applicable	Not Applicable	Not Applicable

MEI = maximally exposed individual, GTCC = Greater-Than-Class C, HIC = high-integrity container, LSA = low specific activity waste, NDA = NRC-licensed Disposal Area, SDA = State-licensed Disposal Area.
Maximum accident consequence and risk for each alternative is displayed in bold.
Note: To convert from rem or person-rem to sieverts or person-sieverts, multiply by 0.01.

Table I–25 shows that the Sitewide Removal, Sitewide Close-In-Place, and Phased Decisionmaking (Phase 1) Alternatives have the same largest calculated accident dose consequence of 3.4 person-rem for the population (from the HIC Fire), and the Sitewide Removal Alternative has the highest MEI accident dose consequence of 0.68 rem (from the GTCC Class 2 Drum Puncture). The Sitewide Removal Alternative has the largest calculated accident annual risk of 9.1×10^{-5} for the population and 3.3×10^{-5} for the MEI, as compared to the other three alternatives. This alternative has the highest risk because it is the only alternative that handles Greater-Than-Class C Drums, which have a relatively large source term as shown in Tables I–17 and I–20. The Remote-Handled Transuranic Drum Puncture, Greater-Than-Class C Drum Puncture and HIC Fire accidents are dominant for dose and risk for the Sitewide Removal, Sitewide Close-In-Place, and Phased Decisionmaking (Phase 1) Alternatives. The highest calculated dose and risk for the No Action Alternative is the Main Plant Process Building Seismic Collapse accident. For all four alternatives, none of the accident population or MEI doses or risks will cause any fatality or serious injury due to radiation exposure.

To put the calculated doses from these accidents in some perspective, the largest MEI dose of 0.68 rem is two times the average annual background radiation dose of 0.36 rem (360 millirem) per person. The maximum MEI latent cancer risk (3.3×10^{-5}) means there is about 1 chance in 30,000 of an LCF to the MEI for the most severe accident. For comparison, the latest National Cancer Institute statistics (NCI 2005) indicate that the chance of a fatal latent cancer in all Americans over their lifetime is about 0.22, or about slightly greater than one chance in five.

The maximum accident population dose of 3.4 person-rem is a small percentage (less than 0.001 percent) of the annual background population dose of 613,000 person-rem that would be received by the approximately 1.7 million residents within an 80-kilometer (50-mile) radius of the WNYNSC. Another perspective on the population dose from this postulated bounding accident is that the risk to the average individual in the general population in terms of developing an LCF from this dose is 1.3×10^{-9} or 1 chance in 765 million. The maximum accident radiation dose to each individual in the 80-kilometer (50-mile) radius population is 0.0000021 rem, or less than 0.001 percent of the radiation received by using a computer monitor.

In considering the overall risk from accidents for an alternative, it is necessary to consider the number of years that decommissioning actions would occur. In addition, in the case of radioactive waste package handling accidents, the total number of packages and annual handling rate must also be considered. **Table I–26** presents a summary of the estimated number of years that each type of operation would occur for each alternative and the respective number of radioactive waste packages handled. This table shows that the largest number of radioactive waste packages would be handled by the Sitewide Removal Alternative, but Phase 1 of the Phased Decisionmaking Alternative has the largest radioactive waste package annual handling rate.

Table I–26 Risk Duration for Major Accident Scenarios

Parameter	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Years before initiating Main Plant Process Building removal or stabilization	7	1	1	No removal or stabilization
Years before radioactive waste tanks' removal or stabilization	24	2	No removal or stabilization	No removal or stabilization
Years of radioactive waste package handling during decommissioning actions	64	7	8	0 [a]
Number of radioactive waste packages handled	234,282	2,630	38,166	3,561 every 25 years [a]
Annual radioactive waste package handling rate	3,661	376	4,771	143 [a]

[a] Average over 25-year time intervals to account for periodic waste disposal along with annual expected waste disposal volumes, and assumes drums for Class A waste and the LSA container for LSA waste. This alternative does not involve preparation for decommissioning. The annual average includes a large spike when NDA/SDA covers are being replaced every 25 years.

Sources: WSMS 2008b, 2008c, 2008d, 2008e.

The combination of the annual risk estimate for various accident types and the activity duration estimates supports the development of an overall relative risk estimate for the four alternatives for accidents that would involve short-term releases of radionuclides to the atmosphere. Activity duration is used to qualitatively assess the time period when a specific facility or action would occur and therefore be vulnerable to a postulated accident. For example, the risk for a radioactive waste tank accident would be the largest for the No Action and Phased Decisionmaking (Phase 1) Alternatives because no removal or stabilization is planned for this facility. This overall relative risk is presented in **Table I–27**. The terms used in this table (highest, low, and lowest) are intended to convey a relative qualitative assessment of the accident risk between the alternatives. The absolute magnitude of accident consequences and risks for all alternatives is estimated to be very small and is not expected to present a significant health risk to the general population.

Table I–27 Relative Accident Risk Comparison Rating Between Alternatives for Entire Time Period

Sitewide Removal Alternative	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Highest [a]	Low [a]	Low [a]	Lowest [a]

[a] These ratings are relative to each other between the alternatives. The absolute magnitude of accident risk for all alternatives is characterized as very small.

The Sitewide Removal Alternative has the greatest potential for an accident with the highest consequences and is expected to have the highest overall accident risk because it has the greatest number and duration of higher radioactivity content waste removal, packaging, and handling operations, and because it occurs over a longer period of time.

The most significant short-term accidents for the Sitewide Close-In-Place, Phased Decisionmaking (Phase 1), and No Action Alternatives have lower projected consequences than the dominant Sitewide Removal Alternative accident scenarios. The overall accident risk for these alternatives is estimated to be less than the overall accident risk for the Sitewide Removal Alternative. The overall accident risk for Phase 1 of the Phased Decisionmaking Alternative is slightly higher than the risk for the Sitewide Close-In-Place and No Action Alternatives as a result of the additional activity related to the Main Plant Process Building removal and the greater number of annual radioactive waste handling operations.

The most serious accident for the No Action Alternative, in terms of population dose, is smaller than the other three alternatives. The No Action Alternative does, however, have a higher risk of groundwater contamination over the long-term as a result of degradation or accidents involving the Main Plant Process Building and high-level radioactive waste tanks, since these facilities are not remediated under this alternative. It should also be noted that Phase 1 of the Phased Decisionmaking Alternative also has no plans for removal of the high-level radioactive waste tanks, and, depending on decisions made for Phase 2, could have similar long-term degradation and accident risks with regard to the high-level radioactive waste tanks. Long-term consequences for each alternative are presented in Appendix H.

I.5.8 Toxic Chemical Accidents

Data on toxic chemicals at the WVDP provide inventories of toxic metal elements such as lead and mercury and salts in the Waste Tank Farm and Main Plant Process Building (WSMS 2005a, 2005b). These inventories exist within equipment and individual components such as switches, lamps, and shielded windows and are not concentrated in one tank or physical location. Their physical and chemical forms are not conducive to an accident because of their highly dispersed distribution. No quantities of toxic chemicals of the same magnitude as in the Waste Tank Farm or Main Plant Process Building have been identified in a specific tank, drum, or pressurized component. Based on the type, form, and distribution of toxic chemicals at the WVDP, no credible hazardous chemical accidents can occur that would affect worker or public health.

Although no significant health effects from postulated accidents involving toxic chemicals are expected, an evaluation of the toxic chemical inventory was performed. **Table I–28** presents a tabulation of all the toxic chemicals present at the WVDP along with their quantities and relevant properties. EPA minimum release reportable quantities (EPA 2001b) and DOE health effect air concentration guidelines (DOE 2005) for each chemical are also presented in this table. In addition, Table I–28 presents the boiling point and vapor pressure (at 21 °C or 70 °F) of each toxic chemical. The purpose of providing the boiling point is to indicate that none of these chemicals could boil into vapor at expected temperatures during normal operations, and that only arsenic, cadmium, mercury, and selenium could vaporize if exposed to typical flame temperatures assumed for accidents of 800 °C (1475 °F) (10 CFR 71.73). The vapor pressure is used as another screening parameter in eliminating toxic chemicals. Such screening methods in other EISs (DOE 1999a) eliminate chemicals with a vapor pressure of less than 0.5 millimeters mercury (Hg) or 0.01 pounds per square inch at normal temperatures. For example, water vapor pressure is 18 millimeter Hg or 0.35 pounds per square inch at 21 °C (70 °F).

Table I–28 Inventory, Properties, and Serious Health Effect Limits of the West Valley Demonstration Project Toxic Chemicals

Chemical	*Highest Total Main Plant Process Building Inventory* [a] *kilograms (pounds)*	*Highest Individual Tank Inventory kilograms (pounds)*	*EPA CERCLA Reportable Release Quantity* [b] *kilograms (pounds)*	*Chemical Boiling Point Temperature at Atmospheric Pressure*	*Chemical Vapor Pressure At 77 °F (25 °C), millimeter Hg*	*ERPG-3 TEEL3* [c] *milligrams per cubic meter*
Silver	26 (57.3)	1.98 (4.36)	454 (1,000)	2,162 °C 3,294 °F	0	10
Arsenic	51 (112.3)	3.92 (8.63)	0.454 (1)	614 °C 1,137 °F	0	5
Barium	70 (154.2)	17.5 (38.6)	None	1,870 °C 3,398 °F	0	125
Beryllium	5.1 (11.2)	0.608 (1.34)	4.54 (10)	2,469 °C 4,476 °F	0	0.1
Cadmium	17 (37.4)	1.66 (3.66)	4.54 (10)	767 °C 1,413 °F	0	7.5
Chromium	144 (317.2)	85.6 (188.6)	2,270 (5,000)	2,671 °C 4,840 °F	0	250
Mercury	0.81 (1.8)	1.15 (2.53)	0.454 (1)	357 °C 674 °F	0.0018	4.1
Nickel	457 (1006.7)	85.9 (189.2)	45.4 (100)	2,913 °C 5,275 °F	0	10
Lead	337 (742.3)	14.2 (31.3)	4.54 (10)	1,749 °C 3,180 °F	0	100
Antimony	18 (39.7)	9.76 (21.5)	2,270 (5,000)	1,587 °C 2,889 °F	0	50
Selenium	29 (63.9)	4.87 (10.7)	45.4 (100)	685 °C 1,265 °F	0	1
Thallium	6 (13.2)	9.68 (21.3)	454 (1,000)	1,473 °C 2,683 °F	0	15

EPA = U.S. Environmental Protection Agency, CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act, F = Fahrenheit, C = Celsius, ERPG-3 = Emergency Response Planning Guideline 3, TEEL3 = Temporary Emergency Exposure Limits 3.

[a] This total inventory represents the sum of the existence of this element distributed in components and structures throughout the Main Plant Process Building.

[b] For metals (silver, beryllium, cadmium, chromium, nickel, lead, antimony, selenium, and thallium) no reporting of solid form releases in these quantities is required unless the release is in the form of pieces with a mean diameter of 100 micrometers (100 microns) or smaller. For all materials, only particles of this size are reportable.

[c] Both the Emergency Response Planning Guideline 3 (ERPG-3) and Temporary Emergency Exposure Limits 3 (TEEL3) are the maximum concentration in air below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects. 1 millimeter Hg = 0.019 pounds per square inch.

Shading indicates that inventory is less than EPA CERCLA reportable release quantity.

Sources: DOE 2005; EPA 2001b; NYenvlaw 2002; Webelements 2006; WSMS 2005b, 2005c, 2008a, 2008b, 2008c.

Based on the ratio of individual toxic chemical inventory to ERPG-3 limit for those chemicals that are above the EPA CERCLA reportable release quantity, an accidental release of beryllium encompasses the impacts of the other toxic chemicals listed in Table I–28. Assuming an accident that would release toxic chemicals from the Main Plant Process Building or High-Level Waste Tanks having the same respirable particle release fraction that was used for the radiological accidents as presented in Table I–15, the higher inventory of toxic chemicals in the Main Plant Process Building would bound the inventory of the high-level waste tanks. The Main Plant Process Building Seismic Collapse accident scenario also results in a higher source term than the high-level waste tank accident scenario.

A postulated seismic collapse accident involving all 5.1 kilograms (11.2 pounds) of beryllium in the Main Plant Process Building results in a concentration of respirable particles of beryllium at 100 meters (328 feet) of 0.00043 milligrams per cubic meter (0.0000012 milligrams per cubic foot) for a 10-minute release time and average meteorology atmospheric dispersion conditions. This is a factor of more than 200 below or about 0.4 per cent of the ERPG-3 value of 0.1 milligrams per cubic meter (0.003 milligrams per cubic foot). If conservative meteorology atmospheric dispersion were to be assumed, the 100 meter (328 feet) air concentration would be 0.0021 milligrams per cubic meter, which is still significantly below the ERPG-3 limit of 0.1 milligrams per cubic meter (0.003 milligrams per cubic foot). The conservative meteorology 100-meter (328-foot) beryllium concentration is also below the ERPG-2 and ERPG-1 values of 0.025 milligrams per cubic meter and 0.005 milligrams per cubic meter (DOE 2005). Air concentrations below the ERPG-1 level do not cause any long-term or serious health effects. This calculation conservatively assumes that all the beryllium dispersed throughout the Main Plant Process Building would be affected by the Seismic Collapse accident scenario. It should also be noted that the distance of 100 meters (328 feet) is selected for the noninvolved worker and that the nearest public boundary is at a greater distance thereby resulting in an even lower concentration for public exposure to this postulated accident.

Since the beryllium accident release air concentration at 100 meters (328 feet) is below the ERPG-3, ERPG-2, and ERPG-1 levels, accident releases of all other toxic chemicals would be expected to be significantly less than their respective ERPG limits. Therefore, the risk to noninvolved workers and the public due to toxic chemicals released to the atmosphere from accidents is very small and insignificant as compared to the radiological accident risks presented in Section I.5.7.

The aforementioned evaluation is for accident releases of toxic chemicals into the atmosphere and short-term exposure for the public and noninvolved workers. The risks of cancer due to exposure from toxic chemicals have been extensively studied. EPA has developed an Integrated Risk Information System (IRIS) which presents chemical cancer risk data. Studies have shown that long-term exposure to certain chemicals is associated with an increase in the risk of specific organ cancer. For the chemicals listed in Table I–26 that are associated with cancer risk for long-term exposure, IRIS data shows that cadmium has the highest cancer risk level of 1×10^{-6} (a chance of one in one million) for lung cancer. This risk is from a long-term cadmium respirable particle air concentration of 6×10^{-4} micrograms per cubic meter (EPA 2006). Assuming that the entire cadmium inventory in the Main Plant Process Building was released as respirable particles over a 1-year period of time, the air concentration at 100 meters (328 feet) for the noninvolved worker would be less than this cancer risk level. The air concentration of cadmium at the nearest public boundary would be lower than that of the noninvolved worker. Accident short-term atmospheric release of toxic chemicals does not result in an air concentration that would cause a cancer risk to noninvolved workers or the public. Long-term atmospheric release of toxic chemicals at the WVDP results in air concentrations less than the value estimated to result in a cancer risk of 1×10^{-6} (a chance of one in one million) for the noninvolved worker or the nearest public member.

I.5.9 Accident Radiological and Chemical Impacts Conclusion

Radiological analyses of 15 different accidents involving the Main Plant Process Building, radioactive waste tanks, NDA, SDA, and radioactive waste packages for all four alternatives were performed using the MACCS computer code. Radiation doses were calculated for the MEI and the 80-kilometer (50-mile-) radius population. Doses were converted to LCFs and annual risk based on 0.0006 LCFs per rem and the annual frequency for each accident scenario. The largest accident consequence and risk for each alternative is summarized in **Table I–29** and compared to expected normal background radiation doses for expected cancer mortality.

The largest radiological accident risk is calculated for the Sitewide Removal Alternative, while the smallest calculated accident risk exists for the No Action Alternative. For all alternatives, the relative radiological accident risk is very small as compared to such risks as the normal lifetime fatal cancer risk of about one in five.

An evaluation of the nature and quantity of toxic chemicals was performed to determine if a postulated accident could result in the release of these chemicals resulting in a hazard to workers or the public. Although the annual frequency of a postulated accident involving the release of toxic chemicals is equivalent to the radiological release accidents, the relatively low quantity and physical characteristics of the toxic chemicals preclude any significant health hazards in the event of an accidental release of toxic liquids or gases.

Table I–29 Largest Accident [a] Radiological Consequence and Risk

Parameter	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
MEI dose (rem)	0.68	0.053	0.053	0.046
MEI LCF if the accident occurs	4.1×10^{-4}	3.2×10^{-5}	3.2×10^{-5}	2.7×10^{-5}
MEI annual risk	3.3×10^{-5} or 1 chance in 30,000	1.4×10^{-7} or 1 chance in 7.2 million	1.7×10^{-6} or 1 chance in 575,000	2.7×10^{-9} or 1 chance in 370 million
Population dose (person-rem)	3.4	3.4	3.4	0.68
Population LCF if the accident occurs	0.002	0.002	0.002	0.0004
Population annual risk	9.1×10^{-5} or 1 chance in 11,000	1.3×10^{-6} or 1 chance in 770,000	1.6×10^{-5} or 1 chance in 62,500	4.1×10^{-8} or 1 chance in 24 million
Population normal background radiation dose [b] (person-rem)	612,000	612,000	612,000	612,000
Population normal background radiation annual LCFs	368	368	368	368

LCF = latent cancer fatality, MEI = maximally exposed individual.
[a] Different accident scenarios are represented by the value in the table for each alternative.
[b] Based on an average of 0.36 rem per person annually and a population of 1.7 million.

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APPENDIX J
EVALUATION OF HUMAN HEALTH EFFECTS FROM TRANSPORTATION

APPENDIX J
EVALUATION OF HUMAN HEALTH EFFECTS FROM TRANSPORTATION

J.1 Introduction

Transportation of any commodity involves a risk to both transportation crew members and members of the public. This risk results directly from transportation-related accidents and indirectly from increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive waste, can pose an additional risk due to the unique nature of the material itself. To permit a complete appraisal of the environmental impacts of the Proposed Action and alternatives, the human health risks associated with the transportation of radioactive materials on public highways and railroads were assessed.

This appendix provides an overview of the approach used to assess the human health risks that could result from transportation. The topics in this appendix include the scope of the assessment, packaging and determination of potential transportation routes, analytical methods used for the risk assessment (e.g., computer models), and important assessment assumptions. In addition, to aid in the understanding and interpretation of the results, specific areas of uncertainty are described with an emphasis on how the uncertainties may affect comparisons of the alternatives.

The risk assessment results are presented in this appendix in terms of "per-shipment" risk factors, as well as the total risks for a given alternative. Per-shipment risk factors provide an estimate of the risk from a single shipment. The total risks for a given alternative are estimated by multiplying the expected number of shipments by the appropriate per-shipment risk factors.

J.2 Scope of Assessment

The scope of the transportation human health risk assessment, including the alternatives and options, transportation activities, potential radiological and nonradiological impacts, and transportation modes, is described in this section. There are several shipping arrangements for various radioactive wastes that cover all alternatives evaluated. This evaluation focuses on using onsite and offsite public highways and rail systems. Additional details of the assessment are provided in the remaining sections of this appendix.

J.2.1 Transportation-related Activities

The transportation risk assessment is limited to estimating the human health risks related to transportation for each alternative. The risks to workers or to the public during loading, unloading, and handling prior to or after shipment are addressed in Section 4.1.9, Human Health and Safety, of the environmental impact statement (EIS). The impacts of increased transportation levels on local traffic flow or infrastructure are addressed in Section 4.1.2, Site Infrastructure.

J.2.2 Radiological Impacts

For each alternative, radiological risks (i.e., those risks that result from the radioactive nature of the materials) are assessed for both incident-free (i.e., normal) and accident transportation conditions. The radiological risk associated with incident-free transportation conditions would result from the potential exposure of people to external radiation in the vicinity of a shipment. The radiological risk from transportation accidents would come from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people.

All radiological impacts are calculated in terms of committed dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent (see Title 10 of the *Code of Federal Regulations* [CFR], Part 20 [10 CFR Part 20]), which is the sum of the effective dose equivalent from external radiation exposure and the 50-year committed effective dose equivalent from internal radiation exposure. Radiation doses are presented in units of roentgen equivalent man (rem) for individuals and person-rem for collective populations. The impacts are further expressed as health risks in terms of latent cancer fatalities (LCFs) in exposed populations using the dose-to-risk conversion factors recommended by the U.S. Department of Energy (DOE) Office of NEPA [National Environmental Policy Act] Policy and Compliance, based on Interagency Steering Committee on Radiation Standards guidance (DOE 2003a).

J.2.3 Nonradiological Impacts

In addition to the radiological risks posed by transportation activities, vehicle-related risks are also assessed for nonradiological causes (i.e., causes related to the transport vehicles and not the radioactive cargo) for the same transportation routes. The nonradiological transportation risks, which would be incurred for similar shipments of any commodity, are assessed for accident conditions. The nonradiological accident risk refers to the potential occurrence of transportation accidents that result in fatalities unrelated to the radioactive nature of the cargo.

Nonradiological risks during incident-free transportation conditions could also be caused by potential exposure to increased vehicle exhaust emissions. As explained later in Section J.5.2, these emission impacts were not considered.

J.2.4 Transportation Modes

All shipments are assumed to take place by either dedicated truck or rail.

J.2.5 Receptors

Transportation-related risks are calculated and presented separately for workers and members of the general public. The workers considered are truck and rail crew members involved in transportation and inspection of the packages. The general public includes all persons who could be exposed to a shipment while it is moving or stopped during transit. For the incident-free operation, the affected population includes individuals living within 800 meters (0.5 miles) of each side of the road or rail line. Potential risks are estimated for the affected populations and for the hypothetical maximally exposed individual (MEI). For incident-free operation, the MEI would be a resident living near the highway or rail line and exposed to all shipments transported on the road or rail line. For accident conditions, the affected population includes individuals residing within 80 kilometers (50 miles) of the accident, and the MEI would be an individual located 100 meters (330 feet) directly downwind from the accident. The risk to the affected population is a measure of the radiological risk posed to society as a whole by the alternative being considered. As such, the impact on the affected population is used as the primary means of comparing various alternatives.

J.3 Packaging and Transportation Regulations

This section provides a high level, brief summary of packaging and transportation regulations. The regulations pertaining to the transportation of radioactive materials are detailed in the CFR published by the U.S. Department of Transportation (DOT), U.S. Nuclear Regulatory Commission (NRC), and U.S. Postal Service. Specifics on details on these regulations can be found in 49 CFR Part 106, 107, 171-178

(DOT regulations); 10 CFR Part 20, 61, and 71 (NRC regulations), and 39 CFR Part 121 (U.S. Postal Service regulations). Interested readers are encouraged to visit the cited CFRs for current detailed regulations, or review the DOT RAMREG-001-98 (DOT 1998) for a comprehensive discussion on radioactive material regulations.

J.3.1 Packaging Regulations

The primary regulatory approach to promote safety from radiological exposure is the specification of standards for the packaging of radioactive materials. Packaging represents the primary barrier between the radioactive material being transported and radiation exposure to the public, workers, and the environment. Transportation packaging for radioactive materials must be designed, constructed, and maintained to contain and shield its contents during normal transport conditions. For highly radioactive material, such as high-level radioactive waste or spent nuclear fuel, packaging must contain and shield the contents in the event of severe accident conditions. The type of packaging used is determined by the total radioactive hazard presented by the material within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Specific requirements for these packages are detailed in 49 CFR 173.400. All packages are designed to protect and retain their content under normal operations.

Excepted packagings are limited to transporting materials with extremely low levels of radioactivity and very low external radiation. Industrial packagings are used to transport materials that, because of their low concentration of radioactive materials, present a limited hazard to the public and the environment. Type A packagings are designed to protect and retain their contents under normal transport conditions, and because of higher radioactive content it must maintain sufficient shielding to limit radiation exposure to handling personnel. Type A packaging, typically a 0.21-cubic-meter (55-gallon) drum or standard waste box, is commonly used to transport radioactive materials with higher concentrations or amounts of radioactivity than Excepted or Industrial packages. Type B packagings are used to transport material with the highest radioactivity levels, and are designed to protect and retain their contents under transportation accident conditions. They are described in more detail in the following sections. Packaging requirements are an important consideration for transportation risk assessment.

Radioactive materials shipped in Type A containers, or packagings, are subject to specific radioactivity limits, identified as A1 and A2 values in 49 CFR 173.435 ("Table of A1 and A2 Values for Radionuclides"). In addition, external radiation limits, as prescribed in 49 CFR 173.441 ("Radiation Level Limitations"), must be met. If the A1 or A2 limits are exceeded, the material must be shipped in a Type B container unless it can be demonstrated that the material meets the definition of "low specific activity." If the material qualifies as low specific activity as defined in 10 CFR Part 71 ("Packaging and Transportation of Radioactive Material") and 49 CFR Part 173, it may be shipped in a shipping container such as Industrial or Type A Packaging (49 CFR 173.427), see also RAMREG-001-98 (DOT 1998). Type B containers, or casks, are subject to the radiation limits in 49 CFR 173.441, but no quantity limits are imposed except in the case of fissile materials and plutonium.

Type A packagings are designed to retain their radioactive contents in normal transport. Under normal conditions, a Type A package must withstand:

- Operating temperatures ranging from -40 degrees Celsius (°C) (-40 degrees Fahrenheit [°F]) to 70 °C (158 °F);
- External pressures ranging from 0.25 to 1.4 kilograms per square centimeter (3.5 to 20 pounds per square inch);
- Normal vibration experienced during transportation;

- Simulated rainfall of 5 centimeters (2 inches) per hour for 1 hour;
- Free fall from 0.3 to 1.2 meters (1 to 4 feet), depending on the package weight;
- Water immersion-compression tests; and
- Impact of a 6-kilogram (13-pound) steel cylinder with rounded ends dropped from 1 meter (3.3 feet) onto the most vulnerable surface.

Type B packagings are designed to retain their radioactive contents in both normal and accident conditions. In addition to the normal conditions outlined earlier, under accident conditions, a Type B package must withstand:

- Free drop from 9 meters (30 feet) onto an unyielding surface in a position most likely to cause damage;
- Free drop from 1 meter (3.3 feet) onto the end of a 15-centimeter (6-inch) diameter vertical steel bar;
- Exposure to temperatures of 800 °C (1,475 °F) for at least 30 minutes;
- For all packages, immersion in at least 15 meters (50 feet) of water;
- For some packages, immersion in at least 0.9 meters (3 feet) of water in an orientation most likely to result in leakage; and
- For some packages, immersion in at least 200 meters (660 feet) of water for 1 hour.

Compliance with these requirements is demonstrated by using a combination of simple calculation methods, computer modeling techniques, or scale-model or full-scale testing of transportation packages, or casks.

J.3.2 Transportation Regulations

The regulatory standards for packaging and transporting radioactive materials are designed to achieve four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation by specific limitations on the allowable radiation levels;
- Contain radioactive material in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria);
- Prevent nuclear criticality (an unplanned nuclear chain reaction that could occur as a result of concentrating too much fissile material in one place); and
- Provide physical protection against theft and sabotage during transit.

DOT regulates the transportation of hazardous materials in interstate commerce by land, air, and water. DOT specifically regulates the carriers of radioactive materials and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. DOT also regulates the labeling, classification, and marking of radioactive material packagings.

NRC regulates the packaging and transporting of radioactive material for its licensees, including commercial shippers of radioactive materials. In addition, under an agreement with DOT, NRC sets the standards for packages containing fissile materials and Type B packagings.

DOE, through its management directives, Orders, and contractual agreements, ensures the protection of public health and safety by imposing on its transportation activities standards equivalent to those of DOT and NRC. According to 49 CFR 173.7(d), packagings made by or under the direction of DOE may be used for transporting Class 7 materials (radioactive materials) when the packages are evaluated, approved, and certified by DOE against packaging standards equivalent to those specified in 10 CFR Part 71 ("Packaging and Transportation of Radioactive Material").

DOT also has requirements that help to reduce transportation impacts. Some requirements affect drivers, packaging, labeling, marking, and placarding. Others specifying the maximum dose rate from radioactive material shipments help to reduce incident-free transportation doses.

The Federal Emergency Management Agency (FEMA) is responsible for establishing policies for, and coordinating civil emergency management, planning, and interaction with, Federal Executive agencies that have emergency response functions in the event of a transportation incident. FEMA, an agency of the Department of Homeland Security, coordinates Federal and State participation in developing emergency response plans and is responsible for the development of the interim Federal Radiological Emergency Response Plan. This plan is designed to coordinate Federal support to state and local governments, upon request, during the event of a transportation incident involving radioactive materials.

J.4 Transportation Analysis Impact Methodology

The transportation risk assessment is based on the alternatives described in Chapter 2 of the EIS. **Figure J–1** summarizes the transportation risk assessment methodology. After the EIS alternatives were identified and the requirements of the shipping campaign were understood, data was collected on material characteristics and accident parameters.

Transportation impacts calculated in the EIS are presented in two parts: impacts of incident-free or routine transportation and impacts of transportation accidents. Impacts of incident-free transportation and transportation accidents were further divided into nonradiological and radiological impacts. Nonradiological impacts could result from transportation accidents in terms of traffic fatalities. Radiological impacts of incident-free transportation include impacts on members of the public and crew from radiation emanating from materials in the shipment. Radiological impacts from accident conditions consider all foreseeable scenarios that could damage transportation packages leading to releases of radioactive materials to the environment.

The impact of transportation accidents is expressed in terms of probabilistic risk, which is the probability of an accident multiplied by the consequences of that accident and summed over all reasonably conceivable accident conditions. Hypothetical transportation accident conditions ranging from low-speed "fender-bender" collisions to high-speed collisions with or without fires were analyzed. The frequencies of accidents and consequences were evaluated using a method developed by NRC and originally published in the *Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes*, NUREG-0170 (NRC 1977); *Shipping Container Response to Severe Highway and Railway Accident Conditions*, NUREG/CR-4829 (NRC 1987); and, *Reexamination of Spent Fuel Shipping Risk Estimates*, NUREG/CR-6672 (NRC 2000). Hereafter, these reports are cited as: *Radioactive Material Transport Study*, NUREG-0170; *Modal Study*, NUREG/CR-4829; and *Reexamination Study*, NUREG/CR-6672. Radiological accident risk is expressed in terms of additional LCFs, and nonradiological accident risk is expressed in terms of additional immediate (traffic) fatalities. Incident-free risk is also expressed in terms of additional LCFs.

Transportation-related risks were calculated and are presented separately for workers and members of the general public. The workers considered are truck/rail crew members involved in the actual transportation. The general public includes all persons who could be exposed to a shipment while it is moving or stopped during transit.

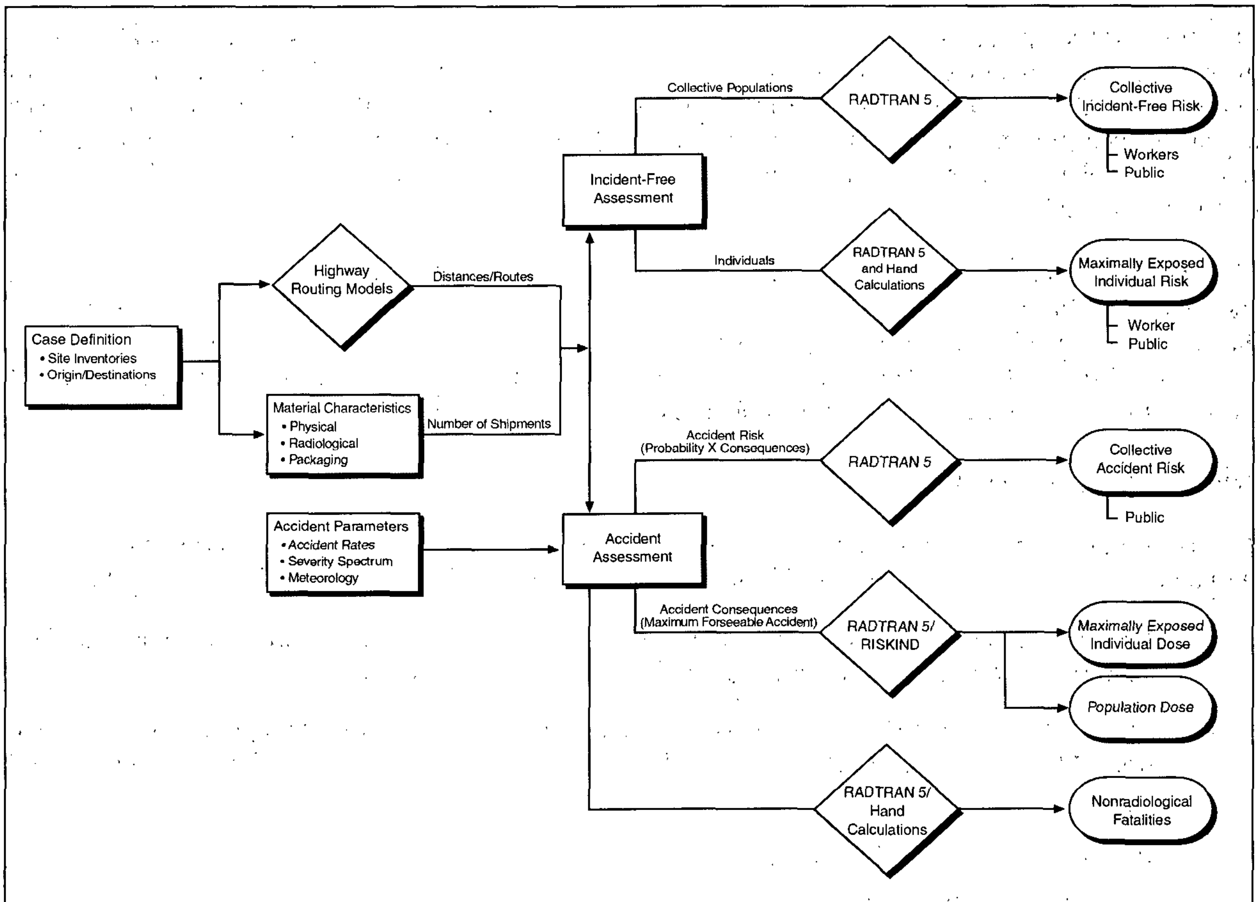

Figure J–1 Transportation Risk Assessment

The first step in the ground transportation analysis was to determine the distances and populations along the routes. The Transportation Routing Analysis Geographic Information System (TRAGIS) computer program (Johnson and Michelhaugh 2003) was used to choose representative routes and the associated distances and populations. This information, along with the properties of the material being shipped and route-specific accident frequencies, was entered into the RADTRAN 5 computer code (Neuhauser and Kanipe 2003), which calculates incident and accident risks on a per-shipment basis. The risks under each alternative were determined by summing the products of per-shipment risks for each waste type by its number of shipments.

The RADTRAN 5 computer code (Neuhauser and Kanipe 2003) was used for incident-free and accident risk assessments to estimate the impacts on populations. RADTRAN 5 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge. RADTRAN 5 was used to calculate the doses to the MEIs during incident-free operations.

The RADTRAN 5 population risk calculations include both the consequences and probabilities of potential exposure events. The RADTRAN 5 code consequence analyses include the following exposure pathways; cloud shine, ground shine, direct radiation (from loss of shielding) inhalation (from dispersed materials), and resuspension (inhalation dose from resuspended materials) (Neuhauser et al. 2000). The collective population risk is a measure of the total radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing the various alternatives.

The RISKIND computer code (Yuan et al. 1995) was used to estimate the doses to MEIs and populations for the worst-case maximum reasonably foreseeable transportation accident. The RISKIND computer code was developed for DOE's Office of Civilian Radioactive Waste Management to analyze the exposure of individuals during incident-free transportation. In addition, the RISKIND code was designed to allow a detailed assessment of the consequences to individuals and population subgroups from severe transportation accidents under various environmental settings.

The RISKIND calculations were conducted to supplement the collective risk results calculated with RADTRAN 5. Whereas the collective risk results provide a measure of the overall risks of each alternative, the RISKIND calculations are meant to address areas of specific concern to individuals and population subgroups. Essentially, the RISKIND analyses are meant to address "What if" questions, such as "What if I live next to a site access road?" or "What if an accident happens near my town?"

J.4.1 Transportation Routes

To assess incident-free and transportation accident impacts, route characteristics were determined for offsite shipments from the Western New York Nuclear Service Center (WNYNSC) Site in New York, to the:

- Hanford Site in Richland, Washington, (the route characteristics for this site were used as a proxy for a commercial Western U.S. disposal site for Class B and Class C wastes);
- Nevada Test Site (NTS) in Mercury, Nevada/Yucca Mountain, Nevada (the route characteristics for Yucca Mountain were used, for purposes of analysis only, for a Greater-Than-Class C waste disposal site.[1]
- EnergySolutions site in Clive, Utah;
- Barnwell site, in Barnwell, South Carolina;[2] and
- Waste Isolation Pilot Plant (WIPP) site in Carlsbad, New Mexico (the route characteristics for this site were used, for purposes of analysis only, for a transuranic waste disposal site[1]).

For offsite transport, highway and rail routes were determined using the routing computer program TRAGIS (Johnson and Michelhaugh 2003).[3]

The TRAGIS computer program is a geographic information system-based transportation analysis computer program used to identify and select highway, rail, and waterway routes for transporting radioactive materials within the United States. Both the road and rail network are 1:100,000-scale databases, which were developed from the U.S. Geological Survey digital line graphs and the U.S. Bureau of the Census Topological Integrated Geographic Encoding and Referencing System. The population densities along each route were derived from 2000 Census Bureau data (Johnson and Michelhaugh 2003). The features in TRAGIS allow users to determine routes for shipment of radioactive materials that conform to DOT regulations as specified in 49 CFR Part 397.

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[1] *A disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste will be determined through the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste Environmental Impact Statement (DOE/EIS-0375).*

[2] *Since July 2008, Barnwell no longer accepts waste from sites outside the Southeast Compact.*

[3] *There is direct rail access to the Hanford Site, Barnwell, and EnergySolutions. Direct rail access to NTS and Yucca Mountain is not available at the present time, but is under consideration as part of the access to the proposed geological repository at Yucca Mountain. For WIPP, while there is currently rail infrastructure at WIPP, there are no current plans to upgrade it so that rail shipments can be received.*

Offsite Route Characteristics

Route characteristics that are important to the radiological risk assessment include the total shipment distance and population distribution along the route. The specific route selected determines both the total potentially exposed population and the expected frequency of transportation-related accidents. Route characteristics for Hanford, NTS, EnergySolutions, Barnwell, and WIPP transportation are summarized in **Table J–1**. Rural, suburban, and urban areas are characterized according to the following breakdown:

- Rural population densities range from 0 to 54 persons per square kilometer (0 to 139 persons per square mile);
- Suburban population densities range from 55 to 1,284 persons per square kilometer (140 to 3,326 persons per square mile); and
- Urban population densities include all population densities greater than 1,284 persons per square kilometer (3,326 persons per square mile).

Table J–1 Offsite Transport Truck and Rail Route Characteristics

Origin	Destination	Nominal Distance (kilometers)	Distance Traveled in Zones (kilometers)			Population Density in Zone (number per square kilometer)			Number of Affected Persons [a]
			Rural	Suburban	Urban	Rural	Suburban	Urban	
Truck Routes									
West Valley	Hanford [b]	4,113	3,240	791	82	11.2	294.6	2,307.8	733,507
	NTS/Yucca Mountain	3,944	3,069	770	105	11.1	305.8	2,406.9	835,796
	EnergySolutions	3,267	2,519	673	75	11.7	300	2,316.1	647,135
	Barnwell	1,507	885	587	35	17.4	310	2,198.9	439,681
	WIPP	3,155	2,104	947	104	14.5	319.2	2,256.3	906,774
Rail Routes									
West Valley	Hanford	4,195	3,348	680	167	7.3	388.7	2,420.1	1,106,846
	NTS [c]/Yucca Mountain	4,158	3,360	630	168	7.9	386.9	2,432.8	1,084,658
	EnergySolutions	3,425	2,636	622	167	9.6	387.6	2,433.7	1,077,758
	Barnwell	1,784	1,170	519	95	15.7	385.7	2,404.4	715,981
	WIPP	2,962	2,344	486	132	8.7	438.3	2,392.6	879,529

WIPP = Waste Isolation Pilot Plant, NTS = Nevada Test Site.

[a] The estimated number of persons residing within 800 meters (0.5 miles) along the transportation route.

[b] West Valley-Hanford site route characteristics were used as a proxy for a commercial Western U.S. disposal site for Class B/C wastes. Barnwell site disposal of this waste was also evaluated in this appendix, to provide environmental impact coverage and flexibility for use, should the site become available in future.

[c] It was assumed that direct rail access to NTS would be available as part of the proposed geological repository at Yucca Mountain.

Note: To convert from kilometers to miles, multiply by 0.6214; to convert from number per square kilometer to number per square mile, multiply by 2.59.

The affected population for route characterization and incident-free dose calculation includes all persons living within 800 meters (0.5 miles) of each side of the transportation route.

Analyzed truck and rail routes for shipments of radioactive waste materials to the Hanford, NTS, Barnwell, EnergySolutions, and WIPP sites are shown on **Figure J–2**.

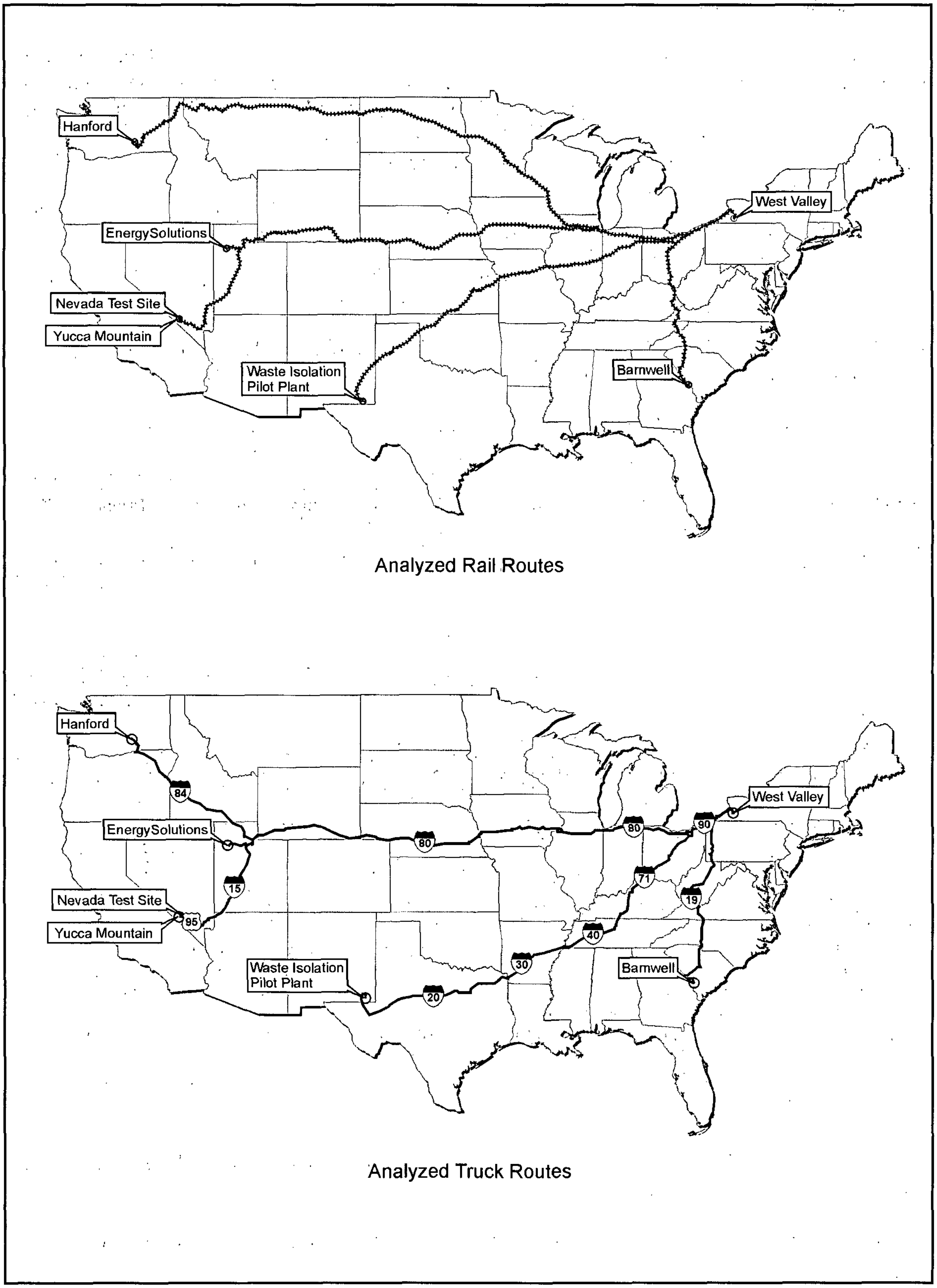

Figure J–2 Analyzed Truck and Rail Routes

J.4.2 Radioactive Material Shipments

Transportation of all waste types is assumed to be in certified or certified-equivalent packaging on exclusive-use vehicles. Legal-weight heavy-haul combination trucks are used for highway transportation. Type A packages are transported on common flatbed or covered trailers; Type B packages are generally shipped on trailers designed specifically for the packaging being used. For transportation by truck, the maximum payload weight is considered to be about 22,000 kilograms (about 48,000 pounds), based on the Federal gross vehicle weight limit of 36,288 kilograms (80,000 pounds). While there are large numbers of multi-trailer combinations (known as longer combination vehicles) with gross weights in excess of the Federal limit in operation on rural roads and turnpikes in some states (FHWA 2003), for evaluation purposes, the load limit for the legal truck was based on the Federal gross vehicle weight.

Rail transport can be done with dedicated and/or general freight trains. For analysis purposes, a dedicated train was assumed. The payload weights for railcars range from 45,359 to 68,039 kilograms (100,000 to 150,000 pounds). A median payload weight of 54,431 kilograms (120,000 pounds) was used in this analysis.

Several types of containers would be used to transport the generated waste. The various wastes that would be transported under the alternatives in this EIS include demolition and construction debris and hazardous waste, low-level radioactive waste, transuranic waste, and mixed low-level radioactive waste. **Table J–2** lists the types of containers used along with their volumes and the number of containers in a shipment. A shipment is defined as the amount of waste transported on a single truck or a single railcar. Multiple railcars (2 or more) per train could be used to reduce the number of rail transport. Since the rail accident and fatalities data are per railcar-kilometer (see section J.6.2), the transportation analysis presented here is based on one railcar per transport. While it may be possible to reduce the number of transports by using multiple railcars per train, there would be a proportional increase in the transportation risks per transport.

The number of shipping containers per shipment was estimated on the basis of dimensions and weight of the shipping containers, the Transport Index,[4] which is the dose rate at 1 meter (3.3 feet) from the container, and the transport vehicle dimensions and weight limits. In general, the various wastes were assumed to be transported on standard truck semi-trailers and railcars in a single stack.

Waste materials to be transported offsite for disposal were classified into three broad disposal groupings: construction and demolition debris, hazardous wastes, and radioactive wastes. Trash, such as waste paper generated from routine office work, is not included. Radioactive wastes were classified in accordance with NRC regulations at 10 CFR Part 61. For DOE radioactive waste to be transported to a DOE radioactive waste disposal site, (e.g., NTS), it was assumed that the wastes would meet the disposal facility's waste acceptance criteria. Wastes exceeding Class C limits that were buried in the NRC-licensed Disposal Area (NDA) and State-licensed Disposal Area (SDA) prior to establishment of the West Valley Demonstration Project (WVDP) were assumed to be Greater-Than-Class C wastes. This waste includes the irradiated, unprocessed reactor fuels that were mixed with concrete in drums and disposed of at NDA. All other wastes exceeding Class C limits were assumed to be transuranic wastes.

For the purposes of analysis, this EIS assumes that all DOE low-level radioactive waste can be disposed of at NTS or EnergySolutions, in Clive, Utah, depending on waste classification. It also assumes that low-level radioactive waste from the SDA, and pre-1982 NDA waste, would be disposed of at a commercial disposal site.

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[4] Transport Index is a dimensionless number (rounded up to the next tenth) placed on label of a package, to designate the degree of control to be exercised by the carrier. Its value is equivalent to the maximum radiation level in millirem per hour at 1 meter (3.3 feet) from the package (10 CFR 71.4 and 49 CFR 173.403).

Table J–2 Waste Type and Container Characteristics

Waste Type	*Container*	*Container Volume (cubic meters)* [a]	*Container Mass (kilograms)* [b]	*Number of Containers per Shipment*
Class A low-level radioactive waste	208-liter drum	0.21	399	80 per truck 160 per rail
Class A low-level radioactive waste and mixed low-level radioactive waste	B-25 Box	2.55	4,536	5 per truck 10 per rail
Class B and Class C low-level radioactive waste	B-25 Box	2.55	4,536	5 per truck 10 per rail
Class B and Class C low-level radioactive waste	High-integrity container [c]	5.10	9,072	1 per truck 2 per rail
Class C (remote-handled) [d]	208-liter drum	0.21	399	10 per truck cask 2 casks per rail
Greater-Than-Class C waste [d]	208-liter drum	0.21	399	10 per truck cask 2 casks per rail
Low specific activity waste	Lift liner	7.31	10,886	2 per truck 4 per rail
Transuranic waste (remote-handled) [e]	208-liter drum	0.21	399	3 per truck cask 2 casks per rail
Transuranic waste (contact-handled)	208-liter drum	0.21	399	14 per TRUPACT II; 3 TRUPACT IIs per truck 6 TRUPACT IIs per rail
Construction/demolition debris	Roll-on/Roll-off	15.30	NA	1 per truck
Hazardous	208-liter drum	0.21	399	40 per truck

[a] Container exterior volume. To convert from cubic meters to cubic feet, multiply by 35.315; from liters to gallons, by 0.26417.
[b] Filled container maximum mass. Container mass includes the mass of the container shell, its internal packaging, and the materials within. To convert from kilograms to pounds, multiply by 2.2046.
[c] High-integrity containers (NUHIC-205) would be transported in a shielded cask, if needed to limit the external dose rate.
[d] Remote-handled Class C and Greater-Than-Class C waste drums are transported in Type B shipping casks. The Greater-Than-Class C waste includes fuel and hardware wastes buried in the NRC-licensed Disposal Area. Class B wastes packaged in drums, are assumed to be transported using shielded cask.
[e] Remote-handled transuranic waste drums must be transported in a Type B cask.
Note: Construction debris and hazardous wastes would be shipped to a local offsite location by truck only.

The commercial sites considered include EnergySolutions for low specific activity and Class A waste, and the Chem-Nuclear Facility in Barnwell or a hypothetical Western site for Class B and Class C waste.

It is also expected that Greater-Than-Class C waste would be generated during the exhumation and closure of the SDA and the pre-WVDP burial areas in the NDA. There is no known disposal facility for this waste at the present time. A disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste will be determined through the *Disposal of Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement (GTCC EIS)* (DOE/EIS-0375). However, for the purposes of analyses in this EIS, it was assumed that Greater-Than-Class C waste could be disposed at Yucca Mountain geological repository. In addition to Yucca Mountain, the *GTCC EIS* will evaluate several other DOE sites and generic commercial locations for the disposal of Greater-Than-Class C waste.

Transuranic and Class A mixed low-level radioactive waste would also be generated during closure activities. Class A mixed low-level radioactive waste is assumed to be disposed of at EnergySolutions under all disposal options. The only disposal location currently approved for transuranic waste is WIPP. WIPP is currently authorized to accept only DOE defense waste, and the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (WIPP SEIS)* (DOE 1997) evaluated disposal of

WVDP transuranic waste. However, DOE is not currently authorized to dispose of WVDP non-defense transuranic waste at WIPP. As stated above, a disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste would be determined through the Record of Decision for the *Disposal of Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375). Nevertheless, for the purposes of analysis only, in this EIS the generated transuranic waste was assumed to be disposed of at WIPP.

J.4.3 Radionuclide Inventories

The details on the volumes and types of generated wastes and potential radioactive inventories at each of the Waste Management Areas (WMAs) are provided in the technical reports and their supporting documents for each of the alternatives (WSMS 2008a, 2008b, 2008c, 2008d), and are summarized in Appendix C of this EIS. As indicated in Appendix C and the related referenced documents, the activities under each alternative would include closure (excavation) or remediation of 12 WMAs, the Cesium Prong, and North Plateau Groundwater Plume; decontamination, demolition, decommissioning of buildings and underground structures; and construction, operation, and demolition of additional support facilities. These activities would result in multiple waste volumes of similar waste class with different radioactive inventories. Among the WMAs, the three largest radionuclide inventories are in the buried waste or equipment in the NDA, SDA, and Waste Tank Farm. Therefore, for the purposes of evaluating transportation accidents, the radionuclide inventories in various waste classes were estimated from radionuclide inventories in these three areas (URS 2000, 2002; WVNS 2005). The radionuclide inventory estimates at these areas were converted to radionuclide concentrations in each waste class based on the estimated disposed waste volumes in the NDA and SDA area, and the expected waste volumes in the Waste Tank Farm. The use of disposed volume would lead to a higher calculated radionuclide concentration than would be expected using that of retrieved volume. The waste retrieval process would lead to a higher waste volume due to cross contamination of the soil around the disposed waste. For similar waste classes with different radionuclide concentrations, the maximum radionuclide concentrations were selected to lead to the greatest radiological hazards for transportation risk assessment. The selected radionuclide concentrations were assumed to represent the concentrations for all similar waste classes that could be generated in other waste management areas. This method was deemed necessary to eliminate producing multiple radionuclide concentrations for the same waste class and to produce an enveloping set of transportation accident risks.

Tables J–3 and **J–4** provide the container radionuclide inventories for each waste class. The list of radionuclides in these tables is limited to those that in sum contribute more than 99 percent of the total dose in an accident. Given the list, the corresponding concentration is derived from waste inventory. Note that values given represent the maximum concentration that could be present in a container. If the actual waste container inventory were to exceed the A_2 limit (10 CFR Part 71 or 49 CFR 173.435), the waste class would be shipped in a Type B cask. Since Class B and Class C wastes could be shipped to a disposal site on the same type of transporter, a conservative inventory applicable to both waste class types was selected and provided in Table J–3. In the absence of a precise waste characterization for the low specific activity waste, the inventory for low specific activity waste was assumed to correspond to a low specific activity waste with the maximum concentration that was disposed of at the SDA.

Table J–3 Low Specific Activity, Class A, B, C and Greater-Than-Class C Waste Container Inventories (curies)

	Low Specific Activity	*Class A LLW*		*Class B and Class C LLW*		*GTCC*
Nuclides	*Lift liner* [a]	*Drum*	*Box* [b]	*Box*	*HIC*	*Drum*
Hydrogen-3	2.84×10^{-2}	1.14×10^{-2}	1.24×10^{-1}	3.72×10^{1}	7.35×10^{1}	2.00
Carbon-14	1.63×10^{-3}	8.44×10^{-5}	9.18×10^{-4}	2.76×10^{-1}	5.45×10^{-1}	1.48×10^{-2}
Iron-55	–	5.12×10^{-5}	5.57×10^{-4}	1.67×10^{-1}	3.30×10^{-1}	8.98×10^{-3}
Cobalt-60	3.10×10^{-3}	1.47×10^{-3}	1.60×10^{-2}	4.80	9.49	2.58×10^{-1}
Nickel-63	–	5.69×10^{-3}	6.20×10^{-2}	1.86×10^{1}	3.67×10^{1}	9.99×10^{-1}
Strontium-90	9.20×10^{-4}	4.12×10^{-4}	4.49×10^{-3}	2.04×10^{-1}	4.03×10^{-1}	1.85
Yttrium-90	9.20×10^{-4}	4.12×10^{-4}	4.49×10^{-3}	2.04×10^{-1}	4.03×10^{-1}	1.85
Cesium-137	1.52×10^{-3}	4.03×10^{-3}	4.39×10^{-2}	1.32×10^{1}	2.60×10^{1}	2.35
Barium-137m	1.44×10^{-3}	3.81×10^{-3}	4.15×10^{-2}	1.25×10^{1}	2.46×10^{1}	2.23
Thorium-234	–	5.29×10^{-5}	5.76×10^{-4}	1.73×10^{-1}	3.41×10^{-1}	2.68×10^{-2}
Uranium-238	–	5.29×10^{-5}	5.76×10^{-4}	1.73×10^{-1}	3.41×10^{-1}	9.28×10^{-3}
Plutonium-238 [c]	1.10×10^{-6}	3.09×10^{-5}	3.37×10^{-4}	1.01×10^{-1}	2.00×10^{-1}	2.67
Plutonium-239 [c]	1.10×10^{-6}	5.08×10^{-5}	5.53×10^{-4}	1.66×10^{-1}	3.28×10^{-1}	3.63×10^{-2}
Plutonium-240 [c]	1.10×10^{-6}	3.02×10^{-5}	3.28×10^{-4}	9.85×10^{-2}	1.95×10^{-1}	1.88×10^{-1}
Plutonium-241 [c]	1.10×10^{-6}	1.07×10^{-3}	1.17×10^{-2}	3.50	6.91	1.05
Americium-241	1.10×10^{-6}	1.21×10^{-4}	1.32×10^{-3}	3.95×10^{-1}	7.80×10^{-1}	1.16×10^{-1}

GTCC = Greater-Than-Class C waste, HIC = high integrity container, LLW = low-level radioactive waste.
[a] The values are curies per cubic meter.
[b] Also used for mixed low-level radioactive waste.
[c] These nuclides were added to the low specific activity waste using similar concentration as that for Americium-241.

Table J–4 Fuel and Hardware, Remote-Handled Class C and Transuranic Container Inventories (curies)

Nuclides	*Fuel/ Hardware*	*Class C-R*	*TRU*	*Nuclides*	*Fuel/ Hardware*	*Class C-R*	*TRU*
Hydrogen-3	3.11	–	–	Neptunium-237	7.94×10^{-3}	2.79×10^{-5}	6.64×10^{-4}
Carbon-14	4.75×10^{-1}	1.42×10^{-6}	1.60×10^{-6}	Uranium-238	1.31×10^{-1}	2.85×10^{-5}	8.93×10^{-6}
Cobalt-60	2.73×10^{1}	–	–	Plutonium-238	1.05×10^{1}	4.01×10^{-3}	1.83×10^{-1}
Strontium-90	1.33×10^{3}	2.16	4.93×10^{1}	Plutonium-239	4.12×10^{1}	7.59×10^{-4}	4.58×10^{-2}
Yttrium-90	1.33×10^{3}	2.16	4.93×10^{1}	Plutonium-240	2.21×10^{1}	5.46×10^{-4}	3.32×10^{-2}
Cesium-137	1.73×10^{3}	6.40×10^{2}	8.82×10^{1}	Plutonium-241	6.71×10^{2}	4.51×10^{-2}	9.85×10^{-1}
Barium-137m	1.64×10^{3}	6.05×10^{2}	8.34×10^{1}	Americium-241	7.99×10^{1}	1.15×10^{-2}	4.81×10^{-1}
				Curium-244	6.26×10^{-1}	2.02×10^{-3}	9.97×10^{-2}

Class C-R = Class C remote-handled waste, TRU = transuranic waste.
The inventories refer to the amount of curies in a 208-liter (55-gallon) drum.

J.5 Incident-free Transportation Risks

J.5.1 Radiological Risk

During incident-free transportation of radioactive materials, radiological dose results from exposure to the external radiation field that surrounds the shipping containers. The population dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the containers.

Radiological impacts were determined for crew members and the general population during incident-free transportation. For truck shipments, the crew members are the drivers of the shipment vehicle. For rail shipments, the crew consists of workers in close proximity to the shipping containers during inspection or classification of railcars. The general population is composed of the persons residing within 800 meters (0.50 miles) of the truck or rail routes (off-link), persons sharing the road or railway (on-link), and persons at stops. Exposures to workers who would load and unload the shipments are not included in this analysis, but are included in the occupational estimates for plant workers. Exposures to the inspectors and escorts are evaluated and presented separately.

Collective doses for the crew and general population were calculated by using the RADTRAN 5 computer code (Neuhauser and Kanipe 2003). The radioactive material shipments were assigned an external dose rate based on their radiological characteristics. Offsite transportation of the radioactive material has a defined regulatory limit of 10 millirem per hour at 2 meters (about 6.6 feet) from the cask (10 CFR 71.47 and 49 CFR 173.441). If a waste container shows a high external dose rate that could exceed the DOT limit of 10 millirem per hour at 2 meters (6.6 feet) from the outer, or lateral, edge of the vehicle, it would be transported in a Type A or Type B shielded shipping container. Waste container dose rate, or its Transport Index, is dependent on distribution and quantities of radionuclides, waste density, shielding provided by the packaging, and self-shielding provided by the waste mixture. The most important gamma-emitting radionuclides in the waste are cobalt-60 and cesium-137. The MicroShield computer program (Grove 2003) was used to estimate the external dose rates for the various waste containers based on the unit concentrations of cobalt-60 and cesium-137. Dose rate calculations were performed assuming both shielded and bare containers. For the shielded option, waste containers were assumed to be in appropriate Type A or Type B shipping containers. For example, Greater-Than-Class C and remote-handled transuranic wastes were assumed to be shipped in a CNS 10-160B or a RH-72B cask (both are Type B casks), and Class C remote-handled waste in a CNS 10-160B cask. Using an enveloping waste composition (i.e., wastes with the highest potential cobalt-60 and/or cesium-137 concentrations) for each waste type, a conservative dose rate for its container was calculated. These dose rates were compared with those used in other DOE NEPA documentation, and an appropriate conservative value was assigned to each waste type. Dose rates for Class A low-level radioactive waste and mixed low-level radioactive waste were assigned at 2 millirem per hour at 1 meter (about 3.3 feet). Dose rate for low specific activity waste was assigned at 0.10 millirem per hour at 1 meter. Dose rate for the remote-handled Class C and Greater-Than-Class C wastes in Type B casks were assigned at 16 millirem per hour at 1 meter. Dose rates for the contact handled Class B and Class C wastes in unshielded B-25 boxes or high integrity containers were also assigned at 16 millirem per hour at 1 meter. The dose rate for the remote-handled transuranic waste in a CNS 10-160B package at 1 meter was assigned at 5 millirem per hour. The dose rate for the contact-handled transuranic[5] waste was assigned at 4 millirem per hour at 1 meter (DOE 1997). In all cases, the maximum external dose rate is less than the regulatory limit of 10 millirem per hour at 2 meters from each container.

To calculate the collective dose, a unit risk factor was developed to estimate the impact of transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors were combined with routing information, such as the shipment distances in various population density zones, to determine the risk for a single shipment (a shipment risk factor) between a given origin and destination. Unit risk factors were developed on the basis of travel on interstate highways and freeways, as required by 49 CFR Part 171 to 177 for highway-route-controlled quantities of radioactive material within rural, suburban, and urban population zones by using RADTRAN 5 and its default data. In addition, the analysis assumed that 10 percent of the time travel through suburban and urban zones would encounter rush-hour conditions, leading to lower average speed and higher traffic density. The unit risk factors for a Transport Index of 1 (i.e., dose rate of 1 millirem per hour at 1 meter [3.3 feet]) from the surface of the

[5] *Note that no contact-handled transuranic waste was identified, however, this dose rate was given for completeness.*

shipping container, or the conveyance, for truck and rail shipments are summarized in **Table J–5**. Note that the size of the waste package and assumptions regarding public shielding afforded by its general housing structure within each zone would be major contributing factors in the calculated dose.

Table J–5 Incident-free Unit Risk Factors for a Dose Rate of 1 Millirem per Hour at 1 Meter from the Shipping Container for Truck and Rail Shipments

Mode	*Exposure Group*	*Unit Risk Factors* [a]		
		Rural	*Suburban* [b]	*Urban* [b]
Truck	Occupational [c] (person-rem per kilometer)	5.33×10^{-6}	5.86×10^{-6}	5.86×10^{-6}
	General Population			
	Off-link [d] (person-rem per kilometer per person per square kilometer)	2.62×10^{-9}	2.50×10^{-9}	5.18×10^{-11}
	On-link [e] (person-rem per kilometer)	7.21×10^{-7}	1.79×10^{-6}	5.66×10^{-6}
	Stops [f] (person-rem per kilometer per person per square kilometer)	2.30×10^{-10}	2.30×10^{-10}	2.30×10^{-10}
	Escorts [g] (person-rem per kilometer)	2.42×10^{-7}	2.55×10^{-7}	2.55×10^{-7}
Rail	Occupational [h] (person-rem per kilometer)	2.10×10^{-7}	2.10×10^{-7}	2.10×10^{-7}
	General Population			
	Off-link [d] (person-rem per kilometer per person per square kilometer)	3.52×10^{-9}	4.90×10^{-9}	1.69×10^{-10}
	On-link [e] (person-rem per kilometer)	8.23×10^{-9}	1.06×10^{-7}	2.94×10^{-7}
	Stops [f] (person-rem per kilometer per person per square kilometer)	8.10×10^{-10}	8.10×10^{-10}	8.10×10^{-10}
	Escorts [i] (person-rem per kilometer)	1.57×10^{-6}	2.52×10^{-6}	4.21×10^{-6}

[a] The methodology, equations, and data used to develop the unit risk factors are discussed in the *RADTRAN 5 User Manual* (Neuhauser and Kanipe 2003). The risk factors provided here are for a truck and rail cask with the following characteristic length and diameters: 5.2-meter (17.06-foot) length and 1.0-meter (3.28-foot) diameter for a truck cask, and 5.06-meter (16.6-foot) length and 2.0-meter (6.56-foot) diameter for a rail cask. Because the characteristics of transuranic waste shipment are different from those used here, the contact-handled transuranic shipment risk factors would be higher than the values given here by a factor of 1.387 and 1.756 for the population dose and crew dose, respectively.
[b] Ten percent of travel within these zones encounters rush-hour traffic with a higher traffic density and a lower speed.
[c] Maximum dose in the truck cabin (crew dose) is 2 millirem per hour, per 10 CFR 71.47, unless the crew member is a trained radiation worker, which would administratively limit the annual dose to 2 rem per year (DOE Administrative Control, DOE-STD-1098-99 [DOE 1999]).
[d] Off-link general population refers to persons within 800 meters (0.50 miles) of the transportation route. The difference in doses between the rural, suburban, and urban populations is due to the assumptions regarding public shielding afforded by its general housing structure within each zone.
[e] On-link general population refers to persons sharing the transportation route.
[f] Dose to residents from frequent stops along the routes.
[g] Escorts (two persons) in a vehicle that follows or leads the truck by 60 meters (about 200 feet). The dose to this vehicle is estimated to be 0.15 millirem per hour for a cask at the regulatory dose limit (i.e., 10 millirem per hour at 2 meters), (DOE 2002a).
[h] Need to add the nonlinear component of incident-free rail dose for crew members because of railcar inspections and classifications, which is 0.000233 person-rem per shipment. *RADTRAN 5 Technical Manual*, Appendix B (Neuhauser et al. 2000), contains an explanation of the rail exposure model.
[i] Escorts (two persons) at a distance of 30 meters (about 100 feet) from the end of the shipping cask. The dose to the escort is estimated to be 0.71 millirem per hour for a cask at the regulatory dose limit (DOE 2002a).
Note: To convert from meters to feet, multiply by 3.281.

The radiological risks from transporting the waste are estimated in terms of the number of LCFs among the crew and the exposed population. A health risk conversion factor of 0.0006 LCFs per person-rem of exposure was used for both the public and workers (DOE 2003a).

J.5.2 Nonradiological Risk

The nonradiological risks, or vehicle-related health risks, resulting from incident-free transport may be associated with the generation of air pollutants by transport vehicles during shipment and are independent of the radioactive nature of the shipment. The health endpoint assessed under incident-free transport conditions is the excess latent mortality due to inhalation of vehicle emissions. Unit risk factors for pollutant inhalation in terms of mortality have been generated (Rao et al. 1982), however, the emergence of considerable data regarding threshold values for various chemical constituents of vehicle exhaust has made linear extrapolation to estimate the risks from vehicle/rail emissions untenable (Neuhauser et al. 2000). This calculation has been dropped from RADTRAN in its recent revision (Neuhauser and Kanipe 2003). Therefore, no risk factors have been assigned to the vehicle emissions in this EIS.

J.5.3 Maximally Exposed Individual Exposure Scenarios

The maximum individual doses for routine offsite transportation were estimated for transportation workers, as well as for members of the general population.

For truck shipments, three hypothetical scenarios were evaluated to determine the MEI in the general population. These scenarios are (DOE 2002a):

- A person caught in traffic and located 1.2 meters (4 feet) from the surface of the shipping container for 30 minutes;
- A resident living 30 meters (98 feet) from the highway used to transport the shipping container; and
- A service station worker at a distance of 16 meters (52 feet) from the shipping container for 50 minutes.

The hypothetical MEI doses were accumulated over a single year for all transportation shipments. However, for the scenario involving an individual caught in traffic next to a shipping container, the radiological exposures were calculated for only one event because it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the maximally exposed transportation worker is the driver who was assumed to have been trained as a radiation worker and to drive shipments for up to 2,000 hours per year, or accumulate an exposure of 2 rem per year. A member of the truck crew would be a non-radiation worker; the maximum annual dose rate for a non-radiation worker is 100 millirem (10 CFR 20.1301).

Three hypothetical scenarios were also evaluated for railcar shipments. They are:

- A rail yard worker working at a distance of 10 meters (33 feet) from the shipping container for 2 hours;
- A resident living 30 meters (98 feet) from the rail line where the shipping container was being transported; and
- A resident living 200 meters (656 feet) from a rail stop during classification and inspection for 20 hours.

For rail shipments, the maximally exposed transportation worker is an individual inspecting the cargo at 1 meter (3.3 feet) from the shipping container for 1 hour.

J.6 Transportation Accident Risks

J.6.1 Methodology

The offsite transportation accident analysis considers the impact of accidents during the transportation of waste by truck or rail. Under accident conditions, impacts on human health and the environment could result from the release and dispersal of radioactive material. Transportation accident impacts were assessed using an accident analysis methodology developed by NRC. This section provides an overview of the methodologies; detailed descriptions of various methodologies are found in the *Radioactive Material Transportation Study,* NUREG-0170, *Modal Study*, NUREG/CR-4829, and *Reexamination Study,* NUREG/CR-6672 (NRC 1977, 1987, 2000). Accidents that could potentially breach the shipping container are represented by a spectrum of accident severities and radioactive release conditions. Historically, most transportation accidents involving radioactive materials have resulted in little or no release of radioactive material from the shipping container. Consequently, the analysis of accident risks takes into account a spectrum of accidents ranging from high-probability accidents of low severity to hypothetical high-severity accidents that have a correspondingly low probability of occurrence. The accident analysis calculates the probabilities and consequences from this spectrum of accidents.

To provide DOE and the public with a reasonable assessment of radioactive waste transportation accident impacts, two types of analysis were performed. First an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of potential accident severities using a methodology developed by the NRC (NRC 1977, 1987, 2000). For the spectrum of accidents considered in the analysis, accident consequences in terms of collective "dose risk" to the population within 80 kilometers (50 miles) were determined using the RADTRAN 5 computer program (Neuhauser et al. 2000). The RADTRAN 5 code sums the product of consequences and probability over all accident severity categories to obtain a probability-weighted risk value referred to in this appendix as "dose risk," which is expressed in units of person-rem. Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, maximum radiological consequences were calculated in an urban or suburban population zone for an accidental release with a likelihood of occurrence greater than 1-in-10 million per year using the RISKIND computer program (Yuan et al. 1995).

For accidents where a waste container or the cask shielding was undamaged, population and individual radiation exposure from the waste package was evaluated for the duration that would be needed to recover and resume shipment. The collective dose over all segments of transportation routes was evaluated for an affected population up to a distance of 800 meters (0.5 miles) from the accident location. This dose is an external dose, and is approximately inversely proportional to the square of the distance of the affected population from accident. Any additional dose to those residing beyond 800 meters (0.5 miles) from the accident would be negligible. The dose to an individual (first responder) was calculated assuming that the individual would be located at 2 to 10 meters (6.6 to 33 feet) from the package. For the accidents leading to loss of cask shielding, a method similar to that provided in the *Reexamination Study* and adapted in the *Yucca Mountain EIS* was used (NRC 2000; DOE 2002b, 2008).

J.6.2 Accident Rates

For the calculation of accident risks, vehicle accident and fatality rates were taken from data provided in *State-Level Accident Rates for Surface Freight Transportation: A Reexamination*, ANL/ESD/TM-150 (Saricks and Tompkins 1999). Accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel in that same year. Therefore, the rate is a fractional value, with accident involvement count as the numerator of the fraction and vehicular activity (total travel distance in truck kilometers) as its denominator. Accident rates were generally determined for a multi-year period. For assessment purposes, the total number of expected accidents or fatalities was calculated by multiplying the total shipment distance for a specific case by the appropriate accident or fatality rate.

For truck transportation, the rates presented are specifically for heavy-haul combination trucks involved in interstate commerce (Saricks and Tompkins 1999). Heavy-haul combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other. Heavy-haul combination trucks are typically used for radioactive material shipments. Truck accident rates were computed for each state based on statistics compiled by the Federal Highway Administration, Office of Motor Carriers, from 1994 to 1996. A fatality caused by an accident is the death of a member of the public who is killed instantly or dies within 30 days due to the injuries sustained in the accident.

For offsite truck transportation, separate accident rates and accident fatality risks were used for rural, suburban, and urban population zones. The values selected were the "mean" accident and fatality rates given in ANL/ESD/TM-150 (Saricks and Tompkins 1999) under interstate, primary, and total categories for rural, suburban, and urban population zones, respectively. The accident rates were 3.15, 3.52, and 3.66 per 10 million truck kilometers, and the fatality rates were 0.88, 1.49, and 2.32 per 100 million truck kilometers for rural, suburban, and urban zones, respectively. For rail transportation, the accident and fatality rates were the mean value rates applicable to all population zones. The rates used in this analysis were 2.74 accidents per 10 million railcar kilometers and 7.82 fatalities per 100 million railcar kilometers.

For local and regional transport, New York State accident and fatality rates were used. The data were provided in ANL/ESD/TM-150 (Saricks and Tompkins 1999). The rates used were 3.45 accidents per 10 million truck kilometers and 1.24 fatalities per 100 million truck kilometers.

J.6.3 Accident Severity Categories and Conditional Probabilities

Accident severity categories for potential radioactive waste transportation accidents are described in the *Radioactive Material Transportation Study* (NRC 1977) for radioactive waste in general, the *Modal Study* (NRC 1987), and the *Reexamination Study* (NRC 2000) for spent nuclear fuel. The methods described in the *Modal Study* and the *Reexamination Study* are applicable to transportation of radioactive materials in a Type B spent fuel cask. The accident severity categories presented in the *Radioactive Material Transportation Study* would be applicable to all other waste transported offsite.

The *Radioactive Material Transportation Study* (NRC 1977) originally was used to estimate conditional probabilities associated with accidents involving transportation of radioactive materials. The *Modal Study* and the *Reexamination Study* (NRC 1987, 2000) are initiatives taken by NRC to refine more precisely the analysis presented in *Radioactive Material Transportation Study* for spent nuclear fuel shipping casks.

Whereas the *Radioactive Material Transportation Study* (NRC 1977) analysis was primarily performed using best engineering judgments and presumptions concerning cask response, the later studies rely on sophisticated structural and thermal engineering analysis and a probabilistic assessment of the conditions that could be experienced in severe transportation accidents. The latter results are based on representative spent nuclear fuel casks assumed to have been designed, manufactured, operated, and maintained according to national codes and standards. Design parameters of the representative casks were chosen to meet the minimum test criteria specified in 10 CFR Part 71. The study is believed to provide realistic, yet conservative, results for radiological releases under transport accident conditions.

In the *Modal Study* and the *Reexamination Study*, potential accident damage to a cask is categorized according to the magnitude of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a cask is subjected to forces within a certain range of values is assigned to the accident severity region associated with that range. The accident severity scheme is designed to take into account all potential foreseeable transportation accidents, including accidents with low probability but high consequences, and those with high probability but low consequences.

As discussed earlier, the accident consequence assessment considers the potential impacts of severe transportation accidents. In terms of risk, the severity of an accident must be viewed in terms of potential radiological consequences, which are directly proportional to the fraction of the radioactive material within a cask that is released to the environment during the accident. Although accident severity regions span the entire range of mechanical and thermal accident loads, they are grouped into accident categories that can be characterized by a single set of release fractions and are, therefore, considered together in the accident consequence assessment. The accident category severity fraction is the sum of all conditional probabilities in that accident category.

For the accident risk assessment, accident "dose risk" was generically defined as the product of the consequences of an accident and the probability of occurrence of that accident, an approach consistent with the methodology used by RADTRAN 5 computer code. The RADTRAN 5 code sums the product of consequences and probability over all accident categories to obtain a probability-weighted risk value referred to in this appendix as "dose risk," which is expressed in units of person-rem.

J.6.4 Atmospheric Conditions

Because it is impossible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. On the basis of observations from National Weather Service surface meteorological stations at over 177 locations in the United States, on an annual average, neutral conditions (Pasquill Stability Classes C and D) occur 58.5 percent of the time, and stable (Pasquill Stability Classes E, F, and G) and unstable (Pasquill Stability Classes A and B) conditions occur 33.5 percent and 8 percent of the time, respectively (DOE 2002a). The neutral weather conditions predominate in each season, but most frequently in the winter (nearly 60 percent of the observations).

Neutral weather conditions (Pasquill Stability Class D) compose the most frequently occurring atmospheric stability condition in the United States and are thus most likely to be present in the event of an accident involving a radioactive waste shipment. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Stable weather conditions are typified by low windspeeds, very little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. The atmospheric condition used in RADTRAN 5 is an average weather condition that corresponds to a stability class spread between Class D (for near distance) and Class E (for farther distance).

The accident consequences for the maximum reasonably foreseeable accident (an accident with likelihood of occurrence greater than 1 in 10 million per year) were assessed under both stable (Class F with a wind speed of 1 meter [3.3 feet] per second) and neutral (Class D with a wind speed of 4 meters [13 feet] per second) atmospheric conditions. The population dose is evaluated under neutral atmospheric conditions and the MEI dose under stable atmospheric conditions. The MEI dose would represent an accident under worst-case weather conditions (stable condition, with minimum diffusion and dilution). The population dose would represent an average weather condition.

J.6.5 Radioactive Release Characteristics

Radiological consequences were calculated by assigning radionuclide release fractions on the basis of the type of waste, the type of shipping container, and the accident severity category. The release fraction is defined as the fraction of the radioactivity in the container that could be released to the atmosphere in a given severity of accident. Release fractions vary according to waste type and the physical or chemical properties of the radioisotopes. Most solid radionuclides are nonvolatile and are, therefore, relatively nondispersible.

Representative release fractions were developed for each waste and container type on the basis of DOE and NRC reports (DOE 1994, 2002b, 2003a; NRC 1977, 2000). The severity categories and corresponding release fractions provided in these documents cover a range of accidents from no impact (zero speed) to impacts with speed in excess of 193 kilometers (120 miles) per hour onto an unyielding surface. Traffic accidents that could occur at the site would be of minor impact due to lower local speed, with no release potential.

For radioactive wastes transported in a Type B cask, the particulate release fractions were developed consistent with the models in the *Reexamination Study* (NRC 2000) and adapted in the *West Valley Demonstration Project Waste Management Environmental Impact Statement* (DOE 2003b). For wastes transported in Type A containers (e.g., 208-liter [55-gallon] drums and boxes), the fractions of radioactive material released from the shipping container were based on recommended values from *Radioactive Material Transportation Study* and *DOE Handbook on Airborne Release and Respirable Fractions* (NRC 1977, DOE 1994). For contact-handled and remote-handled transuranic waste, the release fractions corresponding to the *Radioactive Material Transportation Study* severity categories as adapted in the *WIPP SEIS* were used (DOE 1997, 2002b). For wastes transported in high integrity containers, and lift liners in intermodal (or Sealand) containers, release fractions were calculated using a method similar to that used in the *WIPP SEIS*.

For those accidents where the waste container or cask shielding were undamaged and no radioactive material released, it was assumed that it would take 12 hours to recover from the accident and resume shipment. During this period, no individual would remain close to the cask. A first responder could stay at a location 2 to 10 meters (6.6 to 33 feet) from the package, at a position where the dose rate would be the highest, for 30 minutes in a loss of shielding accident, and 1 hour for other accidents with no release (DOE 2002b).

J.6.6 Acts of Sabotage or Terrorism

In the aftermath of the tragic events of September 11, 2001, DOE is continuing to assess measures to minimize the risk or potential consequences of radiological sabotage. While it is not possible to determine terrorists' motives and targets with certainty, DOE considers the threat of terrorist attack to be real, and makes all efforts to reduce any vulnerability to this threat.

Nevertheless, DOE has evaluated the impacts of acts of sabotage and terrorism on transportation of spent nuclear fuel and high-level radioactive waste shipments (DOE 1996, 2002a). The spectrum of accidents considered ranges from direct attack on the cask from afar to hijacking and exploding the shipping cask in an urban area. Both of these actions would result in damaging the cask and its contents and releasing radioactive materials. The fraction of the materials released is dependent on the nature of the attack (type of explosive or weapon used). The sabotage event evaluated in the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain EIS)* was considered as the enveloping analysis for this EIS. The event was assumed to involve either a truck-sized, or a rail-sized cask containing light water reactor spent nuclear fuel. The consequences of such an act were calculated to result in an MEI dose (at 140 meters [460 feet]) of 40 to 110 rem for events involving rail-sized or truck-sized cask, respectively. These events would lead to an increase in risk of fatal cancer to the MEI by 2 to 7 percent (DOE 2002a). The quantity of radioactive materials transported under all West Valley decommissioning alternatives considered here would be less than that considered in this analysis. Therefore, estimates of risk in the *Yucca Mountain EIS* envelop the risks from an act of sabotage or terrorism involving the radioactive material transported under all alternatives considered in this EIS.

J.7 Risk Analysis Results

Per-shipment risk factors have been calculated for the collective populations of exposed persons and for the crew for all anticipated routes and shipment configurations. Radiological risks are presented in doses per-shipment for each unique route, material, and container combination. Radiological risk factors per-shipment for incident-free transportation and accident conditions are presented in **Table J–6**. For incident-free transportation, both dose and LCF risk factors are provided for the crew and exposed population. The radiological risks would result from potential exposure of people to external radiation emanating from the packaged waste. The exposed population includes the off-link public (i.e., people living along the route), on-link public (i.e., pedestrian and car occupants along the route) and public at rest and fuel stops.

For transportation accidents, the risk factors are given for both the radiological, in terms of potential LCFs in the exposed population, and the nonradiological, in terms of number of traffic fatalities. LCFs represent the number of additional latent fatal cancers among the exposed population. Under accident conditions, the population would be exposed to radiation from released radioactivity if the package is damaged, and would receive direct dose if the package is unbreached. For the accidents with no release, the analysis conservatively assumed that it would take about 12 hours to remove the package and/or vehicle from the accident area (DOE 2002a). Accidents leading to loss of cask shielding would only be applicable to those shipments that use shielded casks, such as shipments of Greater-Than-Class C, remote-handled Class C, and remote-handled transuranic wastes.

As indicated in this table, all risk factors are less than one. This means that no LCF or traffic fatalities are expected to occur during each transport. For example, the risk factors to truck crew and population for transporting one shipment of Class B and Class C waste to Nevada Test Site are given as 3.79×10^{-4} and 1.19×10^{-4} LCFs. This risk can also be interpreted as meaning that there is a chance of 1 in 2,600 that an additional latent fatal cancer could be experienced among the exposed workers from exposure to radiation during one shipment of Class B and Class C waste to Nevada. Similarly, there is a chance of 1 in 8,400 that an additional latent fatal cancer could be experienced among the exposed population residing along the transport route. These are essentially equivalent to zero risk. It should be noted that the maximum allowable dose rate in the truck cabin is less than or equal to 2 millirem per hour, and the maximum annual dose to a commercial truck driver is 100 millirem per year. Therefore an individual receiving a dose of 100 millirem would have an expected risk of developing a latent fatal cancer of 6.0×10^{-5}. The same individual is expected to receive a dose of about 360 millirem per year from background radiation.

Transportation risks were calculated assuming that wastes are transported using either all rail or all truck. DOE could decide to use a combination of both truck and rail for transporting wastes to any of the disposal site options. Shipments involving a combination of rail and truck for a specific shipment would involve workers who would transfer waste containers from railcars to trucks (or visa versa) at an intermodal station. Based on a study of total risk to workers and population from truck only transportation and a combination of truck-rail transportation (PNNL 1999), it is estimated that the total dose to workers and public for a combination of rail and truck shipment is less than would occur if the entire transportation occurred on truck. The accident and fatality rates are per truck-kilometer or railcar-kilometer.

Table J–6 Risk Factors per Shipment of Radioactive Waste

Waste Materials and Mode of Transport	*Transport Destination*	*Incident-Free*				*Accident*	
		Crew Dose (person-rem)	*Crew Risk (LCF)*	*Population Dose (person rem)*	*Population Risk (LCF)*	*Radiological Risk (LCF)*	*Non-radiological Risk (traffic fatalities)*
Truck Shipments							
Class A (B) [a]	Nevada Test Site	7.90×10^{-2}	4.75×10^{-5}	2.49×10^{-2}	1.49×10^{-5}	6.73×10^{-10}	8.18×10^{-5}
Class A (D) [b]		9.50×10^{-2}	5.70×10^{-5}	4.22×10^{-2}	2.53×10^{-5}	1.07×10^{-9}	8.18×10^{-5}
Class B and Class C [c]		6.32×10^{-1}	3.79×10^{-4}	1.99×10^{-1}	1.19×10^{-4}	1.15×10^{-7}	8.18×10^{-5}
Class C (RH) [d]		5.50×10^{-1}	3.30×10^{-4}	6.95×10^{-2}	4.17×10^{-5}	1.42×10^{-9}	8.18×10^{-5}
Low Specific Activity		4.35×10^{-3}	2.61×10^{-6}	8.69×10^{-4}	5.22×10^{-7}	2.15×10^{-10}	8.18×10^{-5}
GTCC [e, f]	Yucca Mountain [f]	3.44×10^{-2}	2.06×10^{-5}	4.34×10^{-3}	2.61×10^{-6}	2.85×10^{-9}	8.18×10^{-5}
GTCC [f, g]		3.21×10^{-1}	1.93×10^{-4}	9.02×10^{-2}	5.41×10^{-5}	6.82×10^{-9}	8.18×10^{-5}
Low Specific Activity	EnergySolutions	3.60×10^{-3}	2.16×10^{-6}	7.16×10^{-4}	4.30×10^{-7}	1.71×10^{-10}	6.79×10^{-5}
Class A (B) [a]		6.55×10^{-2}	3.93×10^{-5}	2.05×10^{-2}	1.23×10^{-5}	5.71×10^{-10}	6.79×10^{-5}
Class A (D) [b]		7.87×10^{-2}	4.72×10^{-5}	3.48×10^{-2}	2.09×10^{-5}	9.08×10^{-10}	6.79×10^{-5}
Class B and Class C [h]	Barnwell	3.49×10^{-1}	2.09×10^{-4}	2.04×10^{-2}	1.22×10^{-5}	6.19×10^{-7}	3.47×10^{-5}
Class C (RH) [d]		2.14×10^{-1}	1.28×10^{-4}	2.75×10^{-2}	1.65×10^{-5}	1.20×10^{-9}	3.47×10^{-5}
RH-TRU [i]	WIPP	1.39×10^{-1}	8.34×10^{-5}	2.14×10^{-2}	1.28×10^{-5}	7.82×10^{-10}	7.01×10^{-5}
Class B and Class C [h]	Hanford Site [j]	9.34×10^{-1}	5.61×10^{-4}	5.16×10^{-2}	3.09×10^{-5}	9.80×10^{-7}	8.44×10^{-5}
Class C (RH) [d]		5.73×10^{-1}	3.44×10^{-4}	7.15×10^{-2}	4.29×10^{-5}	1.38×10^{-9}	8.44×10^{-5}
Rail Shipments							
Class A (B) [a]	Nevada Test Site	6.71×10^{-3}	4.03×10^{-6}	1.09×10^{-2}	6.57×10^{-6}	9.67×10^{-10}	6.50×10^{-4}
Class A (D) [b]		6.06×10^{-3}	3.64×10^{-6}	8.94×10^{-3}	5.36×10^{-6}	1.10×10^{-9}	6.50×10^{-4}
Class B and Class C [c]		5.37×10^{-2}	3.22×10^{-5}	8.75×10^{-2}	5.25×10^{-5}	1.44×10^{-7}	6.50×10^{-4}
Class C (RH) [d]		3.89×10^{-2}	2.34×10^{-5}	4.59×10^{-2}	2.76×10^{-5}	3.74×10^{-9}	6.50×10^{-4}
Low Specific Activity		2.70×10^{-4}	1.62×10^{-7}	3.53×10^{-4}	2.12×10^{-7}	3.22×10^{-10}	6.50×10^{-4}
GTCC [e, f]	Yucca Mountain [f]	2.43×10^{-3}	1.46×10^{-6}	2.87×10^{-3}	1.72×10^{-6}	8.58×10^{-9}	6.50×10^{-4}
GTCC [f, g]		3.41×10^{-2}	2.04×10^{-5}	4.02×10^{-2}	2.41×10^{-5}	2.02×10^{-8}	6.50×10^{-4}
Low Specific Activity	EnergySolutions	2.28×10^{-4}	1.37×10^{-7}	3.48×10^{-4}	2.09×10^{-7}	3.19×10^{-10}	5.36×10^{-4}
Class A (B) [a]		5.67×10^{-3}	3.40×10^{-6}	1.08×10^{-2}	6.48×10^{-6}	9.53×10^{-10}	5.36×10^{-4}
Class A (D) [b]		5.12×10^{-3}	3.07×10^{-6}	8.82×10^{-3}	5.29×10^{-6}	1.09×10^{-9}	5.36×10^{-4}
Class B and Class C [h]	Barnwell	1.57×10^{-2}	9.44×10^{-6}	2.51×10^{-2}	1.51×10^{-5}	1.12×10^{-6}	2.79×10^{-4}
Class C (RH) [d]		1.93×10^{-2}	1.16×10^{-5}	3.79×10^{-2}	2.27×10^{-5}	3.71×10^{-9}	2.79×10^{-4}
RH-TRU	WIPP	9.08×10^{-3}	5.45×10^{-6}	1.30×10^{-2}	7.80×10^{-6}	1.11×10^{-9}	4.63×10^{-4}
Class B and Class C [h]	Hanford Site [i]	3.19×10^{-2}	1.92×10^{-5}	3.20×10^{-2}	1.92×10^{-5}	1.68×10^{-6}	6.56×10^{-4}
Class C (RH) [d]		3.92×10^{-2}	2.35×10^{-5}	4.83×10^{-2}	2.90×10^{-5}	3.95×10^{-9}	6.56×10^{-4}

CH = contact-handled, LCF = latent cancer fatality, RH = remote-handled, TRU = transuranic waste, WIPP = Waste Isolation Pilot Plant, GTCC = Greater-Than-Class C waste, NA = not analyzed.

[a] Class A low-level radioactive waste transported in Type A B-25 boxes.

[b] Class A low-level radioactive waste transported in 208-liter (55-gallon) drums.

[c] Class B and Class C wastes are transported to Nevada Test Site in Type A B-25 boxes. Since these wastes have similar external dose rate and could be transported on the same truck or rail, a single radiological accident risk factor that maximizes the hazards is provided.

[d] Class C Remote-handled Class C wastes are transported in 208-liter (55-gallon) drums.

[e] Greater-Than-Class C waste from contaminations other than those of fuel and hardware stated below.

[f] For purposes of analysis only, Greater-Than-Class C wastes were assumed to be shipped to Yucca Mountain, although there is no disposal site for these wastes at this time. A disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste will be determined through the *Disposal of Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375).

[g] Greater-Than-Class C waste includes the unprocessed irradiated fuel and the hulls and hardware from the processed fuel.

[h] Class B and Class C low-level radioactive wastes are transported to this site in high-integrity containers.

[i] This site is used a proxy for shipment of commercial Class B and Class C wastes to a Western U.S. disposal facility.

Table J–7 provides the estimated number of shipments for various wastes under all alternatives and waste disposal site options. The shipment numbers were calculated using the estimated waste volumes for each waste type as given in Appendix C and summarized in Section 4.1.7 of the EIS, and the waste container and shipment characteristics provided in Table J–2. The shipment numbers are for truck transport of various wastes for the DOE/Commercial Disposal Option (where DOE wastes are disposed of at DOE facilities and commercial wastes are sent to commercial facilities) and the Commercial Disposal Option (where only commercial disposal options are assumed). Some of the wastes would be sent to the commercial sites (both EnergySolutions and Barnwell, or a western U.S. disposal location), irrespective of the disposal site option considered. In the commercial disposal site option, there is no disposition for transuranic and Greater-Than-Class C wastes; no commercial disposal sites are available for these wastes. As explained earlier, a disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste would be determined through the Record of Decision for the *Disposal of Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375). However, for purposes of analysis only, in this EIS, it was assumed that these wastes would be transported to WIPP and Yucca Mountain, respectively.

Both the radiological dose risk factor and nonradiological risk factor for transportation accidents are presented in Table J–6. The radiological and nonradiological accident risk factors are provided in terms of potential fatalities per shipment. The radiological risks are in terms of LCFs. For the population, the radiological risks were calculated by multiplying the accident dose risks by the health risk factor of 6×10^{-4} cancer fatalities per person-rem of exposure. The nonradiological risk factors are nonoccupational traffic fatalities resulting from transportation accidents.

As stated earlier (see Section J.6.3), the accident dose is called "dose risk" because the values incorporate the spectrum of accident severity probabilities and associated consequences (e.g., dose). The accident dose risks are very low because accident severity probabilities (i.e., the likelihood of accidents leading to confinement breach of a package or shipping cask and release of its contents) are small, and the content and form of the wastes (solid dirt-like contamination) are such that would lead to nondispersible and mostly noncombustible release. Although persons are residing in an 80-kilometer (50-mile) radius along the transportation route, they are generally quite far from the route. Because RADTRAN 5 uses an assumption of homogeneous population, it would greatly overestimate the actual doses.

Table J–8 shows the risks of transporting radioactive waste under each alternative. In this table, Barnwell is used as a disposal location for commercial Class B and Class C wastes. **Table J–9** shows the risks of transporting radioactive wastes under each alternative considering a Western U.S. disposal site. This assumption was made to maximize the transportation risks, in light of the uncertainties in waste acceptance at Barnwell, South Carolina, after calendar year 2008. The risks are calculated by multiplying the previously given per-shipment factors by the number of shipments over the duration of the program and, for radiological doses, by the health risk conversion factors. The risks are for the total offsite transport of the radioactive wastes over the entire period under each alternative. As indicated in Chapter 2 of this EIS, there is a large variation in the duration of alternatives ranging from about 10 years (Sitewide Close-In-Place and Phased Decisionmaking Alternatives) to about 60 years (Sitewide Removal Alternative). Review of the sequence of activities under each alternative indicates that except for the Sitewide Removal Alternative where the activities would constantly generate waste requiring offsite transport over a period of about 60 years, the duration of intensive waste generating activities under other alternatives would be less than or equal to 10 years. These activities would occur at the beginning of implementation of the alternatives.

Table J–7 Estimated Number of Truck Shipments Under Each Alternative

Number of Shipments					
DOE/Commercial Disposal Option					
Waste Types	*Assumed Disposal Location*	*Removal Alternative*	*Close-In-Place Alternative*	*Phased Decisionmaking Alternative*	*No Action Alternative* [i]
LSA	NTS/EnergySolutions [j]	93,270	839	10,526	155
Class A [a]	NTS/EnergySolutions [j]	8,382	299	1,472	581
Class A [b]	NTS/EnergySolutions [j]	49	5	28	2
Class B and C [c]	NTS/Commercial [j]	924	0	79	0
Class C-RH [d]	NTS/Commercial [j]	125	35	22	0
Mixed LLW	EnergySolutions	40	28	3	1
GTCC [e]	Yucca	2,357	0	0	0
Transuranic [f]	WIPP	479	19	337	0
Hazardous [g]	Local	3	1	1	3
Other [h]	Local	7,801	1,014	2,315	53
Commercial Disposal Option					
Waste Types	*Assumed Disposal Location*	*Removal Alternative*	*Close-In-Place Alternative*	*Phased Decisionmaking Alternative*	*No Action Alternative* [i]
LSA	EnergySolutions	93,270	839	10,526	155
Class A [a]	EnergySolutions	8,382	299	1,472	581
Class A [b]	EnergySolutions	49	5	28	2
Class B and C [c]	Commercial	1,075	0	221	0
Class C-RH [d]	Commercial	125	35	22	0
Mixed LLW	EnergySolutions	40	28	3	1
GTCC [e]	Yucca	2,357	0	0	0
Transuranic [f]	WIPP	479	19	337	0
Hazardous [g]	Local	3	1	1	3
Other [h]	Local	7,801	1,014	2,315	53

LLW = low-level radioactive waste, RH = remote-handled, GTCC = Greater-Than-Class C waste, NTS = Nevada Test Site.

[a] Class A low-level radioactive waste transported in Type A B-25 boxes.

[b] Class A low-level radioactive waste transported in 208-liter (55-gallon) drums.

[c] Class B and Class C contact-handled wastes are packaged in either high-integrity containers for transport to a Western United States site (for purposes of analysis only), or Type A B-25 boxes for transport to the Hanford Site or NTS.

[d] Class C remote-handled wastes packaged in drums or high-integrity containers and transported in Type B casks. Class-B wastes packaged in drums are also transported in Type B casks.

[e] For purposes of analysis only, it was assumed that GTCC waste would be shipped to Yucca Mountain. Several DOE sites and generic commercial locations are being evaluated in the GTCC EIS as potential disposal locations.

[f] For purposes of analysis only, it was assumed that transuranic waste would be shipped to WIPP.

[g] Hazardous waste would be disposed of at landfills within 160 kilometers (100 miles) of the site.

[h] This includes construction/demolition debris or other wastes that go to local landfills within about 160 kilometers (100 miles) of the site.

[i] Under the No Action Alternative, waste is generated both annually and periodically. Here, for the purposes of comparisons to other alternatives, waste shipments are given for monitoring and maintenance activities over a 25-year period.

[j] DOE waste would go to the Nevada Test Site or EnergySolutions or other appropriate commercial facility. Commercial waste would only go to EnergySolutions or other appropriate commercial facility because commercial wastes cannot be disposed of in a DOE facility.

Note: The values given in this table are for truck shipments. Rail shipments are assumed to be one-half of the number of truck shipments because each rail shipment is assumed to carry twice as much waste as a truck shipment.

Table J–8 Risks of Transporting Radioactive Waste Under Each Alternative [a] (using Barnwell as a disposal site for commercial Class B and C wastes)

Disposal Option	Transport Mode	Number of Shipments	One-way Kilometers Traveled (million)	Incident-Free: Crew Dose (person-rem)	Incident-Free: Crew Risk [b]	Incident-Free: Population Dose (person-rem)	Incident-Free: Population Risk [b]	Accident: Radiological Risk [b]	Accident: Non-radiological Risk [b]
Sitewide Removal Alternative									
DOE/ Commercial	Truck	105,626	360.7	1,602.9	0.96	348.8	0.21	5.6×10^{-4}	7.5
	Rail	52,817	189.4	58.3	0.035	92.5	0.056	5.1×10^{-4}	29.6
Commercial	Truck	105,777	345.0	1,545.6	0.93	318.3	0.191	6.9×10^{-4}	7.2
	Rail	52,891	180.9	55.1	0.033	91.1	0.055	6.3×10^{-4}	28.3
Sitewide Close-In-Place Alternative									
DOE/ Commercial	Truck	1,225	4.4	46.6	0.028	11.0	0.0066	4.4×10^{-7}	0.09
	Rail	615	2.3	1.9	0.0011	2.9	0.0017	3.7×10^{-7}	0.36
Commercial	Truck	1,225	3.9	35.0	0.021	8.9	0.0053	3.8×10^{-7}	0.08
	Rail	615	2.1	1.5	0.0009	2.8	0.0017	3.6×10^{-7}	0.32
Phased Decisionmaking Alternative – Phase 1									
DOE/ Commercial	Truck	12,467	48.8	273.7	0.16	71.4	0.043	1.3×10^{-5}	1.0
	Rail	6,237	25.7	10.6	0.0064	16.3	0.0098	8.4×10^{-6}	4.0
Commercial	Truck	12,609	40.7	265.4	0.16	51.1	0.031	1.4×10^{-4}	0.9
	Rail	6,306	21.3	9.0	0.0054	15.3	0.0092	1.3×10^{-4}	3.3
No Action Alternative [c]									
DOE/ Commercial	Truck	739	2.91	46.9	0.028	14.7	0.0088	4.3×10^{-7}	0.06
	Rail	371	1.54	2.0	0.0012	3.2	0.0019	3.1×10^{-7}	0.24
Commercial	Truck	739	2.4	38.9	0.023	12.1	0.0073	3.6×10^{-7}	0.05
	Rail	370	1.3	1.7	0.001	3.2	0.0019	3.0×10^{-7}	0.20

[a] For purposes of analysis only, the Greater-Than-Class C and transuranic wastes are assumed to be transported to Yucca Mountain and WIPP, respectively. A disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste will be determined through the *Disposal of Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375).
[b] Risk is expressed in terms of LCFs, except for the nonradiological risk, where it refers to the number of traffic accident fatalities.
[c] Under the No Action Alternative, for the purposes of comparisons to other alternatives, transportation impacts are provided for monitoring and maintenance activities over a 25-year period.
Note: To convert kilometers to miles, multiply by 0.62137.

Table J–9 Risks of Transporting Radioactive Waste Under Each Alternative [a] (using a Western U.S. disposal site for commercial Class B and Class C wastes)

Disposal Option	Transport Mode	Number of Shipments	One-way Kilometers Traveled (million)	Incident-Free: Crew Dose (person-rem)	Incident-Free: Crew Risk [b]	Incident-Free: Population Dose (person-rem)	Incident-Free: Population Risk [b]	Accident: Radiological Risk [b]	Accident: Non-radiological Risk [b]
Sitewide Removal Alternative									
DOE/ Commercial	Truck	105,626	362.9	2,098.9	1.26	375.6	0.225	8.6×10^{-4}	7.54
	Rail	52,817	190.4	65.3	0.039	95.5	0.057	7.4×10^{-4}	29.78
Commercial	Truck	105,777	348.1	2,219.7	1.33	357.3	0.21	1.1×10^{-3}	7.2
	Rail	52,891	182.4	65.1	0.039	95.5	0.057	9.4×10^{-4}	28.5
Sitewide Close-In-Place Alternative									
DOE/ Commercial	Truck	1,225	4.4	50.6	0.030	11.5	0.0069	4.4×10^{-7}	0.09
	Rail	615	2.3	1.97	0.0012	2.9	0.0018	3.8×10^{-7}	0.37
Commercial	Truck	1,225	4.0	47.6	0.029	10.4	0.0062	4.0×10^{-7}	0.08
	Rail	615	2.1	1.5	0.0009	2.8	0.0017	3.8×10^{-7}	0.33
Phased Decisionmaking Alternative – Phase 1									
DOE/ Commercial	Truck	12,467	48.8	273.7	0.16	71.4	0.043	1.3×10^{-5}	1.0
	Rail	6,237	25.7	10.6	0.0063	16.3	0.0098	8.4×10^{-6}	4.0
Commercial	Truck	12,609	41.4	402.7	0.24	58.9	0.035	2.2×10^{-4}	0.9
	Rail	6,306	21.6	11.0	0.0066	16.2	0.0097	1.9×10^{-4}	3.4
No Action Alternative [c]									
DOE/ Commercial	Truck	739	2.9	46.9	0.028	14.7	0.0088	4.3×10^{-7}	0.06
	Rail	371	1.5	2.0	0.00119	3.2	0.0019	3.1×10^{-7}	0.2
Commercial	Truck	739	2.4	38.9	0.023	12.1	0.0073	3.6×10^{-7}	0.05
	Rail	370	1.3	1.7	0.001	3.2	0.0019	3.0×10^{-7}	0.2

NTS = Nevada Test Site.

[a] For purposes of analysis only, the Greater-Than-Class C and transuranic wastes are assumed to be transported to Yucca Mountain and WIPP, respectively. A disposal facility for Greater-Than-Class C low-level radioactive waste and potential non-defense transuranic waste will be determined through the *Disposal of Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375).

[b] Risk is expressed in terms of LCFs, except for the nonradiological risk, where it refers to the number of traffic accident fatalities. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003a).

[c] Under the No Action Alternative, for the purposes of comparisons to other alternatives, transportation impacts are provided for monitoring and maintenance activities over a 25-year period.

Note: To convert kilometers to miles, multiply by 0.62137.

The values presented in Tables J–8 and J–9 show that the total radiological risks (the product of consequence and frequency) are very small under all alternatives. It should be noted that the maximum annual dose to a transportation worker would be limited to 100 millirem per year, unless the individual is a trained radiation worker who would have an administrative annual dose limit of 2 rem (DOE 1999).[6] The potential for a trained radiation worker to develop a latent fatal cancer from the maximum annual exposure is 0.0012. Therefore, no individual transportation worker would be expected to develop a latent fatal cancer from exposures during the activities under all alternatives.

[6] *A DOE transportation contractor may choose another dose limit for workers, but this dose is limited to 5 rem per year per 10 CFR 20.1201.*

Nonradiological accident risks (the potential for fatalities as a direct result of traffic accidents) present the greatest risks. Considering that the transportation activities analyzed in this EIS would occur over a 10- to 62-year period and the average number of traffic fatalities in the United States is about 40,000 per year (NHTSA 2006), the traffic fatality risk under all alternatives would be very small.

The risks to various exposed individuals under incident-free transportation conditions have been estimated for hypothetical exposure scenarios identified in Section J.5.3. The estimated doses to workers and the public are presented in **Table J–10**. Doses are presented on a per-event basis (person-rem per event, per exposure, or per shipment), as it is generally unlikely that the same person would be exposed to multiple events. For those individuals that could have multiple exposures, the cumulative dose could be calculated. The maximum dose to a crew member is based on the same individual being responsible for driving every shipment for the duration of the campaign. Note that the potential exists for larger individual exposures under one-time events of a longer duration. For example, the dose to a person stuck in traffic next to a shipment of Class B or Class C wastes for 30 minutes is calculated to be 0.026 rem (26 millirem). This is generally considered a one-time event for that individual. This individual may encounter another exposure of a similar or longer duration in his/her lifetime.

Table J–10 Estimated Dose to Maximally Exposed Individuals Under Incident-Free Transportation Conditions

Receptor	*Dose to Maximally Exposed Individual*
Workers	
Crew member (truck/rail driver)	2 rem per year [a]
Inspector	0.062 rem per event per hour of inspection
Rail yard worker	0.018 rem per event
Public	
Resident (along the rail route)	1.9×10^{-6} rem per event
Resident (along the truck route)	9.3×10^{-7} rem per event
Person in traffic congestion	0.026 rem per event per one-half hour stop
Resident near the rail yard during classification	2.5×10^{-4} rem per event
Person at a rest stop/gas station	2.4×10^{-4} rem per event per hour of stop
Gas station attendant	7.9×10^{-4} rem per event

[a] Maximum administrative dose limit per year for a trained radiation worker (truck/rail crew member).

A member of the public residing along the route would likely receive multiple exposures from passing shipments. The cumulative dose to this resident can be calculated assuming all shipments pass his or her home. The cumulative dose is calculated assuming that the resident is present for every shipment and is unshielded at a distance of 30 meters (about 98 feet) from the route. Therefore, the cumulative dose depends on the number of shipments passing a particular point and is independent of the actual route being considered. If one assumes the maximum resident dose provided in Table J–10 for all waste transport types, then the maximum dose to this resident, if all the materials were to be shipped via this route, would be less than 100 millirem. This dose corresponds to that for truck (or rail) shipments under the Sitewide Removal Alternative, which has an estimated number of shipments of about 105,780 (or 52,890) over about 60 years. This dose translates to less than 2 millirem per year, with a risk of developing a latent fatal cancer of less than 6×10^{-5} over the 60-year duration of transport.

The accident risk assessment and the impacts shown in Tables J–8 and J–9 take into account the entire spectrum of potential accidents, from the fender bender to extremely severe. To provide additional insight into the severity of accidents in terms of the potential dose to a MEI and the public, an accident consequence assessment has been performed for a maximum reasonably foreseeable hypothetical transportation accident with a likelihood of occurrence greater than 1 in 10 million per year. The results, presented in Tables J–8 and J–9, include all conceivable accidents, irrespective of their likelihood.

The following assumptions were used to estimate the consequences of maximum reasonably foreseeable offsite transportation accidents:

- The accident is the most severe with the highest release fraction; high-impact and high-temperature fire accident (highest severity category).
- The individual is 100 meters (330 feet) downwind from a ground release accident.
- The individual is exposed to airborne contamination for 2 hours and ground contamination for 24 hours with no interdiction or cleanup. A stable weather condition (Pasquill Stability Class F) with a wind speed of 1 meter per second (2.2 miles per hour) is considered.
- The population is assumed to be a uniform density to a radius 80 kilometers (50 miles), and exposed to the entire plume passage and 7 days of ground exposure without interdiction and cleanup. A neutral weather condition (Pasquill Stability Class D) with a wind speed of 4 meters per second (8.8 miles per hour) is considered. Since the consequence is proportional to the population density, the accident is assumed to occur in an urban[7] area with the highest density (see Table J–1).
- The number of containers involved in the accident is listed in Table J–2. When multiple Type B or shielded Type A shipping casks are transported in a shipment, a single cask is assumed to have failed in the accident. It is unlikely that a severe accident would breach multiple casks.

Table J–11 provides the estimated dose and risk to an individual and population from a maximum foreseeable truck or rail transportation accident with the highest consequences under each alternative and disposal option. Except for the No Action Alternative and Sitewide Close-In-Place Alternative, the highest consequences for the maximum foreseeable accident are from accidents involving Class B/C waste in a high integrity container in a severe impact in conjunction with a long fire duration. The consequences are driven by the container structural materials, i.e., a poly-hydrocarbon polymer, which in a fire would lead to high airborne releases. Under the No Action and Sitewide Close-In-Place Alternatives, the highest consequences for the maximum foreseeable accident are those involving Class A wastes in boxes.

J.8 Impact of Construction and Operational Material Transport

This section evaluates the impacts of transporting construction/demolition debris and hazardous wastes as well as materials required to construct new facilities, barriers, and erosion controls. The construction materials considered are concrete, cement, sand/gravel/dirt, asphalt, geomembrane fabric, steel, and piping, etc. The impacts were evaluated based on the number of truck shipments required for each of the materials and the distances from their point of origin to the WNYNSC Site. The origins of these materials were assumed to be at an average distance of 160 kilometers (100 miles) from the site. The truck kilometers for all material shipments under each alternative were calculated by summing all of the activities from construction through closure (where applicable). The truck accident and fatality rates were assumed to be those that were provided earlier for the onsite and local area transports. **Table J–12** summarizes the impacts in terms of total number of kilometers, accidents, and fatalities for all alternatives. The results indicate that there are no large differences in the impacts among all alternatives. Under all alternatives, the expected potential traffic fatalities are very low.

[7] *If the likelihood of accident in an urban area is less than 1-in-10 million per year, then the accident is evaluated for a suburban area.*

Table J–11 Estimated Dose to the Population and to Maximally Exposed Individuals Under Most Severe Accident Conditions [a]

Main Disposal Option/ Transport Mode	*Waste Material in the Accident With the Highest Consequences*	*Likelihood of the Accident (per year)*	*Population [b]*		*MEI [c]*	
			Dose (person-rem)	*Risk (LCF)*	*Dose (rem)*	*Risk (LCF)*
Sitewide Removal Alternative						
DOE/Commercial (truck) [d]	Class B and Class C in HIC	6.7×10^{-7}	74.1	0.044	0.15	9.0×10^{-5}
DOE/Commercial (rail)	Class B and Class C in HIC	4.4×10^{-7}	1,186	0.71	0.30	1.8×10^{-4}
Commercial (truck) [d]	Class B and Class C in HIC	8.4×10^{-7}	74.1	0.044	0.15	9.0×10^{-5}
Commercial (rail)	Class B and Class C in HIC	5.8×10^{-7}	1,186	0.71	0.30	1.8×10^{-4}
Sitewide Close-In-Place Alternative						
DOE/Commercial (truck) [d]	Class A in Box	5.9×10^{-7}	0.020	1.2×10^{-5}	3.6×10^{-5}	2.2×10^{-8}
DOE/Commercial (rail) [d]	Class A in Box	1.1×10^{-7}	0.054	3.2×10^{-5}	7.2×10^{-5}	4.3×10^{-8}
Commercial (truck) [d]	Class A in Box	6.6×10^{-7}	0.020	1.2×10^{-5}	3.6×10^{-5}	2.2×10^{-8}
Commercial (rail) [d]	Class A in Box	1.3×10^{-7}	0.054	3.2×10^{-5}	7.2×10^{-5}	4.3×10^{-8}
Phased Decisionmaking Alternative						
DOE/Commercial (truck) [d]	Class B and Class C in Box	2.0×10^{-7}	6.13	0.0037	0.011	6.6×10^{-6}
DOE/Commercial (rail) [d, e]	Class B and Class C in Box	3.5×10^{-8}	16.4	0.0098	0.022	1.3×10^{-5}
Commercial (truck)	Class Band Class C in HIC	1.0×10^{-7}	593	0.356	0.15	9.0×10^{-5}
Commercial (rail)	Class B and Class C in HIC	6.6×10^{-7}	1,186	0.71	0.30	1.8×10^{-4}
No Action Alternative						
DOE/Commercial (truck) [d]	Class A in Box	4.8×10^{-7}	0.020	1.2×10^{-5}	3.6×10^{-5}	2.2×10^{-8}
DOE/Commercial (rail) [d, e]	Class A in Box	8.4×10^{-8}	0.054	3.2×10^{-5}	7.2×10^{-5}	4.3×10^{-8}
Commercial (truck) [d]	Class A in Box	4.2×10^{-7}	0.020	1.2×10^{-5}	3.6×10^{-5}	2.2×10^{-8}
Commercial (rail) [d, e]	Class A in Box	8.3×10^{-8}	0.054	3.2×10^{-5}	7.2×10^{-5}	4.3×10^{-8}

HIC = high-integrity container, LCF = latent cancer fatality, MEI = maximally exposed individual, NTS = Nevada Test Site.

[a] The frequencies are based on using a Western U.S. disposal site for commercial Class B and Class C wastes. If Barnwell is used, the frequencies would be smaller.

[b] Population extends at a uniform density to a radius of 80 kilometers (50 miles). The weather condition was assumed to be Pasquill Stability Class D with a wind speed of 4 meters per second (8.8 miles per hour). Unless otherwise noted, the population doses and risks are presented for an urban area on the transportation route.

[c] The MEI is assumed to be 100 meters (300 feet) downwind from the accident and exposed to the entire plume of the radioactive release. The weather condition is assumed to be Pasquill Stability Class F with a wind speed of 1 meter per second (2.2 miles per hour).

[d] Population dose and risk are for a suburban area along the route. The probability of a maximum foreseeable accident in an urban area along the transportation route is less than 10^{-7} per year.

[e] This accident would have a likelihood of less than 1 in 10 million. It is only provided for completeness.

Table J–12 Estimated Impacts of Construction and Operational Material Transport

Alternative	*Total Distance Traveled (kilometers)*	*Number of Accidents*	*Number of Fatalities*
Sitewide Removal	75.98×10^{6}	26.21	0.94
Sitewide Close-In-Place	79.14×10^{6}	27.30	0.98
Phased Decisionmaking	7.95×10^{6}	2.74	0.10
No Action	0.018×10^{6}	0.006	0.0004

Note: To convert from kilometers to miles, multiply by 0.6214.

J.9 Conclusions

Based on the results presented in the previous section, the following conclusions have been reached (see Tables J–6, and J–9 through J–11):

- It is unlikely that the transportation of radioactive waste would cause an additional fatality as a result of radiation, either from incident-free operation or postulated transportation accidents.
- The highest risk to the public would be under the Sitewide Removal Alternative, NTS disposal site option, where about 105,780 truck or 52,890 rail shipments of radioactive wastes would be transported to Hanford and other commercial (i.e., EnergySolutions and a Western U.S. site) and Government (i.e., assumed, for analysis only, to WIPP and Yucca Mountain) disposal sites.
- The lowest risk to the public would be under the Sitewide Close-In-Place Alternative, commercial disposal site option, where about 1,230 truck or 615 rail shipments of radioactive wastes would be transported to commercial (i.e., EnergySolutions and a Western U.S. site) disposal sites.
- The nonradiological accident risks (the potential for fatalities as a direct result of traffic or rail accidents) present the greatest risks. The maximum risks would occur under the Sitewide Removal Alternative using rail shipments. Considering that the transportation activities would occur over a period of time from about 10 to 60 years and that the average number of traffic fatalities in the United States is about 40,000 per year, the traffic fatality risks under all alternatives are very small.

J.10 Long-term Impacts of Transportation

The *Yucca Mountain EIS* (DOE 2002a, 2008) analyzed the cumulative impacts of the transportation of radioactive material, consisting of impacts of historical shipments of radioactive waste and spent nuclear fuel, reasonably foreseeable actions that include transportation of radioactive material, and general radioactive material transportation that is not related to a particular action. The collective dose to the general population and workers was the measure used to quantify cumulative transportation impacts. This measure of impact was chosen because it may be directly related to the LCFs using a cancer risk coefficient. **Table J–13** provides a summary of the total worker and general population collective doses from various transportation activities. The table shows that the impacts of this program are quite small compared with the overall transportation impacts. The total collective worker dose from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) was estimated to be about 386,500 person-rem (232 LCFs) for the period 1943 through 2073 (131 years). The total general population collective dose was also estimated to be about 350,800 person-rem (210 LCFs). The majority of the collective dose for workers and the general population was due to the general transportation of radioactive material. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level waste to commercial disposal facilities. The total number of LCFs (among the workers and the general population) estimated to result from radioactive material transportation over the period between 1943 and 2073 is about 440, or an average of about 4 LCFs per year. Over this same period (131 years), approximately 73 million people would die from cancer, based on the National Center for Heath Statistics data. The average annual number of cancer deaths in the United States is about 554,000, with less than 1 percent fluctuation in the number of cancer fatalities in any given year (CDC 2007). The transportation-related LCFs would be 0.0006 percent of the total number of LCFs; therefore, it is indistinguishable from the natural fluctuation in the total annual death rate from cancer.

Table J–13 Cumulative Transportation-related Radiological Collective Doses and Latent Cancer Fatalities (1943 to 2047)

Category	*Collective Worker Dose (person-rem)*	*Collective General Population Dose (person-rem)*
Transportation Impacts in this EIS	2,220 [a]	376 [a]
Other Nuclear Material Shipments		
Historical	330	230
Reasonably Foreseeable Actions	28,000	49,000
General Radioactive Material Transport (1943 to 2073)	350,000	300,000
Yucca Mountain EIS [b] (maximum transport) (up to 2073)	5,900	1,200
Total Collective Dose [c] (up to 2073)	386,500	350,800
Total Latent Cancer Fatalities [d]	232	210

[a] Maximum values from Tables J–9.
[b] Impacts for the Proposed Action in the *Draft Yucca Mountain Supplemental EIS* (DOE 2008 Table 8-14). [Similar impacts in the *Yucca Mountain EIS* (DOE 2002a) were 4,600 and 1,600 person-rem for workers and population, respectively.] If DOE decides to expand the program to include all potential high-level and Greater-Than-Class C wastes and spent nuclear fuel (e.g., implement inventory Module 2), then the worker and public doses would be about 20,000 and 3,500 person-rem, respectively.
[c] The values are rounded to the nearest hundred.
[d] Total latent cancer fatalities are calculated assuming 0.0006 latent cancer fatalities per rem of exposure.
Sources: DOE 2002a, 2008.

J.11 Uncertainty and Conservatism in Estimated Impacts

The sequence of analyses performed to generate the estimates of radiological risk for transportation includes (1) determination of the inventory and characteristics, (2) estimation of shipment requirements, (3) determination of route characteristics, (4) calculation of radiation doses to exposed individuals (including estimating of environmental transport and uptake of radionuclides), and (5) estimation of health effects. Uncertainties are associated with each of these steps. Uncertainties exist in the way that the physical systems being analyzed are represented by the computational models; in the data required to exercise the models (due to measurement errors, sampling errors, natural variability, or unknowns caused simply by the future nature of the actions being analyzed); and in the calculations themselves (e.g., approximate algorithms used by the computers).

In principle, one can estimate the uncertainty associated with each input or computational source and predict the resultant uncertainty in each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result; however, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible, especially for actions to be initiated at an unspecified time in the future. Instead, the risk analysis is designed to ensure, through uniform and judicious selection of scenarios, models, and input parameters, that relative comparisons of risk among the various alternatives are meaningful. In the transportation risk assessment, this design is accomplished by uniformly applying common input parameters and assumptions to each alternative. Therefore, although considerable uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative, much less uncertainty is associated with the relative differences among the alternatives in a given measure of risk.

In the following sections, areas of uncertainty are discussed for the assessment steps enumerated above. Special emphasis is placed on identifying whether the uncertainties affect relative or absolute measures of risk. The reality and conservatism of the assumptions are addressed. Where practical, the parameters that most significantly affect the risk assessment results are identified.

J.11.1 Uncertainties in Material Inventory and Characterization

The inventories and the physical and radiological characteristics are important input parameters to the transportation risk assessment. The potential number of shipments for all alternatives is primarily based on the projected dimensions of package contents, the strength of the radiation field, the heat that must be dissipated, and assumptions concerning shipment capacities. The physical and radiological characteristics are important in determining the material released during accidents and the subsequent doses to exposed individuals through multiple environmental exposure pathways.

Uncertainties in the inventory and characterization are reflected in the transportation risk results. If the inventory is overestimated (or underestimated), the resulting transportation risk estimates are also overestimated (or underestimated) by roughly the same factor. However, the same inventory estimates are used to analyze the transportation impacts of each of the alternatives. Therefore, for comparative purposes, the observed differences in transportation risks among the alternatives, as given in Tables J–8 and J–9, are believed to represent unbiased, reasonably accurate estimates from current information in terms of relative risk comparisons.

J.11.2 Uncertainties in Containers, Shipment Capacities, and Number of Shipments

The transportation required for each alternative is based in part on assumptions concerning the packaging characteristics and shipment capacities for commercial trucks. Representative shipment capacities have been defined for assessment purposes based on probable future shipment capacities. In reality, the actual shipment capacities may differ from the predicted capacities such that the projected number of shipments and, consequently, the total transportation risk, would change. However, although the predicted transportation risks would increase or decrease accordingly, the relative differences in risks among alternatives would remain about the same.

J.11.3 Uncertainties in Route Determination

Analyzed routes have been determined between all origin and destination sites considered in the EIS. The routes have been determined to be consistent with current guidelines, regulations, and practices, but may not be the actual routes that would be used in the future. In reality, the actual routes could differ from the representative ones with regard to distances and total population along the routes. Moreover, because materials could be transported over an extended time starting at some time in the future, the highway infrastructure and the demographics along routes could change. These effects have not been accounted for in the transportation assessment; however, it is not anticipated that these changes would significantly affect relative comparisons of risk among the alternatives considered in the EIS. Specific routes cannot be identified in advance because the routes are classified to protect national security interests.

J.11.4 Uncertainties in the Calculation of Radiation Doses

The models used to calculate radiation doses from transportation activities introduce a further uncertainty in the risk assessment process. Estimating the accuracy or absolute uncertainty of the risk assessment results is generally difficult. The accuracy of the calculated results is closely related to the limitations of the computational models and to the uncertainties in each of the input parameters that the model requires. The single greatest limitation facing users of RADTRAN, or any computer code of this type, is the scarcity of data for certain input parameters. Populations (off-link and on-link) along the transportation routes, shipment surface dose rates, and individuals residing near the routes are the most uncertain data in dose calculations. In preparing these data, one makes assumptions that the off-link population is uniformly distributed; the on-link population is proportional to the traffic density, with an assumed occupancy of two persons per car; the shipment surface dose rate is the maximum allowed dose rate; and a potential exists for an individual to be residing at the edge of the highway. It is clear that not all assumptions are accurate. For example, the off-link population is mostly heterogeneous, and the on-link traffic density varies widely within a geographic zone (i.e., urban, suburban, or rural). Finally, added to this complexity are the assumptions regarding the expected distance between the public and the shipment at a traffic stop, rest stop, or traffic jam and the afforded shielding.

Uncertainties associated with the computational models are reduced by using state-of-the-art computer codes that have undergone extensive review. Because many uncertainties are recognized but difficult to quantify, assumptions are made at each step of the risk assessment process intended to produce conservative results (i.e., overestimate the calculated dose and radiological risk). Because parameters and assumptions are applied consistently to all alternatives, this model bias is not expected to affect the meaningfulness of relative comparisons of risk; however, the results may not represent risks in an absolute sense.

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APPENDIX K
METHOD FOR ESTIMATING NONRADIOLOGICAL AIR QUALITY IMPACTS

APPENDIX K
METHOD FOR ESTIMATING NONRADIOLOGICAL AIR QUALITY IMPACTS

K.1 Introduction

This appendix presents the methodology used to estimate nonradiological air quality concentrations for each alternative evaluated in this environmental impact statement (EIS). Air quality impacts were assessed by estimating onsite and offsite concentrations of criteria and toxic air pollutants of environmental concern and comparing them to Federal and State health-based ambient air quality standards. Sources for potential air quality impacts include particulate matter (PM) generated by onsite activities and combustion product releases from operating construction equipment and other equipment and vehicles. The extent of the activities and modeled results varies among the alternatives, with the highest peak year emissions under the Sitewide Close-In-Place Alternative for most pollutants, and the lowest peak year emissions under the No Action or Phased Decisionmaking Alternatives.

Ambient air quality monitoring is conducted in the region to demonstrate that air emissions do not result in violation of the ambient air quality standards. The State of New York has adopted ambient air quality standards for carbon monoxide, sulfur dioxide, and nitrogen dioxide comparable to the National Ambient Air Quality Standards (NAAQS) set by the U.S. Environmental Protection Agency (EPA) to protect public health and welfare. In addition, the State has adopted ambient standards for suspended particulate, settleable particulates, nonmethane hydrocarbons, fluorides, beryllium, and hydrogen sulfide. The State uses the annual standard for suspended particulate (PM with an aerodynamic diameter less than or equal to 10 micrometers [PM_{10}]) of 45 micrograms per cubic meter for prediction purposes. The State has not yet adopted the 8-hour ozone standard or the $PM_{2.5}$ (PM with an aerodynamic diameter less than or equal to 2.5 micrometers) standard. For the purpose of analysis, the more restrictive of the Federal and State ambient standards, as shown in **Table K–1,** is used for assessing compliance and potential for impacts on public health and welfare (40 *Code of Federal Regulations* [CFR] 50, New York Code of Rules and Regulations – 6 NYCRR Part 257). The Western New York Nuclear Service Center (WNYNSC) and the surrounding area in Cattaraugus County are in attainment for all regulated pollutants as described in Chapter 3, except for the northern portion of WNYNSC in Erie County, which is classified as nonattaining for the ozone 8-hour standard. The city of Buffalo, located about 48 kilometers (30 miles) from WNYNSC, and Erie and Niagara Counties, are designated as nonattainment areas for ozone (8-hour averaging). The NAAQS are health-based and generally require that short-term (1 to 24 hours) and annual average concentrations of certain common criteria pollutants do not exceed specified levels. These levels were established at concentrations EPA has determined are "necessary, with an adequate margin of safety, to protect the public health" (40 CFR Part 50.2, "National Primary and Secondary Ambient Air Quality Standards"). These standards, or more restrictive State standards, were used as a basis for comparing the nonradiological air impacts of implementing each alternative.

Five nonradiological air pollutants are of potential concern under the alternatives: nitrogen dioxide, sulfur dioxide, PM_{10}, $PM_{2.5}$, and carbon monoxide. Lead would be produced in such small quantities under the alternatives considered that it was not considered in this analysis. Ozone is not directly emitted, but results from emissions of precursor pollutants, including nitrogen dioxide and volatile organic compounds. These pollutants are quantified in this analysis, and nitrogen dioxide is evaluated separately. Toxic pollutants, including benzene, toluene, xylenes, and other pollutants, are emitted from gasoline-fueled equipment. For the purpose of this EIS, benzene was evaluated as one of the primary toxic pollutants from gasoline equipment. To evaluate the effect of activities on ambient air quality, the following criteria pollutants were modeled using the EPA dispersion model Industrial Source Complex Short Term 3 (ISCST3): carbon monoxide, nitrogen dioxide, PM_{10}, $PM_{2.5}$, and sulfur dioxide (EPA 1995, 2002, 2003a). Concentrations of benzene were also modeled. Modeling results presented in this appendix are derived from emission estimates for the alternatives based on information in the technical reports prepared for each alternative and regional and site-specific meteorological data. Emissions reported in the technical reports represent a conservative (worst-case) estimate for compiling emissions during closure because it was assumed that no mitigative measure to control emissions would be used, except 75 percent control of fugitive dust on unpaved roads using chemical controls and water sprays (EPA 2006). Generally, the use of mitigative control measures during mining, excavation, grading, and construction can reduce fugitive dust and PM_{10} emissions by as much as 80 percent (EPA 2003b). The emissions inventory included fugitive dust as total suspended particulates. It was assumed 36 percent of total suspended particulates could be considered to be PM_{10} (EPA 2006) for the fugitive dust component of the emissions inventory, and that 10 percent of PM_{10} was $PM_{2.5}$ (MRI 2006).

Table K–1 Applicable Ambient Air Quality Standards

Pollutant	*Averaging Period*	*Most Stringent Standard [a] (micrograms per cubic meter)*
Carbon monoxide	8-hour 1-hour	10,000 [b] 40,000 [b]
Nitrogen dioxide	Annual	100 [b]
PM_{10} [c]	Annual 24-hour	45 [d] 150 [b]
$PM_{2.5}$	Annual 24-hour	15 [e] 35 [e]
Sulfur dioxide	Annual 24-hour [f] 3-hour [f]	80 [b] 365 [b] 1,300 [b]
Benzene	Annual 1-hour	0.13 [g] 1,300 [g]

PM_n = particulate matter less than or equal to n micrometers in aerodynamic diameter.

[a] The more stringent of the Federal and New York State standards is presented if both exist for the averaging period. The NAAQS (40 CFR 50), other than those for ozone, particulate matter, lead, and those based on annual averages, are not to be exceeded more than once per year. The 24-hour PM_{10} standard is attained when the standard is not exceeded more than once per year over a 3-year average. The annual $PM_{2.5}$ standard is attained when the 3-year average of the weighted annual mean concentration does not exceed the standard. The 24-hour $PM_{2.5}$ standard is attained when the 3-year average of the 98th percentile of the 24-hour concentrations does not exceed the standards. The 8-hour ozone standard is met when the average of the annual fourth-highest daily maximum 8-hour average concentration is less than or equal to the standard (40 CFR 50).

[b] Federal and New York State standard.

[c] New York State also has particulate matter (PM_{10}) standards, applicable to this area, for 30-, 60-, and 90-day averaging periods of 80, 70, and 65 micrograms per cubic meter, respectively, but assesses the prediction of conformity on the annual average concentration.

[d] New York State standard.

[e] Federal standard.

[f] New York State also has 3- and 24-hour standards for sulfur dioxide, which are met when 99 percent of the concentrations during a year do not exceed the standard value. For the purpose of assessing predicted conformity, the State considers meeting the standards shown (not to be exceeded more than once per year) to be adequate.

[g] New York State air toxic guidance.

Sources: 40 CFR 50, 6 NYCRR 257, NYSDEC 2003.

Emissions were estimated for shipment of waste and other materials for each alternative based on the number of shipments, total travel distances, and emission factors for heavy-duty diesel trucks. The emission factors were calculated using EPA's MOBILE 6.2 vehicle emission factor model (EPA 2003c). These calculations were based on the higher of the truck shipment numbers presented in Chapter 4, Section 4.1.12, of this EIS. Emissions for rail shipment were not calculated because the fuel efficiency of rail shipments is higher than truck shipments, being on average approximately three or more times more fuel efficient than trucks

(AAR 2008). Thus, the corresponding emissions from rail shipments on a ton-mile basis would be expected to be less than the truck shipments reported in this EIS by a factor of three or more.

K.2 Model Description

A dispersion modeling approach using ISCST3 (EPA 1995, 2002) was used to estimate nonradiological pollutant (i.e., carbon monoxide, nitrogen dioxide, PM_{10}, $PM_{2.5}$, sulfur dioxide, and benzene) concentrations at the WNYNSC boundary and along public roads through WNYNSC (see Chapter 3, Figure 3–2, of this EIS for the boundary and nearby roads). Emission rates by pollutant, activity, and year were used to estimate maximum concentrations. The ISCST3 is an EPA dispersion model applicable to areas in complex terrain. U.S. Geological Survey Digital Elevation Model data for the region were used to determine receptor elevations for a polar grid having 16 compass directions (22.5 degrees from north through 360 degrees) at 5 different radial distances (1.6, 3.2, 4.8, 6.4, and 8.0 kilometers [1, 2, 3, 4, and 5 miles]) from the center of the grid. The center of the grid was chosen to be a point centrally located in the West Valley Demonstration Project (WVDP) and was located near the southwest corner of Waste Management Area (WMA) 2. In addition, elevations were determined for special receptors in each direction at the nearest public access (road) and at the WNYNSC boundary. **Tables K–2** and **K–3** summarize the direction, distance, and elevation of each modeled receptor location (directions for the polar grid are shown in **Figure K–1** for reference). The use of the elevation data is discussed in the *ISCST3 User's Guide* (EPA 1995). Where there is elevated simple terrain, the ISCST3 model assumes the mixing height follows the terrain, and the plume stays at the same elevation. The wind speed is a function of height above the surface. Initial runs were made that indicated that the maximum concentrations would occur at the roadway receptors or the WNYNSC boundary. Therefore, concentration runs for each pollutant and alternative were made only for the roadway and WNYNSC boundary receptors.

Table K–2 Elevations at Polar Grid Receptors for ISCST3 Modeling (meters)

Compass Orientation		*Downwind Distance*				
Heading	*Direction*	*1,600*	*3,200*	*4,800*	*6,400*	*8,000*
22.5°	NNE	402	434	391	364	408
45.0°	NE	421	497	486	434	424
67.5°	ENE	440	498	481	518	570
90.0°	E	458	472	479	546	629
112.5°	ESE	426	434	566	540	605
135.0°	SE	422	412	443	561	627
157.5°	SSE	438	442	579	527	603
180.0°	S	462	581	546	610	588
202.5°	SSW	537	557	581	522	590
225.0°	SW	516	533	426	552	538
247.5°	WSW	538	494	414	452	492
270.0°	W	527	476	388	421	469
292.5°	WNW	474	422	409	395	329
315.0°	NW	460	413	389	410	410
337.5°	NNW	412	372	399	420	441
360.0°	N	360	414	363	418	423

Note: To convert meters to feet, multiply by 3.2808.

Table K–3 Elevations at Special Receptor Locations for ISCST3 Modeling (meters)

Compass Orientation		*Nearest Public Access* [a]		*Service Center Fence Line*	
Heading	*Direction*	*Distance*	*Elevation*	*Distance*	*Elevation*
22.5°	NNE	1,067	369	1,638	409
45.0°	NE	914	373	1,372	421
67.5°	ENE	838	378	1,753	421
90.0°	E	991	378	2,286	457
112.5°	ESE	1,105	386	2,438	436
135.0°	SE	1,181	419	2,629	421
157.5°	SSE	914	423	2,515	500
180.0°	S	838	434	2,286	494
202.5°	SSW	495	439	2,248	530
225.0°	SW	381	442	2,210	555
247.5°	WSW	381	445	1,676	536
270.0°	W	457	427	1,524	524
292.5°	WNW	610	439	1,295	476
315.0°	NW	1,372	442	1,524	451
337.5°	NNW	1,905	375	1,905	375
360.0°	N	1,295	369	2,248	396

[a] Although receptors were included along the rail line (receptors in direction NNW through ESE) they were not included in the analysis of short-term concentrations, since this rail line is not in use by the public.

Note: To convert meters to feet, multiply by 3.2808.

The input parameters for ISCST3 include hourly meteorological data, upper air data, receptor location, terrain elevation, emission rate, and source location. Site-specific data for the period 1998 through 2002 were obtained from the onsite meteorological station. This was the most recent dataset available when the analysis was begun and is considered to be representative of the site. Upper air data (twice-daily mixing heights) were obtained for the Buffalo National Weather Service Station for 1998 through 2002. The surface and upper air datasets were preprocessed using an EPA code, Meteorological Processor for Regulatory Models (EPA 1996, 1999), to format the data for use in ISCST3.

The mixing height data are derived values, presented twice daily, and were obtained from the National Climatic Data Center, Asheville, North Carolina (EPA). The Buffalo station was selected because it is most representative of the WNYNSC location (latitude and longitude) and station elevation.

Values for total emissions by alternative by year were calculated using data from the technical reports (WSMS 2008a, 2008b, 2008c, 2008d). These emission estimates were calculated using EPA emission factors as discussed in the technical reports (WSMS 2008e). Emission rates were annualized and converted to grams per second for each alternative. For the purpose of analysis, it was assumed that the work schedule included an 8-hour workday, 7-day workweek, and 52 workweeks per year. If the activities were to be conducted over only a 5-day week, this would result in concentrations 40 percent higher. Annual emissions by alternative used as input to the modeling are summarized in **Table K–4**. Annual emissions for similar activities that occur under more than one alternative vary as a result of the duration of the activity under each alternative. Descriptions of the activities as they would occur under each alternative are provided in Chapter 2 of this EIS. To conservatively estimate impacts, it was assumed that all implementation actions during each year would occur simultaneously.

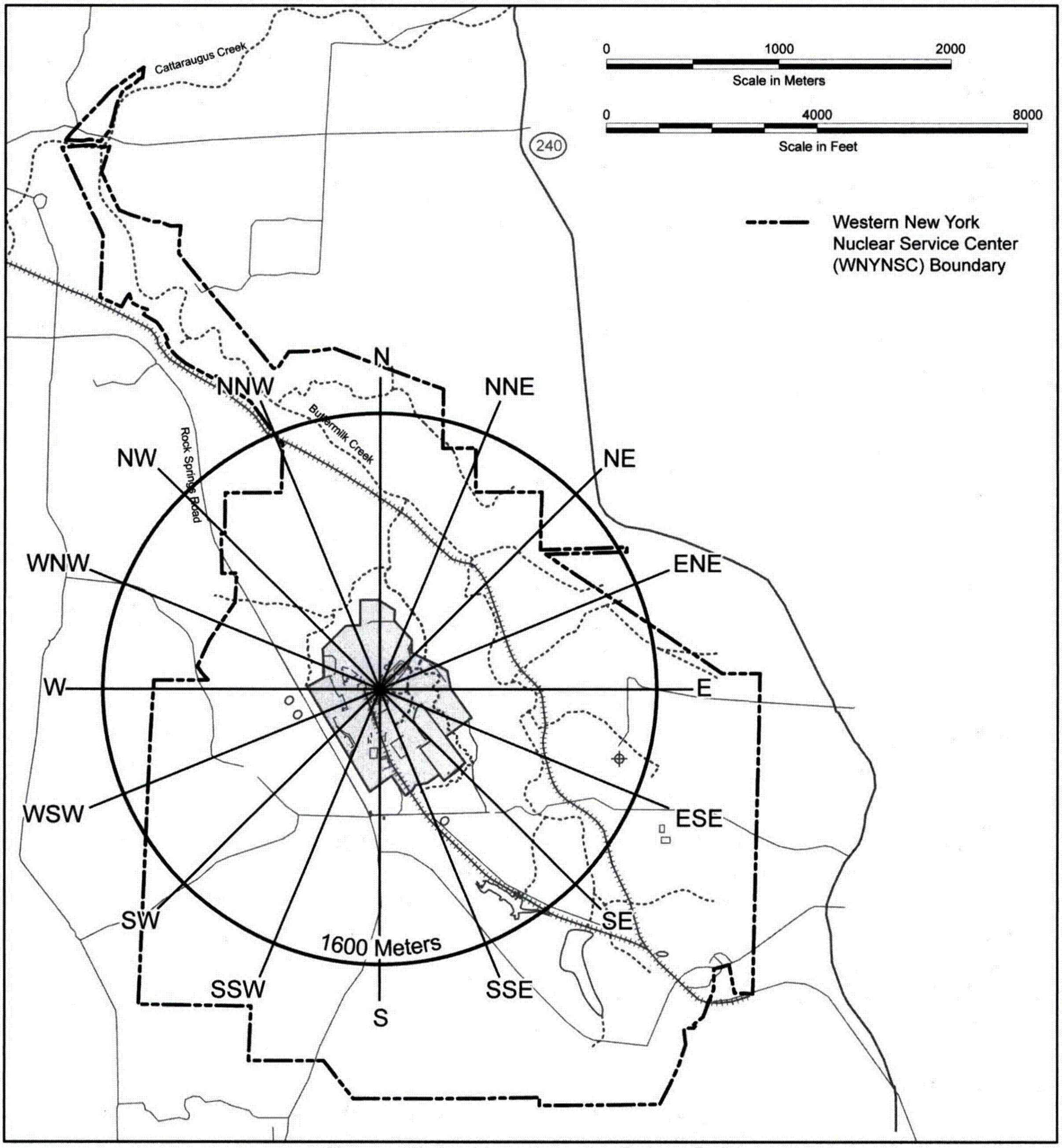

Figure K–1 Directions for Polar Grid

Table K–4 Emissions in Tons Per Year by Alternative

Activities for Each Alternative	*Period*		*Emissions*						
	Start Year	*End Year*	*Carbon Monoxide (tons per year)*	*Nitrogen Dioxide (tons per year)*	*PM_{10} (tons per year)*	*$PM_{2.5}$ (tons per year)*	*Sulfur Dioxide (tons per year)*	*Benzene (tons per year)*	*Nonmethane Hydrocarbons (tons per year)*
Sitewide Removal Alternative									
High-level Radioactive Waste Canister Removal – Construction of Dry Cask Storage Area	4	6	0.34	0.47	0.18	0.04	0.00	0.00	0.06
High-level Radioactive Waste Canister Removal – Load-In/Load-Out Modification and Operation	4	6	0.18	0.22	0.02	0.02	0.00	0.00	0.01
High-level Radioactive Waste Canister Removal – Operation of Dry Cask Storage Area	6	35	0.03	0.04	0.00	0.00	0.00	0.00	0.00
High-level Radioactive Waste Canister Removal – Demolition of Dry Cask Storage Area	36	38	0.2	0.34	0.23	0.04	0.00	0.00	0.06
WMA 1 Closure – Surface Structure Removal	6	13	4.03	2.92	3.95	0.71	0.01	0.00	0.58
WMA 1 Closure – Subsurface Soil Removal	13	18	0.49	0.72	1.86	0.31	0.00	0.00	0.09
WMA 2 Closure	59	62	0.9	1.23	1.29	0.26	0.01	0.00	0.13
WMA 3 Removal of Surface Structures	24	25	0.42	0.56	0.73	0.13	0.00	0.00	0.09
WMA 3 Closure – WTF WPF Construction	18	25	2.4	1.11	0.87	0.19	0.00	0.00	0.18
WMA 3 Closure – WTF WPF Operation	25	45	0.76	1.11	0.07	0.07	0.01	0.00	0.06
WMA 3 Closure – WTF WPF Demolition	45	52	1.03	1.11	1.66	0.33	0.00	0.00	0.43
WMA 4 Closure	61	62	0.2	0.5	0.62	0.11	0.00	0.00	0.06
WMA 5 Closure	59	60	2.3	1.12	1.72	0.3	0.00	0.00	0.23
WMA 6 Closure	59	60	0.14	0.18	0.41	0.07	0.00	0.00	0.03
Leachate Treatment Facility Construction	1	3	0.23	0.05	0.01	0.01	0.00	0.00	0.01
Leachate Treatment Facility Operation (also Years 60-61)	4	55	0.07	0.08	0.01	0.01	0.00	0.00	0.00
Leachate Treatment Facility Closure	56	56	0.57	0.22	0.1	0.03	0.00	0.00	0.04
Container Management Facility Construction	1	3	13.49	2.77	0.41	0.23	0.01	0.02	0.60
Container Management Facility Operation	4	55	0.6	0.76	0.05	0.05	0.00	0.00	0.06
Container Management Facility Closure	55	58	2.9	1.08	1.02	0.2	0.00	0.00	0.19
WMA 7 Closure – Surface Structure Removal	1	1	0.12	0.14	3.67	0.55	0.00	0.00	0.02
WMA 7 Closure – Interceptor Trench Excavation	1	1	0.06	0.14	0.34	0.05	0.00	0.00	0.02

Activities for Each Alternative	*Period*		*Emissions*						
	Start Year	*End Year*	*Carbon Monoxide (tons per year)*	*Nitrogen Dioxide (tons per year)*	*PM_{10} (tons per year)*	*$PM_{2.5}$ (tons per year)*	*Sulfur Dioxide (tons per year)*	*Benzene (tons per year)*	*Nonmethane Hydrocarbons (tons per year)*
WMA 7 Closure – NRC-licensed Disposal Area EE Construction	1	3	4.58	1.23	0.24	0.1	0.00	0.01	0.23
WMA 7 Closure – WVDP Area EE Construction	3	4	0.24	0.59	0.09	0.03	0.00	0.00	0.13
WMA 7 Closure – NDA Excavation/Backfill	4	24	1.02	1.29	0.31	0.12	0.01	0.00	0.1
WMA 7 Closure – WVDP Area EE Demolition	27	29	0.26	0.40	1.0	0.16	0.00	0.00	0.06
WMA 7 Closure – NDA EE Demolition	25	31	6.81	0.88	0.59	0.15	0.00	0.01	0.20
WMA 8 Closure – Surface Structure Removal	24	24	0.37	0.16	0.04	0.02	0.00	0.00	0.02
WMA 8 Closure – South SDA EE Construction	31	34	6.37	1.34	6.17	1.01	0.00	0.01	0.29
WMA 8 Closure – North SDA EE Construction	22	24	6.3	1.57	3.23	0.57	0.00	0.01	0.30
WMA 8 Closure – Lagoon Confinement Construction	25	26	2.47	0.62	0.06	0.04	0.00	0.00	0.12
WMA 8 Closure – SDA Waste Excavation	34	55	2.45	1.97	0.68	0.22	0.01	0.00	0.17
WMA 8 Closure – Lagoon Confinement Demolition	41	44	8.91	1.08	0.36	0.13	0.00	0.01	0.26
WMA 8 Closure – North SDA EE Demolition	41	49	6.98	0.97	1.10	0.23	0.00	0.01	0.22
WMA 8 Closure – South SDA EE Demolition	55	58	22.15	2.92	0.45	0.27	0.01	0.03	0.68
WMA 9 Closure	1	1	0.61	1.49	1.22	0.24	0.00	0.00	0.25
WMA 10 Closure	63	63	0.36	0.85	8.45	1.29	0.00	0.00	0.13
WMA 11 Closure	63	63	0.1	0.22	0.32	0.06	0.00	0.00	0.03
WMA 12 Closure	61	64	0.32	0.67	0.72	0.13	0.00	0.00	0.08
Soil Drying Facility Construction	11	13	0.82	0.94	7.68	1.19	0.00	0.00	0.16
Soil Drying Facility Operation (also years 52-61)	13	18	0.62	0.8	1.09	0.21	0.00	0.00	0.06
Soil Drying Facility Closure	62	63	14.17	1.83	2.17	0.46	0.01	0.02	0.43
North Plateau Groundwater Plume	52	61	0.43	1.35	13.34	2.0	0.00	0.00	0.21
Cesium Prong	63	64	0.64	1.02	3.27	0.54	0.00	0.00	0.11
Monitoring and Maintenance	1	62	0.23	0.17	0.01	0.01	0.00	0.00	0.01
Security	1	64	0.24	0.17	0.01	0.01	0.00	0.00	0.01

Activities for Each Alternative	*Period*		*Emissions*						
	Start Year	*End Year*	*Carbon Monoxide (tons per year)*	*Nitrogen Dioxide (tons per year)*	*PM_{10} (tons per year)*	*$PM_{2.5}$ (tons per year)*	*Sulfur Dioxide (tons per year)*	*Benzene (tons per year)*	*Nonmethane Hydrocarbons (tons per year)*
Sitewide Close-In-Place Alternative									
High-level Radioactive Waste Canister Removal – Construction of Dry Cask Storage Area	1	1	1.02	1.42	0.54	0.12	0.00	0.00	0.18
High-level Radioactive Waste Canister Removal – Load-In/Load-Out Modification and Operation	1	2	0.27	0.32	0.03	0.03	0.00	0.00	0.02
High-level Radioactive Waste Canister Removal – Operation of Dry Cask Storage Area	3	32	0.03	0.04	0.00	0.00	0.00	0.00	0.00
High-level Radioactive Waste Canister Removal – Demolition of Dry Cask Storage Area	33	33	0.51	0.88	0.05	0.05	0.00	0.00	0.18
WMA 1 Closure	1	7	3.57	2.03	2.08	0.4	0.01	0.00	0.41
WMA 2 Closure	3	5	0.49	0.91	7.29	1.12	0.00	0.00	0.13
WMA 3 Surface Storage Removal	2	2	0.61	1.09	1.13	0.22	0.00	0.00	0.13
WMA 3 Grouting Operations	3	5	0.08	0.15	0.25	0.04	0.00	0.00	0.03
North Plateau Cap Construction	5	7	1.09	1.89	9.32	1.45	0.00	0.00	0.29
WMA 4 Closure	1	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WMA 5 Closure	6	6	0.59	1.6	0.5	0.12	0.00	0.00	0.36
WMA 6 Closure	7	7	0.14	0.08	0.13	0.02	0.00	0.00	0.01
WMA 6 Leachate Treatment Facility Construction	1	1	0.69	0.16	0.02	0.02	0.00	0.00	0.03
WMA 6 Leachate Treatment Facility Operation	2	6	0.64	0.76	0.06	0.06	0.00	0.00	0.04
WMA 6 Leachate Treatment Facility Closure	6	6	0.57	0.23	0.1	0.03	0.00	0.00	0.04
WMA 7 Closure	2	6	3.17	1.67	6.83	1.08	0.00	0.00	0.31
WMA 8 Closure	2	6	16.7	6.04	54.7	8.45	0.01	0.02	1.28
WMA 9 Closure	1	1	0.53	1.30	1.13	0.21	0.00	0.00	0.23
WMA 10 Closure	7	7	0.05	0.22	0.1	0.02	0.00	0.00	0.03
WMA 11 Closure	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WMA 12 Closure	7	7	0.02	0.09	0.06	0.01	0.00	0.00	0.01
North Plateau Groundwater Plume (nonsource area)	5	5	0.04	0.01	0.01	0.00	0.00	0.00	0.00
Existing Facility Maintenance	1	6	1.81	1.94	0.15	0.15	0.01	0.00	0.11
Security	1	62	0.02	0.00	0.00	0.00	0.00	0.00	0.00

Activities for Each Alternative	Period		Emissions						
	Start Year	End Year	Carbon Monoxide (tons per year)	Nitrogen Dioxide (tons per year)	PM_{10} (tons per year)	$PM_{2.5}$ (tons per year)	Sulfur Dioxide (tons per year)	Benzene (tons per year)	Nonmethane Hydrocarbons (tons per year)
Environmental Monitoring Installations	7	7	0.40	2.41	1.31	0.24	0.00	0.00	0.33
Security Installations	7	7	1.04	0.44	2.45	0.39	0.00	0.00	0.06
Erosion Control System Replacement (assume WMA 8)	6	7	4.26	10.5	53.8	8.28	0.01	0.00	1.78
Long-term Monitor/Maintain (through Year 62)	8	64	1.56	0.77	3.86	0.60	0.00	0.00	0.14
North Plateau Groundwater Plume Permeable Reactive Barrier Replacement (through Year 62) (also Years 40 and 60)	20	20	0.08	0.17	0.11	0.02	0.00	0.00	0.03
Phased Decisionmaking Alternative (Phase 1)									
High-level Radioactive Waste Canister Removal – Construction of Dry Cask Storage Area	1	1	1.02	1.42	0.53	0.12	0.00	0.0008	0.17
High-level Radioactive Waste Canister Removal – Load-In/Load-Out Modification and Operation	1	2	0.27	0.32	0.03	0.03	0.00	0.000	0.02
High-level Radioactive Waste Canister Removal – Operation of Dry Cask Storage Area	3	29	0.06	0.07	0.01	0.01	0.00	0.000	0.00
High-level Radioactive Waste Canister Removal – Demolition of Dry Cask Storage Area	30	30	0.61	1.03	0.58	0.13	0.00	0.000	0.19
WMA 1 Closure – Surface Storage Removal	1	6	5.37	3.9	5.26	0.95	0.01	0.0047	0.77
WMA 1 Closure – Subsurface Soil Removal	6	8	0.96	1.39	3.75	0.63	0.01	0.0001	0.18
WMA 2 Closure	2	5	0.98	1.45	1.29	0.26	0.01	0.0001	0.17
WMA 3 Closure	3	3	0.88	0.87	1.33	0.24	0.00	0.0005	0.11
WMA 4 Closure	1	7	0.00	0.00	0.00	0.00	0.00	0.000	0.00
WMA 5 Closure	6	6	4.59	2.23	3.43	0.6	0.00	0.005	0.46
WMA 6 Closure	7	7	0.21	0.23	0.66	0.11	0.00	0.0001	0.04
WMA 7 Maintenance	1	30	0.09	0.08	0.01	0.01	0.00	0.000	0.00
WMA 8 Maintenance	1	30	0.23	0.21	0.02	0.02	0.00	0.0001	0.01
WMA 9 Closure	6	6	0.61	1.49	1.22	0.24	0.00	0.000	0.25
WMA 10 Closure	7	7	0.11	0.3	6.96	1.06	0.00	0.000	0.04
WMA 11 Closure	1	7	0.00	0.00	0.00	0.00	0.00	0.000	0.00
WMA 12 Closure	7	7	0.11	0.19	0.01	0.01	0.00	0.000	0.03
Environmental Monitoring Installations	8	8	0.38	2.28	1.29	0.23	0.00	0.000	0.31

Activities for Each Alternative	*Period*		*Emissions*						
	Start Year	*End Year*	*Carbon Monoxide (tons per year)*	*Nitrogen Dioxide (tons per year)*	*PM_{10} (tons per year)*	*$PM_{2.5}$ (tons per year)*	*Sulfur Dioxide (tons per year)*	*Benzene (tons per year)*	*Nonmethane Hydrocarbons (tons per year)*
Security Installations	8	8	1.0	0.44	2.45	0.39	0.00	0.0012	0.06
Annual Environmental Monitoring	8	30	1.27	0.27	0.03	0.03	0.00	0.0015	0.04
North Plateau Groundwater Plume Permeable Reactive Barrier Replacement	20	20	0.07	0.17	0.10	0.02	0.00	0.000	0.03
SDA (WMA 8) Geomembrane Replacement	15	15	0.23	2.33	8.68	1.33	0.00	0.000	0.33
Existing Facility Maintenance	1	7	1.11	0.98	0.07	0.07	0.01	0.0004	0.06
Security	1	30	0.20	0.14	0.01	0.01	0.00	0.0001	0.01
No Action Alternative									
WVDP Annual Maintenance	1	64	0.48	0.22	0.02	0.02	0.001	0.00	0.01
SDA Annual Maintenance [a]	1	64	0.1	0.11	0.01	0.01	0.001	0.00	0.01
Process Building Roof Replacement [a]	16	16	1.66	0.2	0.02	0.02	0.001	0.00	0.01
Other Roofs Replacement [a]	11	11	0.56	0.07	0.01	0.01	0.000	0.00	0.00
SDA Geomembrane Replacement [a]	15	15	0.20	2.30	8.60	1.29	0.000	0.00	0.30
NDA Geomembrane Replacement [a]	22	22	0.00	0.90	3.20	0.48	0.000	0.00	0.10
Permeable Treatment Wall Media Replacement [b]	20	20	0.06	0.17	0.11	0.02	0.000	0.00	0.00

EE = Environmental Enclosure, NDA = NRC-licensed Disposal Area, PM_{10} = particulate matter less than or equal to 10 micrometers in diameter; $PM_{2.5}$ = particulate matter less than or equal to 2.5 microns in diameter, SDA = State-licensed Disposal Area, WMA = Waste Management Area, WTF WPF = Waste Tank Farm Waste Processing Facility, WVDP = West Valley Demonstration Project.

[a] These activities would recur approximately every 25 years.

[b] This activity would recur approximately every 20 years.

Note: To convert tons to metric tons, multiply by 0.90718.

Sources: WSMS 2008a, 2008b, 2008c, 2008d.

Nitrogen dioxide and nonmethane hydrocarbon emissions, which are ozone precursors, were compared to 2001 county emissions of nitrogen dioxide and volatile organic compounds for each alternative. The comparison of the peak year emissions to the county emissions by alternative is presented in **Table K–5**. The 2001 emissions data was the most recent year for which EPA reported county data on its Air Data Website.

Table K–5 Comparison of Ozone Precursor Emissions to Cattaraugus County Emissions by Alternative (percent) [a]

Pollutant	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*
Nitrogen dioxide	0.18	0.53	0.21	0.05
Nonmethane hydrocarbons	0.02	0.08	0.03	0.01

[a] Based on the most recent year reported (2001) in the EPA Air Data database (EPA 2008).

K.3 Summary of Modeling Results

Air pollutant concentrations were modeled for carbon monoxide, nitrogen dioxide, PM_{10}, $PM_{2.5}$, sulfur dioxide, and benzene for the years with highest emissions. Concentrations were modeled at the WNYNSC boundary and along public roads passing through WNYNSC. Short-term concentrations along the rail line through WNYNSC were not evaluated since the rail line is not used by the public. Emission estimates for shipments of waste and other materials are presented in Section K.4.

K.3.1 Sitewide Removal Alternative

Under the Sitewide Removal Alternative, the highest concentrations for PM_{10} (Year 60) would be attributed to WMA 2 closure, WMA 5 closure, Soil Drying Facility operation, and activity at the North Plateau Groundwater Plume. The highest concentrations for $PM_{2.5}$, carbon monoxide, and benzene (Year 55) would be attributed to Container Management Facility closure, WMA 8 closure – State Disposal Area Waste Excavation, WMA 8 – South State-licensed Disposal Area (SDA) Environmental Enclosure demolition, Soil Drying Facility operation, and activity at North Plateau Groundwater Plume. The highest concentrations appropriate for comparison to the ambient standards and guidelines for each pollutant and averaging time and corresponding ambient standards are presented in **Table K–6**. Concentrations to which the public would be exposed are expected to be below the ambient standards, with the exception of $PM_{2.5}$, when background concentrations are included. Background concentrations are based on the nearest available ambient monitoring data as discussed in Chapter 3, Section 3.7, of this EIS.

K.3.2 Sitewide Close-In-Place Alternative

Under the Sitewide Close-In-Place Alternative, the highest concentration for PM_{10}, $PM_{2.5}$, carbon monoxide, sulfur dioxide, benzene, and nitrogen dioxide (Year 6) would be attributed to WMA 1 closure, North Plateau Cap construction, WMA 5 closure, WMA 7 closure, WMA 8 closure, Existing Facility Maintenance, and Erosion Control System replacement. The highest concentrations appropriate for comparison to the ambient standards and guidelines for each pollutant and averaging time and corresponding ambient standards are presented in Table K–6. Concentrations to which the public would be exposed are expected to be below the ambient standards, with the exception of PM_{10} and $PM_{2.5}$, when background concentrations are included.

Table K–6 Nonradiological Air Pollutant Concentrations by Alternative

Criteria Pollutant	*Averaging Period*	*Most Stringent Standard or Guideline (micrograms per cubic meter)* [a]	*Maximum Incremental Concentration (micrograms per cubic meter)* [b]				*Background Concentration (micrograms per cubic meter)* [c]
			Sitewide Removal Alternative	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative (Phase 1)*	*No Action Alternative*	
Carbon monoxide	8 hours 1 hour	10,000 40,000	199 1,130	197 1,120	131 571	30 163	3,500 7,000
Nitrogen dioxide	Annual	100	0.42	1.24	0.722	0.122	30
PM_{10}	Annual 24 hours	45 150	0.871 27.5	5.82 214 [d]	0.901 39.3	0.408 16.5	13 28
$PM_{2.5}$	Annual 24 hours	15 35	0.122 2.47 [d]	0.77 23.3 [d]	0.161 4.18 [d]	0.062 1.73	11 34
Sulfur dioxide	Annual 24 hours 3 hours	80 365 1,300	0.0008 0.0502 0.276	0.00234 0.0665 0.398	0.00142 0.0798 0.451	0.00015 0.0104 0.058	7.9 34 97
Benzene	Annual 1 hours	0.13 1,300	0.00133 1.28	0.00093 0.899	0.00063 0.466	0 0	Not reported Not reported

PM_{10} = particulate matter less than or equal to 10 micrometers in diameter; $PM_{2.5}$ = particulate matter less than or equal to 2.5 microns in diameter.

[a] The more stringent of the Federal and State standards is presented if both exist for the averaging period. The NAAQS (40 CFR 50), other than those for ozone, particulate matter, and lead, and those based on annual averages, are not to be exceeded more than once per year. The annual arithmetic mean PM_{10} standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The 24-hour PM_{10} standard is met when the expected number of exceedances is 1 or less over a 3-year period. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard. Standards and monitored values for pollutants other than particulate matter are stated in parts per million. These values have been converted to micrograms per cubic meter.

[b] Concentrations were analyzed at locations to which the public has continual access and at the WNYNSC boundary.

[c] Based on available regional monitoring data as discussed in Chapter 3, Section 3.7, of this EIS.

[d] Standard could be exceeded when background is added to the modeled increment for this alternative.

K.3.3 Phased Decisionmaking Alternative

Under Phase 1 of the Phased Decisionmaking Alternative, the highest concentration for carbon monoxide, nitrogen dioxide, PM_{10}, $PM_{2.5}$, and sulfur dioxide (Year 6) would be attributed to WMA 1 closure – surface structure removal and subsurface soil removal, WMA 5 closure, and WMA 9 closure. The highest concentrations for benzene (Year 6) would be attributed to WMA 1 closure – surface structure removal and WMA 5 closure. The highest concentrations for PM_{10} (Year 7) would be attributed to WMA 1 closure – subsurface soil removal, and WMA 10 closure. The highest concentrations appropriate for comparison to the ambient standards and guidelines for each pollutant and averaging time and corresponding ambient standards are presented in Table K–6. Concentrations to which the public would be exposed are expected to be below the ambient standards, with the exception of $PM_{2.5}$, when background concentrations are included.

K.3.4 No Action Alternative

Under the No Action Alternative, the highest concentration for all air pollutants would occur in the years when Process Building roof replacement or SDA geomembrane replacement activities occur. For the purpose of this analysis, those are Years 15 and 16. These activities would recur approximately every 25 years. The highest concentrations appropriate for comparison to the ambient standards and guidelines for each pollutant and averaging time and corresponding ambient standards are presented in Table K–6. Concentrations to which the public would be exposed are expected to be below the ambient standards, with the exception of $PM_{2.5}$, when background concentrations are included.

K.4 Comparison of Modeling Results

Table K–6 summarizes modeling results for each alternative, along with regional background concentrations measured at urban and suburban sites in Buffalo, New York, and ambient air quality standards for each modeled pollutant. For comparison, the highest average values are presented for carbon monoxide, nitrogen dioxide, sulfur dioxide, benzene, annual PM_{10}, and annual $PM_{2.5}$. The 98th percentile 24-hour value for $PM_{2.5}$ is presented (represented by the average eighth highest 24-hour value) and the average sixth high 24-hour value for PM_{10} is presented (as recommended by EPA for comparison to the standard).

Regional background concentrations (see Chapter 3) are less than the ambient standards for all the modeled pollutants. The estimated WNYNSC boundary concentrations for each alternative would be below those for the regional background and below the ambient standards, except for 24-hour PM_{10} concentrations. The sum of background concentrations and the modeled results for all pollutants at all locations would be less than the ambient air quality standards, except for PM_{10} and $PM_{2.5}$. The ambient standards were developed based on criteria to protect public health and welfare. Therefore, the modeling results indicate that the impact on public health of nonradiological emissions (except for PM_{10} and $PM_{2.5}$) would be minor under all alternatives.

Generally, it can be concluded that nonradiological air quality impacts under the No Action Alternative would be less than those under the other alternatives. The Sitewide Close-In-Place Alternative results in the highest peak incremental short-term concentrations, except for carbon monoxide and benzene, for which the Sitewide Removal Alternative has the highest concentrations, and sulfur dioxide, for which Phased Decisionmaking has the highest short-term concentrations. For Phase 1 of the Phased Decisionmaking Alternative, impacts principally occur over the first 8 years of alternative implementation. Impacts from Phase 2 activities would be expected to be bounded by the Sitewide Removal Alternative and the Sitewide Close-In-Place Alternative. The impacts of the Sitewide Removal Alternative occur over a period of about 64 years. Although the Sitewide Close-In-Place Alternative extends over a similar period of time, most of the activities with larger emissions occur in the first 7 years.

Air quality impacts in Canada from the activities under the alternatives considered would be negligible as a result of the distance to the nearest border, and the low release height of the nonradiological pollutants. As discussed in Chapter 4, Section 4.1.5.1, of this EIS, the Region of Influence is the area in which concentrations of criteria pollutants would increase more than a significant amount. This distance is expected to be a few kilometers from the source. The increases in concentration resulting from the peak year of activity under each alternative and if nitrogen dioxide for one alternative are presented in Table K–6 and are less than the significance levels at the WVDP boundary, except for PM_{10} and for nitrogen dioxide for one alternative. In the Region of Influence (8 kilometers [5 miles]) in the direction of the closest distance to the Canadian border, the PM_{10} concentrations under the Sitewide Close-In-Place Alternative are estimated to be 0.446 and 9.03 micrograms per cubic meter, respectively, for the annual and 24-hour averaging periods, just below the significance level for the annual average and above for the 24-hour average. At the Canadian border (50 kilometers [31 miles]), the PM_{10} concentrations under the Sitewide Close-In-Place Alternative are estimated to be 0.041 and 1.17 micrograms per cubic meter, respectively, for the annual and 24-hour averaging periods. Concentrations from other alternatives would be less. Since most of the nonradiological releases are from construction type equipment which release exhaust close to the ground and particulate emissions from soil disturbance within a few feet of the ground, the highest concentrations are generally expected to occur on or near the site.

Emissions from shipping wastes and other materials by truck are shown by alternative in **Table K–7**. The highest emissions would be from the Sitewide Removal Alternative, and the lowest from the No Action Alternative. Emissions from shipment by rail would be expected to be less by a factor of 3 or more.

Table K–7 Nonradiological Emissions from Trucking Shipments of Waste and Other Materials (metric tons)

Pollutant	*Sitewide Removal Alternative*	*Sitewide Close-In-Place Alternative*	*Phased Decisionmaking Alternative*	*No Action Alternative*
Carbon monoxide	1,460	18.3	198	11.7
Nitrogen dioxide	5,140	64.3	693	41
PM_{10}	145	1.81	19.5	1.16
$PM_{2.5}$	119	1.5	16.1	0.955
Volatile organic compounds	251	3.14	33.9	2.0

PM_{10} = particulate matter less than or equal to 10 micrometers in diameter; $PM_{2.5}$ = particulate matter less than or equal to 2.5 microns in diameter.

K.5 References

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APPENDIX L
REGULATORY COMPLIANCE DISCUSSION

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REGULATORY COMPLIANCE DISCUSSION

This appendix discusses the compliance with three requirements that would apply to site decommissioning actions:

- The Resource Conservation and Recovery Act (RCRA) of 1976 and the New York State Solid Waste Disposal Act (New York State Environmental Conservation Law Article 27 [Title 9]) govern the generation, storage, handling, and disposal of hazardous wastes, and the closure of treatment, storage, or disposal systems that handle those wastes. The Act was created to ensure that hazardous wastes are managed in a way that protects human health, safety, and the environment. Operation and closure of RCRA "regulated" units are performed in accordance with 6 New York Code of Rules and Regulations (NYCRR) Part 373. Corrective Action for solid waste management units is performed in accordance with the RCRA 3008(h) Administrative Order on Consent.

- The West Valley Decommissioning Policy Statement/License Termination Rule establishes radiological criteria for the decommissioning of West Valley Demonstration Project (WVDP) facilities and the termination of the U.S. Nuclear Regulatory Commission (NRC) licenses (NRC 2007). The Policy Statement/License Termination Rule provides for flexibility in establishing the final levels of residual contamination, but, in all cases, requires decontamination to the extent technically and economically feasible.

- The new regulations that the New York Department of Environmental Conservation (NYSDEC) is proposing to adopt for the cleanup of sites contaminated with radioactive materials (NYSDEC 2008) will be compatible with the NRC's License Termination Rule and will be applied as applicable and whenever NYSDEC requires the cleanup of a site contaminated with radioactive material.

RCRA regulations and the License Termination Rule are discussed more fully in Chapter 5 of this environmental impact statement (EIS).

Compliance with these key regulations is discussed in the following sections. The discussion draws on information and analytical results presented in this EIS. Actual determinations of compliance or non-compliance are made by the regulatory authorities in response to documents submitted by the regulated entities. The information and assessments presented in this appendix do not constrain the judgments that will be made by regulators in evaluating compliance for the alternative finally selected.

There are three decommissioning alternatives described in Chapter 2 of this EIS: Sitewide Removal, Sitewide Close-In-Place, and Phased Decisionmaking. The Sitewide Removal Alternative will, by definition, meet NYSDEC requirements for clean closure for RCRA-regulated units, NRC requirements for license termination without restriction for the NRC-regulated portion of the site, and NYSDEC cleanup requirements for the State-licensed Disposal Area (SDA). The actual determination of when removal is adequate for the Sitewide Removal Alternative to meet the various decommissioning requirements would be made through the appropriate NYSDEC and NRC regulatory review processes as noted in Chapter 1, Section 1.5, of this EIS.

While it is conceptually possible that the Sitewide Close-In-Place Alternative could meet NYSDEC, RCRA, and NRC Policy Statement/ License Termination Rule requirements, it is less clear if or under what conditions this alternative would meet these requirements. The balance of this appendix discusses RCRA and Policy

Statement/License Termination Rule requirements that would apply to this alternative and the issues associated with compliance, while drawing (as appropriate) on the information developed as part of this EIS.

A WVDP Decommissioning Plan has been prepared that develops allowable residual contamination levels for those areas where facilities would be removed under Phase 1 of the Phased Decisionmaking Alternative. These residual contamination levels are termed Derived Concentration Guideline Levels (DCGLs) and are based on limiting the dose to a potential onsite receptor to a total effective dose equivalent of 25 millirem per year, the dose standard for unrestricted release in the NRC License Termination Rule. The technical basis for the establishment of these West Valley-specific DCGLs is being reviewed by the NRC. Cleanup/closure activities performed during Phase 1 or under the Sitewide Removal Alternative would be performed in accordance with RCRA closure and/or corrective action requirements, as applicable. This appendix does not discuss Phase 2 of the Phased Decisionmaking Alternative because Phase 2 actions have not been defined. If Phase 2 were removal of the remaining Waste Management Areas (WMAs), the overall alternative would be the same as the Sitewide Removal Alternative. If Phase 2 were close-in-place for the remaining WMAs, it would involve the same issues identified for the Sitewide Close-In-Place Alternative, although they would be slightly reduced because the Main Plant Process Building and the Low-Level Waste Treatment Facility would have been removed under Phase 1. This appendix does not address the No Action Alternative because it is not intended to meet decommissioning requirements.

L.1 Resource Conservation and Recovery Act (RCRA)

Site cleanups under RCRA are conducted under its corrective action and permitting programs. The RCRA corrective action program is used for the corrective action of Solid Waste Management Units (SWMUs) following the process defined in the facility-operating permit or Consent Order, beginning with investigation and ending with the selection and implementation of a remedy. The Corrective Measures Study (CMS) Reports would be prepared by the DOE and/or New York State Energy Research and Development Authority (NYSERDA) for SWMUs identified by NYSDEC or the U.S. Environmental Protection Agency (EPA). These reports would propose a preferred corrective measure alternative for the SWMU, including applicable or appropriate cleanup standards. The CMS Report would be reviewed by NYSDEC and EPA, and a corrective measure alternative would be selected via the required administrative procedures, which would also include providing the public with an opportunity to review and comment.

Under any of the alternatives evaluated in this EIS, SWMUs subject to RCRA permitting ("regulated units") would be remediated pursuant to respective closure standards and requirements as defined in the regulations. A regulated unit-specific closure plan would be prepared by the owner or operator of a particular regulated unit or the organization that would implement the plan on the owner or operator's behalf. The plan would then be submitted to NYSDEC and/or EPA for review and approval. Upon approval, the closure plan would be implemented for the specific regulated unit. Closure standards may be met through a variety of methods, depending upon the type, design, and performance of the unit and whether any wastes remain in place. Clean closure is the method of closure in which all wastes are removed from the regulated unit and the surrounding media. In-place management is the method of closure in which some or all wastes remain in place, generally subjecting the unit to long-term controls. This would generally require both a regulatory variance and a post-closure permit or Order to document the monitoring and maintenance requirements. The closure requirements would usually satisfy the corrective action requirements. However, closed units may be further subject to corrective action requirements, if deemed necessary. Information regarding Solid Waste Management Units and RCRA Interim Status Units is provided in Chapter 2, Table 2–2, of this EIS.

For the Sitewide Close-In-Place Alternative, the acceptable steps to closure for each regulated unit would be the subject of a regulatory review, through a closure plan for each of the regulated units. Because wastes would be left in place under this option, engineered measures (such as a cover) or long-term controls could be proposed as part of the process. The adequacy of these additional measures would be determined by NYSDEC and/or EPA, as would the need for special administrative provisions, such as a variance to the regulations. It is not clear what the regulators' decisions would be for this alternative, particularly for the units that appear to have the greatest inventory of hazardous constituents (Main Plant Process Building, Waste Tank Farm, NRC-licensed Disposal Area [NDA] and SDA). If such close-in-place actions were authorized for regulated units, it is expected that it would involve a permit with post-closure monitoring and maintenance requirements that would require a review of performance and options on some recurring interval, such as 5 years.

L.2 U.S. Nuclear Regulatory Commission Decommissioning Criteria

The NRC License Termination Rule (10 *Code of Federal Regulations* [CFR] 20, Subpart E) governs the decommissioning of the NRC-licensed portion of the Western New York Nuclear Service Center (WNYNSC). There is flexibility in the License Termination Rule with criteria for unrestricted use (10 CFR 20.1402), criteria for restricted use (10 CFR 20.1403), and alternate criteria (10 CFR 20.1404). In all cases it is necessary to decontaminate to the maximum extent technically and economically feasible. The License Termination Rule is discussed more in Chapter 5 of this EIS.

NRC established decommissioning criteria for WVDP through issuance of a Policy Statement (NRC 2002) under its authority in the WVDP Act, prescribing the License Termination Rule as the decommissioning criteria for WVDP. In this Policy Statement, NRC recognized that decommissioning of the West Valley Site would present unique challenges and acknowledged that the final end-state may involve a long-term, or even a perpetual, license or other innovative approach for some parts of the site where clean up to License Termination Rule requirements would be prohibitively expensive or technically impractical. DOE would document its planned WVDP decommissioning actions and specific cleanup levels in a Decommissioning Plan, which would be reviewed by NRC staff. The NRC Policy Statement on decommissioning criteria for the WVDP is also discussed in Chapter 5 of this EIS.

For the Sitewide Close-In-Place Alternative, there appear to be two primary options under the License Termination Rule: license termination under restricted conditions (CFR 20.1403) and license termination under alternative criteria (CFR 20.1404). While these options are applicable for those portions of the site where waste or contamination is closed-in-place, other portions of the site with minimal residual contamination could be released for unrestricted reuse under the criteria of CFR 20.1402.

The various decommissioning requirements of CFR 20.1403 and CFR 20.1404 include dose standards, standards for institutional controls, and procedural requirements. This appendix only addresses comparison to dose standards. **Table L–1** presents a summary matrix of the regulatory dose standards for the various regulatory options that could be applied to the Sitewide Close-In-Place Alternative.

Table L–1 Summary of U.S. Nuclear Regulatory Commission Dose Standards for Regulatory Options for the Sitewide Close-In-Place Alternative

	Dose Standards	
Regulatory Option	*Dose Standard Assuming Institutional Controls*	*Dose Standard Assuming Immediate Loss of Institutional Controls*
License termination with restriction (10 CFR 20.1403)	25 millirem per year	100/500 millirem per year
License termination under alternate criteria (10 CFR 20.1404)	Up to 100 millirem per year from all manmade sources other than medical	100/500 millirem per year

CFR = *Code of Federal Regulations.*

The balance of this section presents and discusses the result of the dose assessment for the NRC-regulated facilities on WNYNSC under the Sitewide Close-In-Place Alternative. The estimated doses for the situation where it is assumed that institutional controls remain in place are presented first in Section L.2.1.[1]

The estimated doses for the situation where it is assumed that institutional controls fail are presented second in Section L.2.2. Consistent with License Termination Rule compliance guidance (NRC 2006), the analysis assumes loss of institutional controls immediately after license termination. There is uncertainty about when the license might be terminated, so two timeframes are analyzed and presented in the tables. The first assumes license termination immediately following completion of the decommissioning actions. The second assumes license termination after 100 years, a timeframe that might be used to allow for decay of some of the activity in the North Plateau Groundwater Plume or Cesium Prong. It is possible that even longer timeframes might be used to allow for decay prior to license termination, but the effect of these longer timeframes was not analyzed.

L.2.1 Continuation of Institutional Controls

Three offsite receptors, in order of distance from the site, are presented first in this section. They are:

- An individual outside the current site boundary who uses contaminated Cattaraugus Creek water for drinking and irrigation and consumes fish raised in the local Cattaraugus Creek waters;
- An individual along the lower reaches of Cattaraugus Creek near Gowanda who also uses contaminated Cattaraugus Creek water for drinking and irrigation and consumes large amounts of fish raised in the Cattaraugus Creek waters near Gowanda; and
- Lake Erie and Niagara River water users.

In addition to the offsite receptors, a dose estimate for an onsite worker engaged in post close-in-place monitoring and maintenance activities is presented. The dose estimate is based on information from historical measurements for similar activities.

Table L–2 presents the dose to a Cattaraugus Creek receptor immediately outside the current WNYNSC. The total peak annual dose to this receptor from all NRC-regulated facilities/areas is about 0.08 millirem, and the peak would be dominated by the North Plateau Groundwater Plume.

Table L–2 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for Cattaraugus Creek Receptor Outside the Western New York Nuclear Service Center Boundary (years till peak exposure in parentheses) – Continuation of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative*
Main Plant Process Building – WMA 1	0.019 (200)
Vitrification Facility – WMA 1	0.000082 (500)
Low-Level Waste Treatment Facility – WMA 2	0.00015 (100)
Waste Tank Farm – WMA 3	0.0029 (200)
NDA – WMA 7	0.018 (6,800)
North Plateau Groundwater Plume	0.072 (79)
Total	0.079 (79)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

[1] *This information for the offsite receptors is a subset of that presented in Chapter 4, Section 4.1.10, of this EIS, but is limited to the NRC-regulated facilities or areas.*

Figure L–1 shows this same information with emphasis on the peak annual dose as a function of time. The Figure shows the near-term peak which occurs in year 100, as well as a later peak from releases from the NDA.

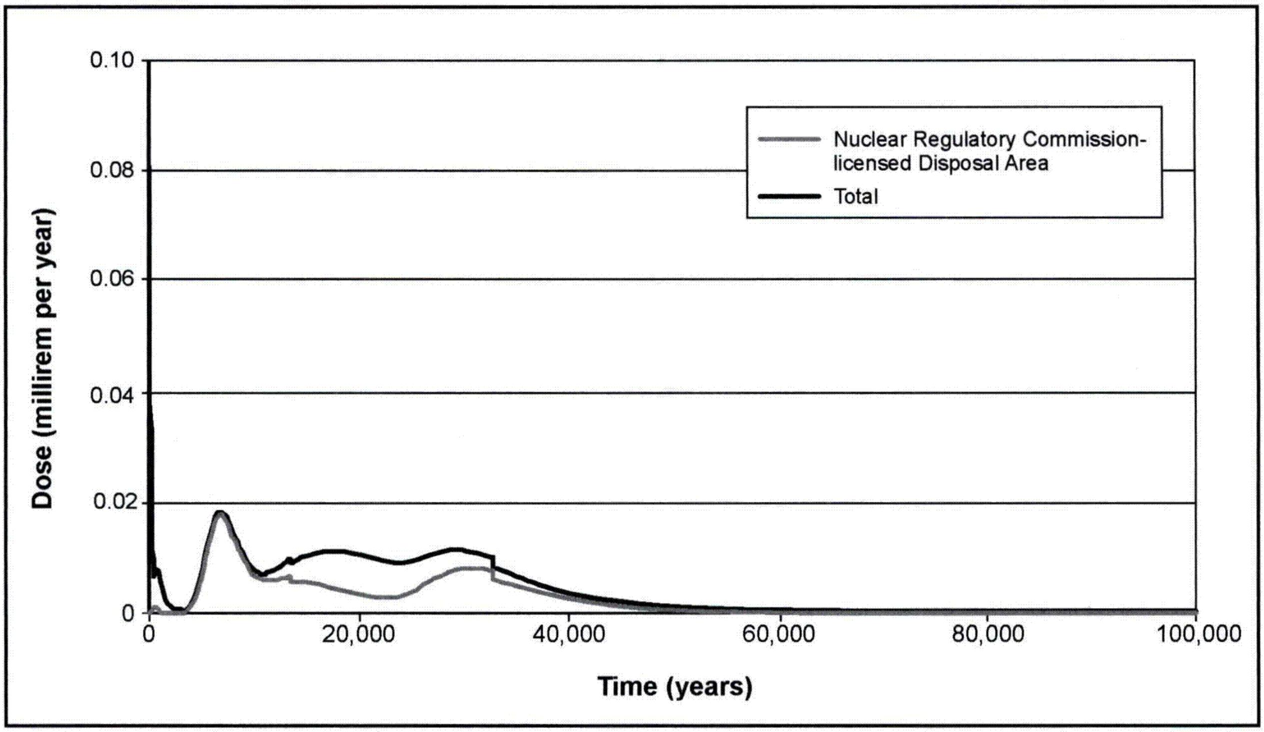

Figure L–1 Annual Dose for the Cattaraugus Creek Receptor for the Sitewide Close-In-Place Alternative with Continuation of Institutional Controls

L.2.1.1 Seneca Nation of Indians Receptor

Table L–3 presents the peak annual dose to the Seneca Nation of Indians receptor. The total peak annual dose to this receptor is slightly higher than the dose for the Cattaraugus Creek receptor because of the higher assumed fish consumption rate. The total peak annual dose is about 0.1 millirem per year and would be dominated in the first few hundred years by releases from the North Plateau Groundwater Plume and the Main Plant Process Building.

Table L–3 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for Seneca Nation of Indians Creek Receptor Near Gowanda (years till peak exposure in parentheses) – Continuation of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative*
Main Plant Process Building – WMA 1	0.052 (200)
Vitrification Facility – WMA 1	0.0002 (500)
Low-Level Waste Treatment Facility – WMA 2	0.00029 (100)
Waste Tank Farm – WMA 3	0.0027 (200)
NDA – WMA 7	0.048 (6,800)
North Plateau Groundwater Plume	0.093 (78)
Total	0.11 (78)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

L.2.1.2 Lake Erie/Niagara River Water User

The Lake Erie/Niagara River water user that would receive the highest dose would be a Sturgeon Point water user because this intake structure would have less dilution than water from other intake structures. The peak annual dose for this receptor is presented in **Table L–4**. This receptor is assumed to drink water from Lake Erie, to eat fish from Lake Erie, and raise produce in a garden irrigated with water from Sturgeon Point. The small total peak annual dose (0.026 millirem per year) would be dominated by releases from the North Plateau Groundwater Plume.

Table L–4 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for Sturgeon Point Water User (years till peak exposure in parentheses) – Continuation of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative*
Main Plant Process Building – WMA 1	0.0021 (200)
Vitrification Facility – WMA 1	0.000011 (500)
Low-Level Waste Treatment Facility – WMA 2	0.000036 (100)
Waste Tank Farm – WMA 3	0.0012 (200)
NDA – WMA 7	0.0019 (30,600)
North Plateau Groundwater Plume	0.024 (80)
Total	0.026 (80)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

L.2.1.3 Site Worker

Site workers would be responsible for monitoring and maintenance activities after the site is closed-in-place. The peak annual dose to such a worker has been estimated based on a review of historical exposure recorders for workers that have done work including environmental monitoring and grounds maintenance (WVES 2008). The estimated annual dose to site workers is estimated to be in the range of 10 to 20 millirem per year.

L.2.1.4 Conclusion about Peak Annual Dose with Continuation of Institutional Controls

The analysis of future offsite receptors indicates that the peak annual dose to an average member of the critical group (receptors outside the current site boundary) for the Sitewide Close-In-Place Alternative would be well below 25 millirem per year. The historical information on the occupational exposure to site monitoring and maintenance workers suggests that the annual dose to monitoring and maintenance workers who would work at the site following implementation of the Sitewide Close-In-Place actions would be below 25 millirem per year.

L.2.2 Loss of Institutional Controls

Multiple scenarios have been analyzed in Appendix H of this EIS. For this presentation, the scenarios are organized according to the estimated time for the scenario to develop, from shortest to longest. These specific scenarios and an estimate of the scenario duration are presented in **Table L–5**. As discussed earlier, two times for these intruder scenarios are analyzed in this appendix. The first analysis assumes the intruder scenario occurs immediately after completion of the decommissioning activities, and would be consistent with a license termination immediately after decommissioning. The second analysis assumes the intruder scenario occurs 100 years after completion of the decommissioning actions. This second analysis would be consistent with an assumption that the license was terminated after 100 years, a strategy that could be used for management of areas such as the Cesium Prong or North Plateau Groundwater Plume, where the contaminating radionuclide has a moderately short half-life (30 years or less).

Table L–5 Exposure Scenarios and Estimated Scenario Development Time

Scenario	*Estimated Scenario Development Time*
Well driller (Section L.2.2.1)	On the order of a few weeks
Resident farmer (with or without a well) (Section L.2.2.2)	1 – 2 years
Erosion (Section L.2.2.3)	Many hundreds of year of unmitigated erosion

L.2.2.1 Well Driller

Table L–6 presents the doses to an intruder worker assumed to be a well driller. For the well driller, exposure pathways include inadvertent ingestion of contaminated soil, inhalation of contaminated dust, and direct exposure to contaminated water in a cuttings pond.

Table L–6 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for Well Driller – Loss of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Main Plant Process Building – WMA 1	Not applicable	Not applicable
Vitrification Facility – WMA 1	Not applicable	Not applicable
Low-Level Waste Treatment Facility – WMA 2	8.6	1.7
Waste Tank Farm – WMA 3	Not applicable	Not applicable
NDA – WMA 7	Not applicable	Not applicable
North Plateau Groundwater Plume	0.000002	2×10^{-9}

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

The projected peak annual dose to the well driller in the area of the Low-Level Waste Treatment Facility is 8.6 millirem per year if the license is terminated immediately after completion of the Sitewide Close-In-Place decommissioning actions. A well driller in areas other than the Low-Level Waste Treatment Facility and North Plateau Groundwater Plume was not analyzed because it was assumed that well drilling equipment would not be placed over areas protected by multi-layered engineered barriers with rock on the sides and top.

L.2.2.2 Resident Farmer (with or without a well)

Three types of resident farmers are presented in this section. The first is a resident farmer along Buttermilk Creek below the confluence with Franks Creek. This receptor is assumed to experience the impacts of releases from all the WMAs on the North and South Plateaus. The second is a resident farmer who places a well directly into a WMA that is not covered by an intrusion barrier for the Sitewide Close-In-Place Alternative. The third is for a resident farmer who places a well downgradient of a WMA. This scenario is particularly relevant for WMAs that have engineered multi-layer caps that would make direct intrusion more difficult.

Resident Farmer on Buttermilk Creek

A resident farmer was analyzed for the lower reaches of Buttermilk Creek. This receptor would use contaminated water in the lower reaches of Buttermilk Creek for drinking and irrigation and would consume fish assumed to be raised in the local contaminated waters. The results of this analysis are presented in **Table L–7.**

Table L–7 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for Buttermilk Creek Receptor (years till peak exposure in parentheses) – Loss of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Main Plant Process Building – WMA 1	0.15 (200)	0.15 (200)
Vitrification Facility – WMA 1	0.00062 (500)	0.00062 (500)
Low-Level Waste Treatment Facility – WMA 2	0.00079 (500)	0.00079 (500)
Waste Tank Farm – WMA 3	0.022 (200)	0.022 (200)
NDA – WMA 7	0.13 (6,800)	0.13 (6,800)
North Plateau Groundwater Plume	0.54 (79)	0.34 (100)
Total	0.59(79)	0.39 (100)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

The predicted peak annual dose to the Buttermilk Creek Receptor is less than 1 millirem per year and is dominated by releases from the North Plateau Groundwater Plume for both the immediate license termination and the delayed license termination analysis.

Resident Farmer Using Contaminated Soil

Table L–8 presents the doses to the resident farmer as a result of direct contact with contamination that would be brought to the surface and placed in a garden following a well drilling or house construction scenario. The highest dose is to the farmer whose garden is contaminated by cuttings from the Low-Level Waste Treatment Facility. These peak doses would occur in the year of license termination.

Table L–8 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year for Resident Farmer whose Garden Contains Contaminated Soil from Well Drilling or House Construction (years till peak exposure in parentheses) – Loss of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Main Plant Process Building – WMA 1	Not applicable	Not applicable
Vitrification Facility – WMA 1	Not applicable	Not applicable
Low-Level Waste Treatment Facility – WMA 2	120 (1)	12 (100)
Waste Tank Farm – WMA 3	Not applicable	Not applicable
NDA – WMA 7	Not applicable	Not applicable
North Plateau Groundwater Plume	0 (1)	0 (100)
Cesium Prong	44 (1)	4.4 (100)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

Resident Farmer Using Contaminated Groundwater

Table L–9 presents the doses to the resident farmer whose contact with the waste would be through an indirect pathway – the use of contaminated water. The receptors for the North Plateau facilities (Main Plant Process Building, Low-Level Waste Treatment Facility, Waste Tank Farm, and North Plateau Groundwater Plume) are assumed to have wells in the sand and gravel layer on the North Plateau about 100 meters (330 feet) downgradient from the edge of the WMA. The scenario is not applied to the NDA because of the low hydraulic conductivity of the unweathered Lavery till and the unsaturated conditions in the Kent Recessional Sequence.

Table L–9 Estimated Peak Total Effective Dose Equivalent in Millirem Per Year for Resident Farmer using Contaminated Groundwater (years till peak exposure in parentheses) – Loss of Institutional Controls

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Main Plant Process Building – WMA 1	366 (200)	366 (200)
Vitrification Facility – WMA 1	1.9 (412)	1.9 (412)
Low-Level Waste Treatment Facility – WMA 2	113 (82)	110 (100)
Waste Tank Farm – WMA 3	556 (200)	556 (200)
NDA – WMA 7	Not applicable	Not applicable
North Plateau Groundwater Plume	24,760 (1)	846 (100)
Cesium Prong	44 (1)	4.4 (100)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

The dose is greatest for the resident farmer with a well in the North Plateau Groundwater Plume, but there is a noticeable decrease with time for this situation due to decay, and the dose would decrease to levels below 100 millirem per year after 125 years as shown in **Figure L–2**. The dose is greater than 100 millirem per year for wells downgradient of the Main Plant Process Building, the Low-Level Waste Treatment Facility, and the Waste Tank Farm, but there is not as noticeable a decrease in the dose from these wells with a delay in license termination.

The time series of dose for the North Plateau Groundwater Plume under the Sitewide Close-In-Place Alternative is presented in Figure L–2 for receptors at 100 and 300 meters (330 and 980 feet) from the source of the plume. The figure illustrates how sensitive the dose is to the time at which the intrusion occurs and where the intruder places his well. The peak doses in Table L–9 come from the receptor at 300 meters (980 feet). The distance of 100 meters (330 feet) is in the vicinity of the peak concentration of the Plume at the first year of the period of analysis and just outside of the downgradient slurry wall for the Sitewide Close-In-Place Alternative. The distance of 300 meters is located just upgradient of the North Plateau drainage ditch, the first location of discharge of the Plume to the surface.

L.2.2.3 Loss of Institutional Controls Leading to Unmitigated Erosion

Erosion is recognized as a site phenomenon, so a bounding erosion scenario (unmitigated erosion where no credit is taken for monitoring and maintenance of erosion control structures) was analyzed to estimate the dose to various receptors. The erosion scenarios presented here are the same ones analyzed in Appendix H of this EIS, although the timeframe for initiation of unmitigated erosion in this analysis is consistent with the assumptions stated earlier in this appendix. The scenarios for erosion in the area of the NDA and Low-Level Waste Treatment Facility are presented in an order consistent with their distance from the industrialized portion of the site.

NDA Resident/Recreational Hiker

Table L–10 presents the peak annual total effective dose equivalent (TEDE) for the resident/recreational hiker for the Low-Level Waste Treatment Facility and the NDA if unmitigated erosion of the site were allowed to take place. Exposure modes for a hiker include inadvertent ingestion of soil, inhalation of fugitive dust, and exposure to direct radiation. The peak annual dose for this receptor is not sensitive to the timing of license termination.

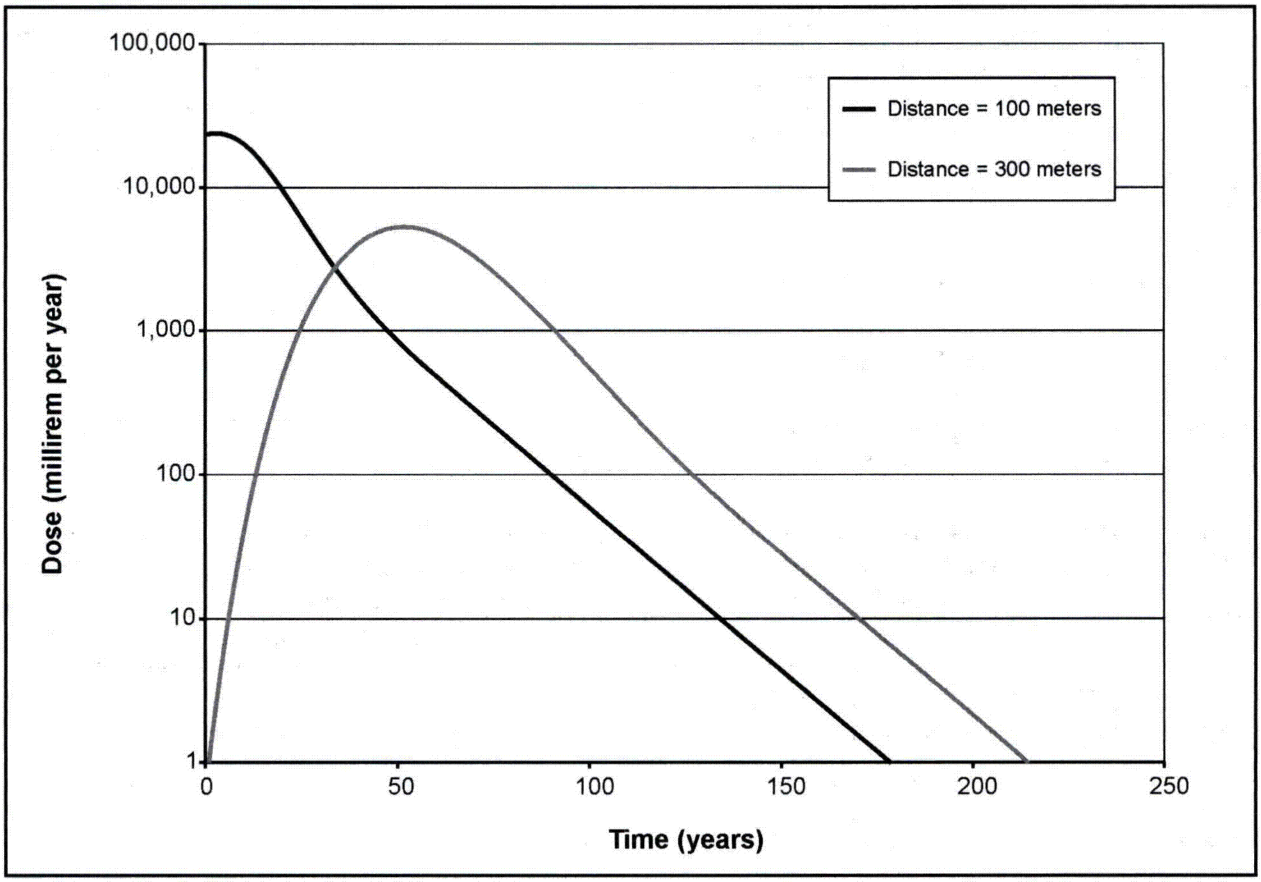

Figure L–2 Time Series of Dose for Onsite Receptors for North Plateau Groundwater Plume Under Sitewide Close-In-Place Alternative

Table L–10 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for a Resident/Recreational Hiker Near the Low-Level Waste Treatment Facility and NRC-licensed Disposal Area – Unmitigated Erosion Scenario (years till peak exposure in parentheses)

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Low-Level Waste Treatment Facility	36 (122)	36 (122)
NDA – WMA 7	10 (500)	10 (500)
Total	36 (122)	36 (122)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

Buttermilk Creek Resident Farmer

Table L–11 presents the peak annual TEDE to a Buttermilk Creek resident farmer given unmitigated erosion at the Low-Level Waste Treatment Facility and NDA. A receptor at this location would experience a dose contribution from both the Low-Level Waste Treatment Facility and NDA, but the peaks are in the future and occur in very different timeframes. The greater peak is associated with the NDA.

Table L–11 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for a Buttermilk Creek Resident Farmer – Unmitigated Erosion Scenario (years till peak exposure in parentheses)

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Low-Level Waste Treatment Facility	16 (156)	16 (156)
NDA – WMA 7	342 (725)	342 (725)
Total	342 (725)	342 (725)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

Cattaraugus Creek Resident Farmer

Table L–12 presents the peak annual TEDE from the Low-Level Waste Treatment Facility and NDA for the Cattaraugus Creek resident farmer for the unmitigated erosion scenario.

Table L–12 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for Cattaraugus Creek Receptor Outside the Western New York Nuclear Service Center Boundary - Unmitigated Erosion Scenario (years till peak exposure in parentheses)

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Low-Level Waste Treatment Facility	2 (156)	2 (156)
NDA – WMA 7	45 (725)	45 (725)
Total	45 (725)	45 (725)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

The results for this receptor show a similar pattern to that seen for the Buttermilk Creek resident farmer, but the doses are lower because of the reduced contaminant concentrations further downstream.

An illustration of how the peak annual dose to the Cattaraugus Creek receptor would vary as a function of time for the Sitewide Close-In-Place Alternative is presented in **Figure L–3**. The figure shows the near-term peak for erosion of the Low-Level Waste Treatment Facility and the later peak for erosion of the NDA. The dose-time curve would have a similar pattern for all three downstream receptors but the magnitude of the peaks will vary.

Seneca Nation of Indians Receptor

A Seneca Nation of Indian receptor is postulated to use Cattaraugus Creek near Gowanda for drinking water and to consume large quantities of fish raised in these waters. The peak annual dose for this receptor is presented in **Table L–13**.

As noted above, the dose-time pattern for the Seneca Nation of Indians receptor is similar to that seen for the other downgradient water users, but the numerical values of the peaks are greater as a result of the higher assumed fish consumption rates.

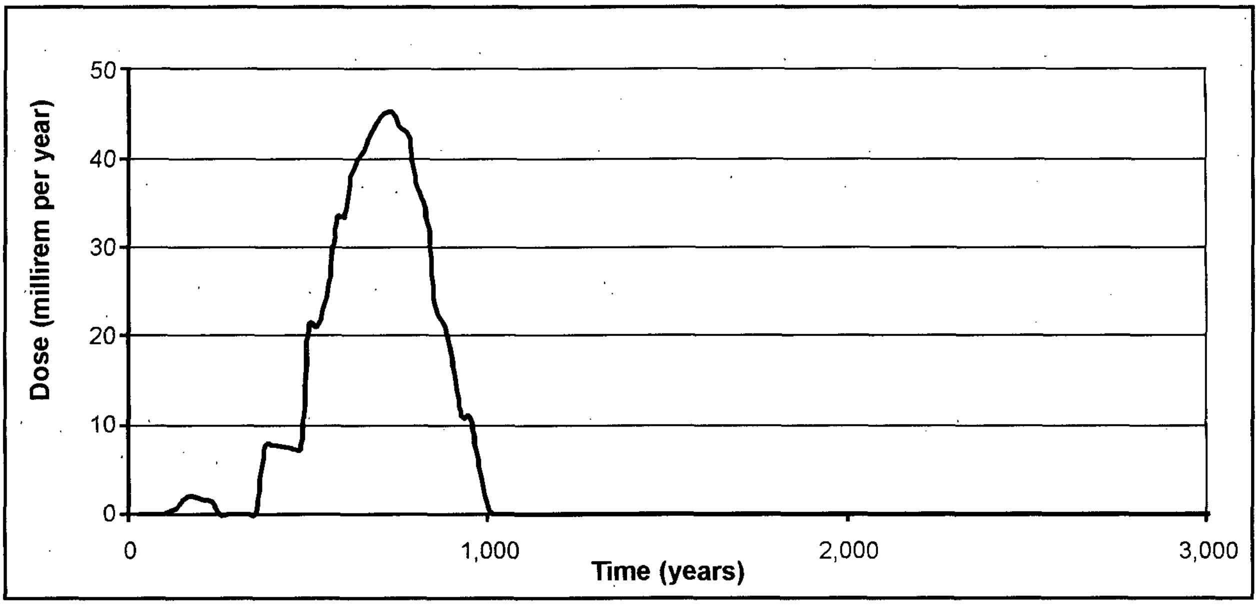

Figure L–3 Annual Total Effective Dose Equivalent (millirem per year) for the Cattaraugus Creek Receptor as a Function of Time – Unmitigated Erosion Scenario

Table L–13 Peak Annual Total Effective Dose Equivalent in Millirem Per Year for the Postulated Seneca Nation of Indians Receptor – Unmitigated Erosion Scenario (years till peak exposure in parentheses)

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Low-Level Waste Treatment Facility	4 (156)	4 (156)
NDA – WMA 7	107 (725)	107 (725)
Total	107 (725)	107 (725)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

Lake Erie Water User

In addition to the Cattaraugus Creek and Seneca Nation of Indians receptors, the peak annual dose for a Sturgeon Point water user has been prepared for the unmitigated erosion release scenario. These are summarized in **Table L–14**. Again, two separate peaks are shown, with releases from the NDA producing the higher dose level.

Table L–14 Peak Annual Total Effective Dose Equivalent Dose in Millirem Per Year for a Sturgeon Point Water User – Unmitigated Erosion Scenario (years till peak exposure in parentheses)

Waste Management Areas	*Sitewide Close-In-Place Alternative – Immediate License Termination*	*Sitewide Close-In-Place Alternative – License Termination After 100 Years*
Low-Level Waste Treatment Facility	0.39 (156)	0.39 (156)
NDA – WMA 7	6.9 (725)	6.9 (725)
Total	6.9 (725)	6.9 (725)

NDA = NRC-licensed Disposal Area, WMA = Waste Management Area.

Dose from Multiple Sources

The previous discussion presented information on the dose to various receptors from individual WMAs. There is the potential for receptors to come in contact with contamination from multiple areas and therefore experience higher doses than those from a single WMA. The highest doses are generally for resident farmers who use contaminated water near a specific WMA (Table L–9). It is conceivable that a single well on the North Plateau could intercept contamination from multiple sources. The information in Table L–9 suggests there may be combined impacts for plumes that have peaks that occur during similar timeframes.

The greatest potential for a dose from multiple sources appears to be a water well on the North Plateau that would intercept the plume from both the Main Plant Process Building and the Waste Tank Farm. The peak dose for the Main Plant Process Building and Waste Tank Farm is estimated to occur around year 200 for both WMAs (see Table L–9). A conservative estimate of the combined dose from the Main Plant Process Building and the Waste Tank Farm would be about 900 millirem per year (366 from Main Plant Process Building and 556 from the Waste Tank Farm).

Other combinations for the Sitewide Close-In-Place Alternative appear to have much less potential for high doses. The thick engineered caps limit the peak annual dose for drilling or home construction scenarios to a few millirem, doses which are small in comparison to the doses from using contaminated water.

L.2.2.4 Conclusions about Sitewide Close-In-Place Alternative Compliance with License Termination Rule Dose Criteria

Assuming the area of institutional controls is consistent with the current site boundary, the analysis in this section indicates that the Sitewide Close-In-Place Alternative could comply with the dose criteria that apply when institutional controls are in effect.

The analysis also indicates that, in some cases, the Sitewide Close-In-Place Alternative could exceed the dose criteria for situations involving the loss of institutional controls. In both cases, the determination of what constitutes the License Termination Rule compliance scenarios and what are justifiable assumptions for the long-term performance will be critical in determining whether the dose criteria are met.

These issues, along with compliance with the decommissioning requirements for institutional controls and procedural requirements, would be addressed and resolved as part of the Decommissioning Plan preparation and review process.

L.3 Radiological Decommissioning of the State-licensed Disposal Area

It is expected that the SDA would continue to be regulated via a Part 380 permit and a New York State Department of Health license. Decommissioning criteria that would apply for a close-in-place option for the SDA have not been established. The 6 NYCRR Part 384 regulations being developed by NYSDEC (NYSDEC 2008) could apply to the SDA, but it is not clear that these regulations would accommodate a close-in-place option. The outreach for public comments on the planned 6 NYCRR Part 384 did not mention the SDA.

L.4 References

NRC (U.S. Nuclear Regulatory Commission), 2002, *Decommissioning Criteria for the West Valley Demonstration Project (M-32) at the West Valley Site; Final Policy Statement*, 67 *Federal Register* 5003, Washington, DC, February 1.

NRC (U.S. Nuclear Regulatory Commission), 2006, *Consolidated Decommissioning Guidance,* NUREG-1757, Volume 2, Rev. 1, Washington, DC, September.

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APPENDIX M
FLOODPLAIN AND WETLAND ASSESSMENT

APPENDIX M
FLOODPLAIN AND WETLAND ASSESSMENT

M.1 Introduction

The U.S. Department of Energy (DOE) proposes to decontaminate and decommission the waste storage tanks and other facilities of the Western New York Nuclear Service Center (WNYNSC) in which the high-level radioactive waste solidified under the West Valley Demonstration Project (WVDP) was stored, the facilities used in the solidification of the waste, and any material and hardware used in connection with the WVDP, in accordance with the requirements of the WVDP Act. DOE is preparing the *Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center (Decommissioning and/or Long-Term Stewardship EIS*) (DOE/EIS-0226-D [Revised]) to present the environmental impacts associated with the range of reasonable alternatives to meet the DOE and New York State Energy Research and Development Authority (NYSERDA) National Environmental Policy Act (NEPA) and New York State Environmental Quality Review Act (SEQR) requirements, respectively.

Executive Order 11988, "Floodplain Management," directs Federal agencies to evaluate the potential effects of any actions that may be taken in a floodplain. When conducting activities in a floodplain, Federal agencies are required to take actions to reduce the risk of flood damage; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Executive Order 11990, "Protection of Wetlands," directs Federal agencies to ensure consideration of wetlands protection in decisionmaking and to evaluate the potential impacts of any new construction proposed in a wetland. Federal agencies shall avoid the destruction or modification of wetlands, and avoid direct or indirect support of new construction in wetlands if a practicable alternative exists.

DOE requirements for compliance with Executive Orders 11988 and 11990 are set forth in 10 *Code of Federal Regulations* (CFR) Part 1022, "Compliance with Floodplain and Wetland Environmental Review Requirements." The Executive Orders direct Federal agencies to implement floodplain and wetland requirements through existing procedures such as those established to implement NEPA, to the extent practicable. Pursuant to 10 CFR Part 1022, this appendix addresses actions that would affect floodplains or wetlands for each of the environmental impact statement (EIS) alternatives.

M.2 Alternatives and Affected Environment

A detailed description of the alternatives is found in Chapter 2 of the EIS. The alternatives include the Sitewide Removal Alternative that would allow unrestricted release of the entire WNYNSC; the Sitewide Close-In-Place Alternative, under which all existing facilities and contamination would be managed at their current locations, and engineered barriers would be used to control contamination in areas with higher levels of long-lived contamination; the Phased Decisionmaking Alternative, under which there would be initial (Phase 1) decommissioning actions for some facilities and a variety of activities intended to expand the information available to support later, additional decommissioning decisionmaking (Phase 2) for those facilities/areas not addressed in Phase 1; and the No Action Alternative. This assessment addresses potential floodplain and wetland impacts for each of these alternatives.

WNYNSC, shown in **Figure M–1**, occupies 1,352 hectares (3,340 acres) of land in Cattaraugus County, New York, and approximately 5.7 hectares (14 acres) in southern Erie County, New York. WNYNSC is drained by Buttermilk Creek, which joins Cattaraugus Creek at the northern end of the property. Cattaraugus Creek flows northwest into Lake Erie approximately 50 kilometers (30 miles) southwest of Buffalo, New York.

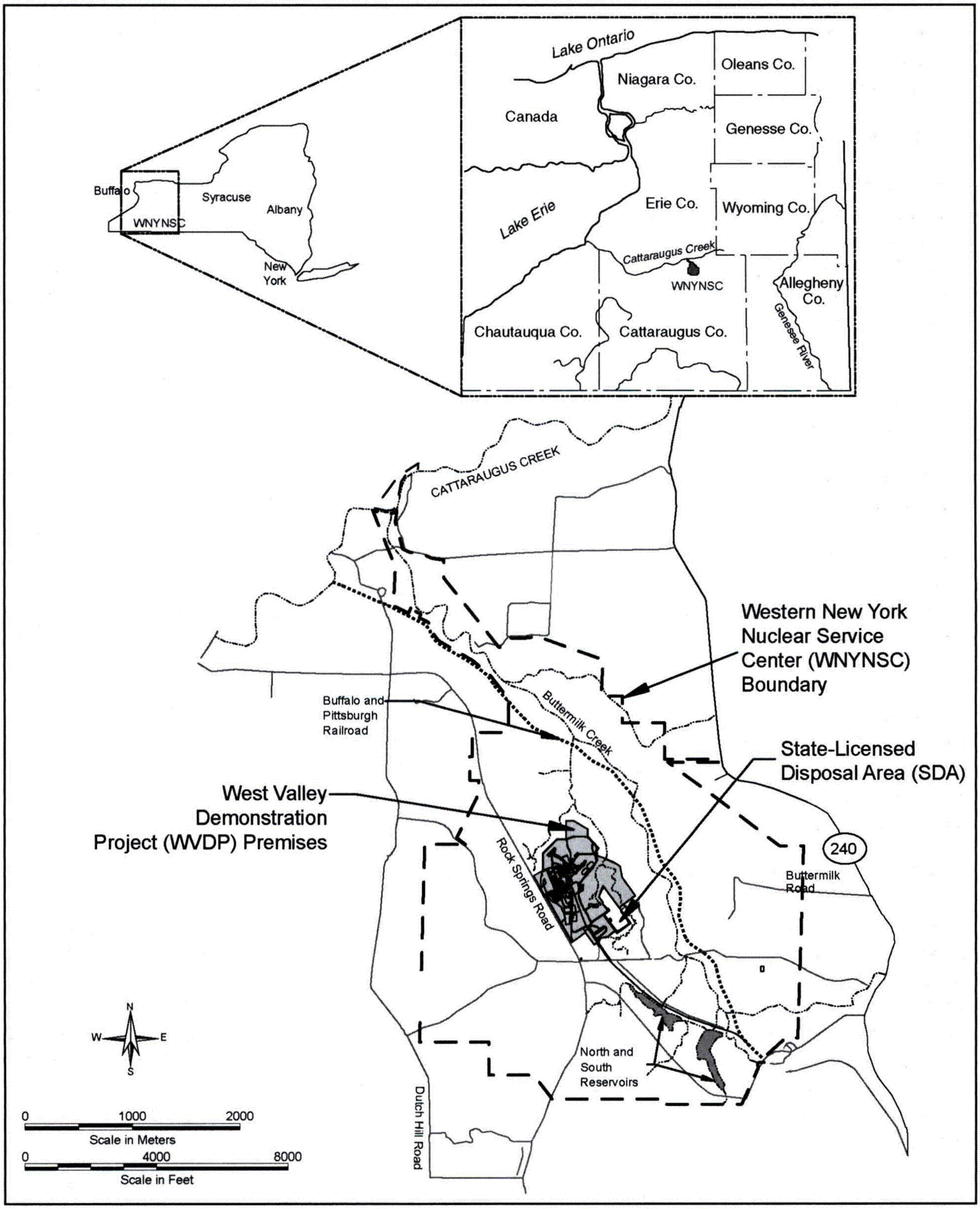

Figure M–1 The Western New York Nuclear Service Center

WNYNSC is divided into 12 Waste Management Areas (WMAs). WMA 1 through WMA 10 are shown in **Figure M–2** and WMA 11 and WMA 12 are shown in **Figure M–3**. The Region of Influence addressed in this Floodplain and Wetland Assessment includes the WNYNSC and nearby offsite areas.

M.2.1 Floodplains

A floodplain is the area of land adjacent to a river, stream, or creek that may become inundated by floodwaters, often following heavy rainfall events that cause the channel to exceed bankfull discharge. Floodplains retain excess water following flood events, allowing water to be slowly released into the river system and seep into groundwater aquifers. Likewise, floodplains are natural recharge areas that help replenish the baseflow of the river system, as well as supply recharge to underlying groundwater aquifers. Vegetation and woody debris in floodplains slow surface flow and floodwaters and act like a sediment trap by causing sediment to settle out of floodwaters, thereby preventing alteration of the downstream channel geography due to sedimentation. This is a benefit because sedimentation can have ecological impacts, as well as impacts on the channel hydraulics and geomorphology. Floodplains often support important wildlife habitat and are frequently used by humans as recreational areas.

A 100-year flood is a flood that has a one percent probability of being equaled or exceeded in any given year. The area inundated by the 100-year flood is called the 100-year floodplain. A 500-year flood is a flood that has a 0.2 percent probability of being equaled or exceeded in any given year, inundating the flood area known as the 500-year floodplain. Probable maximum precipitation is defined as the greatest depth (amount) of precipitation, for a given storm duration, that is theoretically possible for a particular area and geographic location. The probable maximum flood is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area (i.e., the worst theoretical flood that could be expected to occur).

A critical action floodplain means, at a minimum, the 500-year floodplain (10 CFR 1022.4). Critical action means any DOE action for which even a slight chance of flooding would be too great. Such actions may include, but are not limited to, the storage of highly volatile, toxic, or water reactive materials. In a case where an action is determined to be a critical action, a flood less frequent than a 500-year flood may be appropriate for determining the floodplain.

As described in the *Final Environmental Assessment for Decontamination, Demolition, and Removal of Certain Facilities at the West Valley Demonstration Project* (DOE/EA-1552) the WNYNSC's topographic setting renders major flooding unlikely; local runoff and flooding is adequately accommodated by natural and manmade drainage systems in and around the WVDP (DOE 2006). The flood inundation area for the 100-year storm (see **Figure M–4**) show that no existing facilities are in the 100-year floodplain. This is primarily attributable to the fact that Cattaraugus and Buttermilk Creeks, as well as Franks Creek, Quarry Creek, and Erdman Brook, are located in deep valleys such that floodwaters would not overtop their banks flooding the plateau areas where WVDP facilities are located. The floodplains depicted on Figure M–4 are those that would be affected by implementation of alternatives for decommissioning activities as described in this appendix. None of the proposed activities would affect the Buttermilk Creek floodplain in the southern part of the WNYNSC (FEMA 1984).

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps for the town of Ashford, New York, delineate areas of the 100-year floodplain and areas above the 500-year floodplain (FEMA 1984). However, the FEMA maps do not show the floodplains on streams near the developed portion of the site. An analysis of the probable maximum flood (PMF) based on probable maximum precipitation has been performed for this EIS (**Figure M–5**). The probable maximum flood is generally more conservative than the

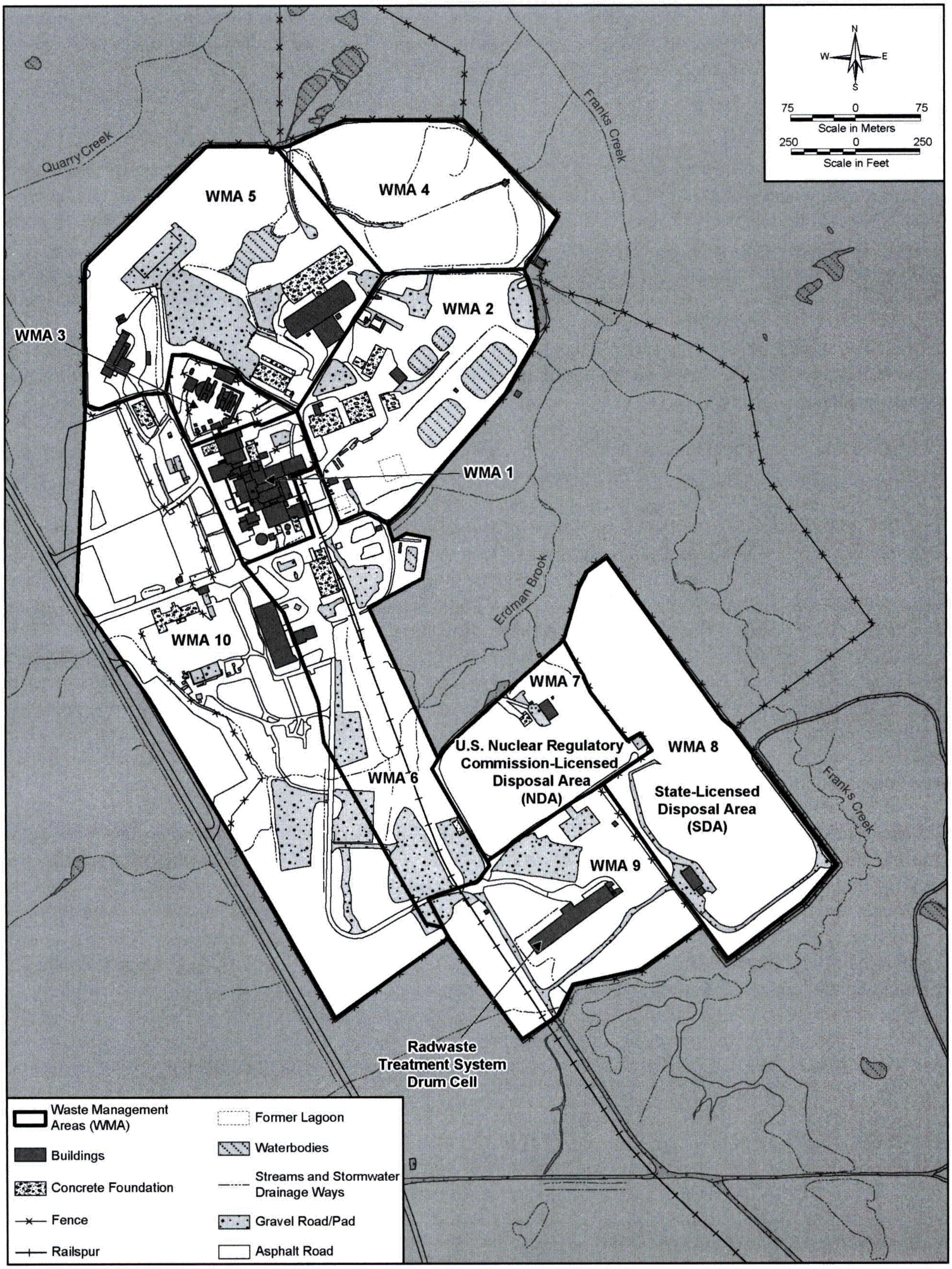

Figure M–2 Location of Waste Management Areas 1 through 10

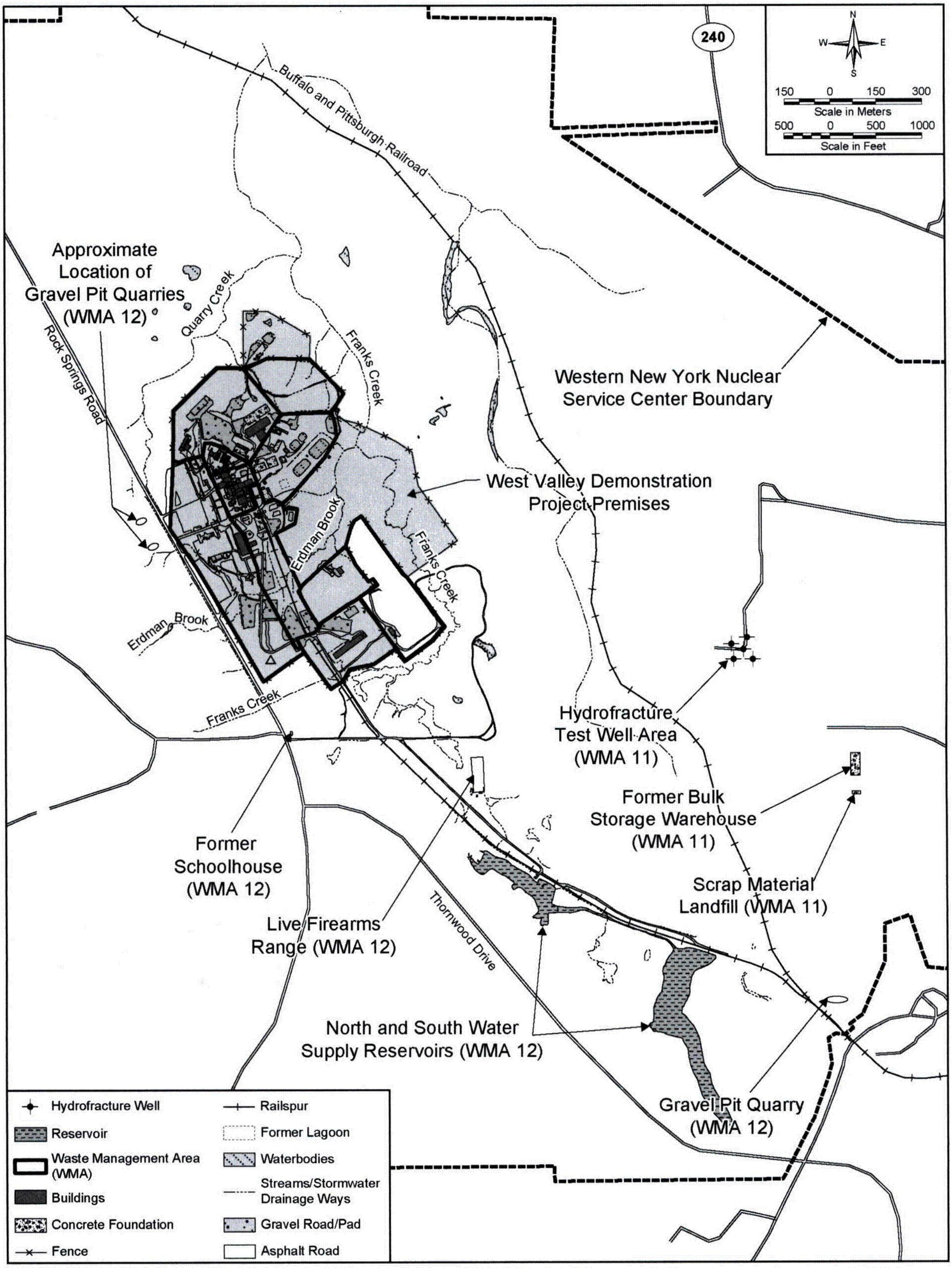

Figure M–3 Waste Management Areas 11 and 12 – Bulk Storage Warehouse Area and Balance of the Western New York Nuclear Service Center

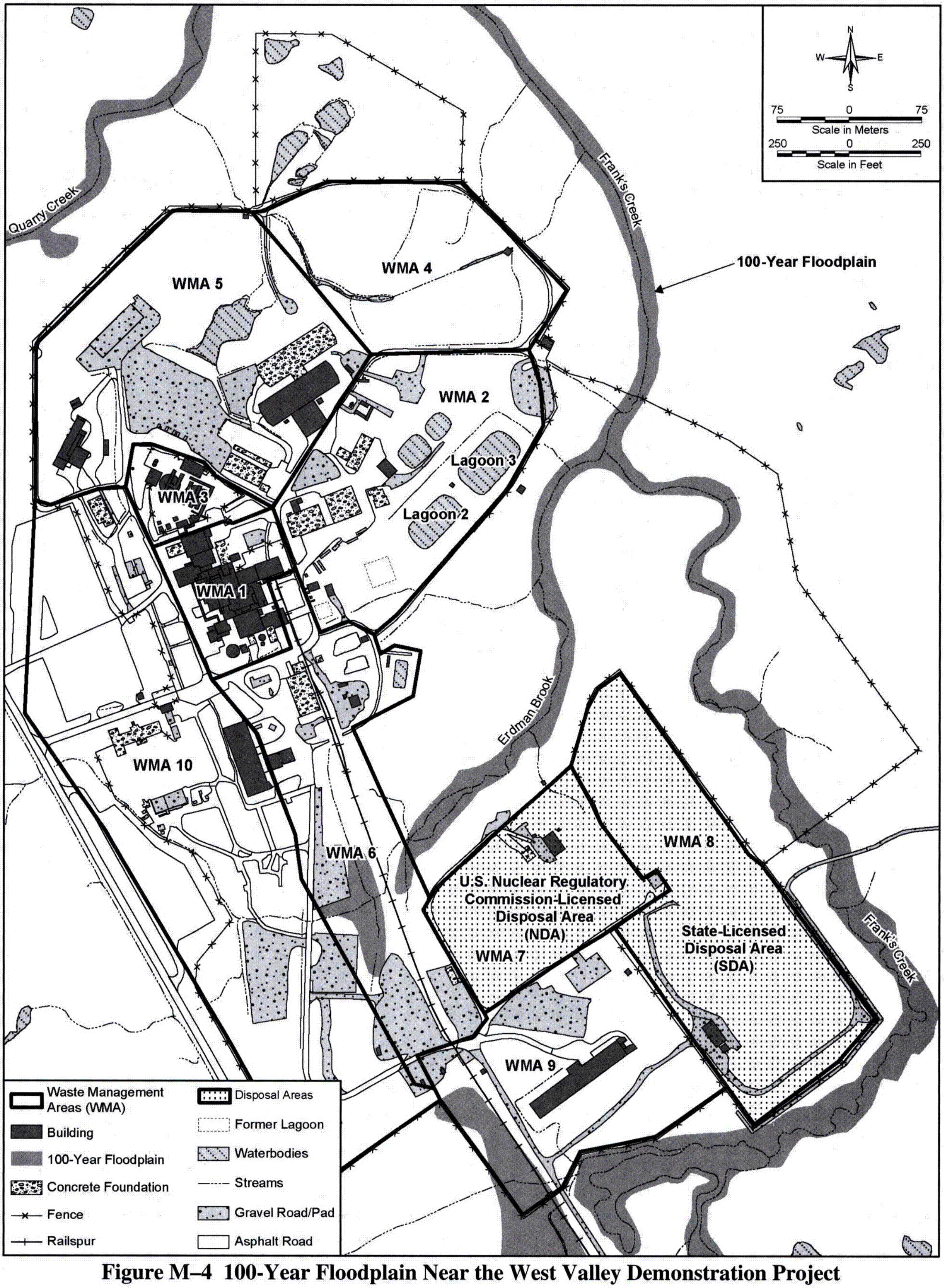

Figure M–4 100-Year Floodplain Near the West Valley Demonstration Project

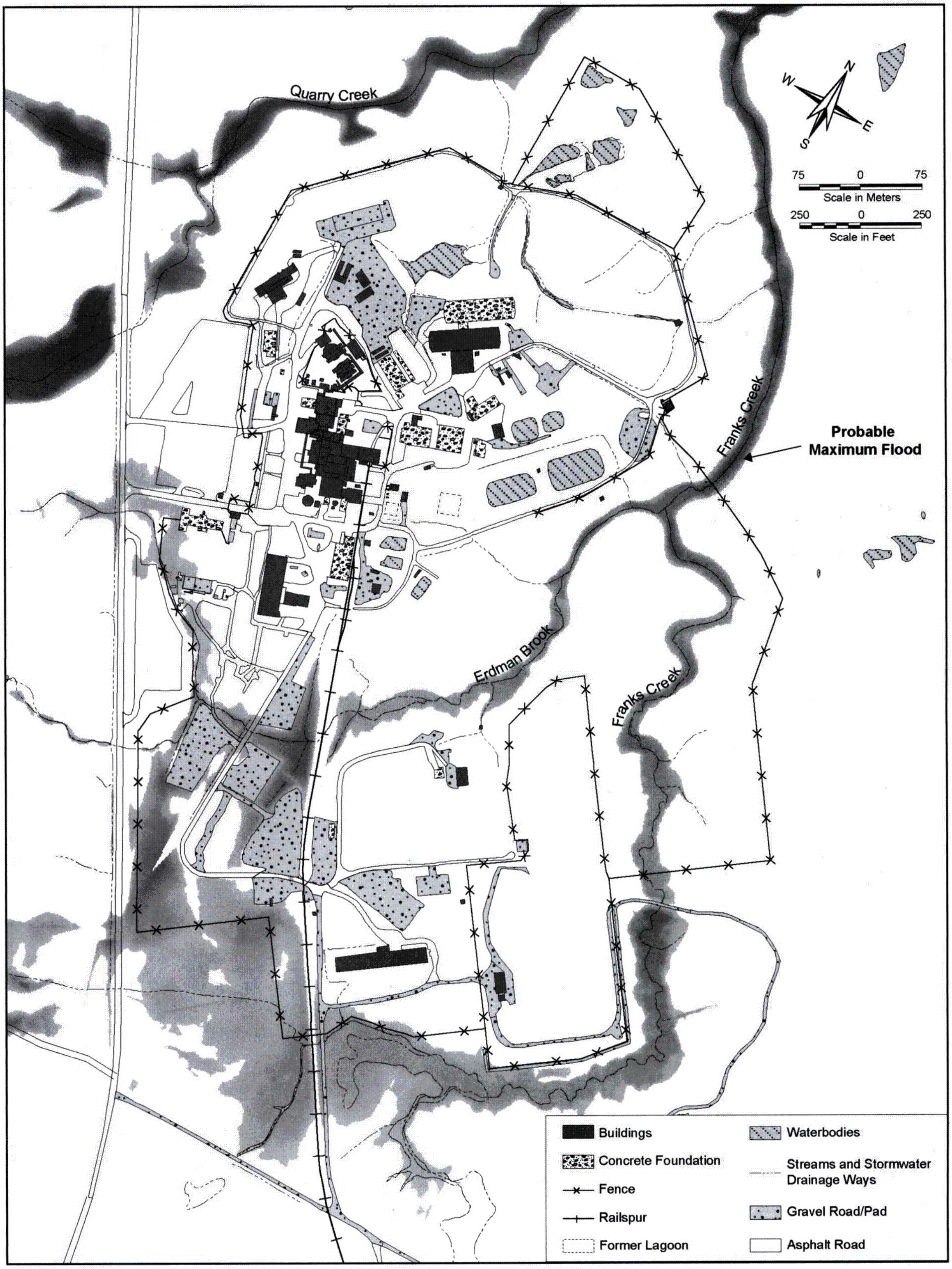

Figure M–5 Probable Maximum Flood

500-year flood because it is defined as the flood resulting from the most severe combination of meteorological and hydrologic conditions that are reasonably possible in a particular area (DOE 2002). The results of this analysis indicate that the PMF floodplain is very similar to the 100-year floodplain, particularly in areas adjacent to the industrialized or developed portions of the site including areas where waste is stored or buried (URS 2008). Most of the stream channels near the industrialized area have relatively steep sides and the PMF flow remains in these channels. The PMF floodplain is wider than the 100-year floodplain in areas where the topography is relatively flat such as the extreme upper reaches of Erdman Brook and Franks Creek. Indirect short-term impacts, including streambank failure and gully head advancement in the event of high streamflows, could impact Lagoon 2 and Lagoon 3 in WMA 2, the U.S. Nuclear Regulatory Commission (NRC)-licensed Disposal Area (NDA), and site access roads in several locations. Under probable maximum flood conditions, it is possible that the integrity of the northern slope of the State-licensed Disposal Area (SDA) could be compromised (WVNS 2007). See Appendix F of the EIS for results of predictive erosion modeling including the effects of sheet and rill erosion, stream valley rim widening, and gully advance over the longer term.

M.2.2 Wetlands

Wetlands include "those areas that are inundated or saturated by surface- or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (EPA 2002). Wetlands perform numerous environmental functions that benefit ecosystems as well as society, such as removing excess nutrients from the water that flows through them. The benefit derived from nutrient removal is improved or maintained water quality. This in turn promotes clean drinking water, safe recreation, and secure fish and wildlife habitat. Further, wetlands absorb, store, and slowly release rain and snowmelt water, which minimizes flooding, stabilizes water flow, retards runoff erosion, and controls sedimentation. Wetlands filter natural and manufactured pollutants by acting as natural biological and chemical oxidation basins. Water leaving a wetland is frequently cleaner than the water entering. Wetlands can also be helpful in recharging groundwater and serve as groundwater discharge sites, thereby maintaining the quality and quantity of surface water supplies. Wetlands are one of the most productive and valuable habitats for feeding, nesting, breeding, spawning, resting, and cover for fish and wildlife (NYSDEC 2005).

The most recent wetland delineation was conducted in July and August of 2003 on approximately 152 hectares (375 acres) of the WNYNSC, including the WVDP Premises and adjacent parcels to the south and east of the WVDP Premises (WVNS and URS 2004, Wierzbicki 2006). Wetland plant communities identified within the limits of the assessment area included wet meadow, emergent marsh, scrub shrub, and forested wetland. The investigation identified 68 areas comprising 14.78 hectares (36.52 acres) as jurisdictional wetlands, with each area ranging from 0.004 to 2.95 hectares (0.01 to 7.30 acres) as shown in **Figures M–6** and **M–7**).

A field investigation conducted on November 2, 2005, by the U.S. Army Corps of Engineers in conjunction with review of relevant reports and maps confirmed the 2003 wetlands delineation results that there are wetlands totaling 14.78 hectares (36.52 acres). Twelve distinct wetlands, totaling 0.98 hectares (2.43 acres), were observed to exhibit no surface water connection to waters of the United States; they are considered isolated, intrastate, and non-navigable wetlands and are not under U.S. Army Corps of Engineers jurisdiction. It was concluded that remaining 13.80 hectares (34.09 acres) of wetlands are waters of the United States subject to regulation under Section 404 of the Clean Water Act. These waters were determined to be part of an ecological continuum constituting a surface water tributary system of Buttermilk Creek, Cattaraugus Creek, and Lake Erie. The U.S. Army Corps of Engineers approved DOE's wetland determination application on January 26, 2006, which will remain valid for a period of 5 years unless new information warrants revision prior to the expiration date (Senus 2006).

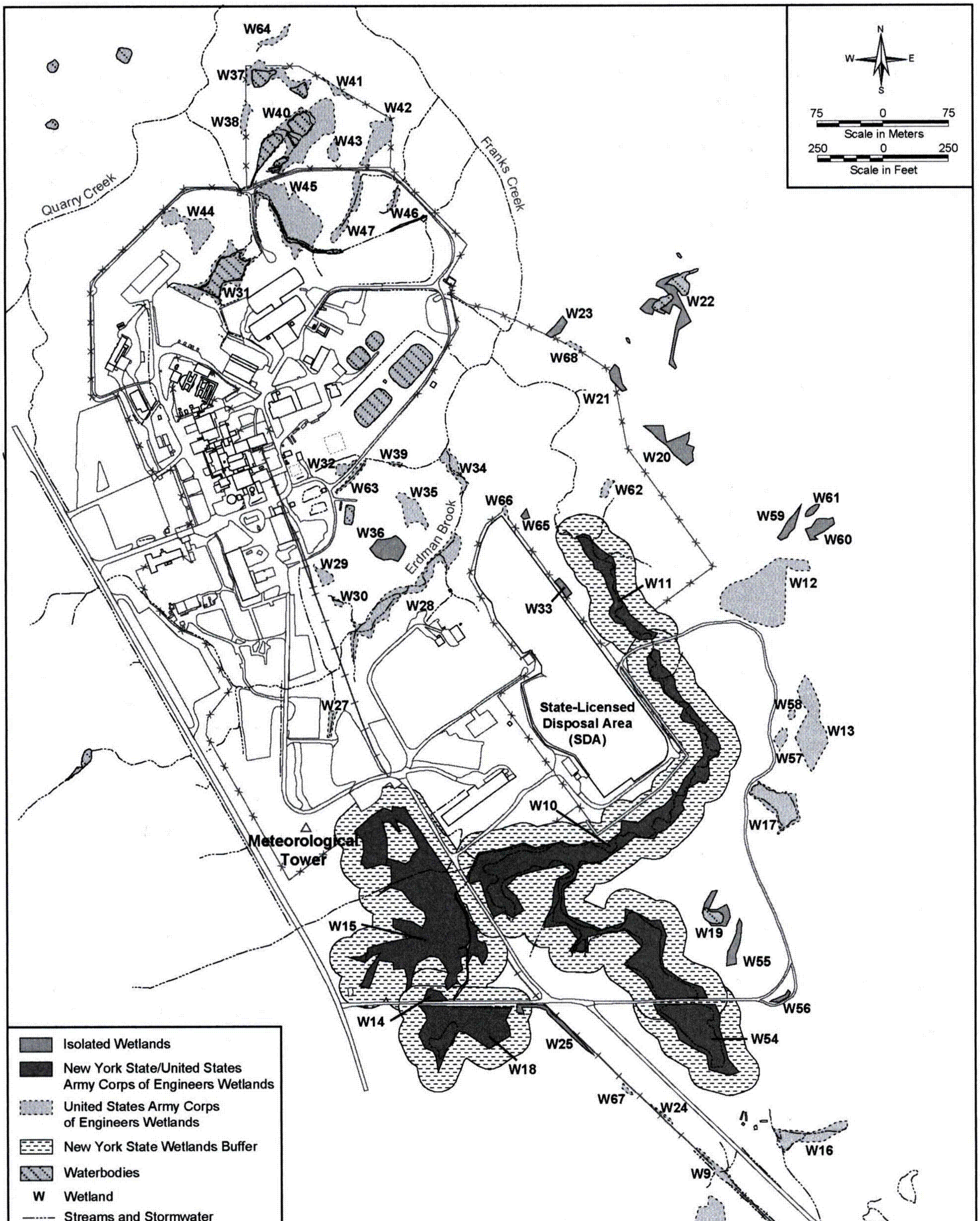

Figure M–6 Wetlands in the Vicinity of the West Valley Demonstration Project Premises

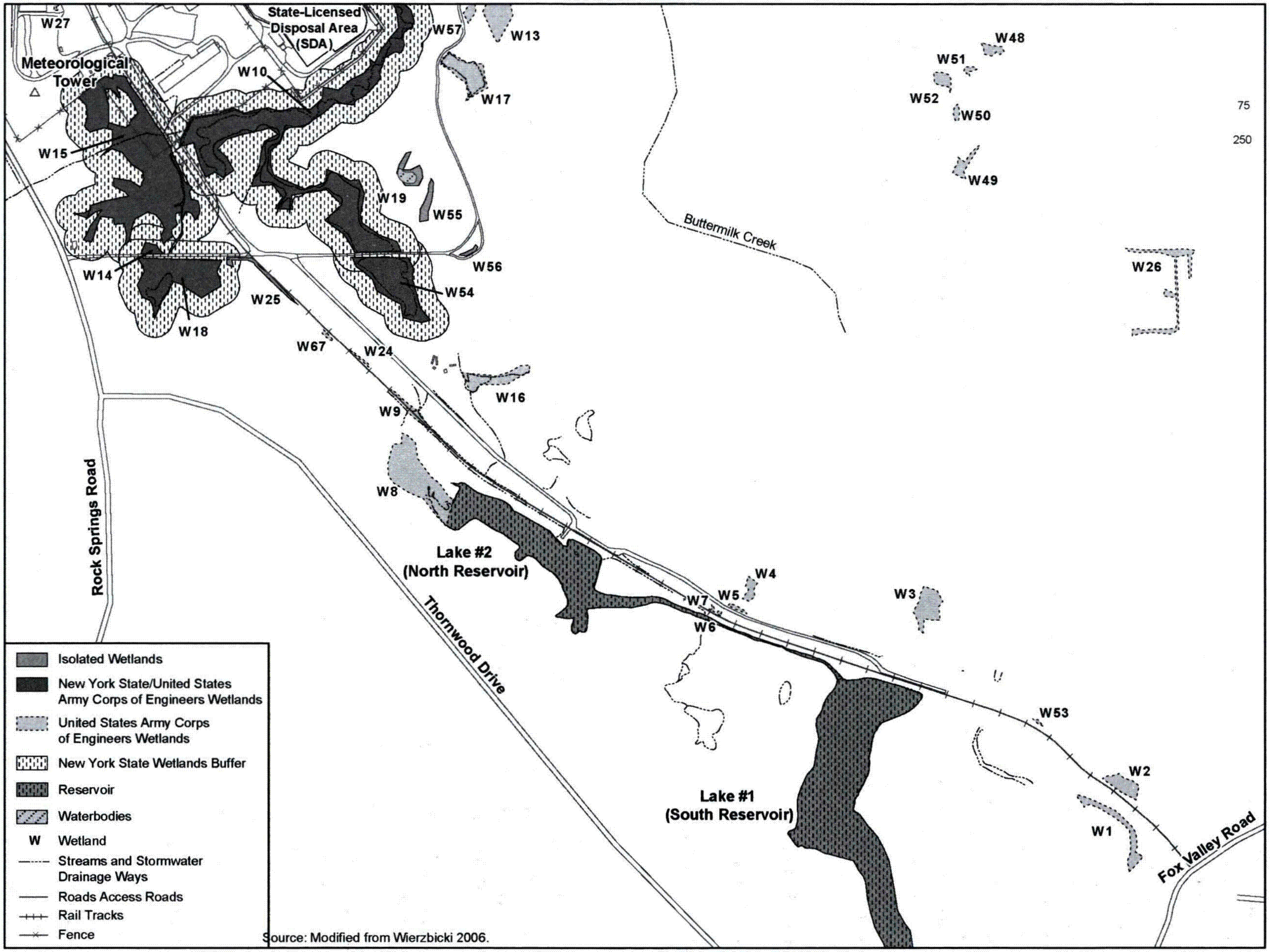

Figure M–7 Wetlands in the Southern Vicinity of the West Valley Demonstration Project Premises

Certain wetlands are also regulated by New York as freshwater wetlands. Article 24 of New York State's Freshwater Wetlands Act regulates draining, filling, construction, pollution or any activity that substantially impairs any of the functions and values provided by wetlands 5.0 hectares (12.4 acres) or larger. The State also regulates work within a 100-foot (30.5-meter) buffer zone around designated freshwater wetlands. Although there are no wetlands currently mapped on the New York State Department of Environmental Conservation (NYSDEC) Map, six wetland areas (W10, W11, W14, W15, W18, and W54) encompassing 7.0 hectares (17.3 acres) and delineated in the 2003 field investigation appear to be hydrologically connected (see Figure M–7). The majority of these wetlands are located just south of the south WVDP Premises fence (WVNS and URS 2004). On December 28, 2005, NYSDEC-Region 9 concurred with the wetland delineation conducted in 2003 and concluded that the six wetland areas are hydrologically connected, exceed 5.0 hectares (12.4 acres) in aggregate and therefore constitute an Article 24 state jurisdictional wetland (Ermer 2005). These wetland areas are dominated by wet meadow plant communities but also include emergent marsh, scrub shrub (shrub swamp), and forested wetland (deciduous swamp) plant communities (WVNS and URS 2004). Because wet meadow plant communities dominate the state wetlands, under the New York State Freshwater Wetlands classification system, these wetlands would be considered Class IV; of the four classes, Class I has the highest value (NYSDEC 1980). The classification system recognizes that different wetland types have different values and applies different standards for permit issuance.

M.3 Floodplain and Wetland Impacts

M.3.1 Sitewide Removal Alternative

M.3.1.1 Floodplains

Short-term impacts to the 100-year floodplain would be expected for the delineated floodplain zone in the proximity of Cesium Prong remediation work, the North and South Reservoirs and dam removal, and streambed sediment remediation in Erdman Brook and Franks Creek. Although major flooding is unlikely, these activities could result in near-term floodway or floodplain alteration impeding or redirecting flows or surface flow impacts to the 100-year floodplain. Changes in floodplain erosion and sedimentation rates are not expected to create adverse unmitigatible impacts as appropriate mitigation measures to control erosion and sediment during decommissioning and closure activities would decrease impacts (see Section M.4.1).

Results of the PMF analysis indicate that the delineation of the PMF floodplain is close to that of the 100-year floodplain (URS 2008). New facilities proposed for construction under the Sitewide Removal Alternative would not be located in the 100-year floodplain. Preliminary analysis using current topography indicates the only facility near the PMF floodplain would be the planned Interim Storage Facility. A more detailed analysis would be required as part of detailed design of the Interim Storage Facility to minimize potential impacts, if any, to the floodplain.

No permanent losses to the 100-year or PMF floodplain areas in the WNYNSC vicinity would result from implementation of the Sitewide Removal Alternative and loss of flood storage volume would not occur.

M.3.1.2 Wetlands

Under the Sitewide Removal Alternative no wetlands would be affected during construction of temporary facilities, because none are present on the proposed building sites. However, wetlands would be directly and indirectly impacted by demolition and remediation activities, particularly during remediation of the Cesium Prong. Indirect impacts include the alteration or destruction of wetlands resulting from sedimentation following earthmoving activities and the removal of contaminated sediments from streams. Noise and human presence may also impact wildlife present within wetland areas.

Direct impacts on wetlands would occur in connection with remediation of the Cesium Prong where six delineated wetland areas (W31, W37, W38, W40, W44, and W45) totaling 2.1 hectares (5.1 acres) are located in and around WMAs 3, 4, and 5. Removal of the SDA would directly impact one jurisdictional wetland (W66) totaling 0.01 hectare (0.02 acre) and two isolated wetlands (W33 and W65) measuring 0.04 hectare (0.1 acre). Work on removal of the SDA also has the potential to impact the 100-foot (30.5-meter) buffer zone around two New York State Freshwater Wetlands (W10 and W11) that border the SDA to the east and south (see Figure M–6). Any work within the buffer zone would require a permit from the State. Additionally, five other wetland areas (W4, W5, W6, W7, and W8) measuring a total of 0.7 hectare (1.8 acres) would be indirectly affected as a result of altered water levels and siltation during closure of the dams and reservoirs in WMA 12 (see Figure M–7). The largest of these wetlands is located at the head end of the North Reservoir, while the other four smaller wetlands are located just downstream from the discharge point from the North Reservoir. Noise and human presence may impact wildlife within the wetland areas. Wetlands not disturbed by activities associated with the Sitewide Removal Alternative would continue to perform water quality functions such as sediment retention and stabilization, nutrient transformation, and flood flow attenuation.

M.3.2 Sitewide Close-In-Place Alternative

M.3.2.1 Floodplains

New facilities proposed for construction under the Sitewide Close-In-Place Alternative (e.g., the Interim Storage Facility and the Leachate Treatment Facility) would not impact the 100-year floodplain because these facilities would not be constructed in the 100-year floodplain. However, replacement of existing geomembrane covers with robust multi-layer caps (i.e., engineered barriers) on the south plateau in WMAs 7 and 8 (on the upgradient side of the NDA and SDA, respectively) would intrude into the 100-year floodplain delineated for Erdman Brook and Franks Creek (see **Figure M–8**). The erosion control structures planned under the Sitewide Close-In Place Alternative would increase water flow around two sides of WMA 8 in the proximity of the 100-year floodplain. This redirection of water to Franks Creek on the floodplain would increase the potential for erosion from the increased flow.

Constructing permanent structures in the 100-floodplain could directly impact channel hydraulics and the extents of downstream flood inundation areas as a result of increasing the floodplain elevation in the vicinity of the south plateau. If elevations are significantly increased in the 100-year floodplain of the south plateau, it is likely that flood events extending into the 100-year floodplain delineated for Erdman Brook and Franks Creek shown on Figure M–8 would occur less frequently because it would require a larger volume of water to reach these extents at a higher elevation. An increased elevation in the floodplain could also result in an increase in flooding downstream of the south plateau because a larger volume of water would be traveling downstream instead of inundating the floodplain in the south plateau. As a result of a larger volume of water flowing in the downstream direction, the frequency and intensity of flood events occurring downstream of the south plateau could increase.

The PMF floodplain is very similar to the 100-year floodplain, and most of the impacts to the PMF floodplain for implementation of the Sitewide Close-In-Place Alternative are expected to be similar to those identified in this section for the 100-year floodplain. Preliminary analysis using current topography indicates the only facility in or near the PMF floodplain would be the planned Interim Storage Facility. A more detailed analysis would be required as part of detailed design of the Interim Storage Facility to minimize potential impacts, if any, to the floodplain.

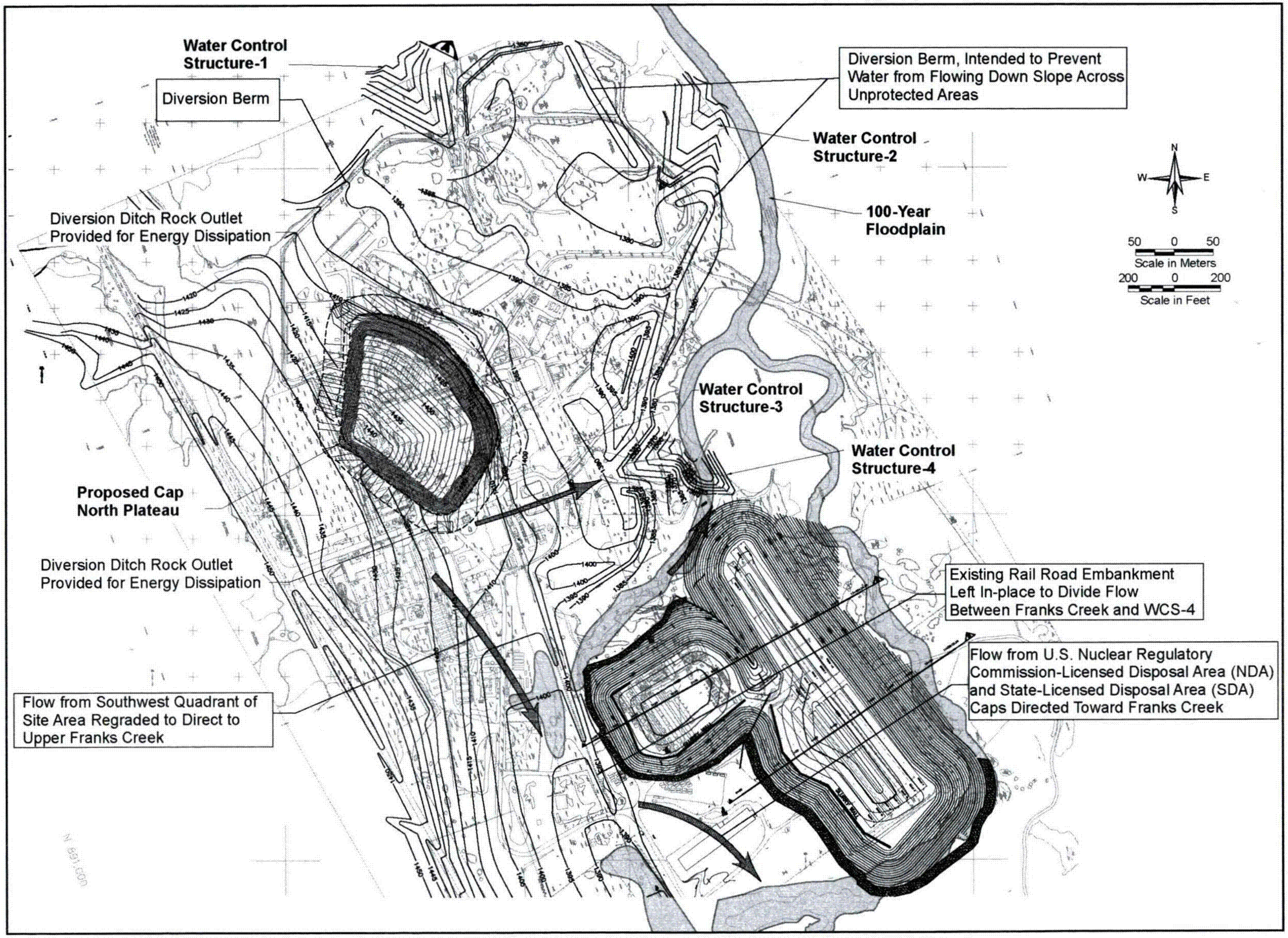

Figure M–8 Floodplain Encroachment by Multi-layer Covers for Waste Management Area 7 and Waste Management Area 8

Potential long-term impacts may occur from repeated flooding events (i.e., 100 year floods or greater) affecting the integrity of the engineered barriers causing potential releases if they are breached, particularly when institutional controls can no longer be assumed. Long-term impacts for the Sitewide Close-In-Place Alternative are presented in Section H.2.2 of Appendix H, Long-term Performance Assessment Results. Section H.2.2 discusses an indefinite continuation of institutional controls including impacts following releases to the local groundwater, discharges to onsite streams (Erdman Brook, Franks Creek, and Buttermilk Creek), and flow into Cattaraugus Creek. Additionally, the loss of institutional controls leading to unmitigated erosion of the NDA and SDA (i.e., no credit is taken for monitoring and maintenance of erosion control structures) is analyzed in Appendix H.

M.3.2.2 Wetlands

No wetlands would be affected during construction of new facilities for the Sitewide Close-In-Place Alternative, because none are present on the proposed building sites. However, construction of erosion control measures under this alternative would directly impact two jurisdictional wetlands (W34 and W39) totaling approximately 0.1 hectare (0.3 acre), while placement of the multi-layer cap over the NDA and SDA would directly impact three jurisdictional wetlands (W10, W11, [both also New York State Freshwater Wetlands] and W66) totaling 3.3 hectares (8.3 acres), and two isolated wetlands (W33 and W65) measuring 0.04 hectare (0.1 acre). The actual disturbance to the jurisdictional wetlands would be less than half of their total area. Impacts to these wetlands would be similar to those addressed in Section M.3.1.2. Additionally, placement of the multi-layer cap has the potential to cause indirect impacts (e.g., sedimentation) to those portions of the New York State wetlands not directly impacted. Placement of the multi-layer cap would impact the 100-foot (30.5-meter) buffer zone around the New York State wetlands. Any work within the State wetlands (and buffer zone) would require a permit from the State, as well as the U.S. Army Corps of Engineers. Mitigation measures such as those addressed in Section M.4.2 and Chapter 6 of the EIS would be implemented to address direct and indirect impacts.

Similar to the Sitewide Removal Alternative, five wetland areas measuring 0.7 hectare (1.8 acres) could be affected during closure activities associated with the dams and reservoirs. Direct and indirect impacts resulting from remediation and closure activities are similar to those addressed for the Sitewide Removal Alternative. For wetland mitigation measures, see Section M.4.2 and Chapter 6 of the EIS. There would be no removal of soil in the nonsource areas of the North Plateau Groundwater Plume and Cesium Prong for the Sitewide Close-In-Place Alternative; therefore, no associated impacts on wetlands would result. Wetlands not disturbed by activities associated with the Sitewide Close-In-Place Alternative would continue to perform water quality functions such as sediment retention and stabilization, nutrient transformation, and flood flow attenuation.

M.3.3 Phased Decisionmaking Alternative

Phase 1 of the Phased Decisionmaking Alternative would involve some decommissioning actions, but would also include additional characterization of site contamination and studies to provide information to support additional evaluations to determine the technical approach to be used to complete the decommissioning. Phase 2 would complete the decommissioning or long-term management decisionmaking, following the approach determined through the additional evaluations to be the most appropriate.

M.3.3.1 Floodplains

Construction proposed for Phase 1 of this alternative (the Interim Storage Facility) would not be located in the 100-year floodplain. The Cesium Prong would be managed in place, dams and reservoirs would be monitored and maintained, and contaminated sediment would not be removed from Erdman Brook and Franks Creek. Similar to the Sitewide Removal Alternative, indirect short-term impacts, including streambank failure and gully head advancement in the event of high streamflows, could impact Lagoon 2 and Lagoon 3 in WMA 2.

No additional impacts to the 100-year floodplain are expected. Most of the impacts to the PMF floodplain for implementation of Phase 1 would be similar to those identified for the 100-year floodplain; preliminary analysis using current topography indicates the only facility in or near the PMF floodplain would be the planned Interim Storage Facility. A more detailed analysis would be required as part of detailed design of the Interim Storage Facility to minimize potential impacts, if any, to the floodplain.

If Phase 2 actions under the Phased Decisionmaking Alternative include removal activities, short-term impacts could be expected for the delineated floodplain zone in the proximity of activities, resulting in near-term floodway or floodplain alteration impeding or redirecting flows or surface flow impacts to the 100-year floodplain. Changes in floodplain erosion and sedimentation rates are not expected to create adverse, unmitigatible impacts, as appropriate mitigation measures to control erosion and sediment during decommissioning and closure activities would be utilized to decrease impacts. If the future Phase 2 decision is to proceed with in-place closure, direct impacts to the floodplains would not exceed those identified for the Sitewide Close-In-Place Alternative and would mainly be attributed to the construction of permanent structures (i.e., engineered barriers for the NDA and SDA in WMAs 7 and 8) that intrude into the 100-year floodplain.

M.3.3.2 Wetlands

No wetlands would be affected during construction of temporary facilities for Phase 1 of the Phased Decisionmaking Alternative, because none are present on the proposed building sites. Proposed remediation and closure activities would not directly impact wetlands, because none are present in the associated WMAs. The removal of existing facilities during Phase 1 could lead to indirect impacts to nearby wetlands as described for the Sitewide Removal Alternative. Since the nonsource area of the North Plateau Groundwater Plume and Cesium Prong would not be remediated for Phase 1 of the Phased Decisionmaking Alternative but allowed to decay in place, there would be no impacts to wetlands associated with these locations. If during Phase 2 closure activities reflect those of the Sitewide Removal Alternative, impacts to wetlands would be similar to those addressed for that alternative in Section M.3.1.2. Thus, direct (2.8 hectares [7.0 acres]) and indirect impacts are possible and would result largely from the remediation of the North Plateau Groundwater Plume and Cesium Prong and removal of the North and South Reservoirs. If activities associated with Phase 2 follow the pattern of the Sitewide Close-In-Place Alternative direct (1.8 hectares [4.4 acres]) and indirect impacts to wetlands would be similar to those addressed for that alternative in Section M.3.2.2. In this case impacts would largely result from the installation of a number of erosion control measures and the placement of a multi-layer cap over the SDA.

M.3.4 No Action Alternative

M.3.4.1 Floodplains

No decommissioning activities would take place under the No Action Alternative; therefore, no floodplain impacts (or changes from the baseline condition) would occur. Floodplains in the vicinity of the WVDP would continue natural recharge functions such as replenishing the base flow of the nearby creek system, as well as supplying recharge to underlying groundwater aquifers. Additionally, vegetation and woody debris in the floodplains would continue to slow surface flow (i.e., floodwaters) and act like a sediment trap, thereby preventing alteration of the downstream channel geography due to sedimentation.

M.3.4.2 Wetlands

No decommissioning actions would be taken for the No Action Alternative; therefore, no impacts to wetlands (or changes from the baseline condition) would occur. Wetlands would continue to perform water quality functions such as sediment retention and stabilization, nutrient transformation, and flood flow attenuation.

M.4 Mitigation Measures

This section discusses the floodplain and wetland mitigation measures considered for the alternatives, and where necessary and feasible, implemented during construction, operation, and decommissioning activities (see also Chapter 6, Potential Mitigation Measures). Applicable regulatory requirements (e.g., Clean Water Act and the New York Freshwater Wetlands Act) are identified in Chapter 5 of the EIS.

In accordance with 10 CFR 1022.12(a)(3), DOE must address measures to mitigate the adverse impacts of actions in a floodplain or wetlands, including but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas. Wherever possible, DOE would avoid disturbing floodplains and wetlands and would minimize impacts to the extent practicable, if avoidance is not possible.

M.4.1 Floodplains

In accordance with Executive Order 11988, Floodplain Management, if activities directly impacting the floodplain are implemented for the Sitewide Removal Alternative or the Sitewide Close-In-Place Alternative, actions within the floodplain would be taken to reduce the risk of flood damage; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by the floodplain. Erosion controls for the engineered barriers, depicted in Figure C–28 in Appendix C of the EIS, would be designed to accommodate the probable maximum flood consistent with guidance in NUREG-1623, Design of Erosion Protection for Long-Term Stabilization (NRC 2002).

NYSDEC is the state's National Flood Insurance Program coordinating agency. Coordination with NYSDEC for technical assistance and guidance would occur prior to Cesium Prong remediation work, North and South Reservoir decommissioning and associated dam removal, and contaminated sediment removal from Erdman Brook and Franks Creek (for the Sitewide Removal Alternative), or installation of engineered multi-layer covers in the South Plateau (for the Sitewide Close-In-Place Alternative). This coordination relative to affected floodplains would assure that requirements of NYSDEC's Floodplain Development and Floodway Guidance are met (NYSDEC 2008).

The potential effects of flood hazards are expected to be minimal for Phase 1 of the Phased Decisionmaking Alternative and the No Action Alternative. Where activities would affect the 100-year floodplain and PMF floodplain (Sitewide Removal Alternative, Close-In-Place Alternative, and possibly Phase 2 of the Phased Decisionmaking Alternative), appropriate mitigation measures would be taken to minimize construction in the floodplain, establish vegetated buffer zones, and avoid soil disturbing activities during wet seasons. Stormwater runoff and erosion control measures identified below would be employed to reduce impacts to the floodplain.

Potential short-term impacts to the existing stormwater drainage infrastructure with the potential to impact floodplains would be mitigated by using appropriate stormwater runoff management during construction and operational phases. These measures include adherence to the State Pollutant Discharge Elimination System (SPDES) General Permit for construction activities occurring in an area of five acres or greater. The SPDES General Permit requires the implementation of best management practices to reduce nonsource pollutant loadings into waters of the State. For the Proposed Action and alternatives, stormwater runoff and erosion can be minimized during construction through the use of best management practices including, but not limited to, the following:

- Diversion structures designed to channel runoff away from disturbed surfaces
- Structures designed to collect, retain and/or treat any water that contacts disturbed surfaces

- Permanent stabilization of exposed surfaces once construction is complete
- Locating roads and access where the effect on water quality will be the least
- Implementing good housekeeping practices such as proper storage and spill prevention measures to prevent runoff from fuels, solvents, etc.
- Properly designing, constructing, and maintaining the affected property in a manner that will minimize contribution of pollutants to the water

Specific requirements for a Sitewide Stormwater Pollution Prevention Plan are listed in Section M.4.2 below.

M.4.2 Wetlands

Wetland mitigation measures for impacts associated with implementation of the Proposed Action and alternatives are as follows:

Activities affecting wetlands would be coordinated with the U.S. Army Corps of Engineers and NYSDEC, and through the project planning the sequence of avoidance to the extent practicable, minimization, and mitigation would be applied. Section 402 of the Clean Water Act requires permits for stormwater discharges from construction activities that disturb one or more acres of land. A Sitewide Stormwater Pollution Prevention Plan for controlling runoff and pollutants from the site during and after construction activities would be required to obtain permit coverage under NYSDEC's General Permit (GP-02-01) for Stormwater Discharges from Construction Activities. The Sitewide Stormwater Pollution Prevention Plan would address the following mitigating measures: (1) reduction or elimination of erosion and sediment loading, (2) controlling the impact of runoff on the water quality of the receiving water, (3) control of the increased volume and peak rate of runoff, and (4) maintenance of stormwater controls during and after completion of construction.

Prior to the disturbance of any wetland, a Section 404 permit would be acquired from the U.S. Army Corps of Engineers along with a Section 401 Water Quality Certificate from the State of New York. Additionally, a mitigation plan would be developed which would fully address the compensation mechanism selected (i.e., compensatory mitigation, mitigation bank, or in-lieu fee mitigation) to mitigate wetland impacts (73 FR 19594). Best management practices, including erosion and sediment controls and stormwater runoff control measures, would be implemented during all remediation work potentially affecting wetlands. These control measures would be inspected and maintained to prevent indirect impacts to wetlands. Proper maintenance of equipment and keeping workers within the work zone would help mitigate the impacts of wildlife (disturbed by noise and increased human presence in affected wetlands) temporarily moving from the area during work activities.

Filling of wetlands during construction and operations would be minimized to the extent practicable. Short-term surface water quality impacts would be mitigated through the use of administrative controls (e.g., delineating work area restrictions and erecting exclusion fencing) and physical controls (e.g., best management practices to decrease erosion, sedimentation, and stormwater runoff) (DOE 2006). Best management practices, as applicable, would include erosion and sediment control structures, runoff interceptor trenches or swales, filter or silt berms/fences, sediment barriers or basins, rock-lined ditches/swales, slope shaping and retaining fences, surface water runoff management, stormwater drainage structures, and waste management systems.

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APPENDIX N
INTENTIONAL DESTRUCTIVE ACTS

APPENDIX N
INTENTIONAL DESTRUCTIVE ACTS

> The purpose of this appendix is to evaluate the human health impacts of intentional destructive acts (IDAs) at the Western New York Nuclear Service Center (WNYNSC). The term "IDA" is used to include intentional malevolent acts, intentional malicious acts, and acts of terrorism.

N.1 Introduction

In accordance with recent U.S. Department of Energy (DOE) National Environmental Policy Act (NEPA) guidance (DOE 2006), this appendix was developed to explicitly consider the potential impacts of IDAs in NEPA documents. A wide range of IDA scenarios involving the release of radiological or toxic chemical materials can be postulated for WNYNSC. Each involves an action by intruders or insiders that affects existing inventories and their distribution at one of the waste management areas (WMAs) or during the transportation of radioactive waste packages from WNYNSC. The human health impacts of an IDA are directly related to the magnitude of radiological or chemical material available for dispersal, as well as the means of dispersing it to the environment. Other factors that affect impacts include population density, distance to the population, and meteorology. Appendix I of this environmental impact statement (EIS) identifies five types of accidents at WNYNSC: high-level radioactive waste tanks in the Waste Tank Farm (WMA 3); the Main Plant Process Building (WMA 1); radioactive waste packages; the U.S. Nuclear Regulatory Commission (NRC)-licensed Disposal Area (NDA) (WMA 7); and the State-licensed Disposal Area (SDA) (WMA 8).

IDA scenarios were selected based on the magnitude of radioactive or chemical materials at a facility or in a package. Other factors that were considered included the physical and chemical form of radioactive or chemical materials that made them more susceptible to environmental dispersion. For each onsite IDA scenario, a calculation of worker, maximally exposed individual (MEI) member of the public, and population doses was performed, as appropriate, using the same computer codes and conservative modeling assumptions that were used for Appendices I and J of this EIS. The MACCS2 V1.13.1 computer code (NRC 1998) was used to calculate radiological consequences. The MACCS computer code is described in detail in Appendix I, which also provides detailed discussions of the methods used in calculating radiation doses and their human health effects. Human health impacts of IDAs relative to the transportation of radioactive waste packages from WNYNSC were also analyzed for each site waste management alternative. The RISKIND 2.0 computer code (ANL 1995) was used to calculate radiation doses to the MEI and population from such an IDA. RISKIND, a code that has been extensively used in transportation accident analyses, is described in Appendix J of this EIS.

The radiological source term for each scenario was developed to represent the consequences of any carefully planned and executed IDA. Acute (short-term) and chronic (long-term) radiation doses were calculated, as was the likelihood of near-term and latent cancer fatalities from such doses. Health effects of acute exposure were assumed to appear within 1 year of exposure, and those of chronic exposure sometime later. Since the frequency of success of these postulated IDA scenarios cannot be quantified, no annual risk was calculated.

N.2 Scenario Development

For onsite IDA scenarios, a group of outsiders is postulated to gain entrance to WNYNSC with the help of an inside employee. These outsiders are carrying weapons, backpacks containing high explosives, and associated detonation equipment. They overpower and eliminate security personnel and gain access to the high-level radioactive waste tanks, Main Plant Process Building, radioactive waste package storage area, NDA, or SDA. They attach the explosives to preselected locations that allow for the breach of any containment or confinement structure or container and release of the maximum possible radioactive source term in the form of respirable airborne particles.

The assumed target is the High-Level Waste Tank 8D-B in WMA 3, which has a larger radioisotope inventory than the Main Plant Process Building, the waste packages, or the licensed disposal areas. Tank 8D-B is a bounding composite of Tanks 8D-1 and 8D-2, which are described in Appendix I of this EIS. The explosive charge brought on site is designed, located, and timed to fail the wall of the tank and cylindrical concrete vault, thereby creating a Radiological Dispersal Device (RDD). In this scenario, the radioactive material in the tank constitutes the material for dispersal, so the intruders need only bring in the appropriate quantities and types of explosive and associated detonation and timing equipment.

No IDA scenarios were analyzed for the NDA and SDA, due to two factors: (1) the radioactive material is distributed over a large area with a concomitantly small density and (2) radioactive material is interspersed with soil and affixed to solids resulting in a relatively small respirable release fraction from any IDA scenario. Tank 8D-B IDA consequences envelope NDA and SDA IDA scenario consequences.

Another IDA scenario analyzed for human health consequences is the attack of a group of outsiders on a radioactive waste transport vehicle en route from WNYNSC to a waste repository. The attackers are postulated to eliminate all crew and use weapons to penetrate the radioactive waste package confinement, resulting in a release of respirable radionuclides to the environment. The waste package with the largest radionuclide inventory is the fuel and hardware drum, which is only transported for the Sitewide Removal Alternative, as shown in Appendix I of this EIS. Therefore, the transportation scenario assumes an attack on a vehicle transporting such drums. The attack and resulting radionuclide release occur when the vehicle is traveling through the area with the highest population density along its route, thus delivering the highest population dose.

The fuel and hardware drum is not transported for the Sitewide Close-In-Place, Phased Decisionmaking, or No Action Alternative. The same IDA scenario assumptions for transportation are analyzed for these alternatives, but the containers are different: a Greater-Than-Class C Drum is used for the Sitewide Close-In-Place and Phased Decisionmaking Alternatives, and the Class A Box for the No Action Alternative. For each of the alternatives, a transportation IDA involving these radioactive waste packages has the greatest MEI and population consequences.

Appendix I of this EIS identifies the bounding toxic chemical as the beryllium that is present in the Main Plant Process Building. Therefore, another IDA scenario was postulated in which outsiders, with assistance from an employee, carry in and set off explosive charges in and around that building, creating a Chemical Dispersal Device (CDD) to release the maximum respirable quantity of beryllium into the atmosphere. Although its effects would include the release of radioactivity present in the Main Plant Process Building, the radioactive source term and human health impacts would be lower than those of the high-level radioactive waste tank RDD scenario.

N.3 Scenarios Considered but Not Analyzed

Other IDA scenarios that were postulated but not analyzed for this appendix are: (1) a commercial aircraft crash into the high-level radioactive waste tanks or Main Plant Process Building; (2) vehicular bomb detonation next to the high-level radioactive waste tanks, Main Plant Process Building, licensed disposal areas, or radioactive waste storage area; (3) use of armor-piercing missiles on the high-level radioactive waste tanks, Main Plant Process Building, or radioactive waste storage facility; (4) detonation of high explosives in the proximity of radioactive waste storage packages; and (5) use of an improvised nuclear device.

The aircraft crash was not analyzed because the radionuclide source term resulting from such a scenario at any of the locations that contain radionuclides would be enveloped by that assumed for the high-explosive detonation scenario analyzed for High-Level Waste Tank 8D-B.

The vehicle bomb scenario was not analyzed because it may not fail the confinement structure of the high-level radioactive waste tanks, Main Plant Process Building, or radioactive waste packages and is not estimated to result in a source term greater than that assumed for the analyzed IDA event at High-Level Waste Tank 8D-B.

Although armor-piercing missiles could fail confinement at the high-level radioactive waste tanks, Main Plant Process Building, or radioactive waste packages, the resulting source term would not be as high as that caused by the carefully designed and placed high explosives that are central to the IDA scenario for Tank 8D-B.

High explosives detonated next to high-level radioactive waste packages would fail their confinements and release a significant fraction of their radionuclide inventories. The effects, however, would be limited by the distance between the packages and that between the package and the explosive. (Explosive overpressure drops as the cube of the distance.) Thus, only a limited number of packages could fail and release radionuclides. Also limiting is the total radionuclide inventory of each package (see Appendix I of this EIS); between 23 and 2,500 packages would have to release their inventories to yield a source term equal to that assumed for the high-level radioactive waste tank IDA scenario. These limiting factors, in addition to the confinement integrity of each waste package, would not release a radiological source term equivalent to that of a failure of the high-level radioactive waste tanks.

The detonation of high explosives on or near the vitrified high-level radioactive waste stored at WNYNSC was not analyzed because the physical and chemical form of this waste would inherently restrict the release of respirable particles to the environment. Tests have shown that the material, which is similar to glass, is very resistant to fracture into very small respirable particles. Explosives or fires would more likely result in segmentation of some of this waste into large, nonrespirable solid forms (DOE 1994, EPA 1992).

An improvised nuclear device requires access to a critical mass of either weapons-grade plutonium or highly enriched uranium, along with extremely sophisticated high explosives and electronic detonation equipment. None of these materials are expected to be present at WNYNSC. Any plutonium or uranium that is present exists in a distributed and diluted form in liquid and solid wastes—not the single, relatively pure mass required for an improvised nuclear device. Thus, intruders would have to construct such a device with components obtained outside of WNYNSC and purposefully bring it onto the site for detonation. The low population density in the area of WNYNSC also makes the site less desirable as a target for an improvised nuclear device.

N.4 Source Terms

Calculations of the source terms for the high-level radioactive waste tank RDD, Main Plant Process Building CDD, and radioactive waste transportation IDA assume dispersal of a fraction of the entire waste inventory via a direct, open pathway to the atmosphere. The source term for the high-level radioactive waste tank RDD, presented as **Table N–1**, is based on a 0.1 percent (0.001) airborne respirable release fraction (DOE 1994) for the material at risk (MAR). Most of the radionuclide activity in Tank 8D-B (the same radionuclide activity assumed in Appendix I accident analyses) is fixed and in nonliquid form, making it more vulnerable to airborne release from the effects of an explosion. Also assumed (see Appendix I of this EIS) is a composite high-level radioactive waste tank, that is, a tank that has the largest inventory of radioisotopes and, thus, one whose breach would result in the highest radiation dose.

Table N–1 High-Level Radioactive Waste Tank Radiological Dispersal Device Source Term

Radionuclide	*Source Term (curies)*
Carbon-14	0.000020
Strontium-90	34
Technetium-99	0.0054
Iodine-129	6.8×10^{-6}
Cesium-137	250
Uranium-232	0.00060
Uranium-233	0.00026
Uranium-234	0.00010
Uranium-235	3.4×10^{-6}
Uranium-238	0.000031
Neptunium-237	0.00050
Plutonium-238	0.15
Plutonium-239	0.036
Plutonium-240	0.026
Plutonium-241	0.74
Americium-241	0.38
Curium-243	0.0036
Curium-244	0.080
Total	285.4

Source: WVNSCO 2005.

The source terms for the different packages that could be breached in a radioactive waste transportation IDA are presented in **Tables N–2, N–3,** and **N–4**. For the fuel and hardware drum, the source term is based on a 0.01 percent (0.0001) respirable release fraction; for the Greater-Than-Class C Drum and Class A Box, a 0.1 percent (0.001) airborne respirable release fraction. The different respirable release fractions reflect the distinctive nature and radionuclide content of the waste packages (DOE 1994).

Table N–2 Fuel and Hardware Drum Intentional Destructive Act Source Term

Radionuclide	*Source Term (curies)*
Tritium	0.0311
Carbon-14	0.0311
Cobalt-60	0.0027
Strontium-90	0.133
Yttrium-90	0.133
Cesium-137	0.173
Thorium-234	0.0000131
Uranium-238	0.0000131
Plutonium-238	0.0000131
Plutonium-239	0.00412
Plutonium-240	0.00221
Plutonium-241	0.0671
Americium-241	0.00799
Neptunium-237	7.94×10^{-7}
Curium-244	0.0000626
Total	0.56

Source: Karimi 2005.

Table N–3 Greater-Than-Class C Drum Intentional Destructive Act Source Term

Radionuclide	*Source Term (curies)*
Tritium	0.0020
Carbon-14	0.0000148
Iron-55	8.98×10^{-6}
Cobalt-60	0.000258
Nickel-63	0.000999
Strontium-90	0.00185
Yttrium-90	0.00185
Cesium-137	0.00235
Thorium-234	0.0000268
Uranium-238	9.28×10^{-6}
Plutonium-238	0.0267
Plutonium-239	0.0000363
Plutonium-240	0.000188
Plutonium-241	0.0105
Americium-241	0.000116
Total	0.047

Source: Karimi 2005.

Table N–4 Class A Box Intentional Destructive Act Source Term

Radionuclide	*Source Term (curies)*
Tritium	1.2×10^{-8}
Carbon-14	9.2×10^{-11}
Iron-55	5.6×10^{-11}
Cobalt-60	1.6×10^{-9}
Nickel-63	6.2×10^{-9}
Strontium-90	4.5×10^{-10}
Yttrium-90	4.5×10^{-10}
Cesium-137	4.4×10^{-9}
Thorium-234	5.8×10^{-11}
Uranium-238	5.8×10^{-11}
Plutonium-238	3.7×10^{-11}
Plutonium-239	5.5×10^{-11}
Plutonium-240	3.3×10^{-11}
Plutonium-241	1.2×10^{-9}
Americium-241	1.2×10^{-10}
Total	2.7×10^{-8}

Source: Karimi 2005.

The release plume for the waste transportation IDA is modeled for two different scenarios: a zero-energy, ground-level plume release and a plume with the energy of a fire created by combustion of the diesel fuel carried in the tanks of the transport truck. As in the case of the RDD, the plume energy assumptions for these two scenarios envelop both close and distant human health impacts.

N.5 Human Health Effects

Calculations by the MACCS and RISKIND computer codes and chemical dispersion modeling result in different human health impacts of the IDA scenarios discussed in Section N.2. Differences have been determined in radiological doses delivered to, and related latent cancer fatalities (LCFs)[1] for, the worker, the MEI, and the population at varying distances from the release site.

N.5.1 High-Level Radioactive Waste Tank Radiological Dispersal Device

The calculated radiation doses to the worker, the MEI, and the population within 80, 160, 320, and 480 kilometers (50, 100, 200, and 300 miles) of an RDD-induced failure of the high-level radioactive waste tank are presented in **Table N–5**. Two plume models were assumed for this scenario: ground-level and elevated-plume. The ground-level plume assumes that all the energy of the high explosives has been expended in failing the tank confinement and in aerosolizing radioactive material. The elevated-plume conversely assumes that all of the energy of the high explosives is available to the plume, resulting in an elevated release. These two diametrically opposite assumptions were used to calculate the range of close-in and distant human health consequences. Doses for the population beyond 80 kilometers (50 miles) were calculated to evaluate the public health impact of an elevated-plume in comparison to a ground-level plume. The analysis assumed no emergency response such as evacuation or sheltering of the population. This assumption is very conservative for the population 320 to 480 kilometers (200 to 300 miles) away, because the plume would not reach these distances for at least 1 day. According to the 2000 U.S. census and the 2001 Canada census (DOC 2008, ESRI 2008, Statistics Canada 2008), the U.S. and Canadian populations within 80, 160, 320, and 480 kilometers (50, 100, 200, and 300 miles) are, respectively, 1.705 million, 7.872 million, 25 million, and 75.1 million.

Table N–5 Radiological Consequences of High-Level Radioactive Waste Tank Radiological Dispersal Device

Radiological Dispersal Device Scenario	*Ground-level Release*		*Elevated-plume Release*	
	Dose	*LCF*	*Dose*	*LCF*
Worker (rem)	608 [a]	0.7	0.0177	0.000010
MEI member of the public (rem)	138	0.2	0.15	0.000090
50-mile population (person-rem)	3,600	2.2	5,860	3.5
100-mile population (person-rem)	4,610	2.8	8,240	4.9
200-mile population (person-rem)	5,240	3.1	9,620	5.8
300-mile population (person-rem)	5,890	3.5	10,700	6.4
Highest population average individual member [b] (rem)	0.0021	1.3×10^{-6}	0.0034	2.1×10^{-6}

LCF = latent cancer fatality, MEI = maximally exposed individual.

[a] This dose of 608 rem, equivalent to 0.7 LCF, can cause a fatality from acute effects in more than 50 percent of humans, but this fatality may be ameliorated by immediate proper medical treatment (NRC 2008, PNNL 2005).

[b] Calculated by dividing the total population dose by the total population for each of the four distances, the highest average for the four distances is presented. Ground-level and elevated-plume release doses are, respectively, 0.0006 and 0.0009 percent of annual background radiation dose, assumed to be 0.36 rem.

Note: LCF calculated by multiplying dose by 0.0006 LCF per rem (DOE 2002); an individual dose of 20 rem or greater is multiplied by twice the 0.0006 LCF factor.

Table N–5 shows that the ground-level release results in the higher worker and MEI dose, whereas the elevated-plume release results in the larger population dose. The largest worker dose (608 rem) results in 0.7 LCF, and the largest MEI dose (138 rem) in 0.2 LCF. The elevated-plume model results in about a 60 percent to 80 percent larger population dose than the ground-level release model. The difference is due to the combined effect of dispersion, dilution, and differences in population distribution at distances from WNYNSC. Although population dose increases with distance, the change in population dose relative to the

[1] *Since fatal cancer is the most probable serious effect of environmental and occupational radiation exposures, estimates of cancer fatalities rather than cancer incidence are presented in this EIS. These effects are referred to as "latent" cancer fatalities (LCFs) because the cancer may take many years to develop.*

increase in population is slight. The highest average individual dose in the population for the four distances analyzed occurs for the 80-kilometer (50-mile) population (0.0034 rem, or 0.94 percent of the U.S. average annual background dose). The largest population consequence within 480 kilometers (300 miles) is 6.4 LCF, assuming no emergency response, evacuation, or sheltering over this distance. The WNYNSC meteorological data used in the MACCS calculations include an average annual wind speed of 2.1 meters per second (4.7 miles per hour). At this wind speed, the plume would reach 80 kilometers (50 miles) 10.6 hours after its release. The time for the plume to travel 320 to 480 kilometers (200 to 300 miles) would be 43 to 64 hours. It is expected that emergency response actions, in the form of public evacuation and sheltering, could be taken during this time period, so that the population dose associated with these distances would be significantly lower.

N.5.2 Radioactive Waste Transportation Intentional Destructive Act

Workers were assumed not to survive a transportation IDA. The only dose receptors for this event are the MEI within 100 meters (328 feet) of the plume release and the population within 80 kilometers (50 miles). As in the case of the high-level radioactive waste tank RDD scenario, no emergency response, such as evacuation or sheltering of the population, is assumed within 80 kilometers (50 miles) of the IDA. The highest population density of the route is assumed so as to envelop the calculated population dose. Consequences for the three transportation IDA scenarios are presented in **Table N–6**, the low-energy plume assumes a release with no fire while the high-energy plume assumes a fire occurring simultaneously with the release.

Table N–6 Transportation Intentional Destructive Act Radiological Consequences

Radiological Consequence	*Low-energy Plume*	*High-energy Plume*
Sitewide Removal Alternative: Fuel and Hardware Drum		
MEI dose, rem	9.65	0.00347
MEI LCF	0.006	2.0×10^{-6}
50-mile population dose, person-rem	281	82.6
50-mile population LCF	0.17	0.05
Sitewide Removal, Sitewide Close-In-Place, and Phased Decisionmaking Alternatives: Greater-Than-Class C Drum		
MEI dose, rem	13.9	0.0389
MEI LCF	0.008	0.000020
50-mile population dose, person-rem	404	119
50-mile population LCF	0.24	0.07
No Action Alternative: Class A Box		
MEI dose, rem	1.1×10^{-6}	9.1×10^{-7}
MEI LCF	7.0×10^{-10}	6.0×10^{-10}
50-mile population dose, person-rem	0.000349	0.000346
50-mile population LCF	2.0×10^{-7}	2.0×10^{-7}

LCF = latent cancer fatality, MEI = maximally exposed individual.
Note: LCF calculated by multiplying dose by 0.0006 LCF per rem (DOE 2002). To convert miles to kilometers, multiply by 1.6.

N.5.3 Chemical Dispersal Device

The CDD source term assumes that the entire inventory (5.1 kilograms [11.2 pounds]) of beryllium in the Main Plant Process Building is released as respirable particles, and that the release lasts for 10 minutes under average atmospheric conditions. The result is a respirable particle concentration of 0.00043 milligrams per cubic meter within 100 meters (328 feet) of the building. Such a concentration is a factor of more than 200 below (i.e., about 0.4 percent of) the Emergency Response Planning Guideline 3 (ERPG-3) value of 0.1 milligrams per cubic meter. If conservative atmospheric dispersion were assumed, the air concentration within the same distance from the release would be 0.0021 milligrams per cubic meter, still significantly below the ERPG-3 value, and even below the respective ERPG-2 and ERPG-1 values of 0.025 and 0.005 milligrams per cubic meter (DOE 2007). Air concentrations below the ERPG-1 level do not cause any serious health effects.

Since the CDD-induced atmospheric concentration of beryllium at 100 meters (328 feet) from the release point is below the ERPG-3, ERPG-2, and ERPG-1 levels, similar results can be expected for all other toxic chemicals; concentrations should be significantly below their respective ERPGs. Accordingly, the risk to workers and the public due to the release of toxic chemicals to the atmosphere is very small. Nevertheless, a CDD is expected to result in toxic chemical deposition around the Main Plant Process Building area that will require cleanup, and workers within 100 meters (328 feet) of the CDD would presumably be injured from blast pressure and airborne debris associated with the explosion.

N.6 Summary of Intentional Destructive Acts Consequences

The IDA human health consequence analyses were performed for each IDA scenario and WNYNSC EIS alternative. The same computer codes (MACCS and RISKIND), analytical methods, and site models were used for these IDA scenarios as for accidents analyzed in Appendices I and J of this EIS. Regardless of alternative, the highest radiological source term for an IDA affecting onsite facilities is that associated with a breach of the high-level radioactive waste tank and the highest hazardous chemical source term from damage to the Main Plant Process Building. For the three action alternatives, the radioactive waste transportation IDA scenario with the most significant human health consequences is that involving the Greater-Than-Class C Drum; for the No Action Alternative, it is failure of the Class A Box. **Table N–7** presents a summary of the human health consequences of onsite facility and offsite transportation IDA scenarios for the alternatives. As indicated, the only distinction in consequences for each alternative is that for the radioactive waste transportation IDA. Radioactive waste transportation IDA consequences are significantly lower for the No Action Alternative, because only Class A waste is transported.

Table N–7 Range of Intentional Destructive Acts Human Health Consequences for the Alternatives

Onsite Radiological IDA		
Receptor	***All Alternatives***	
Worker	Fatal [a] (ground-level release) to 0.00001 LCF (elevated-plume release)	
MEI	0.2 LCF (ground-level release) to 0.00009 LCF (elevated-plume release)	
Population	2 LCF [b] (80 kilometer [50 mile] population, ground-level release) to 7 LCF [b] (300 mile population, elevated-plume release)	
Onsite Chemical IDA		
Receptor	***All Alternatives***	
Worker	No significant health impacts	
MEI	No significant health impacts	
Population	No significant health impacts	
Radioactive Waste Package Transportation IDA		
Receptor	***Action Alternatives***	***No Action***
Worker	Not applicable	
MEI	0.008 LCF (low-energy plume) to 0.00002 LCF (high-energy plume)	7.0×10^{-10} LCF
Population	0.2 LCF (low-energy plume) to 0.07 LCF (high-energy plume)	2.0×10^{-7} LCF

IDA = intentional destructive acts, LCF = latent cancer fatality, MEI = maximally exposed individual.
[a] Dose of 608 rem, equivalent to 0.7 LCF, may cause short-term fatality in more than 50 percent of humans, but may be ameliorated by immediate medical treatment.
[b] Lower consequences if there is emergency response such as sheltering or evacuation.

Another aspect of IDA consequences that can be evaluated is the vulnerable time period for each scenario. The vulnerable time periods for those scenarios are presented in **Table N–8** for each alternative. As indicated, the longest vulnerable time periods (i.e., highest consequences) are for the high-level radioactive waste tank RDD scenario; the shortest vulnerable time periods (i.e., lowest consequences) are for the Main Plant Process Building CDD and the No Action Alternative radioactive waste—specifically, Class A waste—transportation scenarios. The longest vulnerable time period for the high-level radioactive waste tank RDD is for the Sitewide Close-In-Place and No Action Alternatives; the longest for the radioactive waste package transportation scenario is for the Sitewide Removal Alternative. Since the CDD consequences are not significant, the difference between the Main Plant Process Building vulnerable time periods for the alternatives is not considered a significant discriminator of IDA risk.

Table N–8 Intentional Destructive Act Scenario Vulnerable Time Period for Each Alternative

IDA Scenario	*Alternative*			
	Sitewide Removal	***Sitewide Close-In-Place***	***Phased Decisionmaking (Phase 1)***	***No Action***
High-level radioactive waste tanks	25 years	In perpetuity	Up to 30 years [a]	In perpetuity
Main Plant Process Building	12 years	5 years	5 years	In perpetuity
Radioactive waste transport	62 years	7 years	8 years	In perpetuity

IDA = intentional destructive acts.
[a] The total vulnerable time period for the alternative will depend on the implementation decisions and schedule for Phase 2.
Source: WSMS 2008a, 2008b, 2008c, 2008d.

The data in Table N–8 provides a basis for a qualitative comparison of the IDA risks for each alternative, which is presented in **Table N–9**. Specific attention is accorded on site, off site (waste transport), and overall IDA risks, taking into account the vulnerable time period for each scenario. The No Action Alternative is judged to have the highest IDA risk because vulnerable onsite facilities remain in place and periodic offsite transportation of radioactive waste packages is expected to continue in perpetuity. The three action alternatives have lower IDA risks because they involve the demolition of onsite facilities that would otherwise constitute potential targets for IDAs, and because the offsite transport of radioactive waste packages would be temporary (albeit involving a higher radioactivity content than the No Action Alternative). The Sitewide Removal Alternative has a higher IDA risk than the other two action alternatives because it involves transport of the largest number of radioactive waste packages over the longest time period, and because removal of the Main Plant Process Building is deferred for longer than the Phased Decisionmaking (Phase 1) and Close-In-Place Alternatives (12 versus 5 years).

Table N–9 Qualitative Comparison of Intentional Destructive Act Risks for Each Alternative [a]

Type of IDA Risk	*Alternative*			
	Sitewide Removal	***Sitewide Close-In-Place***	***Phased Decisionmaking (Phase 1)***	***No Action***
Onsite radiological	High	Very High	Very High	Highest
Onsite chemical	Medium	Lowest	Lowest	Highest
Radiological waste transportation	Highest	Medium	Medium	Lowest
Overall	High	Medium	Medium	Highest

IDA = intentional destructive acts.
[a] A qualitative comparison of accident risks for each alternative is presented in Chapter 4, Table 4–23 and Appendix I, Table I–27, of this EIS.

N.7 Intentional Destructive Acts Emergency Planning, Response, and Security

The DOE strategy for environmental protection from extreme events, including IDAs or terrorism, has three distinct components: (1) prevent or reduce the probability of occurrence; (2) plan and provide timely and adequate response to emergency situations; and (3) ensure progressive recovery through long-term response in the form of monitoring, remediation, and support for affected communities and their environment.

DOE sites and facilities produce, store, use, and dispose of many different hazardous substances, including radioactive materials, toxic chemicals, and biological agents and toxins. In managing these hazards, DOE considers the safety of workers and the public to be of paramount importance. Owing to high standards for facility design, conduct of operations, safety oversight, and personnel training, DOE activities consistently achieve accident and injury rates that compare very favorably with those of the private sector.

The DOE employs a well-established system of engineered and administrative controls in key facilities to prevent or reduce the probability of occurrence of extreme events and to limit their potential impacts on the environment. This system has evolved over time and will continue to evolve as new environment, safety, and health requirements are identified, as new technologies become available, and as new engineering standards or best practices are developed. The framework and specific requirements for implementing this system of controls are embodied in the *Code of Federal Regulations* and DOE Orders. These are invoked as contractual requirements for DOE management and operating contractors. The DOE safety requirements and quality assurance guidelines and controls cover all aspects of the life-cycle of key nuclear and nonnuclear facilities—design requirements, construction practices, startup and operational readiness reviews, and routine operations and maintenance. They also cover deactivation and disposal activities required at the end of a facility's useful service life. The contractor and Federal staff associated with these facilities receive screening for trustworthiness and reliability. Moreover, they are trained to operate the facilities safely and to recognize quickly, and respond appropriately to, departures from normal operating conditions. Workers with a potential for exposure to harmful substances or radiation are enrolled in monitoring programs to safeguard their health and welfare. In addition to the oversight provided by DOE, reviews and audits of key facilities by outside experts play a role in reducing the probability of occurrence of many potentially extreme events associated with facility design, condition, or operation.

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APPENDIX O
CONSULTATION LETTERS

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June 15, 1995

JUN 1995
RECEIVED
NYSERDA

Paul L. Piciulo, Ph.D.
Program Director
Radioactive Waste Management Program
Department of Energy
P.O. Box 191
West Valley, NY 14171

Dear Dr. Piciulo:

Re: DOE
West Valley Demonstration Project
Ashford, Cattaraugus County
95PR1233

Thank you for requesting the comments of the State Historic Preservation Office (SHPO). We have reviewed the materials submitted in accordance with Section 106 of the National Historic Preservation Act of 1966 and the relevant implementing regulations.

Based upon this review, it is the SHPO's opinion that the West Valley Demonstration Project Site (the site of the former Nuclear Fuels Service Irradiated Fuels Processing Plant) is not eligible for inclusion in the National Register of Historic Places.

When responding, please be sure to refer to the SHPO project review (PR) number noted above. If you have any questions, please feel free to call me at (518) 237-8643 ext. 255.

Sincerely,

Robert D. Kuhn, Ph.D.
Historic Preservation Coordinator
Field Services Bureau

RDK:cm

Department of Energy
West Valley Demonstration Project
10282 Rock Springs Road
West Valley, NY 14171-9799

July 18, 2008

U.S. Fish and Wildlife Service
3817 Luker Road
Cortland, NY 13045

SUBJECT: Rare Species Consultation for the *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center*

Dear Sir or Madam:

The purpose of this letter is to notify you that the U.S. Department of Energy (DOE) and New York State Energy Research and Development Authority (NYSERDA) are in the process of preparing a revised *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (see Enclosure 1). NYSERDA is serving as the lead agency for purposes of State Environmental Quality Review Act (SEQR). In support of this effort DOE is requesting information on rare species and significant natural communities that may be impacted by the proposed project.

The West Valley Demonstration Project (WVDP) is a radioactive waste management demonstration site currently operated by the DOE under Act of the U.S. Congress. The WVDP, a largely industrialized area, is located on approximately 63 hectares within the boundaries of the Western New York Nuclear Service Center (WNYNSC), a 1,335-hectare reserve area of fields and woodlands owned by New York State. The WNYNSC is situated partly in the Town of Concord on the southern border of Erie County and mostly in the Town of Ashford on the northern border of Cattaraugus County. A 7.5 minute U.S. Geological Survey topographical map showing the site is presented in Enclosure 2.

While there has been no change in the project impact area since publication of the Notice of Intent in 2003, there has been a change in the alternatives being considered. Following scoping meetings, the alternatives were revised to include: a Site-wide Removal Alternative, Site-wide Close-In-Place Alternative, Phased Decision-making Alternative (the Preferred Alternative), and No-Action Alternative. Each alternative is summarized below.

Under the Site-wide Removal Alternative, all site facilities would be removed, environmental media decontaminated, and waste characterized, packaged, as necessary, and shipped off site for disposal. Under this alternative, the entire WNYNSC could be available for unrestricted release.

Under the Site-wide Close-In-Place Alternative, key site facilities would be closed in place; however, residual radioactivity in facilities with larger inventories of long-lived radionuclides would be isolated by specially-designed closure structures and engineered barriers. Thus, under this alternative, a sizable portion, but not all of the WNYNSC, could be available for unrestricted release.

Under the Phased Decision-making Alternative, a two-phased approach would be undertaken. Phase 1 would entail the removal of a number of key facilities, but would delay a decision on other facilities pending the undertaking of additional studies and evaluations to clarify and possibly reduce uncertainties related to final decommissioning and long-term management. Phase 2 would complete decommissioning, following the approach determined in Phase 1. The amount of land that could be available for unrestricted release would not be fully known until the approach to Phase 2 is determined.

Under the No-Action Alternative, no actions toward decommissioning would be taken; however, a limited portion of the site could be available for unrestricted release.

Please send the requested information to:

Ms. Jennifer M. Dundas
U. S. Department of Energy
10282 Rock Springs Road
West Valley, NY 14171-9799

If you have any questions regarding this inquiry, Jennifer Dundas of my staff may be reached at (716) 942-4287.

Sincerely,

Bryan C. Bower, Director
West Valley Demonstration Project

Enclosures: 1) Notice of Intent to Prepare an *Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center*

2) 7.5 Minute U.S. Geological Survey Topographical Map for Ashford Hollow Quadrangle

cc: J. E. Loving, DOE-HQ, GC-20/FORS, w/o enc.
J. M. Dundas, DOE-WVDP, AC-DOE, w/o enc.
M. N. Maloney, DOE-WVDP, AC-DOE, w/o enc.
P. J. Bembia, NYSERDA, w/o enc.

CMB:99492 - 451.1

CMB/cmb

Department of Energy
West Valley Demonstration Project
10282 Rock Springs Road
West Valley, NY 14171-9799

July 18, 2008

NYSDEC-DFWMR
New York Natural Heritage Program-Information Services
625 Broadway, 5th Floor
Albany, NY 12233-4757

SUBJECT: Rare Species Consultation for the *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center*

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P. J. Bembia, NYSERDA, w/o enc.

CMB:99493 - 451.1

CMB/cmb

Department of Energy
West Valley Demonstration Project
10282 Rock Springs Road
West Valley, NY 14171-9799

July 21, 2008

Mr. Maurice A. John
President
The Seneca Nation of Indians
P.O. Box 231
Salamanca, New York 14779

ATTENTION: Sylvia Patterson, Environmental Protection Director

SUBJECT: Consultation for the *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* and Public Meeting

Dear President John:

The U.S. Department of Energy (DOE) and the New York State Energy Research and Development Authority (NYSERDA) are jointly preparing a *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center.* The U.S. Nuclear Regulatory Commission (NRC), the U.S. Environmental Protection Agency (EPA), and the New York State Department of Environmental Conservation (NYSDEC) are participating as cooperating agencies.

This Environmental Impact Statement (EIS) will revise the Draft EIS for Completion of the West Valley Demonstration Project and Closure of Long-Term Management of Facilities at the Western New York Nuclear Service Center (DOE/EIS-0226-D), which was issued in 1996. This EIS will evaluate the range of reasonable alternatives for decommissioning and long-term stewardship of the Western New York Nuclear Service Center (WNYNSC).

While there has been no change in the project impact area since publication of the Notice of Intent in 2003, there has been a change in the alternatives being considered. Following scoping meetings, the alternatives were revised to include: a Site-wide Removal Alternative, Site-wide Close-In-Place Alternative, Phased Decision-making Alternative (the Preferred Alternative), and No-Action Alternative. Each alternative is summarized below.

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Under the No-Action Alternative, no actions toward decommissioning would be taken; however, a limited portion of the site could be available for unrestricted release.

Issuance of a draft EIS is planned for the fall of 2008. We would like to meet with you and/or members of your staff to discuss current planning for the EIS and to hear your issues and concerns.

In 1996, DOE held public meetings on two of your reservations. We would again like to extend an offer to hold public meetings on the two main territories, Cattaraugus and Allegany. Public meetings will likely be held in the March or April 2009 timeframe, during the six-month public comment period, to listen to the views of and gather information from Tribal Governments, regulators, elected officials, stakeholders, and the public, to allow the lead agencies to make effective decisions in regards to this EIS.

If you have any questions regarding this information or to schedule a meeting, please contact:

Ms. Catherine M. Bohan, NEPA Compliance Officer and Tribal Point of Contact
U.S. Department of Energy
West Valley Demonstration Project
10282 Rock Springs Road
West Valley, NY 14171-9799
Phone: (716) 942-4159, E-mail: Catherine.M.Bohan@wv.doe.gov

I look forward to working with you as we move toward completion of this important process.

Sincerely,

Bryan C. Bower, Director
West Valley Demonstration Project

cc: J. E. Loving, DOE-HQ, GC-2/FORS
A. Wickham, DOE-EMCBC
M. N. Maloney, DOE-WVDP, AC-DOE
P. J. Bembia, NYSERDA, AC-NYS
S. C. Crede, SAIC
S. E. Robinson, SAIC

CMB:99524 - 451.1

file MNU8

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New York Field Office
3817 Luker Road
Cortland, NY 13045
Phone: (607) 753-9334 Fax: (607) 753-9699
http://www.fws.gov/northeast/nyfo

Project Number: 80643

To: Bryan Bower   Date: Jul 29, 2008

Regarding: DEIS for decommissioning West Valley Demonstration Site

Town/County: Town of Ashford / Cattaraugus County

We have received your request for information regarding occurrences of Federally-listed threatened and endangered species within the vicinity of the above-referenced project/property. Due to increasing workload and reduction of staff, we are no longer able to reply to endangered species list requests in a timely manner. In an effort to streamline project reviews, we are shifting the majority of species list requests to our website at http://www.fws.gov/northeast/nyfo/es/section7.htm. Please go to our website and print the appropriate portions of our county list of endangered, threatened, proposed, and candidate species, and the official list request response. Step-by-step instructions are found on our website.

As a reminder, Section 9 of the Endangered Species Act (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) prohibits unauthorized taking* of listed species and applies to Federal and non-Federal activities. Additionally, endangered species and their habitats are protected by Section 7(a)(2) of the ESA, which requires Federal agencies, in consultation with the U.S. Fish and Wildlife Service (Service), to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. An assessment of the potential direct, indirect, and cumulative impacts is required for all Federal actions that may affect listed species. For projects not authorized, funded, or carried out by a Federal agency, consultation with the Service pursuant to Section 7(a)(2) of the ESA is not required. However, no person is authorized to "take"* any listed species without appropriate authorizations from the Service. Therefore, we provide technical assistance to individuals and agencies to assist with project planning to avoid the potential for "take," or when appropriate, to provide assistance with their application for an incidental take permit pursuant to Section 10(a)(1)(B) of the ESA.

Project construction or implementation should not commence until all requirements of the ESA have been fulfilled. If you have any questions or require further assistance regarding threatened or endangered species, please contact the Endangered Species Program at (607) 753-9334. Please refer to the above document control number in any future correspondence.

Endangered Species Biologist: Sandra Doran *Sandra Doran*

*Under the Act and regulations, it is illegal for any person subject to the jurisdiction of the United States to *take* (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import or export, ship in interstate or foreign commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any endangered fish or wildlife species and most threatened fish and wildlife species. It is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. "Harm" includes any act which actually kills or injures fish or wildlife, and case law has clarified that such acts may include significant habitat modification or degradation that significantly impairs essential behavioral patterns of fish or wildlife.

99590

New York State Department of Environmental Conservation
Division of Fish, Wildlife & Marine Resources
New York Natural Heritage Program
625 Broadway, Albany, New York 12233-4757
Phone: (518) 402-8935 • **FAX:** (518) 402-8925
www.dec.state.ny.us

Alexander B. Grannis
Commissioner

August 6, 2008

Jennifer Dundas
U S Department of Energy
10282 Rock Springs Road
West Valley, NY 14171-9799

U.S. DOE
SEP
4
2008

Dear Ms. Dundas:

In response to your recent request, we have reviewed the New York Natural Heritage Program database with respect to an Environmental Assessment for the proposed Decommissioning and/or Stewardship at West Valley Demo/Project and Western NY Nuclear Service Center, area as indicated on the map you provided, located partly in the Town of Concord, Erie County; and mostly in the Town of Ashford, Cattaraugus County, New York State.

Enclosed is a report of rare or state-listed animals and plants, significant natural communities, and other significant habitats, which our databases indicate occur, or may occur, on your site or in the immediate vicinity of your site.

The presence of the plants and animals identified in the enclosed report may result in this project requiring additional review or permit conditions. For further guidance, and for information regarding other permits that may be required under state law for regulated areas or activities (e.g., regulated wetlands), please contact the appropriate NYS DEC Regional Office, Division of Environmental Permits, at the enclosed address.

For most sites, comprehensive field surveys have not been conducted; the enclosed report only includes records from our databases. We cannot provide a definitive statement on the presence or absence of all rare or state-listed species or significant natural communities. This information should not be substituted for on-site surveys that may be required for environment impact assessment.

Our databases are continually growing as records are added and updated. If this proposed project is still under development one year from now, we recommend that you contact us again so that we may update this response with the most current information.

Sincerely,

Tara Seoane jp

Tara Seoane, Information Services
New York Natural Heritage Program

cc: Reg. 9, Wildlife Mgr.
Reg. 9, Fisheries Mgr.

NY Natural Heritage Program, NYS DEC, 625 Broadway, 5th Floor, Albany, NY
12233-4757
(518) 402-8935

~This report contains **SENSITIVE** information that should not be released to the public without permission from the NY Natural Heritage Program.
~Refer to the User's Guide for explanations of codes, ranks and fields.
~Location maps for certain species and communities may not be provided 1) if the species is vulnerable to disturbance, 2) if the location and/or extent is not precisely known, 3) if the location and/or extent is too large to display, and/or 4) if the animal is listed as Endangered or Threatened by New York State.

Natural Heritage Report on Rare Species and Ecological Communities

BEETLES

Cicindela ancocisconensis

Appalachian Tiger Beetle

Office Use 9083

NY Legal Status: Unlisted
NYS Rank: S2 - Imperiled
Federal Listing:
Global Rank: G3 - Vulnerable
Last Report: 2000-08-28
EO Rank: Excellent or Good
County: Erie, Cattaraugus
Town: Collins, East Otto, Yorkshire, Otto, Persia, Sardinia, Concord, Ashford
Location: Cattaraugus Creek
Directions: The tiger beetle population occurs along a 25 mile stretch of the Cattaraugus Creek from Gowanda east to the area of Hake Road, approximately 3 miles west of Sillimans Corners. The beetles were found on at least 21 cobble bars and sandy terraces scattered throughout this stretch. Most locations where they have been observed are in the vicinity of the bridges which cross the creek and provide access. A number of locations can be accessed from the Gowanda-Zoar Valley Road and the Zoar Valley Multiple Use Area.

General Quality and Habitat: There are no global rank specifications for this species. All locations are combined as one occurrence based on element occurrence specifications from riparian cicindelidae of 2001-12-06. The "AB: rank is based on the fact that the beetles were found atno less than 17 separate cobble bars or sand/cobble terraces along a 25 mile stretch of a large creek with only one small dam and intact hydrological flow which mainatins the high quality and quantity of habitat present. They undoubtedly occur at many ad The Cattaraugus Creek is a large creek which flows through a rural, agricultural setting and a large steep gorge area known as Zoar Valley. The flow is fast in spring with annual spring flooding. In the eastern portion, the creek has many twists and bends and sand and cobble are deposited at bends in the creek forming large cobble bars and sand/cobble terraces. To the west, where the creek flows through Zoar Valley the creek is bordered by steep, high walls and there are fewer bends in the creek and fewer cobble bars. There is a single small (less than 20 foot in height) dam just west of Route 219 which does not effectively alter the creeks hydrological regime.

Cicindela marginipennis

Cobblestone Tiger Beetle

Office Use 10212

NY Legal Status: Unlisted
NYS Rank: S1 - Critically imperiled
Federal Listing:
Global Rank: G2 - Imperiled
Last Report: 1999-08-10
EO Rank: Excellent or Good
County: Erie, Cattaraugus
Town: Otto, Concord, Collins, Ashford, East Otto
Location: At, or in the vicinity of, the project site.
Directions: **
General Quality and Habitat: **For information on the population at this location and management considerations, please contact the NY Natural Heritage Program Zoologist at 518-402-8939.

IRDS

Spizella pallida

Office Use 12458

Clay-colored Sparrow
Breeding

NY Legal Status: Protected
NYS Rank: S2 - Imperiled
Federal Listing:
Global Rank: G5 - Demonstrably secure
Last Report: 2003-06-09
EO Rank: Extant
County: Cattaraugus
Town: Ashford
Location: Bond Road Plantation
Directions: From the intersection of Route 82 and Cattaragus Street in Springville, travel south on Route 82 (Buffalo Street) for 2.0 mi and turn left onto Thomas Corners Road. Travel east on Thomas Corners Road for 1.3 mi and turn left onto Bond Road. The birds were seen in lilac bushes on the west side of the road.

General Quality and Habitat: The birds were observed in lilac (Syringa sp.) bushes in an ornamental shrub plantation.

:OMMUNITIES

Hemlock-northern hardwood forest

Office Use

This occurrence of Hemlock-Northern Hardwood Forest is considered significant from a statewide perspective by the NY Natural Heritage Program. It is either an occurrence of a community type that is rare in the state or a high quality example of a more common community type. By meeting specific, documented significance criteria, the NY Natural Heritage Program considers this occurrence to have high ecological and conservation value.

8473

NY Legal Status: Unlisted
NYS Rank: S4
Federal Listing:
Global Rank: G4G5
Last Report: 2001-09-01
EO Rank:
County: Erie, Cattaraugus
Town: East Otto, Collins, Concord, Persia, Ashford, Dayton, Otto
Location: Cattaraugus Creek Zoar Valley
Directions: Take I-90 west past Buffalo and exit to the south on Highway 219. This highway crosses the Cattaraugus River just south of Springville and about 12 miles east of Gowanda. The community occupies the steep slopes and some of the uplands around Zoar Valleywhich surrounds Cattaraugus Creek and the South Branch of Cattaraugus Creek as well as valleys of tributaries including Thatcher Brook, Point Peter Brook, Connoissarauley Creek, Waterman Brook, Utley Brook, Coon Brook, Derby Brook, and Spooner Creek.

General Quality and Habitat: The community is a very large, diverse complex of multiple patches, with many mature forest to old-growth patches within an landscape that is moderately large and intact, especially for the High Allegheny Plateau. A hemlock dominated to co-dominated forest primarily on the upper slopes of a deep 12.6-mile long gorge and ravines of the adjacent plateau along the Cattaraugus Creek, a major drainage of Lake Erie. The forest occurs above Cattaraugus Creek with its lining of shale cliff and talus community and shale talus slope woodland and forest forms part of a mature forest complex with beech-maple mesic forest, maple-basswood rich mesic forest, rich mesophytic forest and local, very small patches of Appalachian oak-pine forest. Further upland is an abrupt change to successional hardwood forests, successional old fields, maintained and recovering agricultural land and plantations (mostly pine). Scattered residences and roads are interspersed within the forest.

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4 Records Processed

Viore detailed information about many of the rare and listed animals and plants in New York, including biology, identification, habitat, conservation, and management, are available online in Natural Heritage's Conservation Guides at www.acris.nynhp.org, from NatureServe Explorer at http://www.natureserve.org/explorer, from NYSDEC at http://www.dec.ny.gov/animals/7494.html (for animals), and from USDA's Plants Database at http://plants.usda.gov/index.html (for plants).

Viore detailed information about many of the natural community types in New York, including identification, dominant and characteristic vegetation, distribution, conservation, and management, is available online in Natural Heritage's Conservation Guides at www.acris.nynhp.org. For descriptions of all community types, go to http://www.dec.ny.gov/animals/29384.html and click on DRAFT--Ecological Communities of New York State.

USERS GUIDE TO NY NATURAL HERITAGE DATA

New York Natural Heritage Program, 625 Broadway, 5th Floor, Albany, NY 12233-4757 phone: (518) 402-8935

NATURAL HERITAGE PROGRAM: The NY Natural Heritage Program is a partnership between the NYS Department of Environmental Conservation (NYS DEC) and The Nature Conservancy. Our mission is to enable and enhance conservation of rare animals, rare plants, and significant communities. We accomplish this mission by combining thorough field inventories, scientific analyses, expert interpretation, and the most comprehensive database on New York's distinctive biodiversity to deliver the highest quality information for natural resource planning, protection, and management.

DATA SENSITIVITY: The data provided in the report are ecologically sensitive and should be treated in a sensitive manner. The report is for your in-house use and should not be released, distributed or incorporated in a public document without prior permission from the Natural Heritage Program.

EO RANK: A letter code for the quality of the occurrence of the rare species or significant natural community, based on population size or area, condition, and landscape context.

A-E = Extant: A=Excellent, B=Good, C=Fair, D=Poor, E=Extant but with insufficient data to assign a rank of A-D.
F = Failed to find. Did not locate species during a limited search, but habitat is still there and further field work is justified.
H = Historical. Historical occurrence without any recent field information.
X = Extirpated. Field/other data indicates element/habitat is destroyed and the element no longer exists at this location.
U = Extant/Historical status uncertain.
Blank = Not assigned.

LAST REPORT: The date that the rare species or significant natural community was last observed at this location, as documented in the Natural Heritage databases. The format is most often YYYY-MM-DD.

NY LEGAL STATUS – Animals:

Categories of Endangered and Threatened species are defined in New York State Environmental Conservation Law section 11-0535. Endangered, Threatened, and Special Concern species are listed in regulation 6NYCRR 182.5.

E - **Endangered Species**: any species which meet one of the following criteria:
- Any native species in imminent danger of extirpation or extinction in New York.
- Any species listed as endangered by the United States Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

T - **Threatened Species**: any species which meet one of the following criteria:
- Any native species likely to become an endangered species within the foreseeable future in NY.
- Any species listed as threatened by the U.S. Department of the Interior, as enumerated in the Code of the Federal Regulations 50 CFR 17.11.

SC - **Special Concern Species**: those species which are not yet recognized as endangered or threatened, but for which documented concern exists for their continued welfare in New York. Unlike the first two categories, species of special concern receive no additional legal protection under Environmental Conservation Law section 11-0535 (Endangered and Threatened Species).

P - **Protected Wildlife** (defined in Environmental Conservation Law section 11-0103): wild game, protected wild birds, and endangered species of wildlife.

U - **Unprotected** (defined in Environmental Conservation Law section 11-0103): the species may be taken at any time without limit; however a license to take may be required.

G - **Game** (defined in Environmental Conservation Law section 11-0103): any of a variety of big game or small game species as stated in the Environmental Conservation Law; many normally have an open season for at least part of the year, and are protected at other times.

NY LEGAL STATUS – Plants:

The following categories are defined in regulation 6NYCRR part 193.3 and apply to NYS Environmental Conservation Law section 9-1503.

E - **Endangered Species**: listed species are those with:
- 5 or fewer extant sites, or
- fewer than 1,000 individuals, or
- restricted to fewer than 4 U.S.G.S. 7 ½ minute topographical maps, or
- species listed as endangered by U.S. Dept. of Interior, as enumerated in Code of Federal Regulations 50 CFR 17.11.

T - **Threatened**: listed species are those with:
- 6 to fewer than 20 extant sites, or
- 1,000 to fewer than 3,000 individuals, or
- restricted to not less than 4 or more than 7 U.S.G.S. 7 and ½ minute topographical maps, or
- listed as threatened by U.S. Department of Interior, as enumerated in Code of Federal Regulations 50 CFR 17.11.

R - Rare: listed species have:
- 20 to 35 extant sites, or
- 3,000 to 5,000 individuals statewide.

V - Exploitably vulnerable: listed species are likely to become threatened in the near future throughout all or a significant portion of
their range within the state if causal factors continue unchecked.

U - Unprotected; no state status.

FEDERAL STATUS (PLANTS and ANIMALS): The categories of federal status are defined by the United States Department of the Interior as part of the 1974 Endangered Species Act (see Code of Federal Regulations 50 CFR 17). The species listed under this law are enumerated in the Federal Register vol. 50, no. 188, pp. 39526 - 39527. The codes below without parentheses are those used in the Federal Register. The codes below in parentheses are created by Heritage to deal with species which have different listings in different parts of their range, and/or different listings for different subspecies or varieties.

(blank) = No Federal Endangered Species Act status.
LE = Formally listed as endangered.
LT = Formally listed as threatened.
C = Candidate for listing.
LE,LT = Formally listed as endangered in part of its range, and as threatened in the other part; or, one or more subspecies or varieties is listed as endangered, and the others are listed as threatened.
LT,PDL = Populations of the species in New York are formally listed as threatened, and proposed for delisting.

GLOBAL AND STATE RANKS (animals, plants, ecological communities and others): Each element has a global and state rank as determined by the NY Natural Heritage Program. These ranks carry no legal weight. The global rank reflects the rarity of the element throughout the world and the state rank reflects the rarity within New York State. Infraspecific taxa are also assigned a taxon rank to reflect the infraspecific taxon's rank throughout the world. ? = Indicates a question exists about the rank. Range ranks, e.g. S1S2, indicate not enough information is available to distinguish between two ranks.

GLOBAL RANK:
G1 - Critically imperiled globally because of extreme rarity (5 or fewer occurrences), or very few remaining acres, or miles of stream) or especially vulnerable to extinction because of some factor of its biology.
G2 - Imperiled globally because of rarity (6 - 20 occurrences, or few remaining acres, or miles of stream) or very vulnerable to extinction throughout its range because of other factors.
G3 – Vulnerable: Either rare and local throughout its range (21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range (e.g. a physiographic region), or vulnerable to extinction throughout its range because of other factors.
G4 - Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5 - Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GH - Historically known, with the expectation that it might be rediscovered.
GX - Species believed to be extinct.

NYS RANK:
S1 - Critically imperiled: Typically 5 or fewer occurrences, very few remaining individuals, acres, or miles of stream, or some factor of its biology making it especially vulnerable in New York State.
S2 – Imperiled: Typically 6 to 20 occurrences, few remaining individuals, acres, or miles of stream, or factors demonstrably making it very vulnerable in New York State.
S3 - Vulnerable: Typically 21 to 100 occurrences, limited acreage, or miles of stream in New York State.
S4 - Apparently secure in New York State.
S5 - Demonstrably secure in New York State.
SH - Historically known from New York State, but not seen in the past 15 years.
SX - Apparently extirpated from New York State.

SxB and SxN, where Sx is one of the codes above, are used for migratory animals, and refer to the rarity within New York State of the breeding (B)populations and the non-breeding populations (N), respectively, of the species.

TAXON (T) RANK: The T-ranks (T1 - T5) are defined the same way as the Global ranks (G1 - G5), but the T-rank refers only to the rarity of the subspecific taxon.
T1 through T5 - See Global Rank definitions above.
Q - Indicates a question exists whether or not the taxon is a good taxonomic entity.

APPENDIX P
THE SDA QUANTITATIVE RISK ASSESSMENT

APPENDIX P
THE SDA QUANTITATIVE RISK ASSESSMENT

P.1 Introduction

NYSERDA's preferred alternative for the State-Licensed Disposal Area (SDA) is to manage the facility in place for up to 30 more years. As such, NYSERDA is required under State Environmental Quality Review Act (SEQR) to identify and mitigate potential environmental impacts from that action. To meet its requirements under SEQR, NYSERDA tasked Dr. B. John Garrick to provide the analysis needed to assess the impacts from NYSERDA's preferred alternative for the SDA. Dr. Garrick, who is the current Chairperson of the U.S. Nuclear Waste Technical Review Board, and a former President of the Society for Risk Analysis, recommended the preparation of a quantitative risk assessment (QRA) for the SDA. At NYSERDA's request, Dr Garrick assembled a team of highly qualified experts to prepare the QRA[1].

The Quantitative Risk Assessment for the State-Licensed Disposal Area (QRA 2008) evaluates the risk to the public from continued operation of the SDA for the next 30 years with its current physical and administrative controls. The QRA includes detailed models for the mobilization, transport, distribution, dilution, and deposition of released radioactive materials throughout the environment surrounding the SDA site, including the integrated watershed formed by Erdman Brook, Franks Creek and Buttermilk Creek. Exposures to hazardous and toxic chemical impacts are not evaluated as part of the scope of this QRA. Hazardous and toxic chemical impacts are being evaluated as part of the Corrective Measure Study for the SDA being conducted under a RCRA Section 3008 (h) Administrative Order on Consent.

This Appendix to the Draft EIS contains a summary of the QRA for the SDA; the entire QRA report, including supporting models, data, and analyses is available as a separate document from NYSERDA[2].

P.2 The QRA Framework

The fundamental elements of the QRA process are (1) the "triplet" definition of risk (defined below) to serve as a general framework for the meaning of risk, (2) a scenario approach that clearly links initial (*initiating events or initial conditions*) and final states (*consequences*) with well defined intervening events and processes, (3) the representation of uncertainty by a probability distribution (*the probability offrequency concept*), (4) a definition of probability that measures the *credibility* of a hypothesis based on the supporting evidence, and (5) information processing rooted in the fundamental rules of logic.

The general framework for the QRA is the "set of triplets" definition of risk.

$$R = \{<S_i, L_i, X_i>\}_c,$$

In this format, the brackets denote "the set of", and the subscript c implies that the set is complete. The risk ("R") is a comprehensive answer to the following questions:

[1] *The QRA preparation team includes Dr. B. J. Garrick, Study Director, John W. Stetkar, Principal Investigator, Andrew A. Dykes, Thomas E. Potter, and Stephen L. Wampler.*

[2] *The complete QRA report is available on the Internet at http://www.nyserda.org/publications/ sdaquantitativeriskassessment.pdf. Paper copies can be requested from NYSERDA at END@nyserda.org, or by calling Elaine DeGiglio at (716) 942-9960, extension 2423.*

- "What can go wrong?" This question is answered by describing a structured, organized, and complete set of possible damage scenarios ("S").
- "What is the likelihood of each scenario?" This question is answered by performing detailed analyses of each risk scenario, using the best available data and engineering knowledge of the relevant processes, and explicitly accounting for all sources of uncertainty that contribute to the scenario likelihood ("L").
- "What are the consequences?" This question is answered by systematically describing the possible end states for each risk scenario, such as different radiation dose levels that may be received by a member of the public ("X").

P.3 The QRA Scope

This study evaluates the risk from continued operation of the SDA for the next 30 years with its current physical and administrative controls. The scope of this risk assessment is limited to quantification of the radiation dose received by a member of the public, represented by two potential receptors.

- A permanent resident farmer located near the confluence of Buttermilk Creek and Cattaraugus Creek
- A transient recreational hiker / hunter who traverses areas along Buttermilk Creek and the lower reaches of Franks Creek

The study evaluates potential releases of liquid, solid, and gaseous radioactive materials from the 14 waste trenches at the SDA site. It examines a broad spectrum of potential natural and human-caused conditions that may directly cause or contribute to these releases. Threats to the site are grouped into two general categories.

- **Disruptive Events** are unexpected events that cause an immediate change to the site. They are typically characterized by an event occurrence frequency and by directly measurable immediate consequences. Examples are severe storms, tornadoes, earthquakes, fires, and airplane crashes.
- **Nominal Events and Processes** are expected events and natural processes that evolve continuously over the life of the facility. They are typically characterized by a rate, which may be constant or changing over time. The potential consequences from these processes depend on the duration of the exposure period. Examples are groundwater flows, slope subsidence, and the aging of engineered and natural systems.

The QRA includes detailed models for the mobilization, transport, distribution, dilution, and deposition of released radioactive materials throughout the environment surrounding the SDA site, including the integrated watershed formed by Erdman Brook, Franks Creek, and Buttermilk Creek.

The scope of this study does not include intentional acts of destruction, war, terrorism, or sabotage. These types of threats could be evaluated within the SDA risk assessment framework and models. However, due to the limited resources and duration of this study, it was not feasible to evaluate either the specific types of threat scenarios that may evolve from deliberately destructive acts, or to derive realistic estimates for their potential frequencies.

Exposures to hazardous and toxic chemical impacts are not evaluated as part of the scope of this QRA. Hazardous and toxic chemical impacts are being evaluated as part of the Corrective Measure Study for the SDA being conducted under a RCRA Section 3008 (h) Administrative Order on Consent.

P.4 Evaluated Threats

The scope of potential threats considered in this study includes a broad variety of natural phenomena and processes, and human-caused events. Systematic methods were used to examine and screen identified threats for their potential significance to the SDA risk. **Table P-1** lists the threats that were retained for explicit evaluation in the QRA models. **Table P-2** lists the threats that were evaluated and eliminated from further detailed analysis.

P.5 Release Mechanisms and Scenarios

Five release mechanisms were defined to provide a framework and context for the risk scenarios. Each scenario begins with an initiating disruptive event or an evolving site process, and it results in a release of radioactive materials into the external environment. It then continues through the mobilization and transport elements of the risk models, where the released materials are distributed, diluted, and deposited throughout the area surrounding the site. The scenario finally terminates in a source of radiation exposure and dose to the study receptors.

The five SDA release mechanisms are:

- **Release Mechanism 1** involves liquid releases from the waste trenches via groundwater flows though the Unweathered Lavery Till (ULT) and Kent Recessional Sequence (KRS) soil layers. Four risk scenarios were evaluated for this release mechanism.

- **Release Mechanism 2** involves liquid releases from the waste trenches via groundwater flows though the Weathered Lavery Till (WLT) soil layer. One risk scenario was evaluated for this release mechanism.

- **Release Mechanism 3** involves liquid overflows of the waste trenches and releases via surface water runoff. Nine risk scenarios were evaluated for this release mechanism.

- **Release Mechanism 4** involves physical breaches of the waste trenches and releases of liquid and solid radioactive materials. Sixteen risk scenarios were evaluated for this release mechanism.

- **Release Mechanism 5** involves extensive physical disruption of the SDA site and airborne releases from the waste trenches. One risk scenario was evaluated for this release mechanism.

The release mechanisms and scenarios evaluated are listed in **Table P-3**.

P.6 Supporting Analyses

Detailed analyses were performed to quantify the frequencies of all threats that are analyzed in the QRA models. In most cases, extensive effort was required to supplement the limited available information and data from previous assessments, to perform a realistic evaluation of the threat frequencies and their associated uncertainties.

Several "fragility analyses" were performed to quantify the conditional likelihood that a disruptive event or natural process will cause a release of radioactive materials from the SDA waste trenches. Members of the IERT provided technical guidance and input for a number of these analyses, developed some of the analytical models, and performed some of the detailed quantifications. The fragility analyses evaluated the following technical issues.

- Seismic failures of the slopes adjacent to the SDA site
- Failures of the slopes due to landslides that are not related to seismic events or erosion
- Erosion of the waste trench caps
- Erosion and migration of slope gullies
- Groundwater flows through lateral and vertical release pathways
- Trench filling and overflows from water intrusion

NYSERDA engineers provided evaluations of potential intervention efforts to stop or mitigate the consequences of specific radioactive material release scenarios. Analyses were also performed to quantify the effects from conditions that may require extensive repairs or replacement of the geomembranes.

Comprehensive inventories of the SDA waste materials were compiled from existing databases, including the distribution of specific radionuclides at 50-foot intervals in each trench. This information was used to quantify the physical form, quantity, and radioisotopic content of the materials that are released during each risk scenario.

Geohydrologic models were developed for the area surrounding the SDA site, including the integrated drainage basin for Erdman Brook, Franks Creek, and Buttermilk Creek. These models were used to quantify flows and dilution of radioactive liquids that are released into the stream systems, the transport of solids, and the deposition of contaminated material in stream bed sediments. An atmospheric dispersion model was used to quantify flows, transport, and dilution of radioactive aerosols released into the air.

Analyses were performed to evaluate the exposure of each receptor to contaminants that are released during each risk scenario, accounting for the specific form of the material (e.g., liquid, solid, or airborne), its quantity and concentration at the point of exposure, and its radioisotopic content. Potential doses accrue from direct exposure to contaminated creek water, sediments, and airborne species. The analyses also assume that creek water is used for crop irrigation and livestock water supplies, resulting in additional potential doses through these food chain pathways. It is assumed that creek water is not used as a domestic potable water supply. The total effective dose equivalent (TEDE) for each receptor is quantified in terms of millirem (mrem) accumulated in a 1-year period, for comparison with public health standards and other sources of radiation risk.

P.7 The SDA Risk

Figure P-1 shows the integrated risk curves for the SDA site, in the "frequency of exceedance" format that is typically used to display QRA results. The following examples illustrate how these curves are interpreted.

Frequency of Dose Exceeding 0.1 mrem in 1 Year

This result is obtained by taking a vertical "slice" through Figure P-1 at the dose value of 1.0E-01 mrem in 1 year. **Figure P-2** shows that "slice", in the "probability density" format that displays the full uncertainty about the frequency of this dose level.

The mean total frequency of all threats that cause radioactive material releases from the SDA site which result in a total effective dose to all receptors of 0.1 mrem in 1 year, or more, is approximately 2.12E-02 event per year (i.e., one event in 47 years). There is equal probability that the release frequency for this dose is greater than, or less than, the median value of approximately 1.75E-02 event per year (i.e., one event in 57 years). The range of values between the 5th probability percentile and the 95th probability percentile in Figure P-1 is the "90% confidence interval" of the uncertainty about the risk. This means that there is 90% probability that the release frequency for a particular dose level is within this interval. There is 5% probability that the release frequency is less than the lower end of the 90% confidence interval (i.e., lower than the 5th probability percentile), and there is 5% probability that the release frequency is higher than the upper end of the interval (i.e., higher than the 95th probability percentile). For the 0.1-mrem dose "slice" shown in Figure P-2, the QRA authors are 90% confident that the release frequency is between 1.52E-02 event per year and 3.53E-02 event per year (i.e., between one event in 66 years and one event in 28 years). Since the mean value is the "expected" frequency of these releases, the QRA authors do not "expect" to have a release that results in a dose of 0.1 mrem in 1 year, or more, during the next 30 years of SDA operation. However, the uncertainty results show that there is a small probability (slightly more than 5%) that this type of release may occur during the next 30-year operating period.

Frequency of Dose Exceeding 100 mrem in 1 Year

This result is similarly obtained by taking a vertical "slice" through Figure P-1 at the dose value of 1.0E+02 mrem in 1 year. **Figure P-3** shows that "slice".

The mean total frequency of all threats that cause radioactive material releases from the SDA site which result in a total effective dose to all receptors of 100 mrem in 1 year, or more, is approximately 2.04E-03 event per year (i.e., one event in 490 years). There is equal probability that the release frequency for this dose is greater than, or less than, the median value of approximately 1.86E-03 event per year (i.e., one event in 538 years). The QRA authors are 90% confident that the release frequency is between 1.50E-03 event per year and 2.74E-03 event per year (i.e., between one event in 667 years and one event in 365 years). The QRA results confirm that a release which results in a dose of 100 mrem in 1 year, or more, is extremely unlikely during the next 30 years of SDA operation.

Figure P-4 is another representation of the SDA risk results, with an expanded scale that focuses on the dose range from 10 to 1000 mrem in 1 year. It displays the risk in terms of the number of release events that occur during the SDA 30-year operating period that is covered by this study. It is obtained by multiplying the frequency scale in Figure P-1 by 30 years. The maximum value of the y-axis corresponds to 1 event that results in a release of radioactive material from the SDA during the next 30 years. **Figure P-5** shows the uncertainty distribution for the "slice" at the 100 mrem dose level. These results clearly show that it is very unlikely that a release will occur during the next 30 years with the consequences of a 1-year dose of 100 mrem, or more. For example, the 95th probability percentile in Figure P-5 corresponds to a value of 0.082 release events in the 30-year SDA operating period (i.e., less than one-tenth of an event in 30 years, or approximately 1 event in 365 years). This means that the QRA authors are 95% confident that this type of release will occur less often than once in 365 years. The complete uncertainty results conclude that there is 97.5% probability that fewer than 0.103 releases will occur in 30 years (1 release in 291 years), and 99.5% probability that fewer than 0.168 releases will occur in the next 30 years (1 release in 179 years). The maximum release frequency quantified by the QRA uncertainty results corresponds to 0.526 releases in 30 years with the consequences of a 1-year dose of 100 mrem, or more. Thus, it is "extremely unlikely" that this type of release will occur during the next 30 years, and there is more than 99.95% probability that it will not occur in the next 57 years. **Table P-4** lists the mean ("expected") frequency of radioactive material releases for each risk scenario in terms of release events per year, the corresponding mean consequences from that scenario in terms of equivalent mrem dose in 1 year to all exposed receptors, and the product of the scenario frequency and consequences. This tabulation is useful to understand the detailed contributors to the overall SDA risk and their relative importance.

Only five scenarios individually account for more than 1% of the total SDA risk, and these five scenarios collectively account for almost 97% of the total. Each of the remaining 26 scenarios contributes less than 1% of the overall risk, and the 26 scenarios collectively account for just slightly more than 3% of the total. The top five scenarios for total SDA risk are:

- **Scenario 2 – 1** is the only scenario for Release Mechanism 2. It accounts for approximately 38.7% of the total SDA risk. The scenario involves lateral groundwater flows through the WLT soil layer near the surface of the SDA site. These releases can occur only when the water levels in the waste trenches are high, and the trenches are nearly full of water.

- **Scenario 1 – 2** is the second scenario defined for Release Mechanism 1. It accounts for approximately 34.5% of the total SDA risk. The scenario involves lateral groundwater flows through the ULT soil layer. These releases occur when water levels in the waste trenches are at or near the interface between the ULT and WLT soil layers.

- **Scenario 1 – 1** is the first scenario defined for Release Mechanism 1. It accounts for approximately 16.0% of the total SDA risk. The scenario involves lateral groundwater flows through the ULT soil layer. These releases occur when the water levels in the waste trenches are high, and the trenches are nearly full of water.

- **Scenario 3 – 4** is the fourth scenario defined for Release Mechanism 3. It accounts for approximately 4.9% of the total SDA risk. The scenario involves initial site conditions when the geomembranes are not intact, and the trench compacted clay caps are in their normal state. Water levels in the waste trenches are at or near the interface between the ULT and WLT soil layers. Total precipitation during a 14-day period exceeds 9 inches, including at least one storm with rainfall intensity that is severe enough to erode the trench caps and allow water intrusion to fill the trenches. The trenches overflow, and contaminated liquid enters the adjacent streams through surface runoff.

- **Scenario 1 – 4** is the fourth scenario defined for Release Mechanism 1. It accounts for approximately 2.6% of the total SDA risk. The scenario involves vertical groundwater flow through the ULT soil layer and subsequent lateral flow through the KRS soils, with discharges to Buttermilk Creek. The groundwater flow analyses for this release pathway are performed under conditions that are not sensitive to the initial water level in the trenches. Therefore, the results from those analyses apply for all trench water levels.

Table P-4 shows that seismic damage, gully erosion, and landslide scenarios in Release Mechanism 4 contribute increasingly to the "low frequency / high consequence" end of the risk profile in Figure P-1. The table shows that the mean doses from some of these scenarios can be quite significant. However, the release frequencies are extremely small, resulting in negligible contributions to overall site risk. "Intermediate frequency / intermediate consequence" scenarios in Release Mechanism 3 also contribute to the middle range of the risk spectrum.

The fractional risk contribution from each major release mechanism is:

Release Mechanism 1:	Groundwater flows through the ULT	53.4%
Release Mechanism 2:	Groundwater flows through the WLT	38.7%
Release Mechanism 3:	Trench overflows and surface water runoff	5.6%
Release Mechanism 4:	Trench breaches by erosion, landslides, and earthquakes	2.3%
Release Mechanism 5:	Airborne releases from SDA physical impacts	<< 0.1%

P.8 Conclusions

The QRA results confirm that the public health risk from operating the SDA for the next 30 years is well below widely applied radiation dose limits, such as the 100 mrem per year limit specified under "Radiation Dose Limits for Individual Members of the Public" in Part 380 of the State of New York Codes, Rules, and Regulations (6 NYCRR Part 380) and in Part 20 of Title 10 of the Code of Federal Regulations (10 CFR 20). There is extremely high confidence that potential releases of radioactive materials from the SDA which may result in a 1-year dose to any member of the public of 100 mrem, or more, will occur much less often than once in 30 years. These results should not be interpreted to mean that a release of this magnitude is impossible. They simply indicate that a release with these consequences is extremely unlikely during the next 30 years. If the SDA site could be maintained in its current state in perpetuity (including all geohydrologic and meteorological conditions) it would be expected that this type of event would occur only once in approximately 490 years.

This low level of risk will be maintained only if NYSERDA continues to operate the SDA according to its current physical and administrative controls.

The quantified risk from the SDA is dominated by a small number of event scenarios. A total of five scenarios accounts for almost 97 percent of the overall risk. Four of these scenarios involve releases of radioactive liquids from the waste trenches through groundwater flow paths. One scenario involves trench overtopping and radioactive liquid releases via surface runoff during heavy precipitation that occurs while the geomembranes are not intact. The risk from all five scenarios is influenced by two common factors.

- The SDA is most susceptible to these liquid release scenarios when water levels in the waste trenches are at, or above, the interface between the ULT and the WLT soil layers. The current trench levels are substantially below the ULT / WLT interface, and have been slowly decreasing. However, levels could increase in the future, if the geomembranes are not properly maintained, or if the SDA surface remains uncovered during membrane repairs or replacement.

- There are very large uncertainties in the models, parametric data, and analyses that were performed in this study to evaluate potential liquid releases through the groundwater pathways. Those uncertainties contribute significantly to the quantified level of risk from these scenarios. In most cases, the mean (or "expected") consequences from the groundwater release scenarios are determined almost completely by low probability conditions that dominate the overall uncertainty and results.

P.9 Recommendations

There is very large uncertainty about several of the most important risk contributors identified in this study. That uncertainty is determined almost entirely by the models and analyses for the groundwater release pathways. It is likely that these uncertainties can be substantially reduced through further refinements to the groundwater flow models, supporting data, and analyses. Relatively small reductions in the uncertainties may have a rather significant impact on the quantified risk, due to the numerical influence from low probability "tails" of the uncertainty distributions. The QRA authors recommend that NYSERDA should consider these analysis refinements to provide better resolution and improved understanding of the total SDA risk and its contributors.

The risk results are also strongly influenced by the four trench water levels that were defined during the Independent Expert Review Team (IERT) expert elicitations, and their corresponding probabilities. It is recommended that further analyses and more formal elicitations should be performed to refine the evaluations of these water levels and their technical bases.

Apart from decisions regarding possible refinements to the QRA models, data, and analyses, it is recommended that NYSERDA should:

- Continue to actively maintain trench water levels below the ULT / WLT interface level, regardless of the status of the geomembranes and other activities at the site.
- Minimize the amount of time that the geomembrane covers are not intact, and the surface of the trench caps is exposed. This includes expedited repairs or replacement of damaged geomembrane sections, and minimizing the time and extent of surface uncovery during planned geomembrane replacements.
- Formalize emergency preparedness plans and guidelines for responses to the types of release scenarios that are evaluated in this study. The risk from specific scenarios is affected significantly by the credit that has been applied for these intervention and mitigation responses.
- Monitor liquid activity levels in Buttermilk Creek water at a location just upstream from the confluence with Franks Creek, with a sampling interval that is more frequent than once every 5 years. This sampling location would provide more positive detection of possible groundwater releases via the deep ULT / KRS pathways that discharge directly into Buttermilk Creek.
- Periodically sample the water in each trench and monitor the concentrations of radionuclide species.

Table P-1 Threats Included in the SDA Risk Assessment

Disruptive Events

- Aircraft Crashes
  - Commercial
  - General aviation
  - Military
- Erosion
  - Local streams
  - Trenches
- Extraterrestrial Impacts (meteorites)
- Fires
  - Offsite (e.g., grass fires, forest fires)
- Flooding Events
  - Extreme precipitation
  - Rapid snow melt
- High Wind Events
  - Extreme sustained winds
  - Wind gusts
  - Tornadoes
- Landslides
- Pipeline Accidents
  - Site natural gas supply pipe
- Seismic Events
  - Direct seismic failures
- Severe Storms (snow)

Nominal Events and Processes

- Corrosion / Deterioration / Decomposition
  - Geomembrane covers
  - Crates, boxes
  - Steel drums
- Groundwater Intrusion
  - Historic intrusion
  - Rapid intrusion ("bath-tubbing")
- Soil Shrink / Swell / Consolidation

Table P–2 Potential SDA Threats that were Evaluated and Eliminated from further Detailed Analysis

- Avalanches
- Biological Events
- Drought
- Erosion
  - Coastal/lake shore erosion
  - River bank erosion
- Excavation of Contaminated Stream Sediments
- Explosions
- Extraterrestrial Impacts (involving meteorites greater than 1 meter in diameter)
- Extreme Temperatures (heat, cold)
- Fires
  - Onsite facilities ("internal fires")
- Flooding Events
  - Onsite facilities ("internal flooding")
  - Dam failure
  - Site water supply pipe failure
  - Seiche
  - Storm surge
  - Tsunami
- Fog
- Frost
- High Tides
- Hurricanes
- Ice Cover
- Lightning
- Loss of External Power Supplies
- Low Lake or River Water Level
- Nearby Facility Accidents
  - Industrial
  - Chemical
  - Military
- NRC-Licensed Facility Decommissioning Activities
  - Direct accident impacts on SDA
  - Effects on site grading, surface water runoff, erosion
- Radiolytic/Chemical Interactions
- River Diversion
- Seismic Events
  - Seismic-induced fires
  - Seismic-induced flooding (e.g., piping failures)

- Severe Storms
  - Hail
  - Sand storms
  - Dust storms
- Sinkholes
- Site Intrusions (direct intrusion into the SDA during the 30-year period of this study)
- Toxic Gas Releases
- Transportation Accidents
  - Rail
  - Highway
  - Shipping (by navigable waterway)
- Volcanic Activity

Table P–3 Release Mechanisms and Scenarios

Release Mechanism	*Scenario*	*Threat Condition – Damage Scenario*
1 Liquid Releases from Waste Trenches via Groundwater through the Unweathered Lavery Till (ULT) and Kent Recessional Sequence (KRS) Soil Layers	1 – 1	Initial trench water level high; Lateral flow through ULT; NYSERDA detection via stream water sampling; NYSERDA mitigation
	1 – 2	Initial trench water level at the WLT/ULT interface; Lateral flow through ULT; NYSERDA detection via stream water sampling; NYSERDA mitigation
	1 – 3	Initial trench water at the current level; Lateral flow through ULT; NYSERDA detection via stream water sampling; NYSERDA mitigation
	1 – 4	Vertical flow through ULT and lateral flow through KRS; All trench water levels; NYSERDA detection via Buttermilk Creek sediment sampling; External intervention to limit receptor exposure
2 Liquid Releases from Waste Trenches via Groundwater through the Weathered Lavery Till (WLT) Soil Layer	2 – 1	Initial trench water level high; Lateral flow through WLT; NYSERDA detection via stream water sampling; NYSERDA mitigation
3 Liquid Overflows of the Waste Trenches and Releases via Surface Water Runoff	3 – 1	Initial trench water level high; Geomembranes unavailable; Trench caps intact; Severe precipitation (24- or 48-hour precipitation event) erodes caps
	3 – 2	Initial trench water level high; Geomembranes initially in place; Trench caps intact; Severe storm destroys geomembranes and erodes caps
	3 – 3	Initial trench water level high; Geomembranes damaged; Trench caps disrupted; Precipitation ≥ 1 inch in 14 days
	3 – 4	Initial trench water level at the WLT/ULT interface; Geomembranes unavailable; Trench caps intact; Precipitation ≥ 9 inches in 14 days (assumed to erode caps)
	3 – 5	Initial trench water level at the WLT/ULT interface; Geomembranes intact; Trench caps intact; Severe storm (Wind or Tornado) destroys geomembranes and erodes caps; Precipitation ≥ 9 inches total accumulation in 14 days
	3 –6	Initial trench water level at the WLT/ULT interface; Geomembranes unavailable; Trench caps disrupted; Precipitation ≥ 9 inches in 14 days
	3 – 7	Initial trench water at the current level or lower; Geomembranes unavailable; Trench caps intact; Precipitation ≥ 25 inches in 14 days (assumed to erode caps)
	3 – 8	Initial trench water at the current level or lower; Geomembranes initially in place; Trench caps intact; Severe storm (Wind or Tornado) destroys geomembranes and erodes caps; Precipitation ≥ 25 inches accumulation in 14 days
	3 – 9	Initial trench water at the current level or lower; Geomembranes unavailable; Trench caps disrupted; Precipitation ≥ 25 inches in 14 days

Release Mechanism	Scenario	Threat Condition – Damage Scenario
4 Physical Breaches of the Waste Trenches and Releases of Liquid and Solid Radioactive Material	4 – 1	Localized landslide or seismic-induced slope failure Damage Condition 1[a]; Solid releases
	4 – 1a	Initial trench water level high; Localized landslide or seismic-induced slope failure Damage Condition 1; Liquid releases
	4 – 1b	Initial trench water level at the WLT/ULT interface; Localized landslide or seismic-induced slope failure Damage Condition 1; Liquid releases
	4 – 1c	Initial trench water at current level or lower; Localized landslide or seismic-induced slope failure Damage Condition 1; Liquid releases
	4 – 2	Geomembranes unavailable; Gully erosion; Solid releases
	4 – 2a	Initial trench water level high; Geomembranes unavailable; Gully erosion; Liquid releases
	4 – 2b	Initial trench water level at the WLT/ULT interface; Geomembranes unavailable; Gully erosion; Liquid releases
	4 – 2c	Initial trench water at current level or lower; Geomembranes unavailable; Gully erosion; Liquid releases
	4 – 3	Seismic – induced slope failure Damage Condition 2[b]; Solid releases
	4 – 3a	Initial trench water level high; Seismic-induced slope failure Damage Condition 2; Liquid releases
	4 – 3b	Initial trench water level at the WLT/ULT interface; Seismic-induced slope failure Damage Condition 2; Liquid releases
	4 – 3c	Initial trench water at the current level or lower; Seismic-induced slope failure Damage Condition 2; Liquid releases
	4 – 4	Regional/Global landslide; Solid releases
	4 – 4a	Initial trench water level high; Regional/Global landslide; Liquid releases
	4 – 4b	Initial trench water level at the WLT/ULT interface; Regional/Global landslide; Liquid releases
	4 – 4c	Initial trench water at current level or lower; Regional/Global landslide; Liquid releases
5 Extensive Physical Disruption of the SDA Site and Airborne Releases from the Waste Trenches	5 – 1	Aircraft crash or meteorite; Geomembranes damaged and surface disturbed; Airborne releases

[a] Damage Condition 1 – Slope failures intersect Trenches 1/2, Trench 8 and 125 feet of the north ends of Trenches 3, 4 and 5.
[b] Damage Condition 2 – Slope failures intersect Trenches 1/2, Trench 3, 8 and 9, and 250 feet of the north ends of Trenches 4 and 5.

Table P–4 SDA Risk Scenarios

Scenario	*Mean Frequency (event / year)*	*Mean Dose (mrem in 1 year)*	*Mean Frequency x Dose [(mrem in 1 year) / year]*	*Fraction of Total Risk*	*Cumulative Fraction of Total Risk*	*Contributing Conditions*
2 – 1	3.33E-03	431.50	1.44E+00	3.87E-01	0.387	Groundwater, Level = High, WLT Lateral
1 – 2	1.00E-02	128.36	1.28E+00	3.45E-01	0.732	Groundwater, Level = ULT / WLT, ULT Lateral
1 – 1	3.33E-03	178.46	5.95E-01	1.60E-01	0.892	Groundwater, Level = High, ULT Lateral
3 – 4	5.50E-03	33.15	1.80E-01	4.85E-02	0.941	Overflow, Level = ULT / WLT, Geomembranes unavailable, Precipitation > 9 inches in 14 days
1 – 4	3.33E-02	2.94	9.79E-02	2.63E-02	0.967	Groundwater, ULT-KRS
4 – 1	6.30E-05	491.54	3.09E-02	8.30E-03	0.975	Local Landslide or Seismic Damage 1, Solids
3 – 3	1.18E-03	22.88	2.59E-02	6.97E-03	0.982	Overflow, Level = High, Geomembranes damaged and surface disturbed, Precipitation > 1 inch in 14 days
4 – 1b	1.89E-05	1109.61	2.05E-02	5.53E-03	0.988	Local Landslide or Seismic Damage 1, Level = WLT / ULT, Liquids
4 – 1c	3.78E-05	532.61	1.97E-02	5.31E-03	0.993	Local Landslide or Seismic Damage 1, Level = Current / Low, Liquids
4 – 1a	6.30E-06	2307.98	1.42E-02	3.83E-03	0.997	Local Landslide or Seismic Damage 1, Level = High, Liquids
1 – 3	1.83E-02	0.38	6.97E-03	1.88E-03	0.999	Groundwater, Level = Current, ULT Lateral
3 – 5	2.17E-05	46.69	1.01E-03	2.72E-04	0.999	Overflow, Level = ULT / WLT, Geomembranes intact, Wind or Tornado, Precipitation > 9 inches in 14 days
3 – 6	1.51E-05	46.69	7.03E-04	1.89E-04	0.999	Overflow, Level = ULT / WLT, Geomembranes damaged and surface disturbed, Precipitation > 9 inches in 14 days
3 – 2	1.64E-05	33.15	5.40E-04	1.45E-04	1.000	Overflow, Level = High, Geomembranes intact, Wind or Tornado
4 – 3b	2.64E-07	1331.53	3.73E-04	1.00E-04	1.000	Seismic Damage 2, Level = WLT / ULT, Liquids
4 – 3	8.81E-07	387.71	3.44E-04	9.25E-05	1.000	Seismic Damage 2, Solids
4 – 3c	5.28E-07	576.99	3.23E-04	8.69E-05	1.000	Seismic Damage 2, Level = Current / Low, Liquids
4 – 3a	8.81E-08	2751.82	2.57E-04	6.91E-05	1.000	Seismic Damage 2, Level = High, Liquids
3 – 7	2.91E-06	46.69	1.33E-04	3.57E-05	1.000	Overflow, Level = Current / Low, Geomembranes unavailable, Precipitation > 25 inches in 14 days
3 – 1	1.65E-06	33.15	5.82E-05	1.57E-05	1.000	Overflow, Level = High, Geomembranes unavailable, Precipitation 24- or 48-Hour Storm

Scenario	*Mean Frequency (event / year)*	*Mean Dose (mrem in 1 year)*	*Mean Frequency x Dose [(mrem in 1 year) / year]*	*Fraction of Total Risk*	*Cumulative Fraction of Total Risk*	*Contributing Conditions*
4 – 2	7.00E-08	491.54	3.44E-05	9.26E-06	1.000	Gully Erosion, Solids
4 – 2b	2.10E-08	1109.61	2.47E-05	6.64E-06	1.000	Gully Erosion, Level = WLT / ULT, Liquids
4 – 2c	4.20E-08	532.61	2.37E-05	6.37E-06	1.000	Gully Erosion, Level = Current / Low, Liquids
4 – 2a	7.00E-09	2307.98	1.71E-05	4.60E-06	1.000	Gully Erosion, Level = High, Liquids
4 – 4b	1.51E-09	2929.36	4.58E-06	1.23E-06	1.000	Global Landslide, Level = WLT / ULT, Liquids
4 – 4c	3.02E-09	1242.76	3.89E-06	1.05E-06	1.000	Global Landslide, Level = Current / Low, Liquids
4 – 4a	5.03E-10	4749.11	2.48E-06	6.66E-07	1.000	Global Landslide, Level = High, Liquids
3 – 8	1.17E-08	46.69	4.70E-07	1.26E-07	1.000	Overflow, Level = Current / Low, Geomembranes intact, Wind or Tornado, Precipitation > 25 inches in 14 days
3 – 9	8.96E-09	46.69	3.58E-07	9.64E-08	1.000	Overflow, Level = Current / Low, Geomembranes damaged and surface disturbed, Precipitation > 25 inches in 14 days
4 – 4	5.03E-09	41.94	2.01E-07	5.40E-08	1.000	Global Landslide, Solids
5 – 1	3.73E-07	0.20	7.48E-08	2.01E-08	1.000	Aircraft crash or meteorite

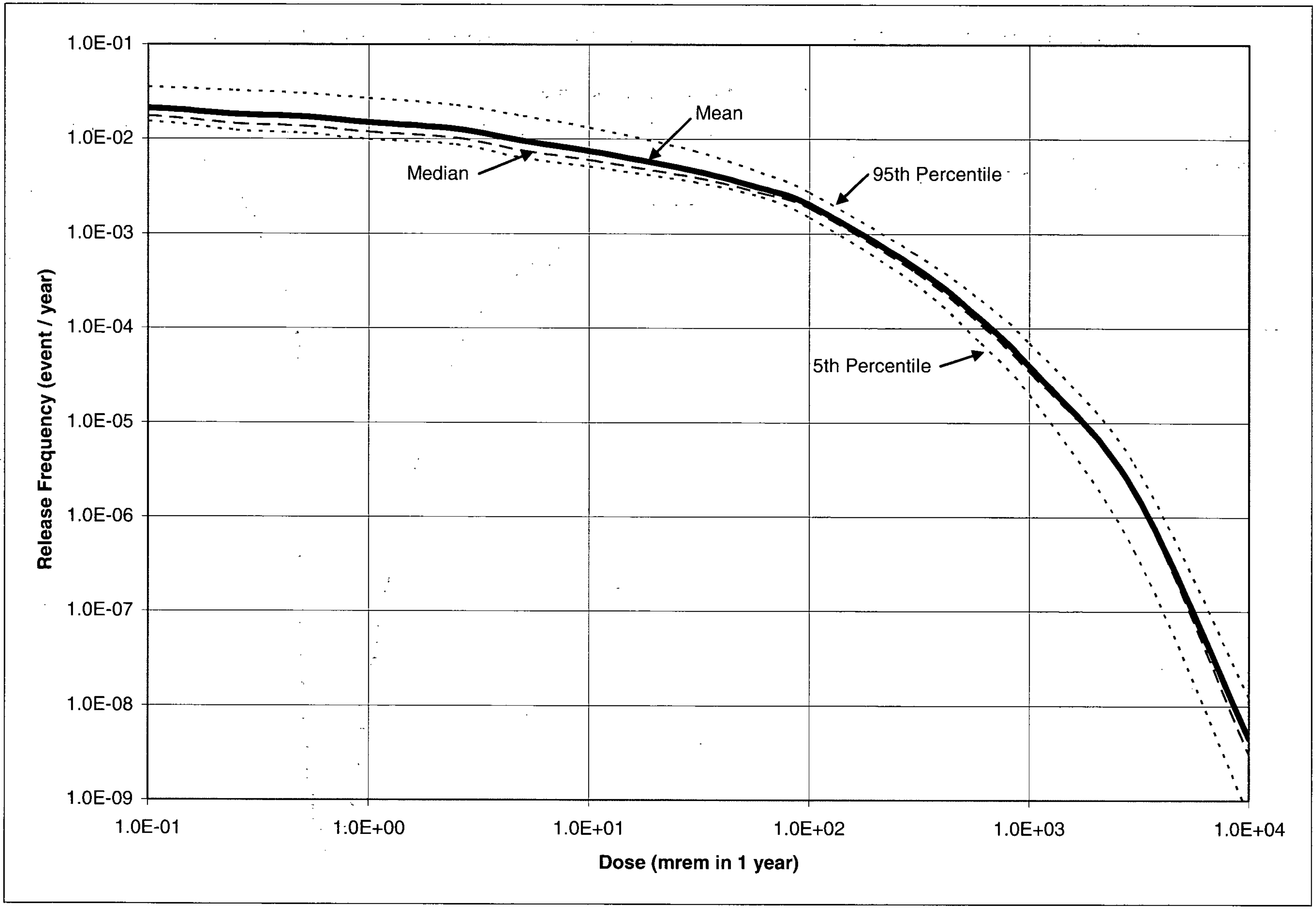

Figure P–1 SDA Risk Curves, Exceedance Frequency Format

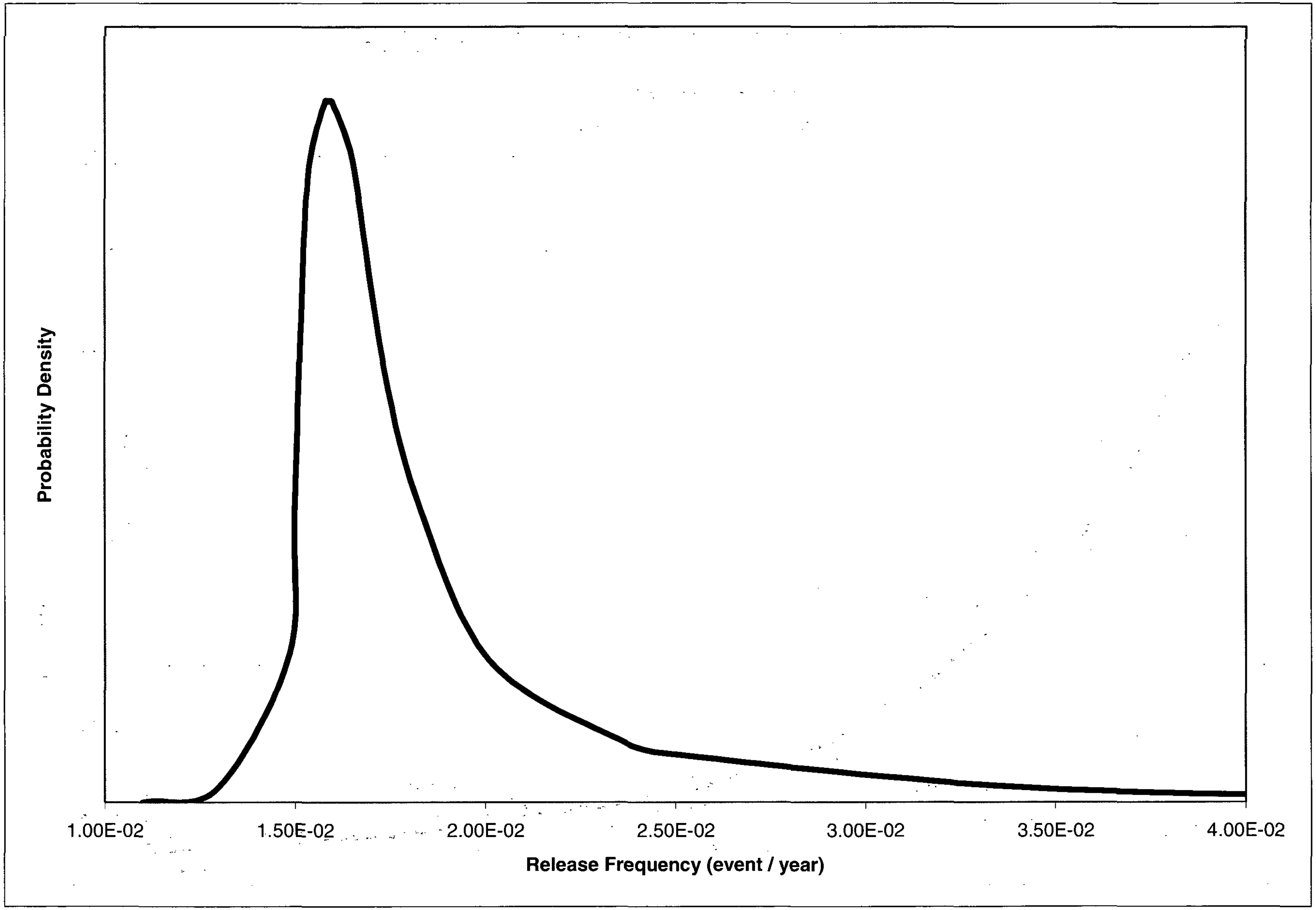

Figure P–2 Release Frequency for Exceeding a Dose of 0.1 mrem in 1 Year, Probability Density Format

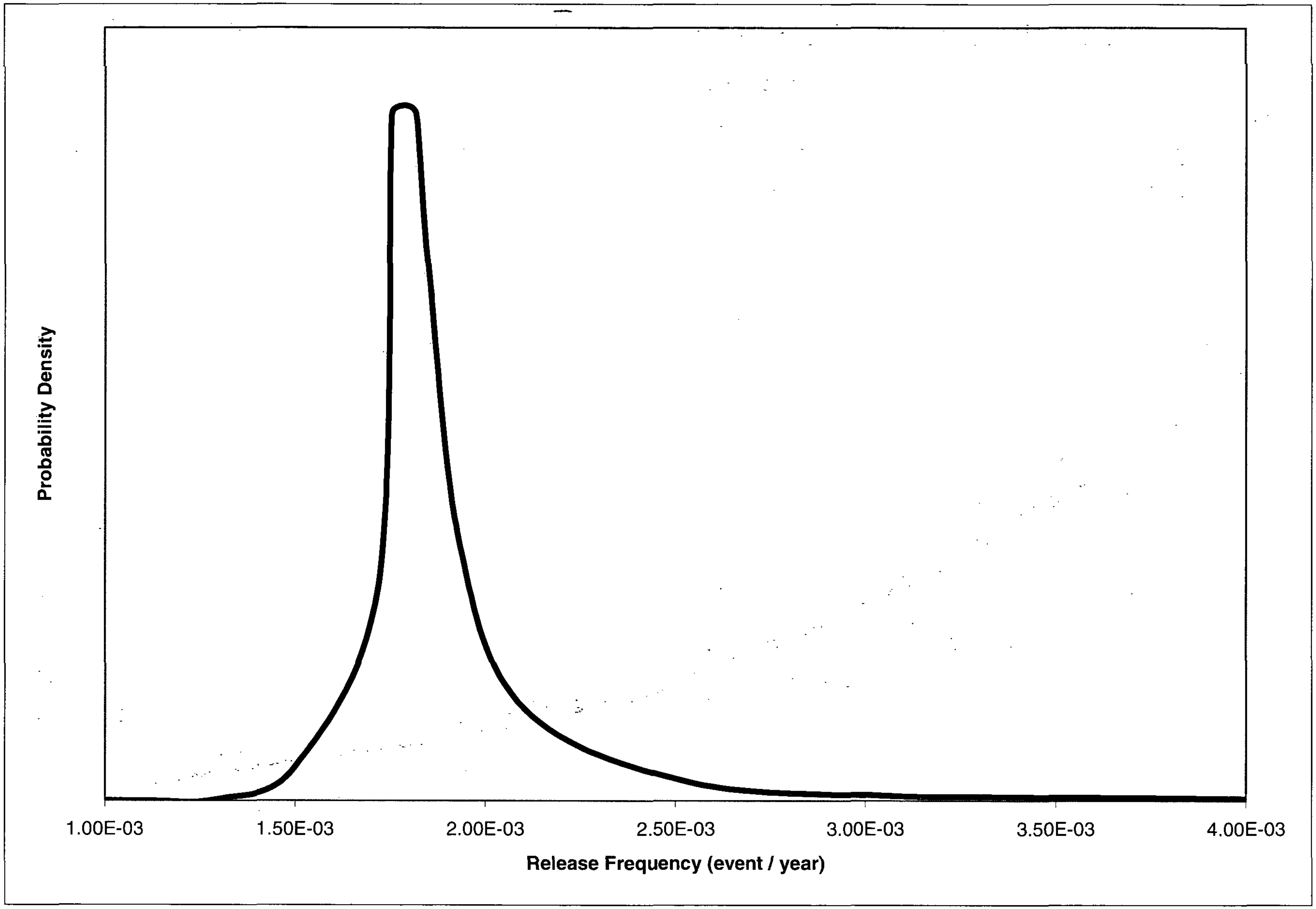

Figure P–3 Release Frequency for Exceeding a Dose of 100 mrem in 1 Year, Probability Density Format

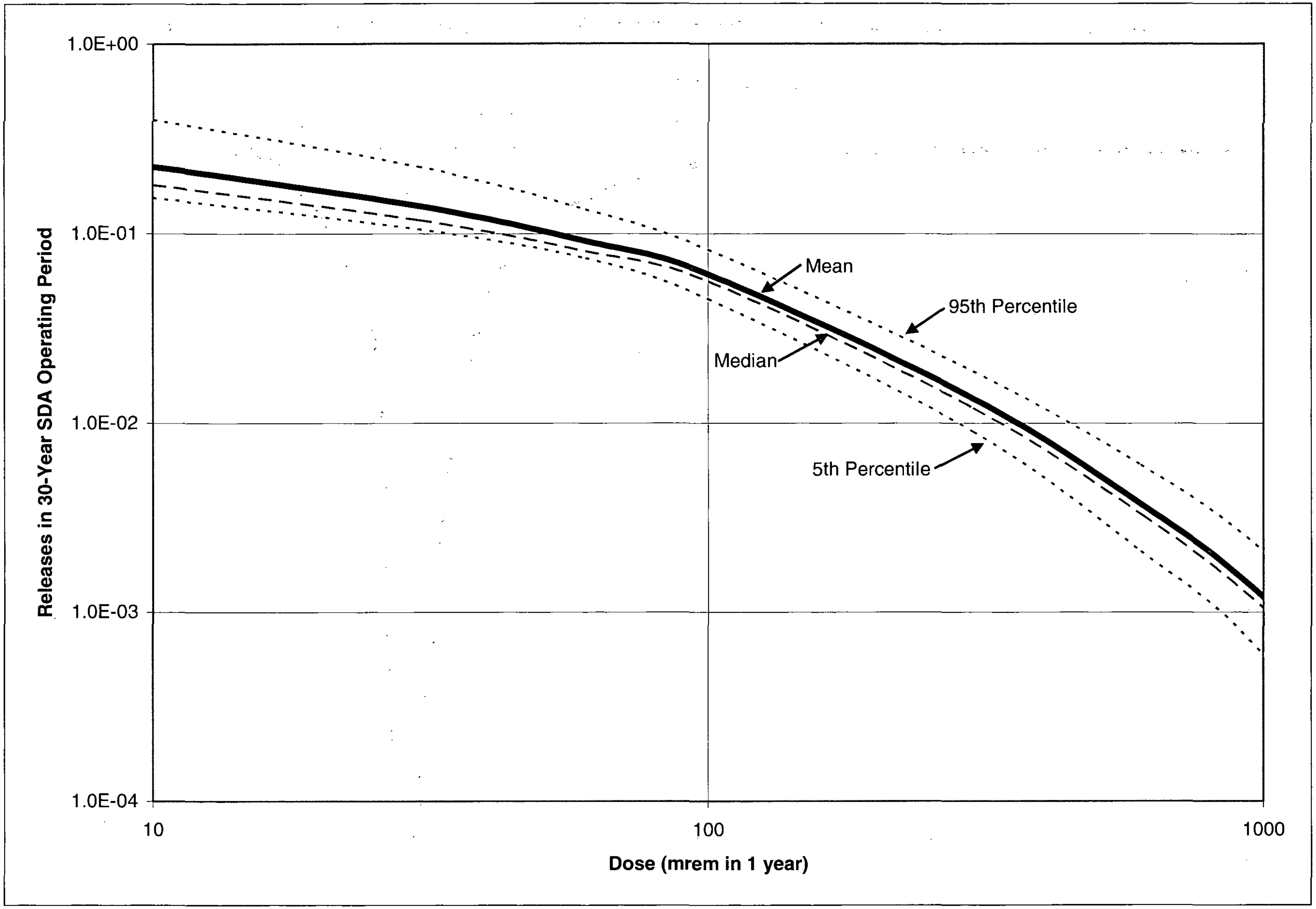

Figure P–4 SDA Risk Curves, 30-Year Operation Period Exceedance Format (Expanded Scale)

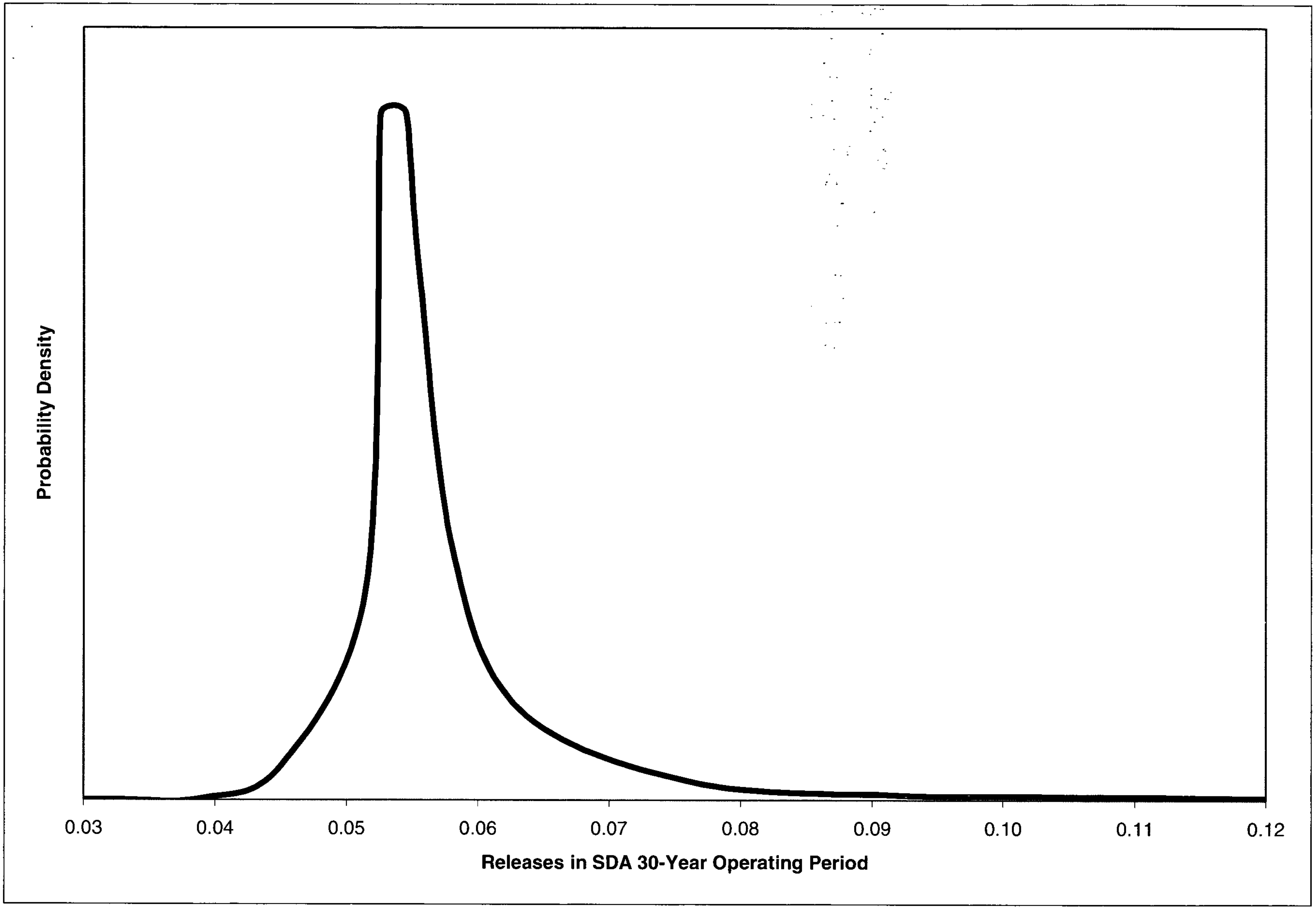

Figure P–5 Releases in SDA 30-Year Operation Period with Doses that Exceed 100 mrem in 1 Year

APPENDIX Q
CONCURRENCE LETTERS

NYSERDA New York State Energy Research and Development Authority
Vincent A. DeIorio, Esq., *Chairman*
Toll Free: 1 (866) NYSERDA
www.nyserda.org • info@nyserda.org

October 14, 2008

James A. Rispoli
Asst. Secretary for Environmental Management
EM-1/Forrestal Building
U.S. Department of Energy
1000 Independence Ave., S.W.
Washington, DC 20585

SUBJECT: Acknowledgment of Agency Concurrence to Release the *Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE/EIS-0226-R) to the Public

Dear Mr. Rispoli:

The U. S. Department of Energy prepared the *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE/EIS-0226-R) (DEIS) for issuance to the public after receiving extensive comments from the New York State Energy Research and Development Authority (NYSERDA) and other governmental agencies. NYSERDA strongly supports the preferred cleanup alternative identified in the DEIS because it calls for near-term removal of significant site facilities and areas of contamination such as the Main Plant Process Building, the low-level waste treatment system lagoons, and the source area of the North Plateau groundwater plume. As you know, NYSERDA has expressed concerns about the long-term performance assessment contained in the DEIS. Given our agreement that NYSERDA's "View" statement[1] will be published in the Foreword to the Revised DEIS, NYSERDA recommends issuance of the Revised DEIS for public review.

We look forward to working with you as our agencies proceed toward a final EIS.

---

[1]"The View of the New York State Energy Research and Development Authority on the Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center"

PJB/08end083.end

Sincerely,

WEST VALLEY SITE MANAGEMENT PROGRAM

Paul J. Bembia

Paul J. Bembia, Director

PJB/end

cc: C. M. Borgstrom, DOE-HQ, GC-20/FORS.
E. B. Cohen, DOE-HQ, GC-20/FORS.
B. M. Diamond, DOE-HQ, GC-51/FORS.
J. E. Loving, DOE-HQ, GC-20/FORS.
F. Marcinowski, DOE-HQ, EM-10/FORS.
B. C. Bower, DOE-WVDP, AC-DOE
C. M. Bohan, DOE-WVDP, AC-DOE
M. N. Maloney, DOE-WVDP, AC-DOE
File #60416

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 15, 2008

Mr. James Rispoli, Assistant Secretary
Office of Environmental Management
EM-1/Forrestal Building
U. S. Department of Energy
1000 Independence Ave., S.W.
Washington, D.C. 20585

SUBJECT: ACKNOWLEDGMENT OF AGENCY CONCURRENCE TO RELEASE THE *REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR DECOMMISSIONING AND/OR LONG-TERM STEWARDSHIP AT THE WEST VALLEY DEMONSTRATION PROJECT AND WESTERN NEW YORK NUCLEAR SERVICE CENTER* (DOE/EIS-0226-R) TO THE PUBLIC

Dear Mr. Rispoli:

The U.S. Department of Energy and the New York State Energy Research and Development Authority have been jointly preparing the *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE/EIS-0226-R) (EIS) for release to the public. As a cooperating agency on this EIS, the U.S. Nuclear Regulatory Commission (NRC) has participated in multi-agency concurrence meetings related to the development of the draft EIS for the West Valley project. Based on the agency's participation in this process, the NRC concurs in release of the draft EIS for public comment.

NRC appreciates the opportunity to be involved in this EIS, and reserves the right to further comment on the draft EIS during the public comment period. We look forward to working with you as you proceed toward a final EIS.

Sincerely,

Larry W. Camper, Director
Division of Waste Management
and Environmental Protection
Office of Federal and States Materials
and Environmental Management Programs

cc: See next page

cc:

C. M. Borgstrom, DOE-HQ, GC-20/FORS.
E. B. Cohen, DOE-HQ, GC-20/FORS.
B. M. Diamond, DOE-HQ, GC-51/FORS.
J. E. Loving, DOE-HQ, GC-20/FORS.
F. Marcinowski, DOE-HQ, EM-10/FORS.
B. C. Bower, DOE-WVDP, AC-DOE.
C. M. Bohan, DOE-WVDP, AC-DOE
M. N. Maloney, DOE-WVDP, AC-DOE
G. Baker, NYSDOH
P. Bembia, NYSERDA
P. Giardina, USEPA
E. Dassatti, NYSDEC
M. John, Seneca Nation of Indians

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

James Rispoli, Assistant Secretary
Office of Environmental Management
EM-1/Forrestal Building
U. S. Department of Energy
1000 Independence Ave., S.W.
Washington, D.C. 20585

SUBJECT: Acknowledgment of Agency Concurrence to Release the *Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE/EIS-0226-R) to the Public

Dear Mr. Rispoli:

The U. S. Department of Energy and the New York State Energy Research and Development Authority have been jointly preparing the revised *Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE/EIS-0226-R) (DEIS) for release to the public. As a cooperating agency on this DEIS, the U.S. Environmental Protection Agency (EPA) has reviewed the concurrence draft of this document. EPA concurs that the draft represents an adequate compilation of relevant information, has not ignored pertinent data, and that the information has been analyzed reasonably. Therefore, EPA recommends release of the revised DEIS for public review.

However, we want to point out that our participation as a cooperating agency and our recommendation to release the DEIS neither precludes our review under the National Environmental Policy Act nor negates our comment authority under Section 309 of the Clean Air Act.

EPA thanks you for the opportunity to be involved in the preparation of this DEIS. We look forward to working with you as you proceed toward a final EIS.

Sincerely yours,

John Filippelli

John Filippelli, Chief
Strategic Planning Multi-Media Programs Branch

New York State Department of Environmental Conservation
Division of Solid and Hazardous Materials, 9th Floor
625 Broadway, Albany, New York 12233-7250
Phone: (518) 402-8651 • **FAX:** (518) 402-9024
Website: www.dec.ny.gov

Alexander B. Grannis
Commissioner

OCT 14 2008

Mr. James Rispoli
Assistant Secretary, Office of Environmental Management
EM-1/Forrestal Building
U.S. Department of Energy
1000 Independence Ave., S.W.
Washington, D.C. 20585

Dear Mr. Rispoli:

RE: Concurrence Meeting Letter for the Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Services Center (DEIS)

At the end of August, the New York State Departments of Environmental Conservation and Health (the Departments) received your letter inviting their management and technical staff to the West Valley DEIS Concurrence Review Meeting at the U.S. Department of Energy (DOE) Headquarters in Washington, D.C., from October 6-10. While we regret that we were not able to physically attend the meeting, staff from the Departments did participate via teleconference.

The Departments have received and reviewed the proposed resolutions provided by DOE in response to comments made by the Departments during the "Fatal Flaw" review of the DEIS. Based on these responses and proposed resolutions, the Departments agree that the DEIS is acceptable for release to the public. This does not constitute the Departments' concurrence with the DEIS, but that it is sufficiently complete for release for public review and comment. As staffs have repeatedly stated, in person during Core Team meetings, in writing in our August 22 letter, and during our Concurrence meeting opening remarks, the full and detailed review of the DEIS by both Departments will take place during the public comment period.

If you have any questions, please do not hesitate to contact either Robert Phaneuf or Lynn Winterberger, of the New York State Department of Environmental Conservation (518-402-8594), or Gary Baker, of the New York State Department of Health (315-477-4884).

Sincerely,

Edwin Dassatti, P.E.
Director
Division of Solid and Hazardous Materials
New York State Department of
Environmental Conservation

for G. Anders Carlson, Ph.D.
Director
Division of Environmental Health Investigation
New York State Department of Health

cc: C. M. Borgstrom, DOE-HQ, GC-20/FORS
E. B. Cohen, DOE-HQ, GC-20/FORS
B. M. Diamond, DOE-HQ, GC-51/FORS
J. E. Loving, DOE-HQ, GC-20/FORS
F. Marcinowski, DOE-HQ, EM-10/FORS
B. C. Bower, DOE-WVDP, AC-DOE
C. M. Bohan, DOE-WVDP, AC-DOE
M. N. Maloney, DOE-WVDP, AC-DOE
V. Washington, NYSDEC Central Office
A. Crocker, NYSDEC Central Office
K. McConnell, NRC
P. Bembia, NYSERDA
J. Reidy, US EPA
P. Giardina, US EPA
S. Gavitt, NYSDOH
G. Baker, NYSDOH

APPENDIX R
CONTRACTOR DISCLOSURE STATEMENTS

NEPA DISCLOSURE STATEMENT FOR THE INTEGRATION AND EXECUTION OF THE WEST VALLEY ENVIRONMENTAL IMPACT STATEMENT AND DECOMMISSIONING PLAN

The Council on Environmental Quality (CEQ) Regulations at Title 40 of the *Code of Federal Regulations* (CFR) Section 1506.5(c), which have been adopted by the U.S. Department of Energy (10 CFR 1021), require contractors and subcontractors who will prepare an environmental impact statement to execute a disclosure specifying that they have no financial or other interest in the outcome of the project.

"Financial or other interest in the outcome of the project" is defined as any direct financial benefit such as a promise of future construction or design work in the project, as well as indirect financial benefits the contractor is aware of.

In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows, to the best of their actual knowledge as of the date set forth below:

(a) X Offeror and any proposed subcontractors have no financial or other interest in the outcome of the project.

(b) __ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract, or agree to the attached plan to mitigate, neutralize or avoid any such conflict of interest.

Financial or Other Interests

1.
2.
3.

Certified by:

Sandra L. Reid
Signature

Sandra L. Reid
Name

Senior Contracts Representative
Title

Science Applications International Corporation
Company

January 25, 2005
Date

ORGANIZATIONAL CONFLICT OF INTEREST

I. INSTRUCTIONS

Read Part II carefully. If a disclosure statement is required, complete Part III. If a representation is submitted, complete Part IV. Complete Part V in every case.

II. ORGANIZATIONAL CONFLICT OF INTEREST DISCLOSURE OR REPRESENTATION

It is Department of Energy (DOE) policy to avoid situations which place an offeror in a position where its judgment may be biased because of any past, present, or currently planned interest, financial or otherwise, the offerer may have which relates to the work performed pursuant to this solicitation or where the offerors performance of such work may provide it with an unfair competitive advantage. (As used herein, an offeror means the proposer or any of its affiliates or proposed consultants or subcontractors of any tier.)

Therefore:

(a) The offeror shall provide a statement which describes in a concise manner all relevant facts concerning any past, present or currently planned interest (financial, contractual, organizational, or otherwise) relating to the work to be performed hereunder and bearing on whether the offeror has a possible organizational conflict of interest with respect to (1) being able to render impartial, technically sound, and other objective assistance or advise, or (2) being given an unfair competitive advantage. The offeror may also provide relevant facts that show how possible organizational conflict of interest relating to other divisions or sections of the organizations and how that structure or system would avoid or mitigate such organizational conflict.

(b) In the absence of any relevant interest referred to above, the offeror shall submit a statement certifying that to its best knowledge and belief no such facts exist relevant to possible organizational conflicts of interest. Proposed consultants and subcontractors are responsible for submitting information and may submit it directly to the DOE Contract Representative.

(c) DOE will review the statement submitted and may require additional relevant information from the offeror. All such information, and any other relevant information will be used by DOE to determine whether an award to the offeror may create an organizational conflict of interest. If found to exist, DOE may direct the offeror to (1) impose appropriate conditions which avoid such conflict, (2) disqualify the offeror, or DOE may determine that it is otherwise in the best interest of the United States for DOE to contract with the offeror by including appropriate conditions mitigating such conflict in the contract awarded.

(d) The refusal to provide the disclosure or representation of any additional information as required shall result in disqualification of the offeror for award. The nondisclosure or misrepresentation of any relevant interest may also result in the disqualification of the offeror for award, or if such nondisclosure or misrepresentation is discovered after award, DOE may terminate the contract for default, recommend that the offeror be disqualified from subsequent related contracts, or be subject to such other remedial actions as may be permitted or provided by law. The attention of the offeror in complying with this provision is directed to 18 U.S.C. 1001 and 31 U.S.C. 3802(a)(2).

(e) Depending on the nature of the contract activities, the offeror may, because of possible organizational conflicts of interest, propose to exclude specific kinds of work from the statement, unless the solicitation specifically prohibits such exclusion. Any such proposed exclusion by an offeror shall be considered by DOE in the evaluation of proposals, and if DOE considers the proposed excluded work to be an essential or integral part of the required work, the proposal may be rejected as unacceptable.

(f) No award shall be made until the disclosure or representation has been evaluated by DOE. Failure to provide the disclosure or representation will be deemed to be a minor informality and the offeror or contractor shall be required to promptly correct the omission.

III. DISCLOSURE STATEMENT
(attach additional pages if more space is needed)

IV. REPRESENTATION

The offeror, Washington Safety Management Solutions LLC hereby represents that it is aware of no past, present, or currently planned interest (financial, contractual, organizational, or otherwise) relating to the work to be performed under the contract resulting from Request for Proposal No. 44001084I1 that would indicate any impingement upon its ability to render impartial, technically sound, and objective assistance or advice or result in it being given an unfair competitive advantage. This representation applies to all affiliates of the offeror and its proposed consultants or subcontractors of any tier.

V. SIGNATURE

Offeror's Name Washington Safety Management Solution LLC

RFP/Contract No. 44001084I1

Signature [signature]

Title Manager, Contracts and Procurement

Date 1/28/08

(e) Depending on the nature of the contract activities, the offeror may, because of possible organizational conflicts of interest, propose to exclude specific kinds of work from the statement, unless the solicitation specifically prohibits such exclusion. Any such proposed exclusion by an offeror shall be considered by DOE in the evaluation of proposals, and if DOE considers the proposed excluded work to be an essential or integral part of the required work, the proposal may be rejected as unacceptable.

(f) No award shall be made until the disclosure or representation has been evaluated by DOE. Failure to provide the disclosure or representation will be deemed to be a minor informality and the offeror or contractor shall be required to promptly correct the omission.

III. DISCLOSURE STATEMENT
(attach additional pages if more space is needed)

IV. REPRESENTATION

The offeror, Gregory E. Tucker, hereby represents that it is aware of no past, present or currently planned interest (financial, contractual, organizational, or otherwise) relating to the work to be performed under the contract resulting from the Department of Energy's December 3,2004 Request for Proposal titled "Integration and Execution of the Environmental Impact Statement and Decommissioning Plan Preparation Efforts". That would indicate any impingement upon its ability to render impartial, technically sound, and objective assistance or advice or result in it being given an unfair competitive advantage. This representation applies to all affiliates of the offeror and its proposed consultants or subcontractors of any tier.

V. SIGNATURE

Offeror's Name: Gregory E. Tucker

RFP/Contract: Department of Energy's December 3, 2004 Request for Proposal titled "Integration and Execution of the Environmental Impact Statement and Decommissioning Plan Preparation Efforts".

Signature: [signature]

Title: Consultant

Date: 10/23/08

DOE/EIS-0226-D (Revised)

http://www.wv.doe.gov